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European Union CO_2 emissions: different accounting perspectives

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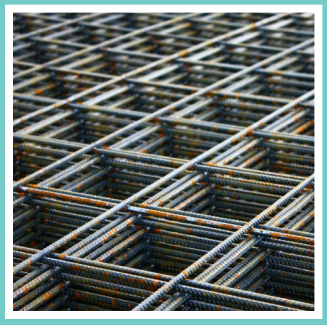

European Environment Agency

European Union CO_2 emissions: different accounting perspectives

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Executive summary

The aim of this technical report is to explain to a wider audience the concepts and methodologies behind different air emission accounting perspectives and the resulting emissions data at the EU level.

In brief, there are three of these different accounting perspectives: territorial, production and consumption.

Three perspectives on air emissions

The **territorial perspective** considers emissions that are released to the atmosphere from within a country's borders and from areas that are under a country's jurisdiction. This perspective is the only method accepted by international environmental law to account for a country's emissions and mitigation efforts. Territorial-emission datasets that focus on the physical location of emissions are also used as the basis for the atmospheric modelling of environmental impacts.

The **production perspective** considers those emissions from companies that have their economic interest within the economic territory of the country (known as being 'resident') irrespective of the geographic location where their activities take place. It also considers emissions from resident households in relation to their economic output (production), irrespective of the geographic location where these activities take place. The production perspective stems from the System of Environmental Economic Accounting (SEEA), and a legal basis for reporting of environmental economic accounts has recently been implemented in the EU.

The **consumption perspective** considers those emissions that result from the national consumption of goods and services within a country, irrespective of the geographic location where production of these goods and services result in emissions. The consumption perspective complements the territorial perspective and the production perspective by relating environmental impacts to demand for goods and services by citizens. The consumption-based perspective is not addressed in international conventions, although consumption emissions are embedded in the EU's policy framework on sustainable production and consumption, for example via product standards.

In order to reduce complexity and facilitate understanding of methodology, this report will only use these perspectives to look at CO_2 emissions in the EU-27.

Different data, different results

In principle these accounting perspectives provide a complementary source of information on air pollutants and greenhouse gases being released into the atmosphere. This information includes the amount and location of air pollutants and greenhouse gases as well as the economical, technical and societal drivers of these emissions.

However, before using these perspectives in a complementary manner, users should be aware of some issues. These three perspectives are all based on different datasets. These datasets use different 'system boundaries' (the type of information that is included) and calculation methods. They also vary in terms of the quality of data they use. These differences in underlying methods and input data affect the resulting emissions calculations. Some results therefore have a percentage of 'uncertainty' attached to them that reflects the gaps that exist in the data they are based upon. This in turn has an effect on how applicable some of the resulting data is to policymaking.

Consumption-based emissions calculations are especially vulnerable to this uncertainty because of the 'sequenced' nature of the accounting methods. This 'sequencing' means that territorial emissions are used as a basis for calculating production emissions, and production emissions are in turn used as an input to consumption-based emission calculations. Thus the quality of information (and degree of uncertainty) in the resulting consumption-based emission calculations is dependent on the quality of the territorial emissions and production emissions information. It is also dependent on the availability

of global data on the supply, use and trade of goods and services.

The absence of standardised calculation methods is a further weakness of consumption-based calculations. In contrast to territorial- and production-based methods, there are no standardised methods for calculating consumption-based emissions, and the choice of method will lead to different results in emission estimates. An important limitation to providing time-series of consumption emissions is the fact that statistical data on supply, use, and international trade are not updated frequently. This means that approximations have to be made to provide complete time series.

Another issue, which affects all three accounting methods, is the quality of information on non-OECD countries. The quality of emission information for non-OECD countries is rather uncertain, and this affects the quality of territorial and production emission inventories.

All these differences produce different final results. For example, based on available data, EU-27 emissions according to the consumption perspective appear to be higher than those calculated according to the production and territorial perspectives. Note should be taken on the uncertainty in the different datasets which means that these differences can be larger or smaller when more accurate data becomes available in the future.

Consumption perspective emissions show a trend of increasing emissions over time, whereas the production and territorial perspectives show a trend of reducing emissions. In spite of this difference in emission results, when it comes to considering the contribution of EU-27 emissions to global CO_2 emissions, all three accounting methods point toward a decreasing contribution over time.

Recommendations

This report makes the following recommendations to both the emission inventory community and statistical offices for improving the quality and applicability of consumption- and production emissions data:

- There is a need to improve non-OECD emissions datasets in particular so as to make available more complete and more frequently updated emissions data reflecting the national technology circumstances.
- In order to understand better the differences between territorial emissions and production emissions, a 'bridging table', which shows the adjustments for resident and non-resident units, covering the whole of the EU is needed.
- There is a need to develop and agree upon a standardised method for calculating consumption perspective emissions.
- There is a need to make available more up-to-date Environmentally Extended Input Output Tables (EE-IOT) and publish them more frequently requiring long-term funding.

1 Introduction

The term 'air emissions' refers to the release to the atmosphere of air pollutants and greenhouse gases due to both anthropogenic activities (e.g. fuel combustion) and natural processes (e.g. volcanoes). In order to understand and limit the harm that these emissions are doing to human health and the environment, information must cover the volume and location of these air emissions as well their economic, technical, and societal drivers. It can come from two principal sources: (i) quantification of the physical release of air emissions over a specific moment in time within a specific geographic area (a so-called 'emission inventory') and (ii) relating these emissions to socio-economic drivers and actors (known as 'environmental accounting' or 'emissions accounting').

This EEA technical report focuses on air emissions, and shows results for the EU as a whole. The concept of accounting for environmental pressures is not limited to air emissions and is applied to other environmental themes, such as waste, materials, water, and land use. It can also be applied to smaller units of analysis than an individual country, such as a company, a product or an individual (e.g. Stechemesser and Guenther, 2012).

Over time, there has been considerable change in the way in which emissions have been accounted for and in which emission inventories have been compiled. Since the 1970s, data for air emission inventories have been compiled in three different forms: as national annual emissions classed by polluting sector; as spatially-resolved data using 'sub-national' levels of resolution (i.e. using units of space smaller than individual countries); or as time-resolved data using 'sub-annual' data (i.e. with data provided for monthly, weekly or daily time units).

These different types of inventories helped to improve understanding of how the composition of the atmosphere could change, and how these changes would affect human health and the environment. These inventories were also useful in monitoring progress toward emission reduction targets, and helped to determine which emissions sources most needed to be reduced using measures such as environmental legislation. International treaties such as the UNFCCC (EEA, 2013a) or CLRTAP Convention (EEA, 2013b) have their own specific reporting obligations for air emissions. Under these treaties, air emissions are calculated using standardised methods and definitions on which emission-source categories are to be included.

Air emissions data to support climate modelling and local, regional and global air quality requires more detailed 'sub-national' information (for example emissions must be spatially allocated to an individual facility or along a particular highway) as well as 'sub-annual' information regarding the time during which the emissions are released (for example by allocating emissions to particular seasons or weekdays; see EMEP, 2011).

Emission inventory data can be supplemented with information on developments and trends in the national economy (e.g. average incomes, GDP, volume and value of exports, energy use. See Leontief, 1970; De Boo et al., 1993). The concept of combining environmental data and economic accounts is reflected in the UN Systems of Environmental Economic Accounting (SEEA, 2003, 2012) and the European Environmental Economic Accounts (see Regulation (EU) No 691/2011; Eurostat, 2009).These types of combined datasets can be used to understand the national economy as a driver of air emissions, and when combined with international trade data, provide insights on national consumption of goods and services as a driver of global emissions (e.g. Davis and Cadeira, 2009; Hertwich and Peters, 2009; Peters et al., 2012).

The emissions covered in inventories and accounts are based upon three different perspectives in terms of coverage and scope (Wilting and Vringer, 2009; Wiedman, 2010):

1. Emissions data compiled using a **territorial perspective** account for those emissions that occur within a country's borders or within the borders of a country's jurisdiction. Territorial emissions accounting is applied in emission inventories linked to international conventions such as the UNFCCC and CLRTAP Convention,

as well as in scientific inventories supporting the modelling of impacts of these emissions.

2. Emissions data compiled using a **production perspective** account for those emissions resulting from the economic activities of a country's resident companies and households in relation to their economic output (production) irrespective of the geographic location of where these activities take place. A resident company is one that has its economic interest within the economic territory of country for more than one year (Eurostat, 2009). In this perspective, a country is accountable for the emissions resulting from its national economy. Reporting of national production-based emissions to Eurostat is based on EU Regulation 691/2011 on European environmental economic accounts.

3. Emissions data compiled following the **consumption perspective** account for those emissions resulting from the national consumption of goods and services within a country, irrespective of the geographic location where production of these good and services results in emissions. In this perspective, a country is accountable for the emissions resulting from domestic final demand of goods and services. At present there is no EU regulation requiring the reporting of consumption-based emissions.

The concept of different accounting perspectives in relation to air emissions is not new. However, experience with these different perspectives — and even awareness that these different perspectives exist — differs amongst the EEA countries, partly due to differences in reporting obligations. In general, the use of the territorial perspective to compile emissions data seems to be widespread in environmental ministries, statistical offices, and the scientific community. Emissions data compiled from a production perspective is mainly used by statistical offices, whereas emissions data compiled from a consumption perspective is more commonly used in the scientific community. Consumption-perspective emissions data is used by only a limited number of statistical offices and environment ministries in EEA countries.

Therefore the aim of this technical report is to explain to a wider audience the concepts and methodologies behind different air emission accounting perspectives, and the resulting emissions data they produce at the EU level. For a number of reasons, this report focuses principally on emissions of CO_2. Not only is more information available on CO_2 emissions, but focusing on one compound also makes it easier to understand the differences between the different emission perspectives. Follow-up work could consider analysis of non-CO_2 air pollutant emissions.

This report is structured as follows:

Chapters 2, 3 and 4 are methodology chapters. They describe each of the three perspectives for compiling emissions data: the territorial, production and consumption perspective. These chapters also describe the background and methodologies used, as well as the emissions trends that result from them.

Chaper 5 explains the main differences between the territorial, production and consumption emission datasets. This chapter deals with conceptual differences, and the different ways the datasets cover the economy and environmental pressures. This chapter also compares the differences between the datasets in terms of the resulting emission information they produce.

Chapter 6 highlights important findings on how to use the information included in territorial-based, production-based, and consumption-based emission datasets. It also looks at the maturity of the methods and where they can complement each other in supporting policy.

Definitions, acronyms and terms used in this report are described in Annex 1. Classification schemes of economic activities and emission sources are described in Annex 2.

Note concerning data presented in this report

The EU data in this report represent data for the EU-27. On 1 July 2013, Croatia became the 28th Member State of the European Union. During the writing of this report, EU-28 information was not available.

2 Territorial emissions

2.1 Methodology

Emissions data compiled according to the **territorial perspective** account for those emissions that occur within a country's border or within the borders of a country's jurisdiction. Quantifying territorial emissions is known as 'emission inventorying', (Section 2.1.1), a process that also requires accounting for emissions according to 'system boundaries' defined by environmental legislation (Section 2.1.2).

2.1.1 Emission inventorying

There are a large number of different anthropogenic activities and natural processes that lead to the release of air pollutants (AP) and greenhouse gases (GHG) into the atmosphere. It is possible to quantify the amount that is actually released to the atmosphere by individual emission sources or groups of emission sources by using a variety of monitoring and calculation methodologies. Box 2.1 provides an overview of the different methods used to calculate emissions of air pollutants and greenhouse gases. Combining data from these different methods makes it possible to quantify the amount of emissions released to atmosphere within a specific geographic area over a specific period of time, an activity normally referred to as 'emission inventorying'.

Air emission inventories are compiled for various reasons. A general distinction can be made between three types of emission inventories. Firstly, there are those that support reporting obligations under international agreements and European legislation. Secondly, there are those that are used to assist assessment studies on drivers, trends, and projections of air emissions. Thirdly, there are emission inventories that support atmospheric chemistry modelling to calculate the environmental impacts that result from the release, dispersion, conversion and deposition of air emissions.

International treaties such as the UNFCCC (EEA, 2013a) or CLRTAP Convention (EEA, 2013b) have their own specific reporting obligations for air emissions. Under these treaties, national annual air emission inventories are calculated by standardised methods and definitions on which emission source categories are to be included. Emission inventories are calculated by a combination of emission factor calculations, monitored facility level data (e.g. large points sources, CLRTAP), and ETS facilities. In the case of road transport, road transport emission modelling is applied. Standardised methods for the UNFCCC and CLRTAP emission inventories are described in Box 2.2. Often the inventories calculated under UNFCCC and CLRTAP reporting obligations form the basis of the second type of use mentioned in the paragraph above (assessment studies on drivers, trends and projections) .

More detailed information is required for air emission inventories compiled for the third purpose, i.e. supporting local, regional, and global air quality and climate modelling studies. The information has to be more detailed in terms of sub-national information on the location of emissions (e.g. road transport emissions that are spatially allocated to highways, EMEP/EEA, 2013) as well as 'sub-annual' information detailing the moment air emissions are released into the atmosphere (e.g. temporal allocation to seasons, weekdays etc.). Sometimes, the UNFCCC and CLRTAP emission inventories are 'post-processed' to provide spatially-resolved and temporally-resolved inventory data for modelling. This post-processing can also include filling gaps on emissions and sectors not reported in official inventories (see for example work by the European Monitoring and Evaluation Programme EMEP, 2011).

2.1.2 System boundaries

Depending on the purpose of the territorial emissions accounting, the emission inventory data is further processed to take into account reporting obligations as part of environmental legislation or to account for rules that determine whether or not emission reduction targets (e.g. under the Kyoto Protocol) have been achieved. As a result,

Box 2.1 Monitoring and calculation methods for quantifying air emissions

Method	Description	Examples
Continuous emissions monitoring (CEM)	Continuous measurement of pollutant concentrations taken at the stack or vent outlet of an emitting facility. Measured pollutant concentrations are transferred into an emission value using flow meter data and volumetric gas flow rate of pollutant data.	Application by facilities reporting under Directive 2003/87/EC (Emissions Trading)
Source sampling	Same principle as CEM, however measurements are taken during a short time period, which represents specific emission process conditions. Results can be extrapolated to estimate longer-term emissions, assuming the same or similar emission process conditions apply. Source sampling often forms the basis for emission factor development.	Application by facilities reporting under Directive 2003/87/EC (Emissions Trading) On-board, laboratory and tunnel measurements of vehicle emissions
Mass balance approach	(i) Stock based: Calculation of the production-consumption-product loss chain of a specific emitting species. (ii) Process based: balancing the amount of material/energy through a full process cycle from input, transfer into end product, losses.	Montreal Protocol inventories Calculations of carbon stock changes in the land use change and forestry sector
Emissions modelling	Calculation of emissions using software tools including both linear and non-linear equations of activities and resulting emissions under different process conditions based on measured or empirical data.	Road transport models (e.g. COPERT) Evaporative losses from storage tanks (TANKS)
Technology-based emission factor calculations	Calculation of emissions by combining activity data ([a]) with an emission factor where both activity data and emission factor ([b]) represent detailed emission process conditions and abatement measures.	Greenhouse Gas and Air Pollution Interactions and Synergies — GAINS model Tier 2/3 methods in EEA/EMEP inventory guidebook
Implied emission factor calculations	Same principle as above, difference is that both activity data and emission factors represent standard/default conditions taken from guidance documentation.	Tier 1 methods in EEA/EMEP inventory guidebook
Extrapolation of existing data	Extrapolation of existing emissions data using statistical techniques or with proxy data such as population or energy consumption.	Gap-filling procedures in CLRTAP emission inventory

Note: ([a]) Amount of fuel or process input material consumed.
([b]) Amount of pollutant released during specific activity.

Source: EEA, 2009; US-EPA, 2006; EC, 2012; Environment Australia, 1999.

Box 2.2 Standardised methods for calculatign air emissions under CLRTAP and UNFCCC

Convention	Air emissions covered	Reporting guidelines and methodological support	Reporting formats and years covered
CLRTAP	**Main pollutants:** nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), sulphur oxides (SO_x), ammonia (NH_3), and carbon monoxide (CO). **Particulate matter (PM):** primary PM (consisting of fine particulate matter ($PM_{2.5}$) and coarse particulate matter (PM_{10})), and total suspended particulates (TSPs). **Priority heavy metals (HMs):** lead (Pb), cadmium (Cd), and mercury (Hg)); additional HMs (arsenic (As), chromium (Cr), copper (Cu), nickel (Ni), selenium (Se), and zinc (Zn). **Persistent organic pollutants (POPs):** polychlorinated dibenzodioxins/ dibenzofurans (PCDD/Fs), polycyclic aromatic hydrocarbons (PAHs), hexachlorobenzene (HCB), hexachlorocyclohexane (HCH), and polychlorinated biphenyls (PCBs).	Guidelines for reporting emission data under the Convention on Long-range Transboundary Air Pollution (UNECE, 2009). EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2013).	Annual and sector total emissions using NFR09 during the year before last (X-2). Total and aggregated sector emissions of NO_x, NMVOC, sulphur, NH_3, PM, CO, Pb, Cd, Hg, PCDD/Fs, PAHs, HCB, HCH, and PCBs, for the EMEP grid squares of 50 km × 50 km, and emissions from Large Point Sources (every fifth year).
UNFCCC	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). Carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOCs) .	UNFCCC guidelines for the preparation of national communications by parties included in Annex 1 to the Convention, Part 1: UNFCCC reporting guidelines on annual inventories. Revised IPCC 1996 guidelines for national greenhouse gas inventories. IPCC Good Practice Guidance and IPCC Good Practice Guidance for LULUCF. IPCC Good Practice Guidance and uncertainty management in national greenhouse gas inventories.	Annual and sector total emissions using CRF classification during the year before last (X-2).

Source: EEA, 2013a, 2013b.

the 'system boundaries' (which determine what types of emissions are accounted for) are different between territorial emission datasets. As a result, 'annual national total emissions' can have a different meaning in different territorial emission datasets.

International transport

Table 2.1 presents the difference in accounting for aviation and maritime transport in national total emissions under CLRTAP, UNFCCC, and the Kyoto Protocol. In aviation, under the UNFCCC and Kyoto Protocol, all domestic flights are accounted for in the national total reported emissions, whereas under the CLRTAP, the landing and take-off cycle emissions of both domestic and international flights are accounted for. The emissions that are not accounted for in the national total are often calculated and reported as memo items in the national UNFCCC and CLRTAP inventories. Variations also exist in the case of maritime transport: CLRTAP national total

Table 2.1 Different accounting for aviation and maritime transport emissions under the territorial perspective

	CLRTAP	UNFCCC	Kyoto Protocol
Domestic aviation (landing and take-off phases)	•	•	•
Domestic aviation (cruise phase)	memo	•	•
International aviation (landing and take-off phases)	•	memo	-
International aviation (cruise phase)	memo	memo	-
Domestic inland shipping	•	•	•
International inland shipping	•	memo	-
International maritime shipping	memo	memo	-

Note: Items marked as dot are included in national total reported emissions under different legislative requirements.

emissions include both domestic and international shipping over inland waters, whereas the UNFCCC only includes emissions from domestic shipping.

Road transport emissions are another cause of difference in emissions reporting. Under the CLRTAP, some EU Member States report emissions based on fuel used or kilometres driven in the geographic area, and in so doing they exclude part of the emissions that would be included if fuel sales were used in the emission calculation (see EEA, 2013b).

Geographic coverage

International environmental agreements often require official emission inventories to account for emission processes taking place within the territorial borders of country or within its territorial jurisdiction. However, there are differences in the way these borders are defined by international conventions, such as the UNFCCC/Kyoto Protocol, CLRTAP, and EU legislation (e.g. NEC, EU-MMR). These differences can be caused by territorial borders that fall outside the domain of the legislation (as is the case with the CLRTAP), the inclusion of overseas territories, and (in the case of the EU) which countries were part of the EU when countries or the EU signed up to conventions (for example, the EU-15 is a party to the Kyoto Protocol, but the EU expanded after the Protocol was signed, so these new EU members have different obligations under the Kyoto Protocol than older EU Member States). This is shown in Table. 2.2.

In addition, the Kyoto Protocol permits emission reductions under the so-called flexible mechanisms (such as international emissions trading, joint implementation mechanisms and clean development mechanisms) to be accounted for under national total emissions. This means that emission reductions from outside the national territory are included in emissions totals. For further details regarding the Kyoto Protocol emission calculations, see EEA (2013c).

Table 2.2 Territorial borders as defined under international and EU legislation requiring the reporting of greenhouse gases and air pollutants presented the EU and a selection of EU Member States (status 1 August 2013)

Country	Agreements regulating greenhouse gases			Agreements regulating air pollutants		
Reporting under:	UNFCCC	Kyoto Protocol	Monitoring Mechanism Regulation (EU MMR)	LRTAP	Gothenburg Protocol	National Emission Ceiling Directive
EU	EU-27/EU-15	EU-15	EU-28			
Denmark	DK, GL, FO	DK, GL	DK	DK, GL ([a]), FO ([a])	DK	DK
United Kingdom	UK, GI, GG, JE, KY, FK, BM, MS	UK, GI, GG, JE, KY, FK, BM, MS	UK, GI	UK, GI	UK, GI	UK, GI

Notes: DK (Denmark without Greenland or the Faroes), GL (Greenland), Faroe Islands (FO), UK (United Kingdom consisting only of England, Northern Ireland, Scotland and Wales), GI (Gibraltar), GG (Guernsey), JE (Jersey), IM (Isle of Man), KY (Cayman Islands), FK (Falkland Islands), BM (Bermuda), MS (Montserrat).

([a]) Only when it concerns aviation and maritime transport.

Biomass
Under the UNFCCC, countries are obliged to account for biomass CO_2 as part of reporting on their national total emissions. Nevertheless, territorial inventories often exclude CO_2 emissions from biomass (e.g. wood and wood waste) from the national total, although the emissions are reported as memo items. Territorial inventories calculate the amount of CO_2 emissions/uptake from biomass decrease and carbon storage in biomass as an effect of land use change or change of carbon storage in soil. Therefore, different total emissions data are provided in EU official national inventories depending on whether the data includes or excludes LULUCF (land use, land-use change and forestry. see Figure 2.1).

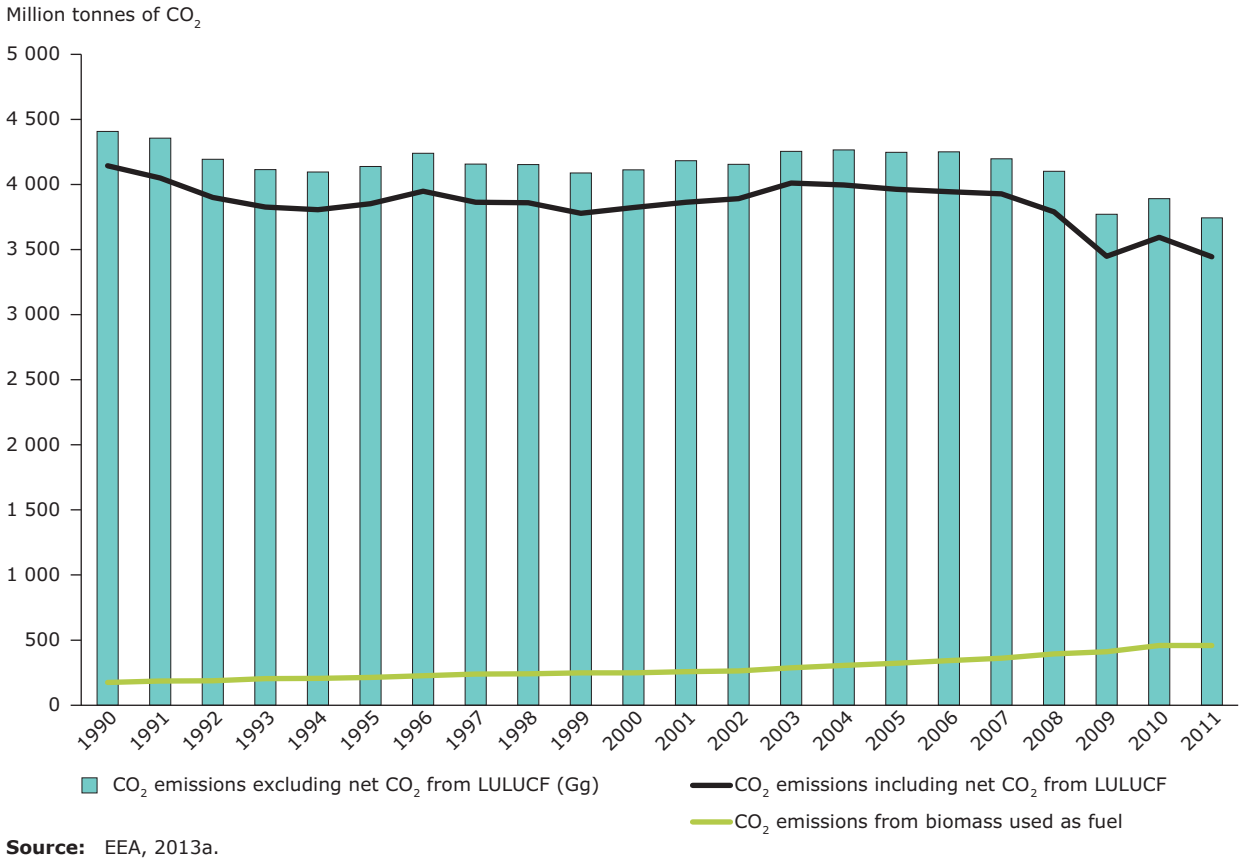
2.2 European territorial emissions datasets

2.2.1 Overview of European territorial emissions data and their applications

Table 2.3 presents a selection of European datasets — with information at the national level — that are part of reporting obligations under international agreements and EU legislation. Most of these datasets are updated annually and are compiled by the EEA with the support of Member States and the European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM). The table provides a description of the type of information that is included as well as a short description of the methodology.

In addition to territorial emission inventories complied in relation to reporting obligations, other territorial emissions are being developed to support policymaking and atmospheric modelling. These are presented in Table 2.4 and comprise datasets that include or complement the official (e.g. UNFCCC/CLRTAP) emissions data. This complementing can include providing information for countries where official (recent) inventories are incomplete (a service carried out by the Emission Database for Global Atmospheric Research — EDGAR) or spatial and temporal allocation of official emissions to assist in atmospheric chemistry modelling (as is done by the European Monitoring and Evaluation Programme — EMEP). There are other methods of complementing existing inventories. These other methods involve

Figure 2.1 Annual EU-27 CO_2 emissions between 1990–2011 from a territorial perspective



Source: EEA, 2013a.

Table 2.3 Selection of territorial emissions data covering the EU, its Member States, and EEA member countries

Application	Description	Methodology
EU CLRTAP inventory	Emissions of air pollutants, aerosols, heavy metals, and persistent organic pollutants for the EU as group and the individual EEA member countries — as reported to CLRTAP and its protocols (EEA, 2013b).	Emission inventory focusing on territorial emissions prepared according to the Guidelines for reporting emissions data (ECE/EB.AIR/97). Inventory data is a combination of emission factor calculations and facility-level-monitored or facility-level-calculated emissions data. The EEA applies a 'gap-filling' procedure to some Member States' incomplete inventories to provide a complete EU-27 inventory.
Air pollutants reported under the NEC Directive	Emissions of NO_x, NMVOCs, SO_2 and NH_3 as reported under the Directive 2001/81/EC by EU Member States (EEA, 2013d) and available via the EEA AP data viewer.	Emission inventory and projections focusing on territorial emissions of the EU-27 and its Member States using the methodologies agreed upon by the CLRTAP. Often the combination of emission factor calculations and facility-level-monitored or facility-level-calculated emissions data.
Greenhouse gases reported to the UNFCCC	Emissions of CO_2, CH_4, N_2O, PFCs, HFCs and SF_6 as reported to the United Nations Framework Convention on Climate Change (UNFCCC; EEA, 2013a) and available via the EEA GHG data viewer. Also includes information on emissions of CO, NO_x, NMVOCs and SO_2.	The EU as a group (and the individual EEA member countries) report emissions annually following the 'UNFCCC guidelines on reporting and review' (Document FCCC/CP/2002/8). Inventories prepared for the UNFCCC are often the combination of emission factor calculations and facility-level-monitored or facility-level-calculated emissions data. Within the EU, the legal basis for the compilation of the national inventory and the EU inventory is Regulation (EU) 525/2013.
Ozone depleting substances	Data on the production and consumption of Ozone Depleting Substances (EEA, 2012a).	The EU-27 as a group (and the individual EEA member countries) report data using methods and definitions set out in the 'Handbook on Data Reporting under the Montreal Protocol' (UNEP, 1999). The EEA prepares the EU Ozone Depleting Substances submission for official reporting to UNEP.

the provision of an independent calculation of emissions using standardised methods based on — for example — international energy statistics (as is for example done by the IEA, and the Carbon Dioxide Information Analysis Center — CDIAC).

2.2.2 *EU CO_2 emissions from a territorial perspective*

This section used European CO_2 emissions from the territorial perspective in order to highlight European annual total emission trends (Figure 2.1), show the importance of emission source categories (Figure 2.2), and put European emissions in a global context. These figures are based on the EU's UNFCCC inventory (EEA, 2013a), and global emissions data are taken from the EDGAR project (PBL/JRC, 2012). At present, territorial emissions data is available for the period 1990–2011.

EU-27 territorial emissions, excluding emissions from LULUCF, amount to 3 743 million tonnes of CO_2 in the year 2011, which is a 15 % reduction compared to 1990 emissions. When including the impact of LULUCF the EU-27 emissions are slightly lower with 3 445 million tonnes of CO_2. Emissions of CO_2 from biomass as fuel (excluded from annual total emissions, see Section 2.1.2) range from 175 to 458 million tonnes of CO_2 between 1990 and 2011. The emissions data show a small interannual variability (EEA, 2013a).

Contribution of main sectors to CO_2 emissions total

Another area of interest for policymaking is the contribution of various emission source categories and economic sectors to annual and multi-annual emissions. Knowing more about the level of these contributions can highlight where emission reductions have been very effective and where further emission reductions could be considered to make policy more effective. The contribution of emission source categories is shown in Figure 2.2, which shows that electricity/heat production and transport are the largest sources of CO_2 in Europe,

Table 2.4 Selection of regional and global territorial-emission datasets

Dataset	Description	Methodology
EMEP emission inventory	Air pollutant emission inventory as used by the European Monitoring and Evaluation Programme (EMEP) to calculate dispersion and deposition of acidifying and eutrophying compounds, ground level ozone, particulate matter (MSC-W models), and heavy metals and persistent organic pollutants (MSC-E models). EMEP, 2011.	Complement reported CLRTAP emission inventory data to support atmospheric chemistry modelling through spatial and temporal allocation, as well as through gap-filling of CLRTAP inventory data.
GAINS	Air pollutant and greenhouse gas projection data covering Europe and other parts of the world. The GAINS model links driving forces of atmospheric pollution to environmental impacts in order to develop cost-effective emission-control strategies to support — for example — the revision of the Gothenburg Protocol. Amann et al., 2011.	Complement emissions data of European countries. Emission inventory calculation taking into account implemented and scheduled environmental policies. In most cases, the GAINS model reproduces officially reported historical data, and in some cases inconsistencies/errors are found. To some extent GAINS therefore provides an alternative emission estimate.
EDGAR	High-spatial-resolution global-emission dataset for air pollutants and greenhouse gases for the period 1970–2008. EDGAR supports regional and global atmospheric chemistry modelling and provides a consistent global reference dataset for policy purposes. http://edgar.jrc.it.	Complement emissions data of European countries by providing consistent estimates for all countries at the global level. Emission calculation based on activity data derived from international activity datasets and the combination of default and country-specific emission factors. EDGAR supports atmospheric chemistry modelling through spatial and temporal allocation of emissions of official and EDGAR calculations (e.g. EDGAR-HTAP).
International Energy Agency (IEA)	Global emission inventory of CO_2 territorial emissions from fuel combustion in the period 1971–2011. Used as reference dataset by policymakers to evaluate official national inventories or to provide emission information in situations where no official inventory data are available. IEA, 2012.	Alternative calculation of carbon dioxide emissions from fossil fuel combustion for EEA member countries. IEA energy data statistics are combined with default methods and emission factors from IPCC Guidelines. One dataset is based on fuel supply data (the so-called 'reference approach') and another uses detailed, sector fuel-use data (the so-called 'sectoral approach').
Monitoring Atmospheric Composition and Climate (MACC)	High-spatial-resolution regional-emission inventory for Europe for the years 2003–2007, supporting air quality forecasting modelling and re-analysis of air quality in the MACC project. Keunen et al., 2011.	Includes official reported greenhouse gas and air pollutant data from CLTRAP and UNFCCC inventories covering the years 2003–2007. Complement CLRTAP and UNFCCC data for those countries/sectors where data gaps were identified with data from the GAINS model for the years 2000, 2005 and 2010. The methodology also applies linear extrapolation to simulate interannual variability of emissions (in particular of selected non-EU EMEP domain countries). Country emissions have been allocated to detailed spatial and temporal resolutions.

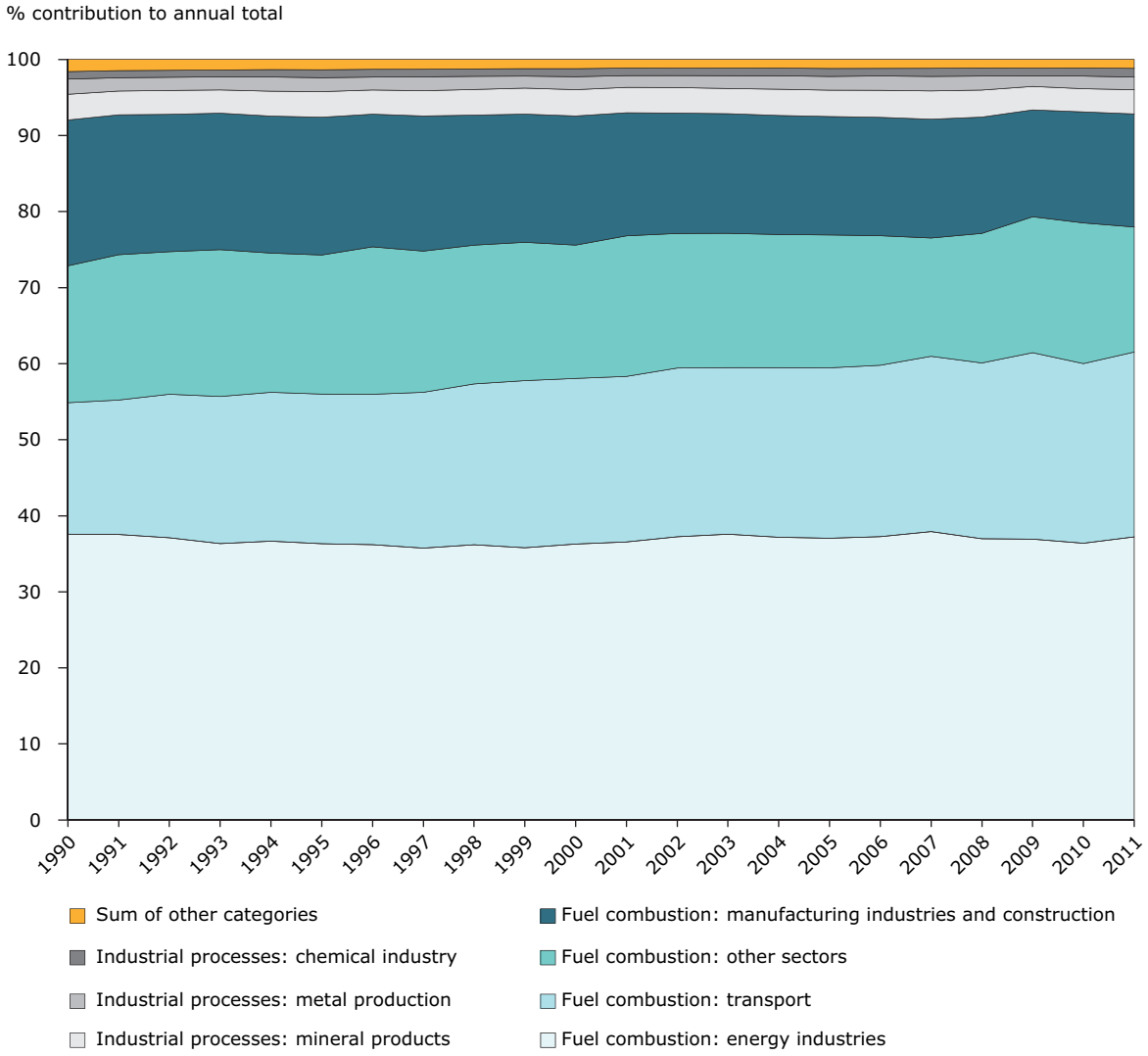
together accounting for more than 50 % of total emissions. Whereas emissions from fuel combustion in the energy industries have reduced slightly over time, emissions from transport show a large increase in emissions.

European emissions in a global context

It is also useful to not only have an insight on global greenhouse gas emission trends but also to understand the drivers of these trends, and to understand the impact that European emissions have on global greenhouse gas emissions.

Figure 2.3 presents the CO_2 emissions of the European Union (EEA, 2013a) together with those from China, Japan, India, the Russian Federation, and the USA, along with the sum of international emissions from 'bunker fuels' (fuels used by international aviation and shipping) taken from PBL/JRC (2012). Other countries that are not specified by name are grouped under a separate heading. Global CO_2 emissions increased from 23 billion tonnes to 34 billion tonnes in the period 1990–2011. The contribution of European Union (EU-27) CO_2 emissions to global CO_2 emissions has decreased over time from 20 % in 1990 to 11 % in

Figure 2.2 Contribution by emission source categories to annual EU-27 CO_2 emissions using a territorial perspective



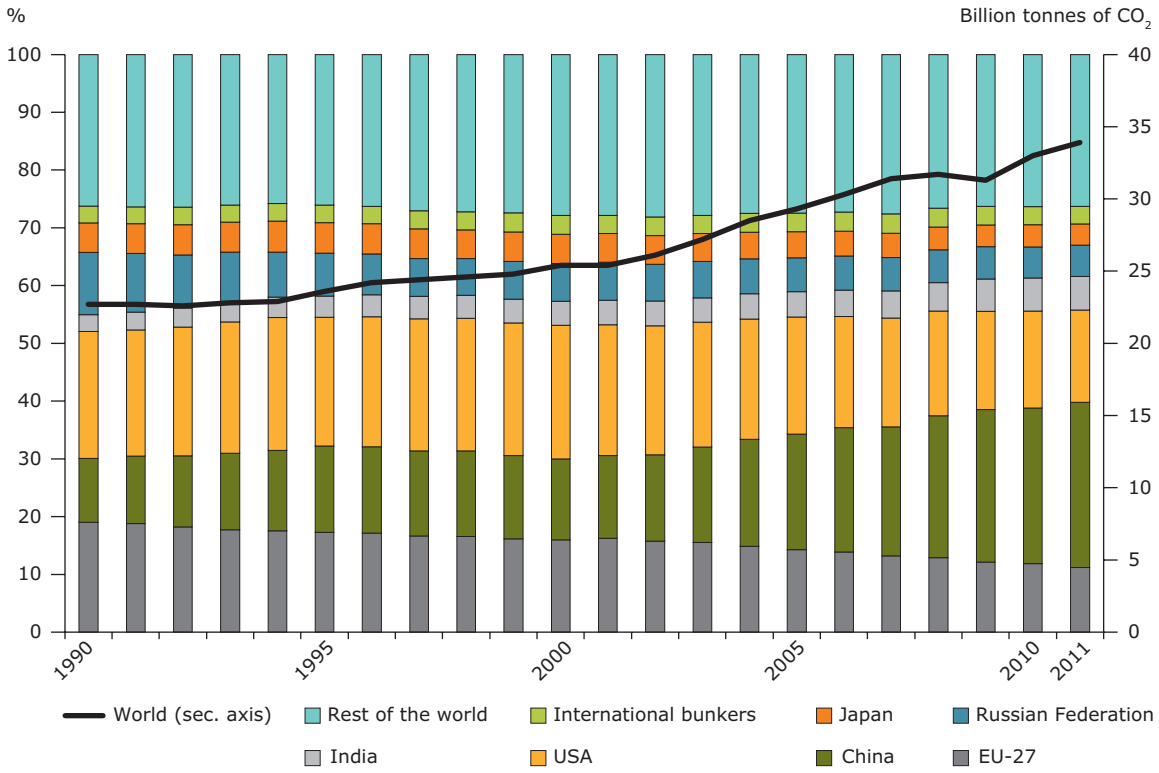
Source: EEA, 2013a.

2011. The trend of two other major CO_2-emitting countries shows that the relative contribution of USA emissions is decreasing over time, whereas the contribution from China is increasing.

Difference between territorial datasets on EU-27 CO_2 emissions

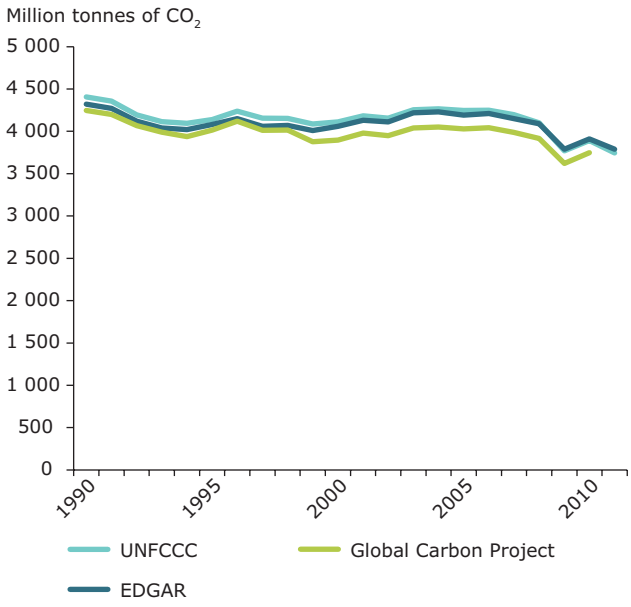
Due to the difference in source categories included, methodologies applied, and access to detailed country-specific information (e.g. installed control measures, detailed vehicle data) differences are to be expected between UNFCCC emission inventories, CLRTAP emission inventories, and scientific emission inventories (such as those compiled by PBL/JRC, 2012). For CO_2 emissions, a detailed analysis has been performed by Andres et al. (2012), who concluded that the uncertainty of global CO_2 emissions from fossil fuel combustion is within 10 %, and that for some countries (especially those where unreliable statistics on fuel consumption and fuel quality are available) uncertainty can be more than 50 %. Emission inventories covering the EU-27 show rather similar emission trends over time (Figure 2.4) with differences of between 4 % and 5 %.

Figure 2.3 Percentage contribution of world regions to annual global CO_2 emissions and global CO_2 emissions in billion tonnes of CO_2 according to the territorial perspective



Source: EU-27: EEA, 2013a; other countries: PBL/JRC, 2012.

Figure 2.4 CO_2 emission in the EU-27 according to different emission inventories



Source: UNFCC: EEA, 2013a; EDGAR: PBL/JRC, 2012; Global Carbon Project (based on CDIAC data): Peters et al., 2012.

3 Production emissions

Air emissions data compiled using a **production perspective** account for those emissions that result from the economic activities of a country's resident companies and private households (together known as 'resident units') in relation to their economic output (production) irrespective of the geographic location of where these activities take place. In simple terms, all economic activities by resident units with a given country, including its exports, fall within this emissions approach. A 'resident company' is defined as one that has its economic interest within the economic territory of country for more than one year (Eurostat, 2009).

The concept of production-based emissions accounting stems from the System of Environmental-Economic Accounting (SEEA), which sets out the framework for the production of 'physical flow' accounts (SEEA, 2003, 2012). In Europe, the framework of SEEA is implemented via the European Statistical System, i.e. the community of national statistical institutes coordinated by Eurostat. Regulation (EU) No 691/2011 (EU, 2011) established the legal basis for European environmental economic accounts. Currently, SEEA comprises three modules, one of which is the Air Emissions Accounts ([1]).

3.1 Methodology

3.1.1 Inventory-first approach

The compilation of Air Emissions Accounts is often based on territorial emission inventories — the so-called 'inventory-first' approach (Eurostat, 2013). In this approach, the territorial emissions have to be allocated to economic activities by resident units as delineated in economic national accounts. An alternative approach is the 'energy-first' approach (Eurostat, 2013) where — as is the case with emission inventory calculations — energy statistics are organised by resident unit activities combined with emission factors. The focus in this report is on the inventory-first approach, which is a standardised method used by many Member States and by Eurostat.

The compilation of production emissions following the inventory-first approach requires two types of actions (i) allocation of territorial emissions to economic activities and (ii) adjustment of territorial emissions to account for direct ([2]) emissions of resident and non-resident units. These two processes are described in greater detail in the paragraphs below.

(i) **Allocation of territorial emissions to economic activities:** As described in Chapter 2, territorial emissions datasets prepared by countries following environmental legislation present emissions that are classified according to standardised emission-source categories (CRF). The CRF classification is in several instances different from the economic activities as defined in the economic accounting frameworks. These frameworks use the National Accounts Classification of Economic activities (NACE) for production activities and the Classification of Individual Consumption According to Purpose (COICOP) for household consumption activities. As a result the first action in compiling a production-based emissions dataset requires the allocation of territorial emissions to NACE categories. An example of this is provided in Box 3.1. Allocating territorial emissions to NACE categories in this way requires a good understanding of the links between Common Reporting Format (CRF) and NACE and other classification schemes. Annex 2 provides an overview of the different classification schemes and the links between them.

([1]) Regulation (EU) No 691/2011 covers at present the three modules: air emissions accounts, environmental taxes and material flow accounts. Three further modules will be added in the near future: environmental protection expenditure, environmental goods and services sector and energy accounts.

([2]) This means removing from the data emissions that occur in a country, but which are the result of non-resident activities.

Box 3.1 On the allocation of territorial emissions to economic sectors to calculate production-based emissions

Under the 'inventory-first' approach, Air Emissions Accounts are compiled by assigning NFR/CRF source categories used in the CLRTAP and UNFCCC inventories to the two standard economic classifications. These two classifications are NACE, as used in Air Emission Accounts for production activities, and COICOP for household consumption activities.

The allocation depends to a considerable extent on the structure of the economic accounts. In particular, compilers of the Air Emissions Accounts consider whether an activity is:

- the **principal** activity of companies, i.e. the value added by that activity is greater than the value added by other activities that are also carried out by the company;
- a **secondary** activity of companies carried out in addition to the principal activity;
- or an **ancillary** activity not undertaken for its own sake but purely in order to provide supporting services for principal or secondary activities.

For example, the dairy industry produces a range of dairy products (e.g. milk, cheese, yoghurt) as its primary activity. Companies may also produce heat and electricity in a combined heat and power plant (as autoproducers), part of which is sold externally. The production of electricity for sale would in this case be a secondary activity. Finally, the companies transport the dairy products in lorries to their customers: this is an ancillary activity. Emissions from the primary and ancillary activities are allocated to the dairy industry. The emissions associated with the electricity sold might be allocated to the dairy industry or to the electricity supply industry depending on the structure of the economic accounts.

Road transport emissions are treated differently in Air Emissions Accounts. It is necessary to allocate the transport emissions to the economic activity (resident unit) actually undertaking it:

- the land transport industries, for which the transport of passengers and freight is the principal activity (e.g. bus companies, freight transport agencies);
- companies for whom transport is a secondary activity e.g. buses that also deliver post;
- companies for whom road transport is an ancillary activity required for example to deliver products;
- private households e.g. private car driving.

Source: ESTAT, 2009, 2013; and ETC/ACM, 2010.

(ii) **adjustment of territorial emissions to account for difference between resident and non-resident activities:** The next step requires the adjustment of territorial emissions for resident unit activities outside the country, and the activities of non-resident units within the country. This mainly concerns land, water and air transport as well as fishing ([3]). The adjustment is also known as 'bridging' and consists of the following steps to calculate the production emissions for a given country (Eurostat, 2013):

Production emissions (resident units) in country x
= territorial emissions (according to UNFCCC/ CLRTAP)
+ emissions from resident units abroad
– emissions from non-residents within country x

([3]) The following activities could also be taken into account: embassies, transportation of liquids and gases in pipelines, military bases in other countries (Eurostat, 2013), or heating of secondary homes or campfires abroad (comment received during Eionet review).

Territorial emissions information is taken from the UNFCCC for greenhouse gas emissions or from CLRTAP for air pollutants. For countries with resident activities for which no territorial emission inventory is available, the assumption is made that economic activities in foreign countries take place using the same technologies as applied domestically. This assumption is known as the Domestic Technology Assumption. For example, the Domestic Technology Assumption assumed that if a resident unit from country x is driving a car in country y, the amount of emissions per unit of fuel consumed driving is assumed to be the same. Due to incomplete reporting by EU Member States, a bridging table (which explains the differences between production perspective and territorial perspective datasets) is not available for the aggregated EU-27.

3.1.2 System boundaries

The production perspective focuses on the economic borders of a national economy (including economic actors operating abroad) and not on the national geographic/jurisdiction border as in the territorial perspective. The production perspective therefore excludes several emission categories that are sometimes included in terrestrial emission datasets. These categories are:

- emissions from non-residents, e.g. transport by foreign lorries or tourists within the territory;
- natural emissions (in comparison to CLRTAP inventories);
- accidents such as human-induced forest fires;
- emissions from land use change and forestry ([4]).

For the same reason, some emission source categories that are normally excluded from territorial emission accounting — or reported as memo items but not counted into the national total emissions — are included in the production accounts totals. These categories are:

- residents driving abroad (e.g. tourism, excluded in territorial accounting);
- international shipping and aviation operated by resident units (see Table 2.1);
- emissions of CO_2 from biomass used as fuel ([5]) (included as a memo item in UNFCCC emission inventories datasets, but excluded from total CO_2 emissions).

3.2 European production emissions datasets

3.2.1 Overview of European production emissions data and their applications

Table 3.1 presents datasets that provide air emissions data from a production perspective for the EU and its Member States. In comparison to territorial datasets (Tables 2.3 and 2.4) the number of European datasets from a production perspective is smaller. Official country data from a production perspective is reported as Air Emissions Accounts, and there are two research projects with a global focus (WIOD, Global Carbon Project) providing production-based emission inventories for EU Member States (the WIOD data is based on Air Emissions Accounts data).

The production perspective and available datasets help to give a better understanding of the economic drivers of air emissions. For example it allows scientists and policymakers to identify which parts of domestic production and household activities (both in the individual Member States and in the EU as a whole) are important drivers of air emissions (EEA, 2013d; Arto et al., 2012). The production perspective can provide insights into (i) the share of emissions associated with each industry; (ii) the quantity of emissions per unit of production output for specific industries, or for the economy as a whole; and (iii) the quantity of emissions per unit of gross value added for specific industries or for the economy as a whole.

([4]) There are a number of activities within the 'land-use change and forestry' category that can be considered economic activities in the strict sense. These include amongst others: emissions of NMVOCs from trees in managed forests, emissions or removals of N_2O or CH_4 from the soil of managed forests, changes in forests and other woody biomass stocks. Eurostat (2009) states that currently these emissions are excluded from the Air Emission Accounts due to difficulties in calculation.

([5]) The Eurostat air emission accounts by industry and households (env_ac_ainah_r1) do not include emissions of CO_2 from biomass combustion for the EU-27 due to data not being available.

Table 3.1 Production emissions datasets covering the EU

Dataset	Description	Methodology
Air emissions accounts	Emissions of greenhouse gases (CO_2, CH_4, N_2O, PFCs, HFCs and SF_6) and air pollutants (NO_X, NMVOCs, CO, PM_{10}, $PM_{2.5}$, SO_2 and NH_3) by economic activities (production perspective) (Eurostat, 2013).	Regulation No. 691/2011 on European Environmental Economic Accounts forms the legal basis for Air Emissions Accounts (Annex 1) according to which EU Member States are obliged to report data on an annual basis (entering into force in 2013). Two data sets are available at Eurostat: 1) 1995–2008: broken down by NACE rev.1.1 2) 2008–2010: broken down by NACE rev.2 The on-going 2013 survey collects data ranging from 1995 to 2012 (NACE rev.2).
Global Carbon project	Project aimed at understanding changes in observed CO_2 concentrations in relation to emissions and sinks (Quéré et al., 2013). Includes production/consumption emissions data as described in Andrew and Peters (2013).	Calculation of carbon dioxide emissions from a production perspective combining CDIAC emissions data with trade data.
WIOD	World Input-Output Databases (WIOD) provides trade and emission statistics for 41 countries and 37 economic sectors for the years 1995–2009. (Arto et al., 2012; Boitier, 2012).	Calculation of emissions according to both the production perspective and consumption perspective. Production emissions based on method for Environmental Accounts complemented with World Input-Output Database tables to provide a consumption perspective.

3.2.2 EU CO_2 emissions from a production perspective

This section shows European CO_2 emissions from a production perspective in order to highlight European annual total emission trends (Figure 3.1); the contribution different production activities to household activities' ([6]) CO_2 emissions (Figure 3.2); and European emissions in a global context (Figure 3.3). These figures are based upon data from the WIOD project (Arto et al., 2012).

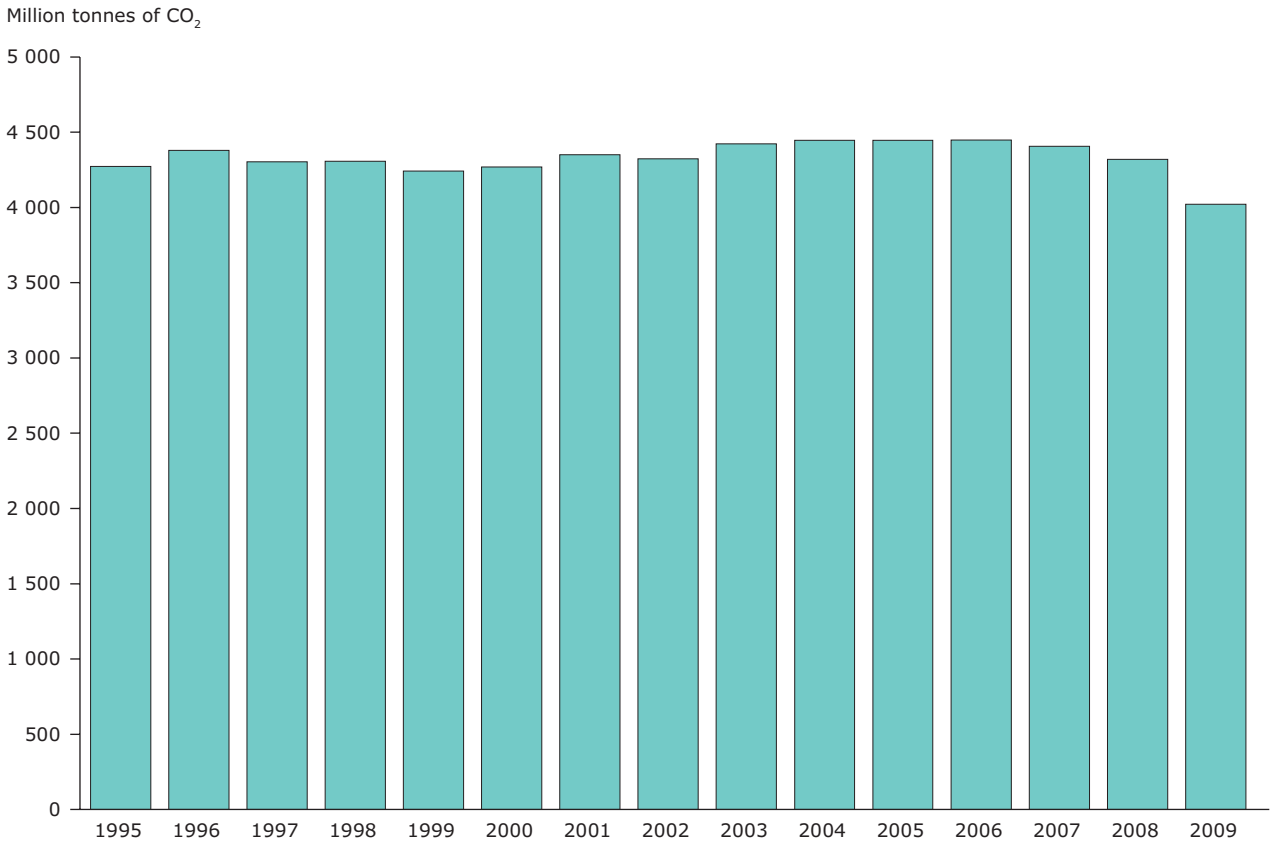
In the EU, most Member States report Air Emissions Accounts, and these CO_2 emissions are included in the WIOD project data, which provides a global database of emissions from both a production and consumption perspective. At present, production-perspective emissions data are available for the period 1995–2009.

EU-27 production emissions amounted to slightly more than 4 000 million tonnes of CO_2 in 2009, which is a 5 % reduction compared to 1995 (Figure 3.1). The emissions show a small interannual variability, which increases later in the times series at the start of the economic downturn in the period 2008–2009.

Figure 3.2 shows the contribution made by different production activities to total annual CO_2 emissions. The WIOD project presents the different economic activities as aggregated NACE categories (See Annex 2). The largest contribution to EU CO_2 emissions from a production perspective comes from the category 'electricity, gas and water supply' (31 %), followed by emissions from households (21 %). Other large production activities are 'inland, air and water transport' and 'production of minerals, metals and fuel'. Some of these production activities show a rather large increase over the period 1995–2009. For example, air transport emissions doubled and both land and water transport increased by 30 % over the period. Activities that show a reduction in CO_2 emissions compared to 1995 are the production of basic metals and fabricated metal (down by 36 %) and

([6]) Although household activities may be commonly believed to fall under the heading of 'consumption', many household activities, such as driving a car, are treated as production activities for statistical purposes.

Figure 3.1 Annual EU-27 CO_2 emissions between 1995 and 2009 from a production perspective



Source: WIOD project: Arto et al., 2012 and Boitier et al., 2012.

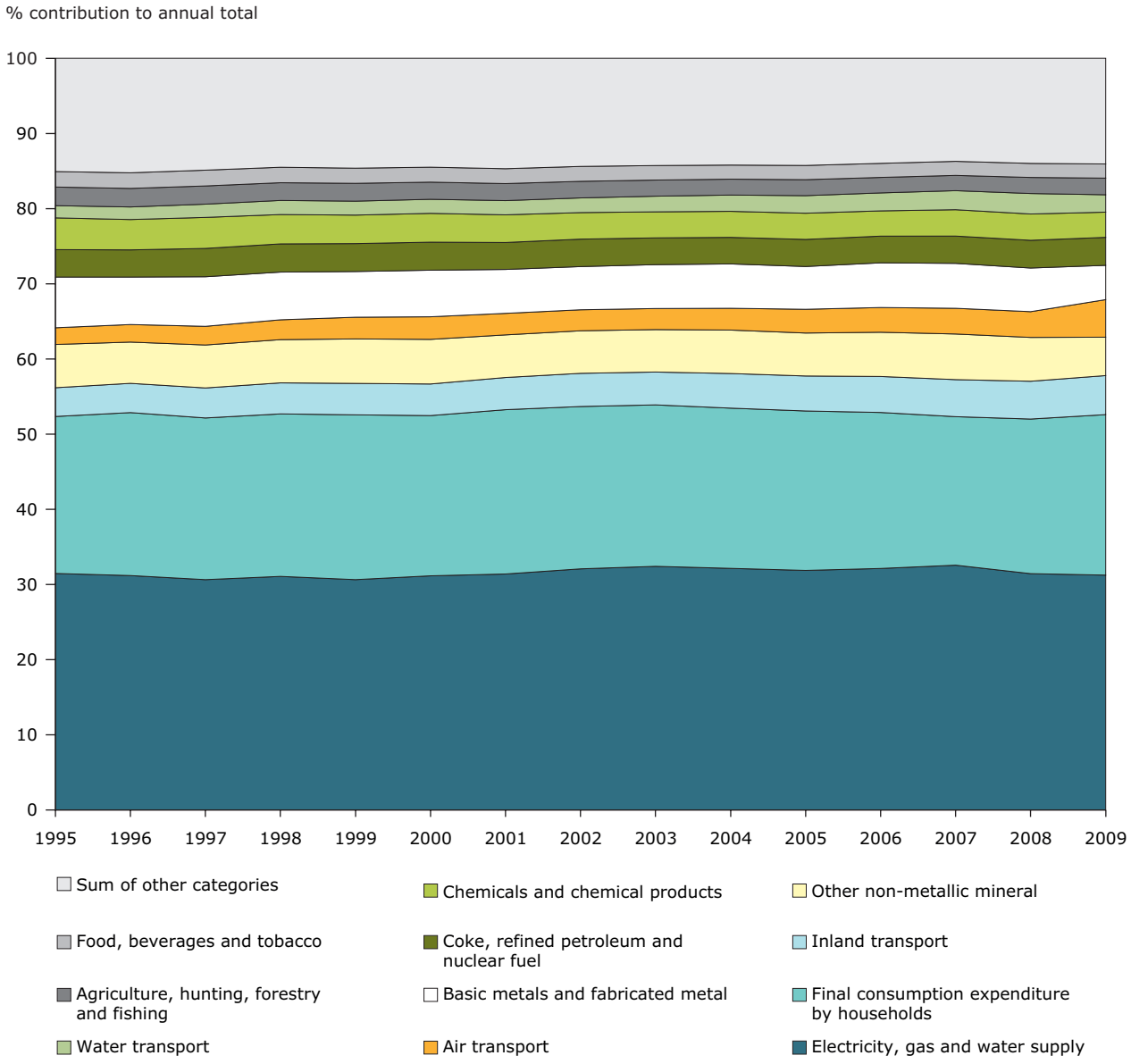
production of chemicals and chemical products (down 25 %). It should be noted that such emission trends reflect both the economic development of the sector (amount of goods and services produced) and technological developments (including shifts in fuel use and energy improvements). For further analysis on the effectiveness of emissions mitigation policy see EEA, 2013c.

It is also useful to understand from a production perspective the contribution made by European emissions to global CO_2 emissions. Figure 3.3 presents emissions of the EU-27 together with the emissions of China, India, Japan, the Russian Federation and the USA. Emissions from international marine bunker fuels are assigned to individual countries based on the residency principle (the country of the ship owner). Emissions from other countries not mentioned by name are aggregated under the category 'rest of the world'. The data shows that between 1995 and 2009 global CO_2 emissions increased from 22 billion tonnes to about 29 billion tonnes of CO_2. The EU's contribution of production emissions to total production emissions was 14 % in 2009, a decline from 1995, when EU emissions were 19 % of total global emissions. This relative decline in Europe's contribution to global emissions is the result of decreasing European emissions (in absolute terms), and increased emissions in the 'rest of the world' category and in other countries such as China.

Difference between production-emission datasets

Due to the difference in methodologies used to compile them, differences are to be expected between production-based datasets. For example, the Global Carbon project users territorial emissions data from the CDIAC project in order to calculate production-based emissions. The WIOD project uses data from Eurostat air emission accounts (to the extent the data is available), which in turn are based on territorial emissions data from the EU inventory submitted to the UNFCCC. Emission inventories covering the EU-27 show rather similar emission trends over time (Figure 2.4) with differences of between 6 % and 10 %.

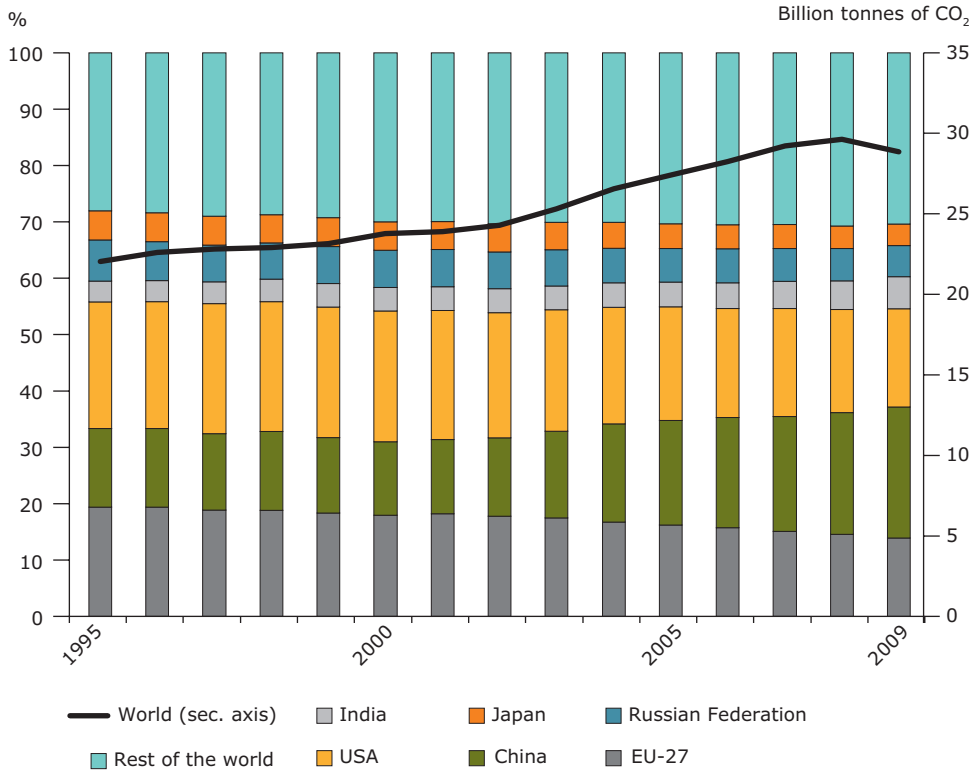
Figure 3.2 Contribution of economic sectors to annual total EU-27 CO_2 emissions according to the production perspective



Note: Emissions classified according to aggregated NACE Rev.2.

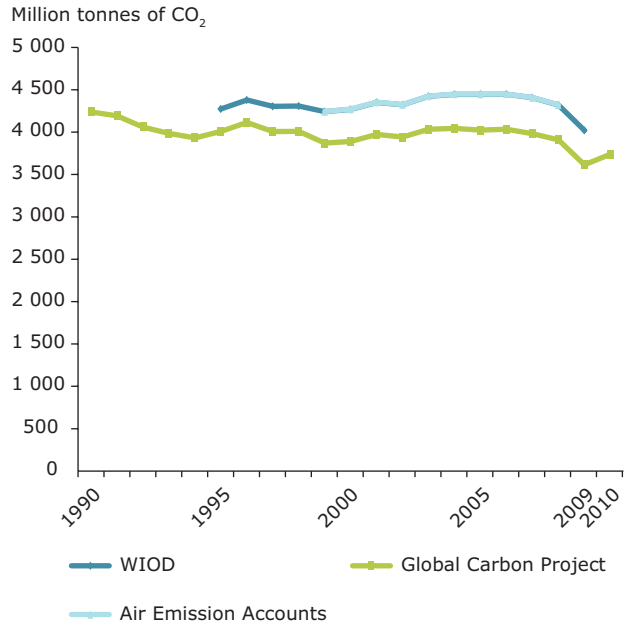
Source: Arto et al., 2012.

Figure 3.3 Percentage contribution of world regions to annual global CO_2 emissions (1995–2009) and global CO_2 emissions from a production perspective



Source: Arto et al., 2012; PBL/JRC, 2012.

Figure 3.4 CO_2 emissions in the EU-27 according to different production-emission datasets



Source: Eurostat, 2013; WIOD (Arto et al., 2012); Global Carbon Project (Le Quéré et al., 2013).

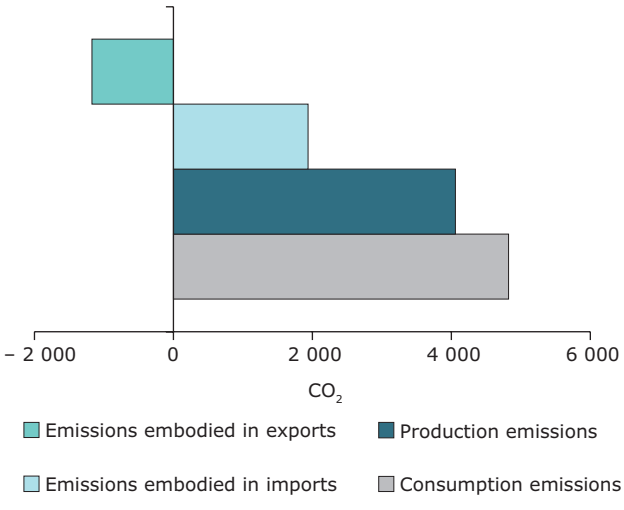
4 Consumption emissions

Air emissions data compiled using a **consumption perspective** account for those emissions induced by the final consumption of goods and services within a country, irrespective of the geographic location where the production of these consumed goods and services takes place (e.g. Davis and Cadeira, 2009).

4.1 Methodology

Most consumption-based emission datasets share the same principle that emissions released during the production of goods and services in other territories are accounted to those countries in which the final consumption of these products take place (emissions embodied in imports). These emissions are combined with emissions of goods and services that are both produced and consumed locally (production emissions). Emissions for production of goods and services that are exported are excluded from the national total (emissions embodied in exports). Figure 4.1 illustrates the difference between these categories with results from the WIOD project for the year 2009, as presented by Boitier (2012). The difference between production and consumption emissions is determined by the net effect of emissions embodied in imports and exports.

Figure 4.1 EU-27 consumption emissions in 2009



Source: WIOD: Boitier, 2012.

4.1.1 Environmentally-extended input-output tables

In contrast to territorial emissions datasets and production emissions datasets, there is no standardised method to calculate consumption-based emissions, nor is there a requirement for annual or frequent updates of datasets (see Chapters 2 and 3). Source categories are often based on standardised methods such as NACE or COICOP. As a result, consumption-based air emission datasets differ in three main ways: (i) the choice of methods used to link air emissions to the production of goods and services; (ii) the selection of trade statistics used for the datasets; and (iii) the way in which the datasets include information on air emissions in third countries that are the result of producing the goods and services that are being imported.

Calculation of consumption-based emissions starts with information from production-based datasets. In principle, the production-based datasets that are used should be Air Emission Accounts. However, territorial-emission datasets are sometimes used due to lack of data (Timmer et al., 2012). The next step is to derive consumption-based emissions data by combining Air Emissions Accounts with trade data (volume in weight or number of goods, origin, destination, and value of imported and exported goods), usually employing 'input-output' modelling techniques (e.g. Peters et al., 2008; Wiedmann, 2009).

Such techniques combine monetary input-output tables with environmental data to produce so-called 'environmentally-extended' input-output tables (EE-IOT). An input-output table is a modification of the so-called 'supply-use' tables. Input-output tables show the elements of the production process, the use of the goods and services (products), and the income generated in that production (Eurostat, 2008), a principle first developed by Leontief (1970). Combining this information with data such as the Air Emissions Accounts allows for the modelling

of the environmental pressures that result from product use and trade. Examples of input-output tables are shown in Box 4.1.

There are two main types of modelling systems using the EE-IOT: the single-region input-output (SRIO) model and the multi-region input-output (MRIO) model. A key difference between SRIO models and most MRIO models is the so-called Domestic Technology Assumption (DTA), which assumes that imported goods are produced using the same technology and resulting in the same environmental pressures as they would if they were produced in the importing country. DTA is used in SRIO. For a more detailed description of methodologies see (EEA, 2013d; and Arto et al., 2012).

European input-output tables are available from Eurostat. Global input-output tables and trade (import-export) matrices are available from GTAP, WIOD, and Eora datasets (Lenzen et al., 2012) and from EXIOBASE datasets (EXIOPOL, 2011).

At present there are no standardised methodologies for performing EE-IOT, and often studies are performed with older data due to lack of availability of more recent data. For example, in 2011 Eurostat published an EE-IOT for the years 2000–2006.

Performing EE-IOT is further limited by the fact that supply and use tables are only updated every few years (Eurostat, 2011; EEA, 2013d). This means that statistical data on supply, use and international trade are available only for specific years. For example GTAPv8 provides data for the years 2004 and 2007 only. Thus, in order to calculate time series, GDP expenditure data or other data are used as proxies (e.g. Peters et al., 2011).

4.1.2 System boundaries

Under the consumption perspective emissions are included irrespective of the geographic location where these emissions are released into the atmosphere, and emissions are assigned to the national total when these emissions:

- have occurred within the country to meet the demand for domestic consumption of goods and services;
- have occurred abroad to meet the domestic demand for imports of goods and services (imports);
- are direct emissions from households (e.g. driving a car).

Box 4.1 Examples of input-output tables

		Products			Industries			Final users			Total
		Agricultural products	Industrial products	Services	Agriculture	Industry	Service activities	Final consumption	Gross capital formation	Exports	
Products	Agricultural products				Intermediate consumption by product and insustry			Final uses by product and by category			Total use by product
	Industrial products										
	Services										
Industries	Agriculture	Output pf industries by product									Total output by industry
	Industry										
	Service activities										
Value added					Value added by component and by industry						Total value added
Imports		Total imports by product									Total imports
Total		Total supply by product			Total output by industry			Total final uses by category			

Note: Grey areas = not applicable. Table items represent production and consumption of products (number, mass) and the total value added this represent.

Source: Eurostat, 2009.

Emissions are excluded from the national total when these emissions have occurred due to the production of goods and services to be exported to other countries. Also excluded from the national total are emissions associated with the use of imported intermediate products that will subsequently also be exported. Including information on the use of intermediate products is not straightforward, and sometimes the assumption is made that imported products are not in fact used as intermediates. This assumption thus overestimates the final consumption emissions of a country (a problem identified by Hertwich and Peters, 2008) and is not always accounted for in consumption-based emission datasets.

Due to the fact that the consumption perspective focuses on emission sources in relation to the economy, it excludes several emission categories, which are sometimes included in terrestrial emission datasets. These excluded emission categories are:

- natural emissions (in comparison to CLRTAP inventories);
- accidents such as human-induced forest fires;
- emissions from land use change and forestry.

Some emission source categories that are normally excluded from territorial emission accounting — or reported as memo items but not counted into the national total emissions — are included in the consumption accounts totals. These included emissions categories are:

- international shipping and aviation
- emissions of CO_2 from biomass used as fuel (included as a memo item in UNFCCC emission inventories datasets, but excluded from total CO_2 emissions)

4.2 European consumption emissions datasets

4.2.1 Overview of European consumption emissions data and their applications

At present there is no standard methodology or international reporting for this kind of analysis. However, there is a limited, but growing, number of assessment studies that are able to provide emissions data in the form of accounts compiled from the consumption perspective. Table 4.1 presents three datasets that provide air emissions data from a consumption perspective for the EU and its Member States.

The consumption perspective allows for a better understanding of the economic drivers of air emissions. For example it helps identify which activities and which products within the EU and its Member States are important drivers of air emissions worldwide (EEA, 2013d; Arto et al., 2012). Examples of results that in the future could be worked into EEA indicators for sustainable production and consumption are identified in EEA (2013c). Examples are:

- Emissions from final consumption organised by end-use group (industry groups, household activities);
- Emissions from final consumption by consumed product groups;
- Emissions embodied in imports.

4.2.2 EU CO_2 emissions from a consumption perspective

This section shows European CO_2 emissions from a consumption perspective in order to: highlight European annual total emission trends (Figure 4.2); show the contributions made by different consumption activities (Figure 4.3); and show European emissions in a global context (Figure 4.4). These figures are based upon data from the WIOD project (Arto et al., 2012), supplemented with information from Andrew and Peters (2013). At present, WIOD consumption emissions data (based on Air Emissions accounts from Eurostat) is available for the period 1995–2009. Other datasets provide information for the period 1990–2010 (e.g. Global Carbon Project).

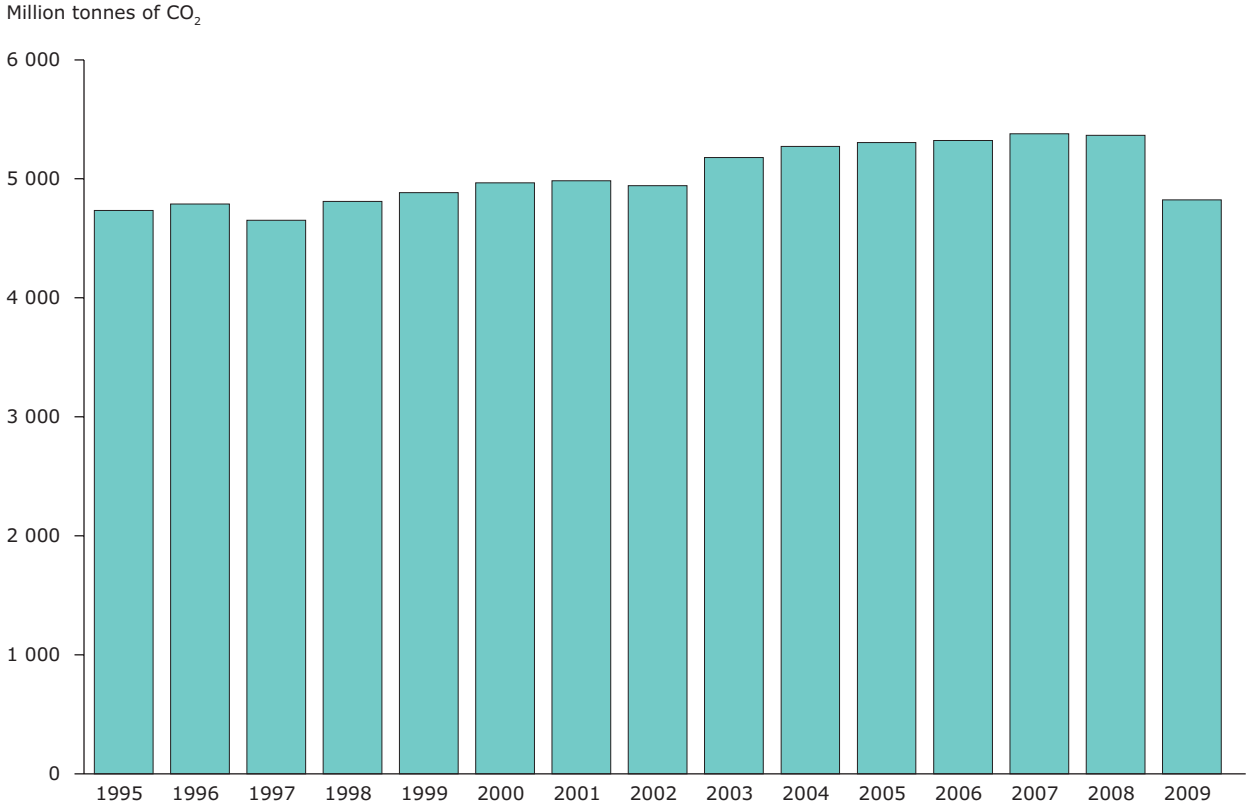
EU-27 consumption emissions amounted to a little more than 4 823 million tonnes of CO_2 in the year 2009, which is a 1.9 % increase compared to 1995 (Figure 4.2). The emissions time series show a gradual increase from 1995 onwards, reaching a peak of 5 378 million tonnes in 2007, followed by a clear decrease after 2008 due to the start of the economic downturn in the period 2008–2009.

Figure 4.3 shows the contribution to EU-27 emissions of different final consumption activities over time. The WIOD project data as available in the public domain only presents consumption emissions by end-use within the household sector, and only for total GHGs in the year 2008 (Arto et al., 2012). In order to highlight which activities

Table 4.1 Selection of consumption emissions datasets covering the EU

Dataset	Description	Methodology
WIOD	World Input-Output Databases (WIOD) provide trade and emission statistics for 41 countries and 37 economic sectors for the years 1995–2009. (Arto et al., 2012; Boitier, 2012).	Calculation of emissions by using the production perspective-based method for Environmental Accounts, and adding World Input-Output Database tables to provide a consumption perspective.
Eurostat	Emissions of greenhouse gases and air pollutants induced by final use of products (modelling results from input-output analysis following the consumption perspective (Eurostat, 2013).	Eurostat undertakes input-output modelling based on their Air Emissions Accounts and the monetary 'supply and use' table. The simple modelling employs the domestic technology assumption (DTA). The following data are available (for the aggregated EU-27 economy as a whole only): 2000–2007: NACE rev 1.1 and CPA02. 2008–2009: NACE rev 2 and CPA08.
Global Carbon Project	Global emission inventory of anthropogenic and natural CO_2 emissions in the period 1960–2010. The inventory helps to improve the understanding of observed CO_2 concentration changes in relation to emissions and sinks in the Global Carbon Project (Quéré et al., 2013). The inventory includes production emissions data and consumption emissions data as described in Andrew and Peters (2013) and Peters et al. (2011).	Calculation of carbon dioxide emissions by using independent methods and data, and comparing this with data from EEA member countries reported under the UNFCCC using CDIAC data. In addition, the Global Carbon Project explores the linkages between emissions and trade by calculating emissions from both a production and consumption perspective, combining CDIAC emissions data with trade data.

Figure 4.2 Annual EU-27 CO_2 emissions between 1995 and 2009 from a consumption perspective

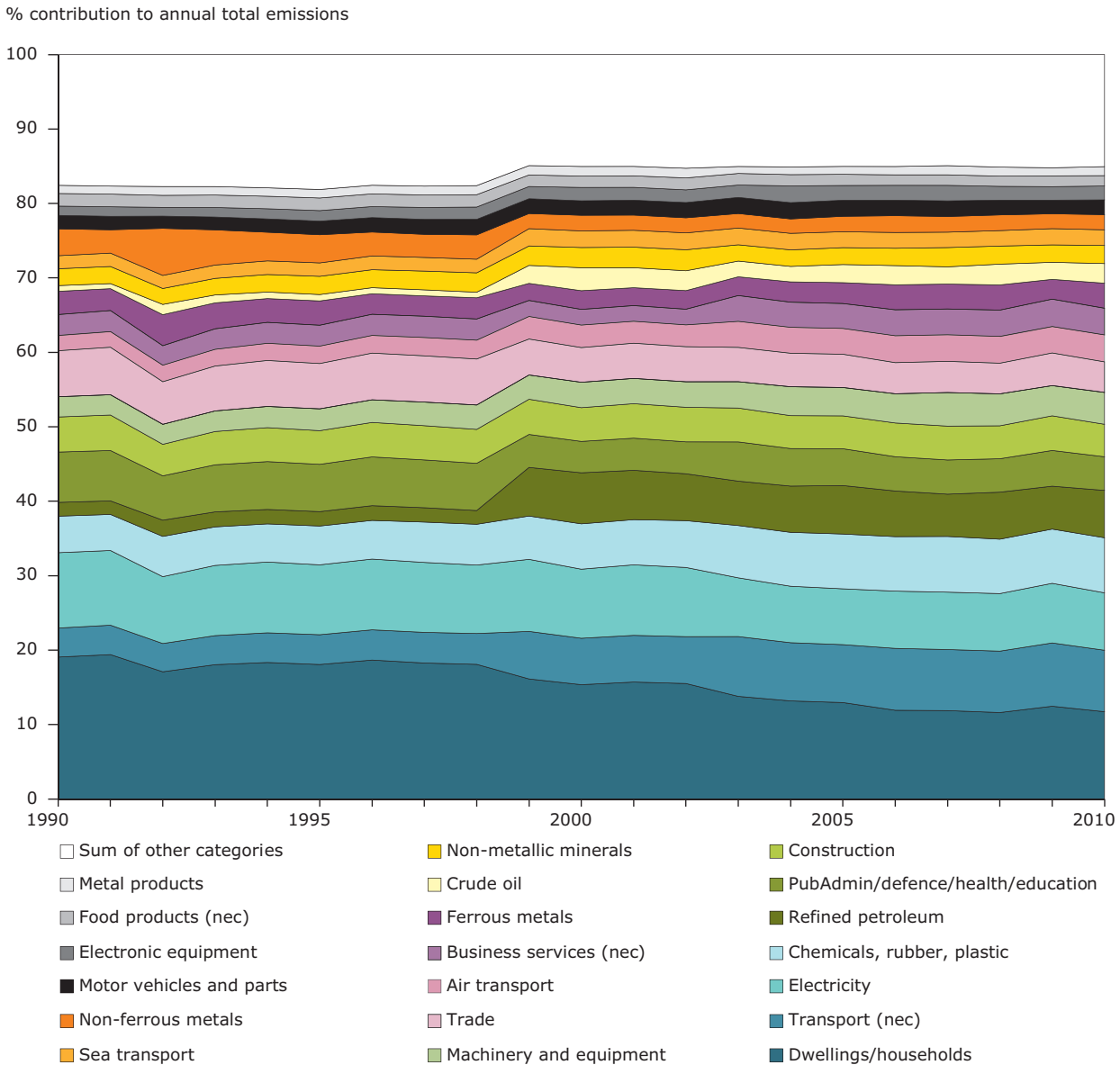


Source: WIOD project: Arto et al., 2012; Boitier, 2012.

contributed to EU CO_2 consumption emissions in other years, the graph uses values provided by Peters and Andrew (2013) using GTAP-MRIO calculations.

When considering emissions from a consumption perspective, activities taking place inside households such as cooking and heating, electricity use, land transport, use of electronic equipment and use of chemicals are responsible for about 40 % of total CO_2 emissions. The trend is that emissions from stationary household activities are decreasing over time, but that emissions from land transport are increasing. The jumps in some sectors over time (e.g. refined petroleum) are due to a methodological issue caused by limited availability of international trade data and of 'supply and use' tables. As a consequence, data is combined for different time periods starting in 1997, 2002 and 2005, and is also combined for aggregated world regions. This results in step changes as seen in Figure 4.3.

Figure 4.3 Contribution of economic sectors to annual total EU-27 CO_2 emissions from the consumption perspective following GTAP definitions

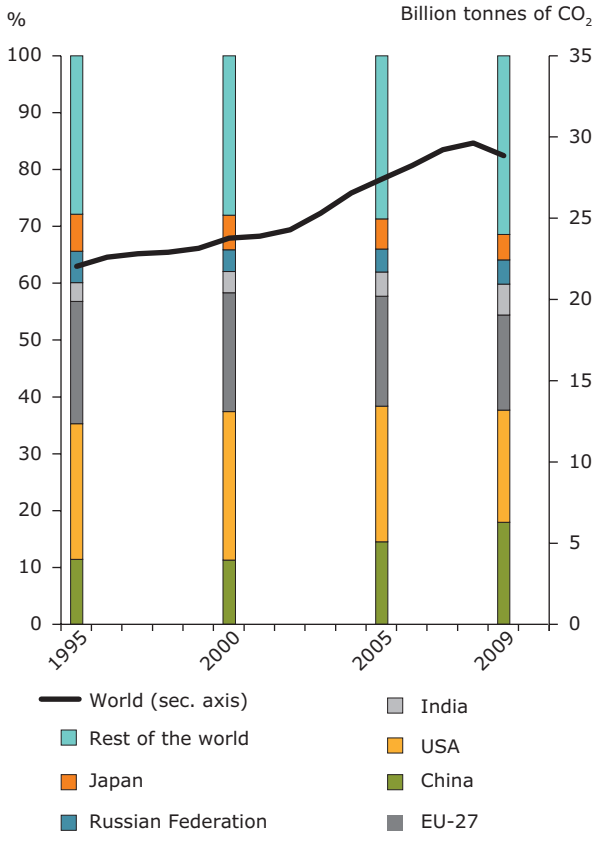


Note: Final consumption classification following GTAP definitions (see Annex 2).
nec = not elsewhere classified.

Source: Andrew and Peters, 2013; Le Quéré et al., 2013.

It is also useful to understand from a consumption perspective the contribution made by European emissions to global CO_2 emissions. Figure 4.4 presents emissions of the EU-27 together with emissions of China, India, Japan, the Russian Federation and USA. Emissions from international bunkers are assigned to countries based on the resident principle. Emissions from other countries not mentioned by name are aggregated under the category 'rest of the world'. The data shows that between 1995 and 2009 global CO_2 emissions increased from 22 billion tonnes to about 29 billion tonnes of CO_2. The EU's contribution of consumption-related emissions to global consumption-related emissions was 17 % in 2009, a decline from 1995, when the EU's contribution to the global total was 21 %. This relative decline in European contributions to global emissions is the result of decreasing European emissions (in absolute terms) and increased emissions in the 'rest of the world' category and in other countries such as China.

Figure 4.4 Percentage contribution of world regions to annual global CO_2 emissions (1995–2009) and global CO_2 emissions from a consumption perspective



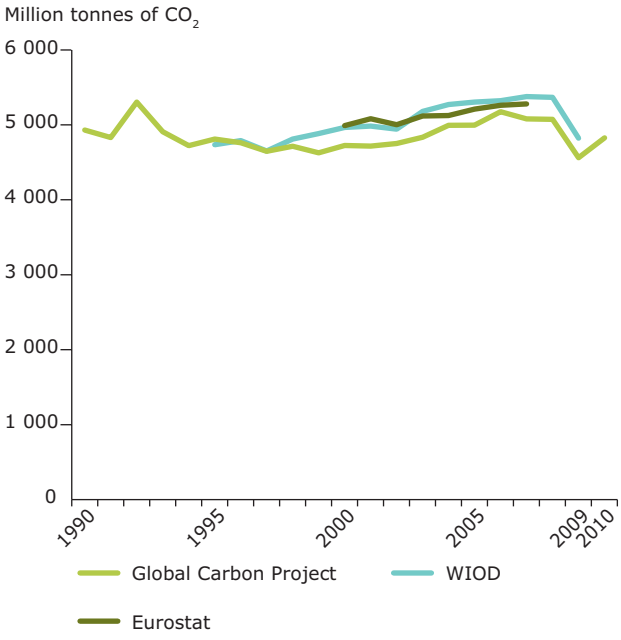
Source: Arto et al., 2012; Boitier, 2012; PBL/JRC, 2012.

Difference between consumption emission datasets

Consumption-emission datasets can differ depending on the underlying data used to create them. This means that two consumption-emission datasets for the same country in the same year would look different and have different emissions totals. There are three possible causes for these differences: differences in the underlying territorial emissions datasets, differences in the underlying production-emission datasets, and differences in the underlying input-output models. This is illustrated in Figure 4.5, which compares the datasets described in Table 4.1, Eurostat, WIOD, and the Global Carbon Project. Although the annual total emissions for most years are rather similar in the case of the EU (varying by no more than 5 %), the variances between the datasets for global total CO_2 emissions are about 10 % (WIOD 29 Pg. in 2009 vs. Global Carbon Project's 32 Pg.). Also, the achieved emission reduction over the period 1995–2009 is another category that can accentuate differences in datasets, showing a 5.1 % decrease according to the Global Carbon Project, and a 1.9 % increase according to WIOD.

A further illustration on the impact of EE-IOT models on the outcome of the consumption emission datasets can be found in Scott et al. (2013). Consumption emissions within the United Kingdom can differ by 60 % depending on the type of model being used. Similar information for the EU-27 was not available at the moment of writing this report.

Figure 4.5 CO_2 emissions in the EU-27 according to different consumption emission datasets



Source: WIOD: Arto et al., 2012; Boitier, 2012; Global Carbon Project: Le Quéré et al., 2013 and Eurostat, 2013.

5 Main differences between air emission accounting perspectives

In the previous three chapters, the methodologies to calculate air emissions according to the territorial, production and consumption accounting methods have been described. This chapter combines the information from each emission accounting method, and will highlight the main differences and similarities. Section 5.1 summarises how concepts differ and methodologies relate. Section 5.2 highlights the differences in system boundaries regarding coverage of emission sources, economic activities, and the geographical boundaries in which these are located. Section 5.3 presents EU CO_2 emissions trends and discusses the application and quality of the available information.

5.1 Concepts and methodologies

One of the reasons for applying the different perspectives as described in the previous chapters is to better understand and quantify the interaction between the national and international environment and between the national economy and the global economy. This is done by grouping CO_2 emissions into three main groups as follows:

Territorial emissions cover those emissions that are released to the atmosphere from within a country's borders and from areas under a country's jurisdiction. From the territorial emissions perspective, a country is accountable for the emissions that take place within its territory.

Production emissions cover those emissions resulting from the economic activities of a country's resident companies and households in relation to their economic output (production) irrespective of the geographic location of where these activities take place. From the production emissions perspective, a country is accountable for the emissions resulting from the domestic economy.

Consumption emissions cover those emissions resulting from the national consumption of goods and services within a country, irrespective of the geographic location where production of these good and services results in emissions. From the consumption emissions perspective, a country is accountable for the emissions resulting from domestic consumption of goods and services.

The methodologies for calculating national emissions according to these three perspectives are different. The calculation of production emissions and consumption emissions are both based on an initial calculation of territorial emissions as follows. Firstly, territorial emissions are calculated by focusing on emission sources and by using emission-inventory methodologies that are often based on standardised methods as defined by reporting obligations under international treaties (Section 2.1.1). Secondly, production emissions are calculated by relating the territorial emissions to domestic economic activities. This is mainly done by applying standardised methods such as the 'inventory-first approach'. Other standardised methods used in this task include the adjustment of territorial emissions for emissions by resident units and by non-resident units (Section 3.1.1). Thirdly and finally, consumption-based emissions are calculated by relating production emissions data with the final consumption of goods and services supplied through domestic production and international trade.

5.2 System boundaries

Because the three accounting perspectives are based on different concepts, differences also exist in the economic activities that are accounted for. These accounting methods also differ in the way they treat emission sources and their location.

5.2.1 Coverage of economic activities

In studying the interaction between the economy and the environment, various economic activities and flows of goods and services must be taken into consideration. These activities and flows must be considered on a national, pan-European and global level.

The accounting perspectives differ in the way that they consider economic activities and resulting emissions. This is shown in Table 5.1, which details the economic activities and associated streams of goods and services (as described in Wiedmann et al., 2010) that are included in the three accounting perspectives. The only economic activities that are included in the same manner in more than one accounting perspective are 'domestic production for domestic final consumption' and 'domestic final consumption' (in territorial and consumption accounts). All other economic activities are covered in a different way, ranging from excluded, included or partially included, depending on whether the economic activity takes place within the national borders or is undertaken by resident units of the economy.

5.2.2 Coverage of environmental pressures

The production of goods and services, as well as the production of intermediate products, results in environmental pressures in the form of air emissions from the following main emission source categories: fuel combustion in the energy and industrial sectors, industrial processes, agriculture, waste handling, and the national and international transport of goods between producers and consumers. Final consumption by households includes emissions from heating and cooking as well as emissions from passenger transport including tourism.

It is important to realise that not all air emissions result from the production, transfer and consumption of goods and services. For example natural emissions are produced by volcanoes, dust events and accidental forest fires. Other phenomena that are difficult to include in any emission calculation are the role of illegal practices (e.g. burning of agricultural waste in open fields) or activities in the informal economy (wood fuel gathered by residents/non-registered sales). These activities are not visible in the fuel sales or economic data of an economy. The decision over whether to include these 'other activities' in emission calculations is dependent on reporting requirements (for example, there is a category for 'natural sources' in the CLRTAP inventory), and the availability of data.

The three accounting methods also differ in the way they allocate emission sources and the geographical location of these sources to the national total emissions. This results in differences in national total emissions.

Table 5.2 indicates where these differences in the inclusion of emission sources between the accounting methods are to be expected. This is illustrated by presenting which emission sources are included by economic activity (as described in Table 5.1) and whether these emissions occur within or outside the national territory. The information in Table 5.2 is intended to highlight the main emission sources associated with the economic activity and is not intended to be a complete list that covers each individual emission source category.

In order to better understand the system boundaries between territorial, production, and consumption emissions accounting, additional information is required to clarify the coverage of emissions in relation to transport of goods and services, use of intermediate products, biomass, and which air pollutants and greenhouse gases are included.

International transport

The different accounting perspectives differ in the way that they treat emissions from international transportation. This is a particularly important issue when it comes to international shipping, through which a large amount of goods are transported between Europe and the rest of the world. Territorial-emission inventories, such as the UNFCCC inventories, include emissions from inland-shipping transport in the national total, and mention the emissions resulting from fuel sales of international bunker fuels as a memo item in the inventory. Production-emission inventories include all international shipping activities as long as it concerns shipping performed by resident companies. The role of international shipping in relation to consumption-emission inventories is clear since it involves transportation between trading economies. However, the way in which ship emissions are assigned in the consumption emissions perspective to the importing or exporting partners and/or goods and services is not well documented in the literature and requires further analysis.

Intermediate products

Under the consumption emissions perspective, the emissions resulting from the production of intermediate products to be exported to other countries are assigned to the country that uses these intermediate products for the production of goods and services for domestic final consumption. The international transports of these intermediate products are only included in territorial

Table 5.1 Overview of economic activities and coverage of emissions from production, transport, and consumption of these flows of goods and services

Economic activity (flows of goods and services) / Emissions resulting from production, transport, consumption of goods and services	Territorial	Production	Consumption
Domestic production for domestic final consumption: Production of goods and services within the EU to meet EU demand for final consumption.			
Domestic production for export: production of goods and services within the EU to meet final demand in the global economy (through export).			
Import of intermediate products to produce goods and services for domestic consumption: Import of intermediate products from non-EU countries used in EU production of goods and services for EU final consumption.			
Import of intermediate products to produce goods and services for export: Import of intermediate products from non-EU countries used in EU production of goods and services that are exported to non-EU countries.			
Imported goods and services: Import of goods and services to meet EU demand for consumption.			
Export of imported goods and services to third countries: Import of goods and services to the EU that are exported to meet demand in the global economy.			
Domestic final consumption (stationary): Purchase of goods and services and their consumption by EU households for stationary activities such as cooking and heating.			
Domestic final consumption (mobile): Purchase of goods and services and their consumption by EU households for transport activities.			

Notes:
- Emissions resulting from the economic activity are covered in the accounting method
- Emissions not covered in the accounting method
- Only those activities that take place within the national/EU border are covered in the accounting method
- Only those activities that are undertaken by residents and resident companies/industries are covered in the accounting method

Source: EEA, based on Wiedmann (2010).

emissions and production emissions datasets. It is also important to note that the actual use of intermediate goods (e.g. sugar in food processing or steel in the auto-manufacturing industry) during the production process might lead to emissions and these are indirectly accounted for in the territorial emissions inventories and in the production emissions inventories under the 'domestic production emissions' category.

Biomass and carbon dioxide

When comparing the results of the different emission accounting methods, it is important to know whether the national total includes or excludes biomass CO_2 emissions. For example, territorial inventories (e.g. UNFCCC) exclude CO_2 emissions from biomass (e.g. wood and wood waste) from the national total, although the emissions are reported as memo items. However, CO_2 emissions

Table 5.2 Overview of economic activities and geographic coverage of emissions from production, transport, and consumption of these flows of goods and services

Economic activities and emission sources included in the accounting method: / Geographic scope of emissions included	Territorial	Production	Consumption
Domestic production for domestic final consumption	Country	National economy	Country
Domestic production for export	Country	National economy	
Import of intermediate products to produce goods and services for domestic consumption	Country ([a,b])	National economy ([a,b])	Rest of the world
Import of intermediate products to produce goods and services for export	Country ([a,b])	National economy ([a,b])	
Imported goods and services	Country ([a,c])	National economy ([a,c])	Rest of the world
Export of imported goods and services to third countries	Country ([a,c])	National economy ([a,c])	
Domestic final consumption (stationary)	Country	National economy	Country
Domestic final consumption (mobile)	Country	National economy	Country

Notes:

All emission sources in category included in emission calculation

Emissions in category not included in emission calculation

Some but not all emission source in category included in emission calculation

- Emission sources associated with domestic production typically include fuel combustion in the energy and industrial sectors, industrial processes, agriculture, national transport of goods ([a]), and waste handling.
- Emission sources from the category 'import of intermediate products to produce goods and services for domestic consumption' and the category 'import of intermediate products to produce goods and services for export' typically include fuel combustion in the industrial sector, and industrial processes to produce intermediate goods (e.g. steel production), agriculture (e.g. sugar production), and the international transport of goods ([a]).
- Emissions in the 'domestic final consumption (stationary)' category typically come from sources such as cooking and heating.

([a]) The transport of goods and services within a country and via import and export involves national and international transportation. Depending on the territorial inventory requirements these are included/excluded (see Table 2.1). In the production inventories, any transport (for national consumption, import, export) performed by resident companies is included in the emission total for international transport.

([b]) The actual use of intermediate goods (e.g. sugar in food processing, or steel in the auto-manufacturing industry) during the production process might lead to emissions, and these are accounted for in both territorial and production inventories.

([c]) Transfer of goods (import and export of goods without national consumption) involves transport, loading and unloading activities in harbours and further transport. Resulting emissions (fugitive emissions, national transport emissions) are included in territorial and production emission calculations.

from biomass are included in the Air Emission Accounts (Eurostat, 2013; see also Section 3.1.2) and in datasets using the Air Emission Accounts to calculate consumption emissions. The removal or emission of CO_2 as a result of land use and land-use changes are not included in production-based and consumption-based datasets, whereas territorial inventories take into account CO_2 emissions from biomass decrease and carbon storage in biomass as an effect of land-use change or change of carbon storage in soil.

5.3 European CO_2 emissions from different perspectives

Because of the differences between concepts, and methodologies, differences are to be expected in the annual EU CO_2 emissions calculated under the territorial, production, and consumption perspectives.

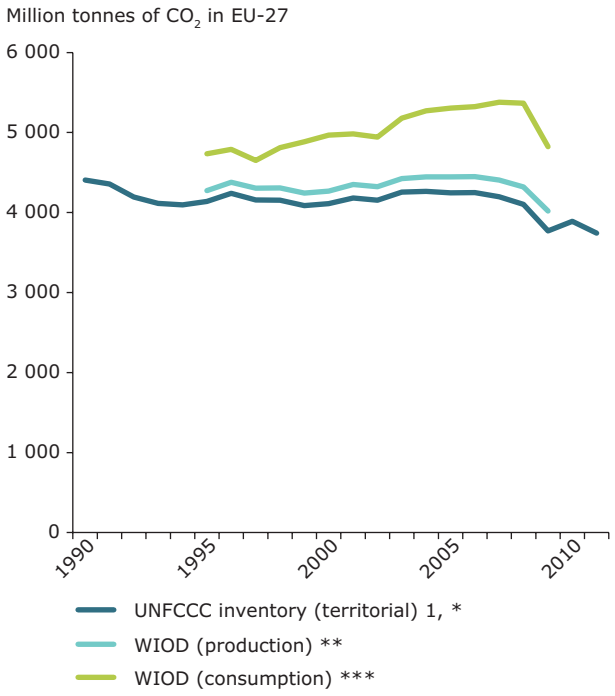
EU-27 CO_2 emission trends

Figure 5.1 presents annual EU-27 CO_2 emissions in million tonnes of CO_2 as calculated according

to the territorial perspective (UNFCCC inventory, Chapter 3), the production perspective (WIOD project, Chapter 4), and the consumption perspective (WIOD project, Chapter 4). It shows EU territorial emissions as reported to the UNFCCC for the period 1990–2011, and production and consumption emissions for the years 1995 to 2009.

From a consumption perspective, EU CO_2 emissions appear to be higher than emissions calculated under the production and territorial perspectives. Furthermore, the multi-annual variability of the territorial emissions and production emissions are rather similar, whereas the consumption-based emissions do not always follow these trends.

Figure 5.1 Territorial (dark blue), production (light blue) and consumption (green) annual CO_2 emissions in the EU-27 between 1990 and 2011



Note: 1 UNFCCC inventory CO_2 annual total emissions exclude net CO_2 from LULUCF.

*,**, *** Expresses the difference in uncertainty in emissions calculations. Due to the sequence of methods used to calculate (i) territorial, (ii) production, and (iii) consumption emissions, the uncertainty in territorial emissions data is lower than the uncertainty in production emissions data, which in turn is lower than the uncertainty in consumption emissions data (Section 5.1, Peters et al., 2008). At present, no quantitative uncertainty assessment is available at the EU-27 level for all accounting methods. See also Section 5.4.

Source: EEA, 2013a; Arto et al., 2012; and Boitier, 2012.

The emission trends also differ according to the emission accounting methods, with territorial and production emissions being relatively stable between 1995 and 2009, followed by a decrease starting with the economic downturn in 2008. Consumption emissions show an increasing trend up until 2008, followed by strong decrease in 2009.

Between the start-point and end-point of the available emission trends (1995–2009), EU territorial emissions show a strong decrease, production emissions show a smaller decrease, and consumption emissions show a slight increase.

The EU contribution to global CO_2 emissions differs between the three accounting methods, although in all three methods this contribution reduces over time. These trends are a combination of decreasing European emissions and increased emissions in other countries.

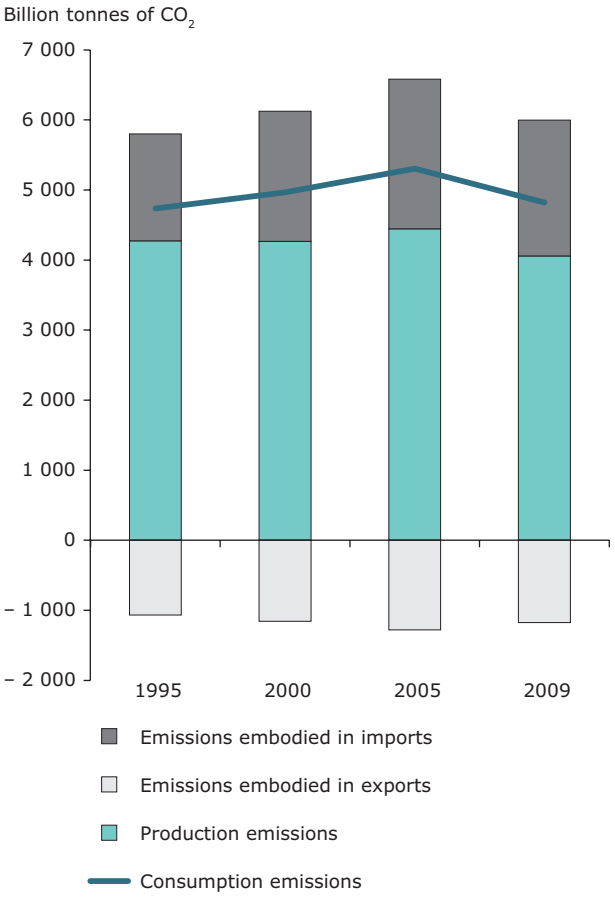
Territorial vs. production emission trends

Differences between territorial and production CO_2 emissions relate mainly to the fact that production emissions accounting includes emissions from outside the national border by resident units of the national economy. Extra-territorial emissions of this type are mainly emissions from international transport, in particular international shipping. International shipping emissions are included in the UNFCCC inventory; however, they are excluded from the national total emissions. For example, when including CO_2 emissions from international marine bunkers to the UNFCCC emissions total in 2009, the resulting 3 931 million tonnes of CO_2 are not much different from the production emissions. The difference between territorial and consumption emissions can be quantified and explaining using a bridging table (Section 3.1.1). At present such tables are not available at the EU level.

Production vs. consumption

The difference between production emissions and consumption emissions is shown in Figure 5.2. As described in Chapter 4, consumption emissions are the sum of production emissions and emissions embodied in imports minus emissions embodied in exports. As shown in Figure 5.2, emissions from imports of goods and services are larger than emissions embodied in exports, and consumption emissions are higher than production emissions. Calculation of emissions associated with imports and exports requires the inclusion of emissions in other parts of the world that occur during both the production and transport of intermediate

Figure 5.2 EU-27 consumption emissions presented as net result of production emissions (+), emissions embedded in imports (+) and embedded in exports (−)



Source: WIOD project: Arto et al., 2012; Boitier, 2012.

products, and the production and transport of goods and services for final consumption. The production-accounting method includes only the national and international transport of these products and goods as long as transport is performed by resident units (e.g. ships owned by companies residing in the country), whereas the territorial emissions accounting method includes only the transport within national borders.

5.4 Uncertainty

Due to the sequenced nature in which the accounts are compiled (production perspective accounts are based on territorial perspective data, and consumption perspective accounts is based on production perspective data), uncertainty will be higher in production-based and consumption-based datasets compared to the uncertainty in territorial data. The uncertainty in consumption-based inventories will be even higher still (e.g. Peters et al., 2008).

Territorial emissions are often based upon the application of statistical data for each inventory year, standardised methods, and in the case of UNFCCC inventories, the territorial emissions data is subject to detailed annual review processes. Nevertheless, territorial emission estimates include an element of uncertainty. According to EU inventories; EU-15 CO_2 emissions data had an uncertainty of 1.7 % in 2011 ([7]).

Production emissions are derived from territorial-emission inventories by relating emission sources to economic sectors, and by adjusting territorial emissions to the boundaries of the national economy. Standardised methods for doing this are available in the case of Air Emission Accounts (Eurostat, 2013). Uncertainties are introduced via the adjustment procedures. For example, international water transport by resident units, and some other niche types of emissions, are not considered in the calculations due to either a lack of data or their being considered too small (e.g. emissions from national embassies). Although legislation is in place to report air emissions accounts to Eurostat, recent data on production emissions are not currently available for the EU-27.

Consumption emissions are compiled by combining production emissions data with information on the supply, use, and international trade of goods and services and their associated emissions. Detailed global trade data in the form of input-output tables such as from GTAP-MRIO or WIOD are only available with delays (for example, the latest WIOD data is for 2009, and the latest available GTAP data is from 2007), and interpolations are used to construct time series. In addition, there is limited availability of non-OECD territorial-emission inventories or production-emission inventories ([8]) and subject to relatively large uncertainty.

This difference in uncertainty can to some extent be highlighted by comparing emissions for the largest exporting country in the world, China. Estimates

([7]) For the EU-27, there are no data for uncertainty due to the lack of uncertainty data for all EU-12 Member States.
([8]) For example, the latest statistical year for which China submitted an official UNFCCC inventory is 2005.

of territorial emissions are relatively similar in the case of China with EDGAR estimating CO_2 emissions of 8.3 billion tonnes (PBL/JRC, 2012) in 2010 compared to an estimate of 7.7 billion tonnes by the Global Carbon Project, based on CDIAC data (Le Quéré et al., 2013), a difference of 0.6 billion tonnes. As for production emissions in China, WIOD estimated 2009 emissions of 6.7 billion tonnes of CO_2 and the Global Carbon Project estimated emissions of 7.7 billion tonnes, a difference of 1 billion tonnes of CO_2. Consumption emissions according to the same two datasets are 5.2 billion tonnes (WIOD) and 6.6 billion tonnes (Global Carbon Project) a difference of 1.4 billion tonnes of CO_2.

Within Europe, results by Scott et al. (2013) showed that for individual countries the consumption emissions can vary substantially depending on the MRIO method being applied. For the United Kingdom, the emissions can differ by as much as 60 %. No information on differences in the estimates of consumption level emissions at the EU level was available during the writing of this report.

6 Conclusion

The aim of this technical report has been to explain to a wider audience the concepts and methodologies behind different air emission accounting methods and resulting emissions at the EU level.

Methodological differences and quality of information

It is important to understanding the differences in system boundaries (which determine what types of emissions are accounted for) between accounting methods, as they can have a significant effect on the final results. Territorial-emission datasets focusing on national/EU borders, while production emission datasets focus on the national/EU economy. Consumption emissions adjust production emissions data to account for emissions embodied in imports and exports. This is done by factoring in emissions in non-EU countries associated with the production of goods and services that are being imported to the EU, and by subtracting emissions within the EU that are associated with the export of goods and services to other countries.

These methods are 'sequenced' in the sense that territorial emissions data is a key basis for production emissions data, which in turn is used to as an input to calculate consumption-based emission calculations). The quality of information (and the degree of uncertainty in the resulting consumption-based emission calculations) are dependent on the quality of the territorial-/ production emissions information, and the availability of global data on supply, use, and trade of goods and services.

Territorial emissions are often calculated using standardised methods and data sources that are updated frequently (annually). In addition, the emission inventories as prepared under the UNFCCC are reviewed annually by independent emission review teams. Nevertheless, the emissions estimates have a degree of uncertainty. Production-based emissions data are calculated following standardised methods but the available time-series are shorter than those available for the territorial emissions data. For EU Air Emissions Accounts (used to calculate production-based emissions), there is no complete reporting by EU Member States nor is there a bridging table available that would support the translation of territorial-based emission data into production-based emission data at the EU-27 level. There are no standardised methods to calculate consumption-based emissions, and most studies are the result of research projects. Several consumption-based emission datasets are published in the scientific literature, which means that the studies have been subject to a peer-review process. An important limitation to the creation of time-series of consumption emissions is the fact that statistical data on supply, use and international trade are not updated frequently, and are not available for recent years. This means that approximations have to be made to provide complete time series. Moreover, the quality of emission information for non-OECD countries such as China is rather uncertain (see Section 5.4).

Differences in emission trends

Useful insights can result from presenting together emissions according to the territorial, production and consumption perspective but note should be taken on the uncertainty in the different datasets. This means that differences as shown in this report can be larger or smaller when more accurate data becomes available in the future. Based on the emissions data presented in this report, consumption emissions appear to be higher than territorial emissions for the EU-27 in the period 1995–2009. This is the result of the methodological differences between the two accounting methods, with the consumption perspective including CO_2 embedded in import and exports. In the case of the EU-27 the embedded CO_2 emissions associated with imported goods and services is higher than those associated with exports. Production emissions are higher than territorial emissions due to the fact that the EU is an important actor in international maritime transport (Section 5.3).

Between the start-point and end-point of the available emission trends (1995–2009), EU territorial emissions show a strong decrease,

production emissions show a smaller decrease, and consumption emissions show an increase.

The EU contribution to global CO_2 emissions differs between the three accounting methods, although in all three methods this contribution reduces over time. These trends in reduced proportional emissions are a combination of decreasing European emissions and increased emissions in other countries.

Highlighting the drivers of European and global air emissions

Different perspectives and methods for calculating air emissions may provide different insights into what is driving European and global air emissions. For example, looking at the territorial emissions data (Figure 2.2), electricity/heat production and road transportation are the most important CO_2 emission source categories in EU-27 (more than 50%). This is partly reflected in the results from the production perspective (Figure 3.2), where the supply of utilities is the largest source of CO_2 emissions followed by households (that includes heating, cooking and driving private vehicles). In the case of consumption perspective emissions (Figure 4.3), final consumption by household activities, land transport, and the use of electronic equipment and chemicals are responsible for 40% of the CO_2 consumption emissions in the EU-27. The consumption-based emissions are an interesting additional information source, because they allow for a different focus on environmental pressures by shifting attention from emission sources to emission causes, namely the demand for particular goods and services by citizens.

Accounting methods in relation to climate change mitigation policies

Emissions from both a territorial and production perspective can be reduced by tackling CO_2 emissions through a range of technical measures including energy efficiency improvements, shifts to different fuel types, and market-based measures such as emissions trading. Information from the territorial-emission datasets and the production-emission datasets can be used to craft public policy responses that prioritise emission reductions from the most heavily-emitting sources. Consumption-emission datasets can also be used in a similar way, but only to target emissions from goods produced in Europe.

Tackling the emissions resulting from the final consumption perspective is embedded in the EU's policy framework on sustainable consumption and production. This framework deals with product standards, labelling, and green procurement among others.

International conventions such as the UNFCCC and CLRTAP also use territorial emissions and — to some extent — production emissions in their target-setting criteria. Consumption-based emissions are not addressed in international conventions.

Recommendations

Here are some suggestions for how to improve the quality and applicability of the consumption-emission datasets and production-emission datasets, compared to territorial emission datasets:

- Improve non-EU emission datasets, in particular by providing more complete and frequent information on territorial/production emissions in China and other large non-OECD countries.
- Develop an EU-28 bridging table to better understand the differences between territorial emissions and production emissions in Europe.
- Develop and agree upon standardisation of consumption-based methodologies.
- Ensure the availability of timely and more frequently updated EE-IOT information. Statistical offices can play an important role in this work. Improved EE-IOT information of this nature would also facilitate more frequent updates of global datasets such as GTAP.
- Initiate more long-term funded projects to provide the relevant EE-IOTs.

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Annex 1 Definitions and acronyms

Definitions

Territorial emissions	Those emissions that are released to the atmosphere from within a countries' border and areas under a countries' jurisdiction. This from the perspective, that a country is accountable for the emissions that take place within its territory.
Production emissions	Those emissions resulting from the economic activities of a countries resident companies and households in relation to their economic output (production) irrespective of the geographic location of where these activities take place. This from the perspective, that a country is accountable for the emissions resulting from the domestic economy.
Consumption emissions	Those emissions resulting from the national consumption of goods and services within a country, irrespective of the geographic location where production of these good and services results in emissions. This from the perspective, that a country is accountable for the emissions resulting from domestic consumption of goods and services.
Embodied emissions	Emissions resulting from the production of goods and services that are either imported or exported.

Acronyms

AP	Air pollutants
As	Arsenic
Cd	Cadmium
CDIAC	Carbon Dioxide Information Analysis Center
CEM	Continuous Emissions Monitoring
CH_4	Methane
CLRTAP	Convention on Long-range Transport of Air Pollution
CO	Carbon monoxide
CO_2	Carbon dioxide
COICOP	Classification of individual consumption by purpose
COPERT	COmputer Programme to calculate Emissions from Road Transportation
Cr	Chromium

CRF	Common Reporting Format
Cu	Copper
DTA	Domestic Technology Assumption
EDGAR	Emission Database for Global Atmospheric Research
EE-IOT	Environmentally extended input-output tables
EMEP	European Monitoring and EvaluationProgramme
ETC/ACM	European Topic Centre for Air Pollution and Climate Change Mitigation
EU	European Union
GAINS Model	Greenhouse Gas and Air Pollution Interactions and Synergies
GDP	Gross Domestic Product
GHG	Greenhouse gases
GTAP	Global Trade Analysis Project
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
HFCs	Hydrofluorocarbon(s)
Hg	Mercury
HMs	Heavy metal(s)
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
KP	Kyoto Protocol
LTO	Landing/Take-off
LULUCF	Land Use, Land Use Change and Foresty
MACC	Monitoring Atmospheric Composition and Climate
MMR	Monitoring Mechanism Regulation
MRIO	Multiple Region Input-Output (model)
MS	Member State (of the European Union)
N_2O	Nitrous oxide

NACE	'Nomenclature générale des Activités économiques dans les Communautés Européennes'
NEC	EU National Emission Ceilings Directive (2001/81/EC)
NFR	Nomenclature for reporting/UNECE nomenclature for reporting of air pollutants
NH_3	Ammonia
Ni	Nickel
NMVOC	Non-methane volatile organic compound(s)
NO_X	Nitrogen oxides
PAHs	Polycyclic aromatic hydrocarbon(s)
Pb	Lead
PCBs	Polychlorinated biphenyl(s)
PCDD/Fs	Polychlorinated dibenzodioxin(s)/dibenzofuran(s)
PFCs	Perfluorocarbon(s)
PM	Particulate matter
PM_{10}	Coarse particulate matter (particles measuring 10 μm or less)
$PM_{2.5}$	Fine particulate matter (particles measuring 2.5 μm or less)
POPs	Persistent organic pollutant(s)
Se	Selenium
SEEA	Systems of Environmental Economic Accounting
SF_6	Sulphur hexafluoride
SO_X	Sulphur oxides
SRIO	Single Region Input-Output (model)
TSP	Total suspended particulate matter
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WIOD	World input-output database
Zn	Zinc

Annex 2 Classification schemes

This annex describes the classification schemes of economic activities and emissions sources as mentioned in this report: CRF, NFR, NACE, COICOP and GTAP.

CRF (UNFCCC)

The Common Reporting Format (CRF) refers to the standard format that is used by countries to report greenhouse gas emission information to the UNFCCC. By using a standard format and standard definition of emission source and emission removal categories, inventory information can easily be compared between countries and allows for the UNFCCC to process the inventory information via automatic procedurses for quality checking and analysis (UNFCCC, 2006). The CRF includes summary, sectoral and trend tables whereby the emission and removal categories are systematically classificated by source category acoording to the so-called CRF classification. Greenhouse gas emission sources according to the CRF classification as used in the EEA greenhouse gas data viewer are shown in Table A2.1

NFR (CLRTAP)

The Nomenclature for Reporting (NFR) refers to the standard format that is used by countries to report air pollutant emissions as defined in the Guidelines for Reporting Emissions Data under CLRTAP. For more information see (UNECE, 2009 and EEA, 2013e). As with the CRF format, such standard format allows for comparison of inventories and to process the inventory information via automatic procudures for quality checking and analysis (UN ECE, 2009). Air pollutant emission sources according to the NFR classification as used in the EEA greenhouse gas data viewer are shown in Table A2.1

Table A2.1 Comparison of CRF and NRF source categories as included to report GHG and AP emissions in the EEA GHG and AP data viewers

CRF	NFR	Name
1	**1**	**Energy**
1A	**1A**	**Fuel Combustion**
1A1	1A1	Energy industries
1A1a	1A1a	Public Electricity and Heat Production
1A1b	1A1b	Petroleum Refining
1A1c	1A1c	Manufacture of Solid Fuels and Other Energy Industries
1A2	**1A2**	**Manufacturing Industries and Construction**
1A2a	1A2a	Iron and Steel
1A2b	1A2b	Non-Ferrous Metals
1A2c	1A2c	Chemicals
1A2d	1A2d	Pulp, Paper and Print
1A2e	1A2e	Food Processing, Beverages and Tobacco
1A2f		Other
	1A2fi	Stationary combustion in manufacturing industries and construction: Other
	1A2fii	Mobile Combustion in manufacturing industries and construction
1A3	**1A3**	**Transport**
1A3a		Civil Aviation
	1A3ai(i)	International aviation (LTO)
	1A3aii (i)	Civil Aviation (Domestic, LTO)
1A3b		Road Transportation
	1A3bi	Road transport: Passenger cars
	1A3bii	Road transport: Light duty vehicles
	1A3biii	Road transport: Heavy duty vehicles
	A3biv	Road transport: Mopeds & motorcycles
	1A3bv	Road transport: Gasoline evaporation
	1A3bvi	Road transport: Automobile tyre and brake wear
	1A3bvii	Road transport: Automobile road abrasion
1A3c	1A3c	Railways
1A3d		Navigation
	1A3di(ii)	International inland waterways
	1A3dii	National navigation (Shipping)
1A3e		Other Transportation
	1A3e	Pipeline compressors
1A4	**1A4**	**Other Sectors**
1A4a		Commercial/Institutional
	1A4ai	Commercial/institutional: Stationary
	1A4aii	Commercial/institutional: Mobile
1A4b		Residential
	1A4bi	Residential: Stationary plants
	1A4bii	Residential: Household and gardening (mobile)
1A4c		Agriculture/Forestry/Fisheries
	1A4ci	Agriculture/Forestry/Fishing: Stationary
	1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery
	1A4ciii	Agriculture/Forestry/Fishing: National fishing
1A5	**1A5**	**Other (Not elsewhere specified)**
1A5a		Stationary

Table A2.1 Comparison of CRF and NRF source categories as included to report GHG and AP emissions in the EEA GHG and AP data viewers (cont.)

CRF	NFR	Name
	1A5a	Other stationary (including military)
1A5b		Mobile
	1A5b	Other, Mobile (including military, land based and recreational boats)
1B	**1B**	**Fugitive Emissions from Fuels**
1B1		Solid Fuels
	1B1a	Fugitive emission from solid fuels: Coal mining and handling
	1B1b	Fugitive emission from solid fuels: Solid fuel transformation
	1B1c	Other fugitive emissions from solid fuels
1B2		Oil and Natural Gas
	1B2ai	Exploration, production, transport
	1B2aiv	Refining/storage
	1B2av	Distribution of oil products
	1B2b	Natural gas
	1B2c	Venting and flaring
	1B3	Other fugitive emissions from geothermal energy production, peat and other energy extraction not included in 1 B 2
2	**2**	**Industrial Processes**
2A	**2A**	**Mineral Products**
2A1	2A1	Cement Production
2A2	2A2	Lime Production
2A3	2A3	Limestone and Dolomite Use
2A4	2A4	Soda Ash Production and Use
2A5	2A5	Asphalt Roofing
2A6	2A6	Road Paving with Asphalt
2A7		Other
	2A7a	Quarrying and mining of minerals other than coal
	2A7b	Construction and demolition
	2A7c	Storage, handling and transport of mineral products
	2A7d	Other Mineral products
2B	**2B**	**Chemical Industry**
2B1	2B1	Ammonia Production
2B2	2B2	Nitric Acid Production
2B3	2B3	Adipic Acid Production
2B4	2B4	Carbide Production
2B5		Other
	2B5a	Other chemical industry
	2B5b	Storage, handling and transport of chemical products
2C	**2C**	**Metal Production**
2C1	2C1	Iron and Steel Production
2C2	2C2	Ferroalloys Production
2C3	2C3	Aluminium Production
2C4		Aluminium and Magnesium Foundries
2C	**2C**	**Metal Production**
2C1	2C1	Iron and Steel Production
2C2	2C2	Ferroalloys Production
2C3	2C3	Aluminium Production
2C4		Aluminium and Magnesium Foundries

Table A2.1 Comparison of CRF and NRF source categories as included to report GHG and AP emissions in the EEA GHG and AP data viewers (cont.)

CRF	NFR	Name
2C5		Other
	2C5a	Copper production
	2C5b	Lead production
	2C5c	Nickel production
	2C5d	Zinc production
	2C5e	Other metal production
	2C5f	Storage, handling and transport of metal products
2D	**2D**	**Other Production**
	2D1	Pulp and paper
2D2	2D2	Food and drink
	2D3	Wood processing
2E		Production of Halocarbons and SF_6
	2E	**Production of POPs**
2E1		By-product Emissions
2E2		Fugitive Emissions
2E3		Other
2F		Consumption of Halocarbons and SF_6
	2F	**Consumption of POPs and heavy metals (e.g. electricial and scientific equipment)**
2F1		Refrigeration and Air Conditioning Equipment
2F2		Foam Blowing
2F3		Fire Extinguishers
2F4		Aerosols/ Metered Dose Inhalers
2F5		Solvents
2F6		Other applications using ODS substitutes
2F7		Semiconductor Manufacture
2F8		Electrical Equipment
2F9		Other
2G		Other
	2G	Other production, consumption, storage, transportation or handling of bulk products
3	3	Solvent and Other Product Use
3A	3A	Paint Application
	3A1	Decorative coating application
	3A2	Industrial coating application
	3A3	Other coating application
3B	**3B**	**Degreasing and Dry Cleaning**
	3B1	Degreasing
	3B2	Dry cleaning
3C	**3C**	**Chemical Products Manufacture and Processing**
3D	**3D**	**Other**
3D1		Use of N_2O for Anaesthesia
3D2		Fire Extinguishers
3D3		N2O from Aerosol Cans
3D4		Other Use of N2O
3D5		Other
	3D1	Printing

Table A2.1 Comparison of CRF and NRF source categories as included to report GHG and AP emissions in the EEA GHG and AP data viewers (cont.)

CRF	NFR	Name
	3D2	Domestic solvent use including fungicides
	3D3	Other product use
4	**4**	**Agriculture**
4A		**Enteric Fermentation**
4A1		Cattle
4A2		Buffalo
4A3		Sheep
4A4		Goats
4A5		Camels and Llamas
4A6		Horses
4A7		Mules and Asses
4A8		Swine
4A9		Poultry
4A10		Other livestock
4B	**4B**	**Manure Management**
4B1		Cattle
	4B1a	Cattle dairy
	4B1b	Cattle non-dairy
4B2	4B2	Buffalo
4B3	4B3	Sheep
4B4	4B4	Goats
4B5	4B5	Camels and Llamas
4B6	4B6	Horses
4B7	4B7	Mules and Asses
4B8		Swine
4B9		Poultry
	4B9a	Laying hens
	4B9b	Broilers
	4B9c	Turkeys
	4B9d	Other poultry
4B10		Other livestock
4B11		Anaerobic Lagoon
4B12		Liquid System
4B13		Solid Storage and Dry Lot
	4B13	Other
4B14		Other AWMS
4B9		Poultry
	4B9a	Laying hens
	4B9b	Broilers
	4B9c	Turkeys
	4B9d	Other poultry
4B10		Other livestock
4B11		Anaerobic Lagoon
4B12		Liquid System
4B13		Solid Storage and Dry Lot
	4B13	Other
4C		**Rice Cultivation**

Table A2.1 Comparison of CRF and NRF source categories as included to report GHG and AP emissions in the EEA GHG and AP data viewers (cont.)

CRF	NFR	Name
4C1		Irrigated
4C2		Rainfed
4C3		Deep Water
4C4		Other
4D	**4D**	**Agricultural Soils**
4D1		Direct Soil Emissions
	4D1a	Synthetic N-fertilisers
4D2		Pasture, Range and Paddock Manure
	4D2a	Farm-level agricultural operations including storage, handling and transport of agricultural products
	4D2b	Off-farm storage, handling and transport of bulk agricultural products
	4D2c	N-excretion on pasture range and paddock unspecified
4E		Prescribed Burning of Savannas
4F	**4F**	**Field Burning of Agricultural Residues**
4F1		Cereals
4F2		Pulse
4F3		Tuber and Root
4F4		Sugar Cane
4F5		Other
4G	**4G**	**Other**
5		LULUCF (land use, land use change and forestry)
5A		**Forest Land**
5A1		Forest Land remaining Forest Land
5A2		Land converted to Forest Land
5B		**Cropland**
5B1		Cropland remaining Cropland
5B2		Land converted to Cropland
5C		**Grassland**
5C1		Grassland remaining Grassland
5C2		Land converted to Grassland
5D		**Wetlands**
5D1		Wetlands remaining Wetlands
5D2		Land converted to Wetlands
5E		Settlements
5E1		Settlements remaining Settlements
5E2		Land converted to Settlements
5E(V)		Biomass Burning
5F		**Other Land**
5F2		Land converted to Other Land
5F(V)		Biomass burning
5G		Other
5F		**Other Land**
5F2		Land converted to Other Land
5F(V)		Biomass burning
5G		Other
6	6	Waste
6A	6A	Solid Waste Disposal on Land

Table A2.1 Comparison of CRF and NRF source categories as included to report GHG and AP emissions in the EEA GHG and AP data viewers (cont.)

CRF	NFR	Name
6A1		Managed Waste Disposal on Land
6A2		Unmanaged Waste Disposal Sites
6A3		Other
6B	**6B**	**Wastewater Handling**
6B1		Industrial Wastewater
6B2		Domestic and Commercial Wastewater
6B3		Other
6C	**6C**	**Waste Incineration**
	6Ca	Clinical waste incineration
	6Cb	Industrial waste incineration
	6Cc	Municipal waste incineration
	6Cd	Cremation
	6Ce	Small scale waste burning
6D	**6D**	**Other**
7	**7**	**Other**
	7A	Other (included in national total for entire territory)

Memo items CRF:	Memo item NFR:
International bunkers	National total (FU) Memo item — Alternative total with transport emissions based on fuel used
International bunkers	1 A 3 a ii (ii) Memo item — Civil aviation (Domestic, Cruise)
International aviation	1 A 3 a i (ii) Memo item — International aviation (Cruise)
International maritime transport	1 A 3 d i (i) Memo item — International maritime navigation
CO_2 emissions from biomass	1 A 3 Memo item — Transport (fuel used)
Multilateral operations	7 B Memo item — Other not included in national total of the entire territory
	11 A Memo item — Volcanoes
	11 B Memo item — Forest fires
	11 C Memo item — Other natural emissions

NACE

NACE is derived from the French title 'Nomenclature générale des Activités économiques dans les Communautés Européennes' (Statistical classification of economic activities in the European

Communities). It is the Statistical classification of economic activities in the European Communities that provides the framework for presenting statistical data according to economic activity. At present the NACE Rev. 2 classification is being used. The main structure of NACE Rev. 2 is presented below, further detailed split can be found in Eurostat, 2008.

Section	Title	Divisions
A	Agriculture, forestry and fishing	01–03
B	Mining and quarrying	05–09
C	Manufacturing	10–33
D	Electricity, gas, steam and air conditioning supply	35
E	Water supply; sewerage, waste management and remediation activities	36–39
F	Construction	41–43
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	45–47
H	Transportation and storage	49–53
I	Accommodation and food service activities	55–56
J	Information and communication	58–63
K	Financial and insurance activities	64–66
L	Real estate activities	68
M	Professional, scientific and technical activities	69–75
N	Administrative and support service activities	77–82
O	Public administration and defence; compulsory social security	84
P	Education	85
Q	Human health and social work activities	86–88
R	Arts, entertainment and recreation	90–93
S	Other service activities	94–96
T	Activities of households as employers; u0ndifferentiated goods- and services-producing activities of households for own use	97–98
U	Activities of extraterritorial organisations and bodies	99

Source: Eurostat, 2008.

COICOP

The Classification of individual consumption by purpose (COICOP) was developed by the United Nations Statistics Division to classify and analyse individual consumption expenditures incurred by households, non-profit institutions serving households and general government according to their purpose. Eurostat subsequently adapted the COICOP classification to the harmonised index of consumer prices (HICP) of the European Union, and collects and maintains country-level indicators on expenditure within each of these categories for the EU-27.

The COICOP includes 14 upper level (one digit) categories of which the first 12 are relevant to household consumption. The 12 categories are as follows:

01 — Food and non-alcoholic beverages

02 — Alcoholic beverages and tobacco

03 — Clothing and footwear

04 — Housing, water, gas, electricity and other fuels

05 — Furnishings, household equipment

06 — Health

07 — Transport

08 — Communications

09 — Recreation and culture

10 — Education

11 — Restaurants and hotels

12 — Miscellaneous goods and services

Each category is further split into a set of two digit categories. For example, the category Transport includes the following two digit categories: 07.1 — Purchase of vehicles, 07.2 — Operation of personal transport equipment, 07.3 — Transport services.

Source: EEA, 2013c.

GTAP

Information from the Global Trade Analysis Project (GTAP), as included in Section 4.2.2 from Andrew and Peters (2013) is usally organised for 57 economic sectors which are shown below. For more information see: https://www.gtap.agecon.purdue.edu/databases/contribute/concord.asp.

1	PDR	Paddy rice
2	WHT	Wheat
3	GRO	Cereal grains nec
4	V_F	Vegetables, fruit, nuts
5	OSD	Oil seeds
6	C_B	Sugar cane, sugar beet
7	PFB	Plant-based fibers
8	OCR	Crops nec
9	CTL	Bovine cattle, sheep and goats, horses
10	OAP	Animal products nec
11	RMK	Raw milk
12	WOL	Wool, silk-worm cocoons
13	FRS	Forestry
14	FSH	Fishing
15	COA	Coal
16	OIL	Oil
17	GAS	Gas
18	OMN	Minerals nec
19	CMT	Bovine meat products
20	OMT	Meat products nec
21	VOL	Vegetable oils and fats
22	MIL	Dairy products
23	PCR	Processed rice
24	SGR	Sugar
25	OFD	Food products nec
26	B_T	Beverages and tobacco products
27	TEX	Textiles
28	WAP	Wearing apparel
29	LEA	Leather products
30	LUM	Wood products
31	PPP	Paper products, publishing
32	P_C	Petroleum, coal products
33	CRP	Chemical, rubber, plastic products
34	NMM	Mineral products nec
35	I_S	Ferrous metals
36	NFM	Metals nec
37	FMP	Metal products
38	MVH	Motor vehicles and parts
39	OTN	Transport equipment nec
40	ELE	Electronic equipment
41	OME	Machinery and equipment nec

42	OMF	Manufactures nec
43	ELY	Electricity
44	GDT	Gas manufacture, distribution
45	WTR	Water
46	CNS	Construction
47	TRD	Trade
48	OTP	Transport nec
49	WTP	Water transport
50	ATP	Air transport
51	CMN	Communication
52	OFI	Financial services nec
53	ISR	Insurance
54	OBS	Business services nec
55	ROS	Recreational and other services
56	OSG	Public Administration, Defense, Education, Health
57	DWE	Dwellings

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