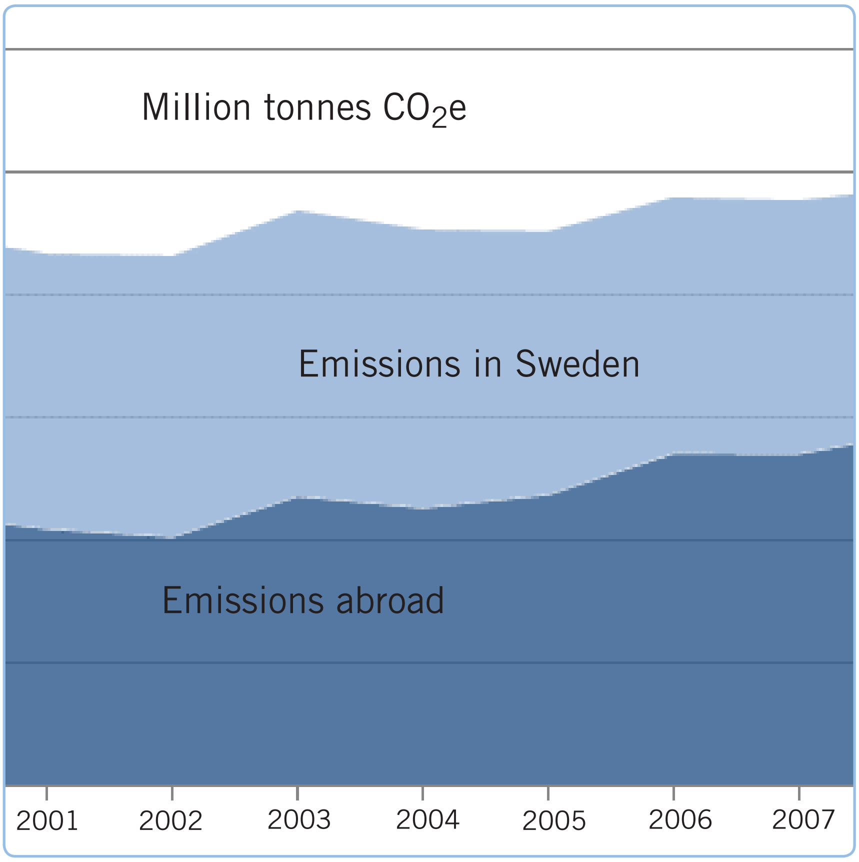
SWEDISH ENVIRONMENTAL PROTECTION AGENCY

Consumption-based indicators in Swedish environmental policy

REPORT 6508 • JANUARY 2013



Consumption-based indicators in Swedish environmental policy

SWEDISH ENVIRONMENTAL PROTECTION AGENCY

Orders
Order tel: +46 (0)8-505 933 40
Order fax: +46 (0)8-505 933 99
E-mail: natur@cm.se
Postal address: CM Gruppen AB, Box 110 93, 161 11 Bromma
Internet: www.naturvardsverket.se/bokhandeln

Swedish Environmental Protection Agency
Tel: +46 (0)010-698 10 00 Fax: 010-698 10 99
E-mail: registrator@naturvardsverket.se
Postal address: Naturvårdsverket, 106 48 Stockholm
Internet: www.naturvardsverket.se

ISBN 978-91-620-6508-9
ISSN 0282-7298

Electronic publication
Cover: Swedish Environmental Protection Agency

Preface

Sweden is a relatively small country with large trade, and our patterns of production and consumption are closely linked to emissions and other environmental impact in the rest of the world. To clarify this international dimension, the Swedish Parliament in 2010 decided to introduce a new general objective for Swedish environmental policy, which reads:

"The overall goal of Swedish environmental policy is to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden's borders."

The difference compared with previous years is that the requirements for environmental improvements in Sweden to take place without environmental and health problems increasing outside Sweden are tightened. A topical issue is whether environmental and health problems associated with our patterns of consumption are gradually being transferred to other countries. To enable us to shed light on this issue, we need to develop ways of monitoring the environmental impact of Swedish consumption in other countries.

This project has been carried out by Statistics Sweden (Hanna Brolinson, project leader, Viveka Palm and Anders Wadeskog in the Environmental Economics and Natural Resources Section, and Louise Sörme in the Environmental Statistics and Tourism Section) in cooperation with the Royal Institute of Technology (KTH) (Yevgeniya Arushanyan and Göran Finnveden in the Division of Environmental Strategies Research - fms) on behalf of the Swedish Environmental Protection Agency.

Valuable opinions have been received from the project reference group, which has comprised Eva Alfredsson (Swedish Agency for Growth Policy Analysis), Katarina Axelsson (Stockholm Environment Institute), Carina Borgström-Hansson (WWF), Johan Jarelin, Swedish Consumer Agency), Marianne Jönsson (Swedish National Board of Trade), Annaa Mattsson (Friends of the Earth Sweden), Sara Sundgren (All-Party Committee on Environmental Objectives), Kristian Skånberg (Swedish Confederation of Professional Employees), Inger Strömdahl (Confederation of Swedish Enterprise, Margareta Östman (Swedish Chemicals Agency), as well as representatives of the Swedish Environmental Protection Agency and the experts Lars Westermark, Anna Hellström, Karin Klingspor, Erik Westin, Anita Lundström, Maria Lidén, Eva Jernbäcker and Helena Bergström. The study was commissioned for the Swedish Environmental Protection Agency by Eva Ahlner.

Stockholm, March 2012

Swedish Environmental Protection Agency

Contents

1 Summary

The generational goal, which sets the direction for Sweden's environmental policy, was reformulated and decided upon in 2010 by the Riksdag.

The overall goal of Swedish environmental policy is to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden's borders.

There are seven bullet points linked to the generational goal. The seventh emphasises that solving the environmental problems we face are to be achieved within one generation, ensuring that: *Patterns of consumption of goods and services cause the least possible problems for the environment and human health.*

The changes from the previous generational goal imply among other things that environmental policy in Sweden must not lead to increased environmental and health problems outside of Sweden. This implies that we have to develop the possibility of following up Sweden's environmental impact in other countries. The environmental impact that Sweden causes in other countries is due among other things to the importing of products. It is therefore necessary to try to quantify the total environmental impact that the manufacturing of the imported products causes in order to gain an understanding of the environmental impact abroad.

The purpose of this project is primarily to develop indicators for emissions of greenhouse gases and other emissions to air caused by Swedish consumption, in order to follow the negative environmental impact in other countries. The indicators are generally aimed at following the trend in emissions over time, not at examining exact emission levels.

The purpose is also to further develop methods to follow the emissions of chemical substances caused by Swedish consumption. The idea here is to try out a data source for point sources of discharge of chemical substances, apply an input-output analysis to them and weigh together the substances to obtain potential toxicity, by life cycle assessment (LCA) methods. This is a first step and the method needs to be further developed before an indicator can be presented.

The results of the project are presented in the following proposals for indicators to follow up the generational goal and its seventh bullet point:

Climate related emissions:

- Emissions of greenhouse gases abroad and in Sweden, measured in carbon dioxide equivalents caused by Swedish consumption, time series 2000-2008

- Emissions of greenhouse gases per person abroad and in Sweden caused by Swedish consumption, measured in carbon dioxide equivalents, time series 2000-2008
- Emissions of greenhouse gases caused by Swedish consumption abroad and in Sweden, indexed with the year 2000 = 100, time series 2000-2008

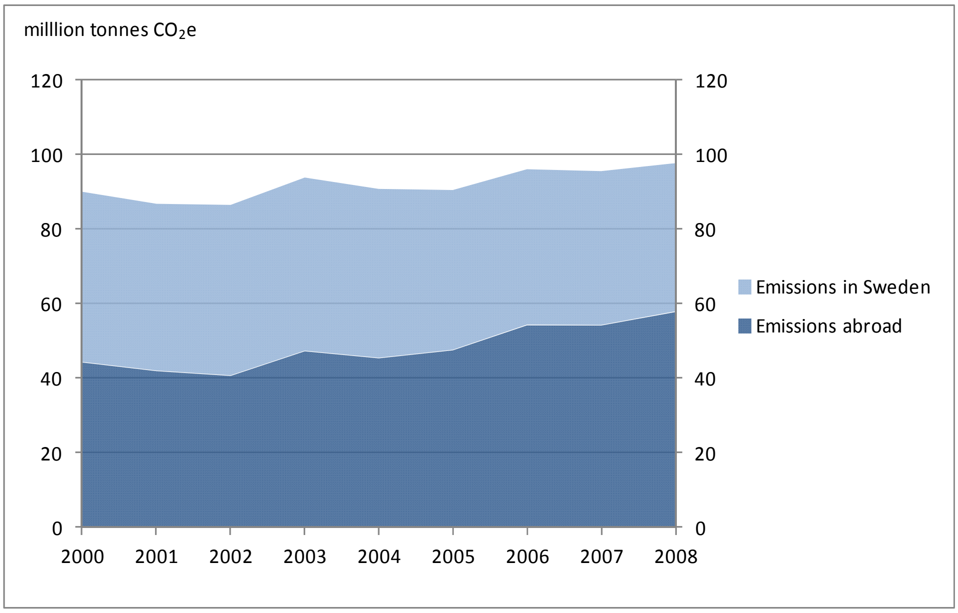
Other emissions to air:

- Emissions of nitrogen oxides caused by Swedish consumption, abroad and in Sweden, time series 2000-2008
- Emissions of sulphur dioxide caused by Swedish consumption abroad and in Sweden, time series 2000-2008
- Emissions of ammonia caused by Swedish consumption abroad and in Sweden, time series 2000-2008

An example of how the indicators can be presented together with relevant issues is available in the report in Annex 5.

Emissions of greenhouse gases caused by Swedish consumption, in Sweden and abroad

The indicator for greenhouse gases emissions caused by Swedish consumption abroad and in Sweden is presented below. Greenhouse gases are measured in millions of tonnes of carbon dioxide equivalents, which is a weighted total of carbon dioxide, methane and nitrous oxide (laughing gas) due to their impact on the greenhouse gas effect.



Model calculated emissions of greenhouse gases caused by Swedish consumption, in millions of tonnes of carbon dioxide equivalents (carbon dioxide, methane and nitrous oxide weighted together) 2000 to 2008. The emissions abroad, caused by imports and emissions in Sweden, mainly the Swedish total emissions incl. international transport minus exports, are shown.

The indicator shows the total greenhouse gas emissions caused by Swedish consumption, consisting of emissions in Sweden and emissions abroad. The total emissions caused by Swedish consumption increased from 90 million tonnes carbon dioxide equivalents in 2000 to 98 million tonnes carbon dioxide equivalents in 2008. This implies an increase of 9 percent during the period.

The emissions abroad have increased from 44 million tonnes to 58 million tonnes, implying an increase of 30 percent between 2000 and 2008. In comparison, domestic emissions caused by Swedish consumption decreased from 46 million tonnes to 40 million tonnes during the same period, implying a decrease of about 13 percent. The exact levels depend on which data are available and model assumptions, and may vary between studies.

The increase shown by the indicator of the total emissions is caused by an increase in emissions abroad and can be explained in the model by increased consumption met by increasing imports. The fact that the imports have increased by approximately 40 percent, in fixed prices, between 2000 and 2008, supports that explanation. An increase can also be the result if the composition of consumption changes, i.e. if other types of products are imported, product types that cause higher emissions, or if the production of imported goods takes place where higher emissions are caused in producing the same type of goods. Nearly half of the increase can be explained by the population growth during the period. To find out more about the driving forces behind the increased emissions, supplementary studies must be performed, which have not been carried out within this project.

The indicator consists of two parts, emissions in Sweden and emissions abroad, both caused by Swedish consumption.

The underlying data source for the emissions in Sweden is the official statistics on emissions reported to UNFCCC, the UN's climate change convention. These emissions are broken down by industry and processed by Environmental Accounts at Statistics Sweden and used in an environmentally extended input-output analysis (Naturvårdsverket, 2010d). The main difference between the domestic emissions caused by Swedish consumption and the domestic emissions reported to UNFCCC is that emissions caused in producing goods for export are not a part of the emissions caused by consumption.

Emissions due to imported goods that are produced in other countries are estimated according to a model. The model for carbon dioxide emissions is based on how much - in economic terms - is imported from other countries (data from Statistics Sweden), emissions of carbon dioxide reported to Eurostat for EU countries and each country's emissions intensity in relation to GDP (data from World Resources

Institute) for countries outside the EU. Emissions of methane and nitrous oxide in other countries are calculated as if they occurred in Sweden.

Use of chemicals and emissions of chemical substances
The project included further development of methods for a future indicator of the area of chemicals from a perspective of consumption. In previous work, data from the products register at the Swedish Chemicals Agency have been used to create indicators for use of chemicals in Sweden for this purpose. In this project the options for developing other indicators as a complement are investigated, where an important prerequisite is data availability abroad.

The focus was to develop the idea which was presented in the background synthesis report (Naturvårdsverket, 2010d). The idea is to try to use the database E-PRTR[1] which contains national emissions of chemical substances from industrial point sources, reported to the EU. Input-output analyses could be applied to these data, to obtain emissions caused by final demand. The emitted chemical substances were weighted using LCA methods to enable potential toxicity to be presented for aquatic ecotoxicity and human toxicity. The results which are presented in the report show contribution to potential toxicity caused by final demand in Sweden in 2008, based on reported emissions in E-PRTR. Substances that contributed most to potential toxicity could also be distinguished.

In the study using E-PRTR as a data source, several limitations should be mentioned which contribute to the fact that no ready-to-use indicator for chemical substances is presented in the report. The emissions are presented for the whole of final demand including exports. Of this followed that the large export products (basic metals, pulp and paper) contributed heavily to the results. The analysis was restricted to domestic emissions, which means that no calculations on the contribution to potential toxicity for imported goods were performed. Another restriction worth noting is that the contents of the data source are limited to those substances that are reportable and that the result depends on which substances are included in the calculation model that is used when the potential toxicity is determined.

Continued work
The work to produce indicators for follow up of the global environmental impact caused by consumption has made some progress through this project. During the project many development areas for methods and data sources have been identified. No development projects have been decided upon, and a decision on estimation of costs must be evaluated first.

1 The European Pollutant Release and Transfer Protocol

For climate related emissions there are the following suggestions for development:

- Add emissions of fluorinated greenhouse gases by industry to the environmentally extended input-output analyses.
- Develop emission intensities based on data from the International Energy Agency (IEA) and World Bank to obtain more detailed and updated intensities than those published by World Resources Institute (WRI).
- Study to what extent the increased levels of greenhouse gas emissions are due to higher imports or higher emissions intensities.
- Study which countries Sweden imports from, and analyse if this has changed over time and has had any impact on emission levels.
- Further enhance the allocation of emissions of methane and nitrous oxide related to the production of food products, so that meat can be separately studied and to enhance the calculation of emissions in other countries.

For emissions to air there are the following suggestions for development:

- Use Eurostat data for the emissions of sulphur dioxide, nitrogen oxides and ammonia to obtain a better understanding of emissions in other countries. The results in this report are based on the “as if” assumption.
- Study the following emissions to air in a consumption perspective: carbon dioxide, volatile aromatic compounds and particulates, to obtain a better understanding about how these can be followed in other countries.

For the area of chemicals, there is no indicator ready to use. A possible way forward is to develop an indicator based on E-PRTR and relate it to other sources of emissions. The following indicates development areas in order to connect emissions of chemical substances to consumption:

- Allocate the emissions from industrial point sources reported to E-PRTR to the components of final demand so that the emissions linked to exports can be excluded in further analyses.
- Try to obtain an understanding of the size of the total industrial emissions that are covered through E-PRTR (the database EU countries report their national PRTR data to)
- Estimate emissions in other countries, related to Sweden’s imports, by using available data sources (available for the EU and several other countries).
- Quantify and estimate the potential toxicity from diffuse emissions from the use of chemical products and from goods, for comparison with the potential toxicity from those emissions that are reported in E-PRTR.

2 Introduction

2.1 Background

The overarching goal of Swedish environmental policy is expressed in what is known as the generational goal. As part of an amended environmental policy for Sweden, the Riksdag (Swedish Parliament) in 2010 adopted the generational goal, which is worded as follows (Government Bill 2009/10:155):

The overall goal of Swedish environmental policy is to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden's borders.

Seven bullet points are linked to the generational goal, describing the transition needed to attain the generational goal. The seventh bullet point relates to our patterns of consumption:

Patterns of consumption of goods and services cause the least possible problems for the environment and human health.

The amendment means, among other things, that environmental policy in Sweden now covers attaining the generational goal outside the borders of Sweden and introduction of the perspective of consumption. To enable us to follow up this goal, we in Sweden need to develop ways of estimating Swedish environmental impact in other countries. The environmental impact in Sweden is caused in part by the importing of products to satisfy consumption in Sweden. It is therefore necessary to try to quantify the combined environmental impact caused by the products we buy from other countries in order to identify the environmental impact abroad.

Several reports on the topic of the global environmental impact of consumption have been published in recent years. An example that can be mentioned is the preliminary study conducted by the Swedish Environmental Protection Agency, "Monitoring the global environmental impact of Swedish consumption in the system of environmental objectives – a preliminary study" (Naturvårdsverket, 2010a). This preliminary study sheds light on ways of tracking the global environmental impact of Swedish consumption as part of the follow-up of the environmental objectives. A quantification of the global environmental impact of Swedish consumption was presented by the Swedish Environmental Protection Agency and the Swedish Chemicals Agency in the report "The global environmental impact of Swedish consumption" (Naturvårdsverket, 2010). This was also the theme of the 2010 in-depth evaluation of the environmental objectives, "The environmental objectives – Swedish consumption and environmental impact, de Facto 2010" (Naturvårdsverket, 2010c).

To enable the environmental impact of Swedish consumption in other countries to be monitored, methods and data are needed to measure and follow this trend. On behalf of the Swedish Environmental Protection Agency, Statistics Sweden, together with two international researchers, listed methods for measuring the environmental impact of Swedish consumption in other countries. This listing was presented in the report "Methods to assess global environmental impacts from Swedish consumption" (Naturvårdsverket, 2010d). Methods in the following six areas were identified and evaluated:

- Greenhouse gas emissions
- Other emissions to air
- Chemicals
- Land use
- Water use
- Biodiversity

The study found that there are robust methods and data for greenhouse gas emissions and other emissions to air with which to calculate and monitor the environmental impact of consumption in Sweden and in other countries over time. The other areas require further development and possibly research to find data and methods so that environmental impact in other countries caused by Swedish consumption can be regularly monitored.

2.2 Aim

The primary aim of this project is to devise indicators, measures that can be monitored, for:

- Greenhouse gas emissions
- Other emissions to air

These indicators are to be formulated in accordance with previous proposals for method and data sources (Swedish Environmental Protection Agency, 2010d). The indicators are to be capable of serving as a basis for the in-depth evaluation of the generational goal in 2012. The indicators developed in this project represent a first attempt at developing measures with which to monitor the global environmental impact of Swedish consumption at macro-level. They are intended to show the trend over time and show the total emissions, abroad and in Sweden, caused by Swedish consumption.

Another aim is to enhance the methodology to be used in monitoring emissions of chemical substances caused by Swedish consumption. The focus in this report is on trying out a data source for point emissions of chemical substances, E-PRTR (the emissions data reported by the Swedish Environmental Protection Agency, Emissions in Figures, to the EU) and to weigh the substances together to give potential toxicity using methodology developed in life-cycle assessment (LCA).

3 Method and data sources

3.1 Environmental accounts and consumption

The system of environmental accounts is a statistical system described in the framework System of Integrated Environmental and Economic Accounting, SEEA (SEEA, 2003). The purpose of environmental accounts is to describe the contribution of the environment to the economy (for example the use of raw materials, water, energy and land) and the impact of the economy on the environment (such as emissions to air, land and water), see Figure 1. This is done by combining and processing environmental statistics with economic statistics and by using the same definitions of industries, product groups and sectors as are used in the national accounts. A consumption perspective on emissions has been adopted in the environmental accounts for many years in order to study how emissions are distributed between domestic emissions and emissions caused in other countries.

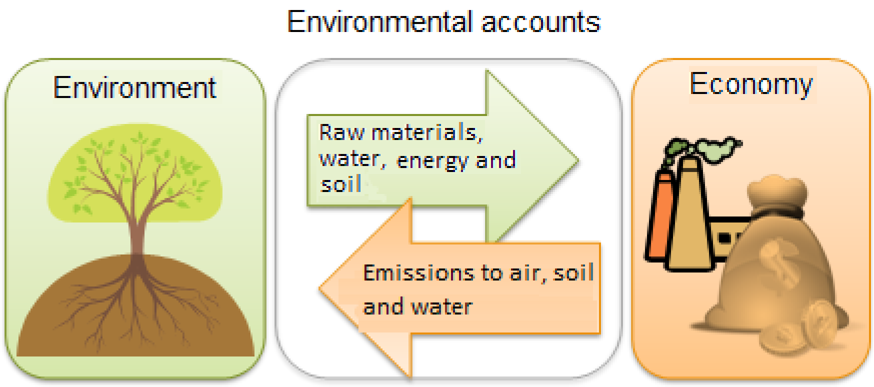


Figure 1 The system of environmental accounts is a statistical system aimed at describing the contribution of the environment to the economy and the impact of the economy on the environment.

3.1.1 How can consumption be measured?

Consumption is understood here to mean the annual purchases of goods and services by private individuals and the public sector. What is consumed is therefore not to be aimed at producing new goods or services, the aim instead being final demand, which is a concept applied in national economics. Final demand is met by domestically produced goods and services (which cause emissions in Sweden) and imported goods and services (which cause emissions in other countries). Emissions within Sweden are additionally caused by direct emissions caused by the use, for example, of petrol for transport. The concept of domestic final demand, or consumption, usually includes private and public consumption and investments and stock changes, see Figure 2. Emissions caused by production which then goes for export are not included in Swedish emissions caused by consumption.

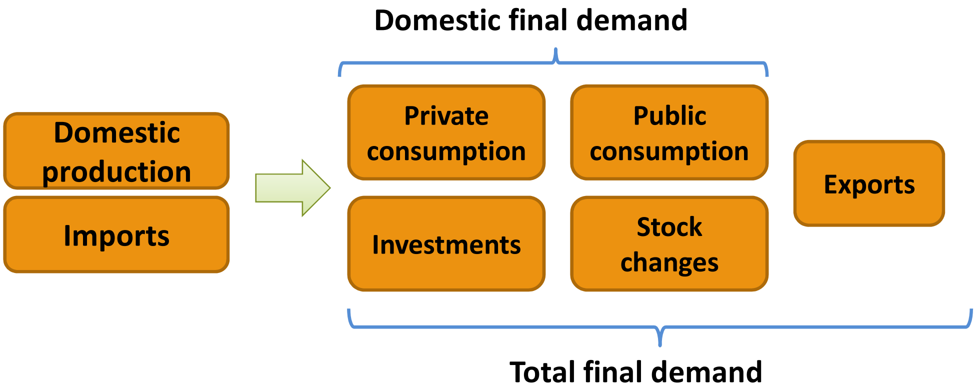


Figure 2 The total final demand in a country is shared between private consumption, public consumption, investments, stock changes and exports and is met by domestically produced goods and services and imported goods and services. Domestic final demand, i.e. consumption, consists of total final demand minus the use that goes for export.

3.1.2 How can environmental impact be linked to consumption?

A consumption perspective is applied in the environmental accounts, where Sweden's total economy is linked to emissions broken down into different production groups consumed during one year. Consumption-related emissions are defined as those that take place in the manufacturing of the consumed product, either in Sweden or abroad, depending on the country of manufacture. In addition, those emissions that take place in the use of the product are counted as being consumption-related, as these emissions take place in Sweden. The method of linking emissions to the economy is known internationally as Environmentally Extended Input-Output Analyses (EE-IOA) (Naturvårdsverket 2010d). All emissions broken down by industry can be studied by environmentally extended input-output analyses from a consumption perspective, that is to say by answering the question "What level of emissions of the substance has been caused in Sweden and in other countries based on our consumption in Sweden?". This differs from the perspective that answers the question "What level of emissions of the substance has been caused within the borders of Sweden?" and that is applied for example when we report national emissions data to UNFCCC.

An environmentally extended input-output analysis is dependent on emissions data broken down by industry for the countries Sweden imports from. If data for other countries are not available, they can be replaced by the model assumption that emissions take place as if the manufacturing had taken place in Sweden. This assumption is known as the "as if" assumption and means that emissions from the products we import are calculated as if they had been manufactured with the same emissions intensities as in Sweden. The "as if" assumption obviously means a simplification and in most cases an underestimate (Statistics Sweden, 2002, and Carlsson-Kanyama et al., 2007).

The outcome of an environmentally extended input-output analysis depends on model assumptions and included data, and the outcome may therefore vary from one study to another. Model assumptions made relate, for example, to how bunkering or investments are handled (see Annex 1). The availability of data applies primarily to emissions abroad, and the result depends on which data are reported for different countries or whether emissions intensities are used or alternatively the “as if” assumption is applied.

3.2 Greenhouse gas emissions associated with Swedish consumption

Three indicators are proposed to follow the trend for greenhouse gas emissions abroad and in Sweden caused by Swedish consumption. The indicators include emissions of carbon dioxide, methane and nitrous oxide, which are weighted to give carbon dioxide equivalents. This weighting is done in accordance with UN guidelines (IPCC, 1996) depending on the contributions of the different gases to the greenhouse effect. In this calculation, emissions of methane are multiplied by a factor of 21 and nitrous oxide by a factor of 310 and these are added together with carbon dioxide emissions to obtain carbon dioxide equivalents.

The greenhouse gas emissions included in the analysis are those that are caused by domestic final demand, i.e. those caused by Swedish consumption. The calculation of the emissions caused by consumption is based on the emissions reported to UNFCCC, but differs from these on some points. The different consists primarily in emissions caused by production of goods and services going for export not being included among emissions caused by consumption. In addition, the emissions caused by consumption are linked to the Swedish economy and are not limited to taking place within the borders of Sweden. This means that consumption-based emissions include the share of the Swedish economy in international transport and shipping, for example cargo transport and international travel purchased in Sweden. Emissions caused by land use change are not included, as there are no methods for linking this type of emissions to consumption. Emissions from land use change are related for example to livestock production and palm oil. Another difference is that fluorinated greenhouse gases, F-gases, are not included in consumption-based emissions. This simplification is due to the fact that at present there are no emissions of F-gases broken down by industry, which is essential if they are to be included in the environmentally extended input-output analysis. According to information on the Swedish Environmental Protection Agency website, F-gases account for 1 per cent of total global emissions of greenhouse gases and 2 per cent of Sweden’s total emissions of greenhouse gases.

Bunkering is also included in the calculations. Emissions from bunkering are calculated on the assumption that Sweden bunkers in other countries to the same extent that other countries bunker in Sweden. Emissions from bunkering in other countries are not, however, multiplied by country-specific emission intensities.

Emissions for investments have been allocated to final demand and export in the calculations on which the results in this report are based. Investments made to produce goods that go for export are therefore not included in the consumption-based emissions. Annex 1 describes how bunkering and investments are handled in the input-output analysis.

Emissions reported to UNFCCC are calculated and reported sector by sector, and the method of calculation differs depending on the sector concerned. Measured values are sometimes available for emissions from industrial processes, but model estimates are generally made where emission factors are utilised. These are based on measurements combined with different types of activity data which, depending on sector, may be fuel consumption, number of vehicle-kilometres, number of livestock etc. The methodology in the case of all sectors has to follow the international IPCC Guidelines (IPCC, 1996). The guidelines allow countries to develop their own methodology provided it is in agreement with the general instructions in the guidelines if there is sufficient knowledge and input data. Sweden's methodology is described in detail in the annual National Inventory Report (NIR)[2].

For carbon dioxide emissions in the EU, there are data reported to Eurostat[3] as well as for some other countries, for example Norway. Such imported data have been used in calculating emissions of greenhouse gases caused in the manufacturing of the products imported from these countries. Imports from the EU-27 amount to 70 per cent of the economic value of total imports in 2008, see Annex 2. Emissions intensities (tonnes of carbon dioxide per GDP dollar) from the World Resources Institute[4] (WRI) are used for countries outside the EU in this study. There are WRI data for around a hundred countries, and the most recent year is 2005; changes in emissions intensities since 2005 are therefore not reflected in the calculations. For methane and nitrous oxide emissions, the assumption that emissions take place as if the imported products had been manufactured in Sweden is applied.

3.3 Other emissions associated with Swedish consumption

Data used for compilation of official statistics in Sweden and to fulfil international reporting obligations are used to produce the indicators. The "as if" assumption is used for emissions in other countries. Previous studies have shown that Sweden has relatively low carbon dioxide and sulphur dioxide emissions but equally high

[2] Swedish NIR submission 2011 , http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php

[3] Eurostat is the EU's statistical office, http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home

[4] World Resources Institute, http://www.wri.org/

nitrogen oxide emissions as other countries (Statistics Sweden, 2002). The “as if” assumption in the case of carbon dioxide and sulphur dioxide signifies an underestimate, while it ought to provide a reasonable picture of nitrogen oxides.

Consumption-based emissions based on environmentally extended input-output analysis together with the “as if” assumption provided a different picture than for nitrogen oxides, sulphur oxides and ammonia for emissions of carbon monoxide, volatile organic compounds and particulates. It appeared that most emissions take place in direct use, that is to say that emissions take place in Sweden and to a very small extent are related to imports. A choice was made in this project not to include these emissions as an indicator as it could not be decided whether this is a correct picture of reality. These emissions largely originate from traffic but are also caused by combustion of fuels in other processes. The emission factors may depend on technical circumstances, and we do not know how representative Swedish data are for the countries and groups of goods imported.

The largest emission sources for nitrogen oxides, in Sweden, are shipping, construction machinery, electrical installations and district heating plants. Emissions of nitrogen oxides can contribute to acidification, eutrophication, formation of ground-level ozone and particulates, as well as direct, adverse effects on health. The principal emission sources for sulphur dioxide in Sweden are energy production, transport and industrial processes. Sulphur dioxide emissions contribute to acidification and particulate formation, and can have direct, adverse effects on health. The principal source of emissions for ammonia is agriculture. Ammonia can contribute to acidification, eutrophication and particulate formation and can have direct, adverse effects on health. Volatile organic compounds, carbon dioxide and particulates contribute to a deterioration in air quality and adverse impact on health. The principal sources of volatile organic compounds are road traffic, energy supply, solvent use and small-scale wood burning (Naturvårdsverket, 2011).

3.4 Emissions of chemical substances associated with Swedish consumption

The area of chemicals is complex, not just because there are so many substances in use, more than 100 000 (Swedish Chemicals Agency, 2011), but also because their environmental and health effects have not always been analysed and the combined effect of different substances may be unknown, leading to what is referred to as a cocktail effect. In addition, emissions take place in various phases of a product’s life cycle, in manufacturing, in use and at the waste stage, contributing to the complexity.

“Chemical” means the same as a “chemical substance” or a “chemical product” (which is a mixture of chemical substances). Chemical products are used deliberately, while chemical substances, as well as being used deliberately, may also be contaminants or may occur naturally in the environment. An "article" is an object which during production has been given a particular form or design which, more than the chemical composition, determines its function. Chemical substances in articles may be various forms of additives that are used to give the article a particular property, such as flame retardants or preservatives.

Emissions of chemical substances take place in various industrial processes, such as paper production or waste incineration. Greenhouse gas emissions, emissions of sulphur dioxide and metal pollutants are examples of emissions of chemical substances. Direct emissions of these can take place to soil, air, leachate or wastewater. In a consumption perspective, these emissions take place abroad or in Sweden. Diffuse emissions of chemical substances take place in the use of chemical products or articles. Examples of diffuse emissions are emissions of solvents in the use of paints and in spreading pesticides on arable land. Antibacterially treated textiles that release the antibacterial substance when they wear or are washed are another example. A large proportion of the diffuse emissions linked to Swedish consumption take place in Sweden. The total emissions have not been analysed, and there is no overview and quantification (Rockström et al, 2009).

There are four different government agencies dealing with chemical issues in Sweden: the Swedish Chemicals Agency, the Medical Products Agency, the National Food Administration and the Swedish Environmental Protection Agency. Differing legislation governs the use of different groups of chemicals. There are two groups of articles that are not counted as chemical products in the legislation: cosmetics and hygiene products and medicines. Emissions linked to these two groups of articles take place both in manufacturing countries and during use in Sweden. In the case of cosmetics and hygiene products, direct emissions take place in use, mostly to wastewater as in the use of shampoo and soap. The volume of cosmetic and hygiene products sold in Sweden was just over 40 000 tonnes in 2006 (Statistics Sweden, 2009a). The medicines used in Sweden contain around 1 800 active substances (Statistics Sweden, 2009). The manufacturing of medical products may be associated with large emissions in other countries (Larsson et al., 2007). Emissions of pharmaceutical substances in Sweden take place principally in the form of diffuse emissions in use when an active substance is partially broken down and partially excreted in unchanged form and enters the wastewater (Statistics Sweden, 2009). Work has been in progress at www.FASS.se for several years to supplement the medical information on particular medicines with an assessment of environmental risk.

Emissions of chemical substances in a consumption perspective include point emissions both in Sweden and abroad, as well as diffuse emissions in Sweden, see Figure 3. With regard to use of chemicals and emissions of chemicals in other countries, knowledge is more scanty than in Sweden.

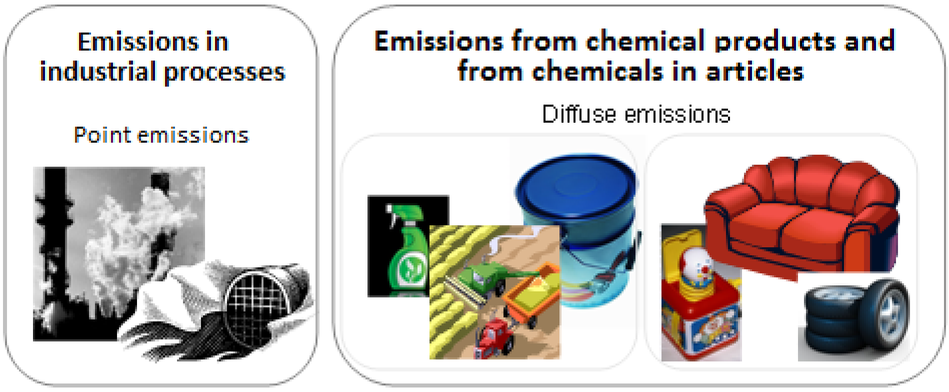


Figure 3 Schematic illustration of emissions of chemical substances, firstly emissions that take place in industrial processes (in manufacturing countries) and secondly diffuse emissions that take place in the use of chemical products and articles (mostly in Sweden).

To obtain a complete indicator of chemical emissions, it would be necessary to combine emissions from industrial processes (at both the manufacturing and waste stages) and diffuse emissions that take place in use. Chemical products, articles, medicines and cosmetic and hygiene products and emissions of pollutants should preferably all be included in the indicator to provide as complete a picture as possible. It is not possible to develop such an indicator in the framework of this project. The following sections of the report describe possible data sources for the various emission components, and the data source for industrial emissions has been tried out in the project.

3.4.1 Emissions from industrial processes

For emissions of chemical substances from industrial processes, including waste management, there is E-PRTR, the European Pollutant Release and Transfer Register, as a data source for EU Member States. Emissions are reported by individual companies with emissions above certain limit values or above certain threshold values for capacity. In Sweden, industrial emissions are published in the Swedish Environmental Protection Agency's Utsläpp i Siffror (Emissions in Figures) (http://utslappisiffror.naturvardsverket.se/) which is Sweden's Pollutant Release and Transfer Register.

Reporting to E-PRTR is governed by an EU regulation (Regulation (EC) No 166/2006)[5], and all Member States have to report data according to this regulation. In the OECD[6] work has also been done towards requiring Member States to start

[5] Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC

[6] http://www.oecd.org/env_prtr_data/

reporting according to PRTR. Guidance on reporting can be found on the PRTR website (http://prtr.ec.europa.eu, E-PRTR Guidance Document). The reporting covers nine sectors and 91 substances. Examples of groups of substances are heavy metals, pesticides, greenhouse gases and chlorinated organic substances.

The data source entails some limitations. Firstly, reporting is not mandatory for all chemical substances. Secondly, as there are threshold values for when an installation must report emissions, the data source constitutes a subset of all industrial emissions. The advantage of the data source is that reporting is regulated within the EU, updating takes place annually and data are available for downloading by the general public.

In the framework of this project, data have been downloaded from E-PRTR. Environmentally extended input-output analysis has been applied to these emissions to obtain emissions in a consumption perspective, i.e. to allocate emissions to categories of articles in final demand in Sweden. The analysis in the study has been done for the whole of total final demand (see Figure 2), which means that emissions associated with the production of goods and services that go for export are included here. Only emissions in Sweden are included in the analysis, and no estimate has therefore been made of emissions that take place in other countries as a consequence of Swedish consumption.

The substances in E-PRTR can be presented individually, but as there are a large number of substances it may also be of interest to aggregate emissions based on their potential toxicity to obtain a smaller number of indicators. In that way an assessment can be made of which substances make the greatest contribution to potential toxicity. Usetox (Rosenbaum et al., 2008) is used in particular in the study. This is a method that has been developed for use in life-cycle assessments, with the aid of which the potential contribution to human toxicity and ecotoxicity from different substances can be calculated. The method takes account of the inherent properties of the individual substances, and transport between different parts of the biosphere, degradation and uptake are modelled. Calculated levels in different environments are then compared with toxicity data to obtain what are known as characterisation data which are then multiplied by the emitted quantities to obtain the potential toxicity contribution. The result for potential ecotoxicity (limited to aquatic toxicity in the method) is stated in the unit CTU (comparative toxic units). The result estimates the potentially affected proportion of species integrated over time and volume, per unit of mass of emitted chemical substance. CTUh is stated for potential human toxicity, corresponding to the estimated mortality in the total population per unit of mass caused by an emitted substance (Rosenbaum et al., 2008).

Usetox has been developed in a broad process of consensus in which many different method developers have been involved (Hauschild et al., 2008), and the method has been recommended by the EU (2011) in the manual for life-cycle impact assessments. Usetox has been used in this study as implemented in the LCA computer program Simapro (www.pre.nl).

A number of substances are reported in E-PRTR that are not included in Usetox, see Annex 3. To decide whether these substances may be significant for toxicity, the calculations were repeated with another method, ReCiPe Midpoint (H) (Goedkoop et al., 2008), and the results were compared.

In this study, the calculation was done for one year, 2008. From that time on, it is possible to perform an annual update in order to be able to see trends in the contribution to toxicity and whether the total toxicity from emissions reported from industrial processes is decreasing or increasing.

3.4.2 Use of chemical products

There has traditionally been control of the industrial use of chemical products, chemicals, in Sweden, through the chemicals legislation that is in place in the country. The Swedish Chemicals Agency (KemI) is the agency for supervision and enforcement and manages the products register. The products register contains information reported by companies on their imports and manufacturing of chemicals. The products register contains pesticides, but not medicines or cosmetics and hygiene products.

The products register is primarily used in KemI's supervisory and enforcement activity but also to produce statistics. An example is chemical indicators that show the use of chemicals, classified by industry, broken down into different hazard classes (www.scb.se/miljorakenskaper under Chemicals). There is no simple link between use of chemicals and emissions, without making model assumptions and estimates. There are examples of such models where emissions from the use of chemical products (such as paints, glues and cleaning products) are calculated. Norway's sustainability indicators include emissions of chemical substances[7] based on the Norwegian equivalent of the products register combined with emission factors. The method is based in part on previous work done by the Swedish Chemicals Agency on an exposure index (KemI, 2005).

The use of chemicals and chemical products has been used in several studies of the environmental impact of Swedish consumption (Palm et al. 2006), in studies for sectors such as agriculture (Engström et al., 2007) and for construction and property (Toller et al., 2011). A problem, however, is that corresponding data for other countries are limited, which means that the "as if" assumption must be applied. According to the Swedish Chemicals Agency the "as if" assumption does

[7] http://www.ssb.no/magasinet/miljo/art-2008-06-17-01.html

not provide a fair picture of the use of chemicals in other countries, as Sweden's use of them cannot be said to be representative of other countries (verbal ref. Margareta Östman, Swedish Chemicals Agency). The focus in this project has therefore been on examining the prospects of developing other types of indicators.

The SPIN database[8] is a database that contains the use of chemicals for the Nordic countries. This database is based on the products registers in Norway, Sweden, Denmark and Finland and is financed by the Nordic Council of Ministers. A UseIndex tool is also presented in SPIN to calculate "potential exposure of chemicals". However, quantities have not been used here, that is to say the purpose is not to estimate emissions but the risk of being exposed to a particular chemical substance.

This project will not present any indicator for use or emissions from chemical products.

3.4.3 Chemicals in articles

There are hazardous substances in many articles, such as furniture, toys and clothing. When chemicals are included in such articles, there is no such requirement for labelling and information as for chemical products. Emissions from articles of this type are difficult to quantify for several reasons. One reason is that there are many different articles that contain many different substances that are emitted in different phases of the life cycle. Another reason is that there are so many different manufacturers throughout the world and different countries have differing legislation on chemicals. The Swedish Chemicals Agency has prepared an Action Plan for a Toxic-Free Everyday Environment[9], in which these aspects are addressed. The Swedish Chemicals Agency has responsibility under the environmental objective A Non-Toxic Environment (www.miljomal.nu), and this includes chemicals in articles. The Agency has drawn up a strategy for work towards attaining the objective (KemI, 2011).

The Commodity Guide (Varuguiden) accessible from the Swedish Chemicals Agency website (https://webapps.kemi.se/varuguiden/) contains an estimate of the average contents of materials and chemicals in articles, in the article groups for final demand in the customs tariff, that is to say for around 10 000 groups of articles. Data on trade for these groups of articles can be found in the Statistics Sweden statistical products foreign trade and industrial production of goods. These data sources in combination can say something about the quantity of chemicals present in the articles imported into and manufactured in Sweden, but do not tell us anything about emissions.

[8] http://www.spin2000.net

[9] http://www.kemi.se/sv/Start/Handlingsplan-for-en-giftfri-vardag/

A research programme, ChEmiTecs (http://www.chemitecs.se/) is under way, financed by the Swedish Environmental Protection Agency, with the aim of analysing how great the problem of emissions of organic substances from articles is. The researchers are studying in particular car tyres, PVC flooring, textiles, electronics and concrete. Based on this selection of articles, the intention is for ChEmiTecs to provide a more general analysis of organic substances in articles.

No indicator will be presented for chemicals in articles in this project.

4 Results

An overarching picture of the trend in the proportions of consumption-based emissions that take place abroad and in Sweden is shown in Figure 4. The diagram shows for all types of emissions shown in Figure 4, i.e. greenhouse gases, nitrogen oxides, sulphur dioxide and ammonia, that the proportion of total emissions caused by Swedish consumption that takes place abroad increased between 2000 and 20008.

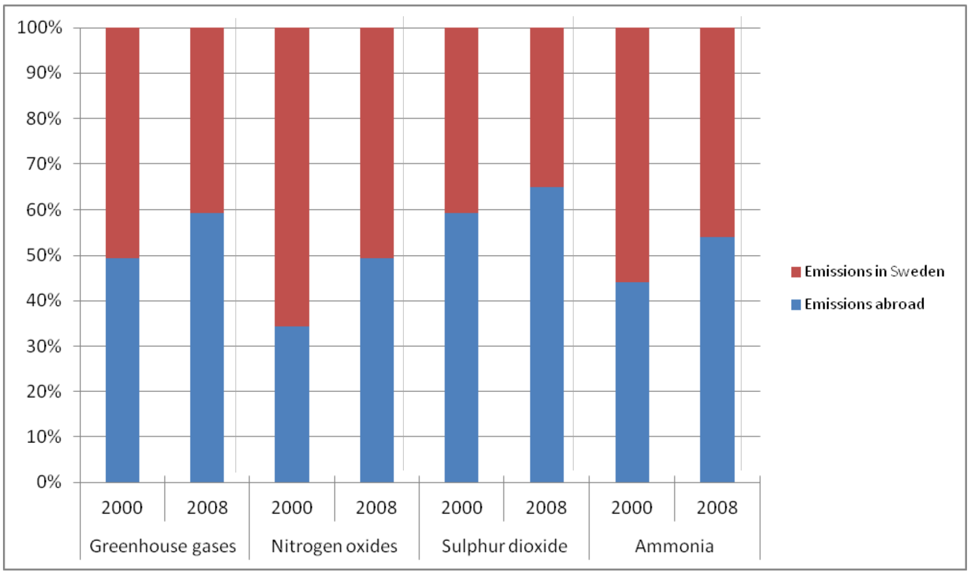


Figure 4 Proportion of the model-calculated emissions of greenhouse gases, nitrogen oxides, sulphur oxides and ammonia resulting from consumption in Sweden, in 2000 and 2008. The emissions are broken down into emissions abroad, associated with imports, and emissions in Sweden, principally Sweden's total emissions including international transport minus exports.

Time series for emissions of greenhouse gases, emissions of nitrogen oxides, sulphur dioxide and ammonia, caused by consumption in Sweden, each presented separately below, are proposed as indicators to monitor the environmental impact of Swedish consumption. The result is broken down into emissions that take place in other countries and the emissions that take place in Sweden. Tables containing data can be found in Annex 2.

4.1 Greenhouse gas emissions associated with Swedish consumption

To follow the trend for emissions of greenhouse gases caused by Swedish consumption, three indicators are proposed: a time series showing emissions of carbon dioxide equivalents abroad and in Sweden, a time series showing the same units of measurement but per person in Sweden, and an indexed diagram clearly showing the trend for emissions over time. These three are each described and shown separately in this chapter.

4.1.1 Indicators for greenhouse gas emissions associated with Swedish consumption

The indicator, see Figure 5, shows emissions of carbon dioxide equivalents, consisting of a weighting (IPCC, 1996) of emissions of carbon dioxide, methane and nitrous oxide, broken down into emissions abroad and emissions in Sweden. The emissions are added together so that the upper line shows the total quantity of emissions caused by Swedish consumption from 2000 to 2008.

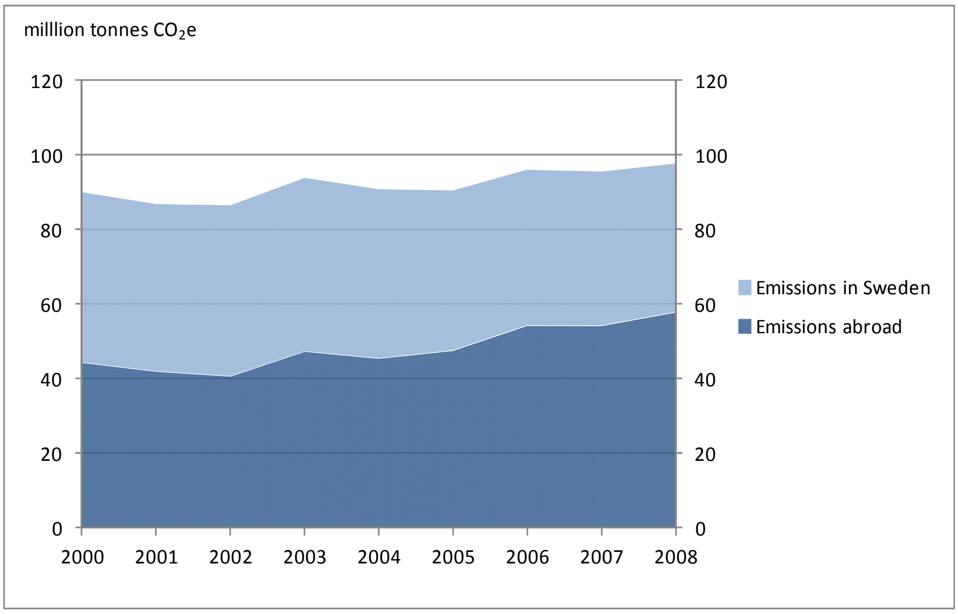


Figure 5 Model-calculated emissions of Swedish consumption in millions of tonnes of carbon dioxide equivalents (carbon dioxide, methane and nitrous oxide weighted together) in 2000 to 2008. The emissions are broken down into emissions abroad, associated with imports, and emissions in Sweden, principally Sweden's total emissions including international transport minus exports.

It is possible to read from the indicator that the total sum of emissions caused by Swedish consumption is 98 million tonnes of carbon dioxide equivalents in 2008. In 2000, the total sum of emissions caused by Swedish consumption was 90 million tonnes of carbon dioxide equivalents. Consumption-based emissions overall increased by 9 per cent over the period.

The indicator shows the total emissions broken down into emissions that take place in Sweden and emissions that take place in other countries due to imports. Emissions abroad increased from 44 million tonnes to 58 million tonnes, signifying a 30 per cent increase between 2000 and 2008. By comparison, emissions in Sweden caused by Swedish consumption fell from 46 million tonnes to 40 million tonnes, equivalent to a decrease of around 13 per cent, over the same period. In

2008, around 60 per cent of total emissions caused by Swedish consumption took place in other countries.

This result can be compared with a previous calculation of greenhouse gas emissions caused by Swedish consumption presented in the report The Climate Impact of Consumption (Naturvårdsverket, 2008) and later in The Global Environmental Impact of Swedish Consumption (Naturvårdsverket 2011a). Greenhouse gas emissions were calculated there as 95 million tonnes in 2003. The indicator in Figure 5 shows that greenhouse gas emissions totalled 94 million tonnes in the same year. The difference in results for these calculations is explained by differences in the underlying calculations. Purchasing power parity-adjusted GDP quotients published for three years by the World Resources Institute were used for the climate impact of consumption. In addition the emissions intensities obtained from WRI were written up to avoid an underestimate (verbal ref. Anders Wadeskog). The precise emission levels depend on what input data are available (for example for emissions in other countries) and model assumptions (for example how bunkering has been handled), and may therefore vary between different studies.

The breakdown between the emission components carbon dioxide, nitrous oxide and methane was relatively unchanged over the period. The breakdown for emissions after weighting to give carbon dioxide equivalents is that carbon dioxide contributes most, with just over 80 per cent, nitrous oxide contributes just over 10 per cent and methane just under 10 per cent. Methane emissions increased somewhat, and carbon dioxide emissions decreased somewhat, relative to one another, over the period.

4.1.2 Greenhouse gas emissions per person associated with Swedish consumption

The indicator, Figure 6, shows emissions from Swedish consumption, abroad and in Sweden, measured in tonnes of carbon dioxide equivalents per person. Carbon dioxide equivalents are made up of a weighting of carbon dioxide, methane and nitrous oxide based on how strongly they contribute to the greenhouse effect.

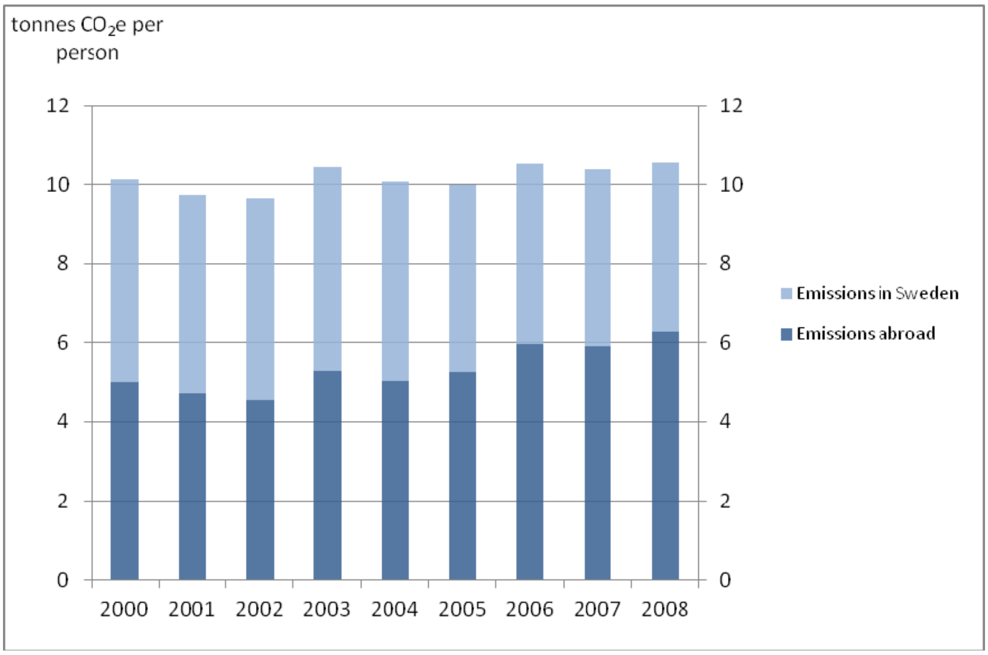


Figure 6 Model-calculated greenhouse gas emissions caused by Swedish consumption, in tonnes of carbon dioxide equivalents (carbon dioxide, methane and nitrous oxide weighted) per person. The emissions are broken down into emissions abroad, associated with imports, and emissions in Sweden, principally Sweden's total emissions including international transport minus exports.

The trend for Sweden in total greenhouse gas emissions per person per year caused by Swedish consumption went from 10.1 tonnes to 10.6 tonnes of carbon dioxide equivalents over the period 2000 and 2008. Emissions per person varied over the period, but emissions abroad overall rose from 5 tonnes of carbon dioxide equivalents per person to just over 6 tonnes per person. The proportion of emissions abroad, out of total emissions, increased over the period from 50 per cent in 2000 to 60 per cent in 2008.

The precise emission levels can vary between different studies as they depend on different input data that are available, for example for emissions in other countries, as well as model assumptions, for example how bunkering is handled.

This result is in very good agreement with a study containing emissions data from 2004, published by the EEA (2010), see Figure 7. Of the total carbon dioxide emissions from consumption, around 40 per cent of emissions on average had arisen in production in other countries. In certain countries, such as Austria, Belgium, the Netherlands, Denmark and Sweden, the equivalent figure is more than 50 per cent (EEA, 2010).

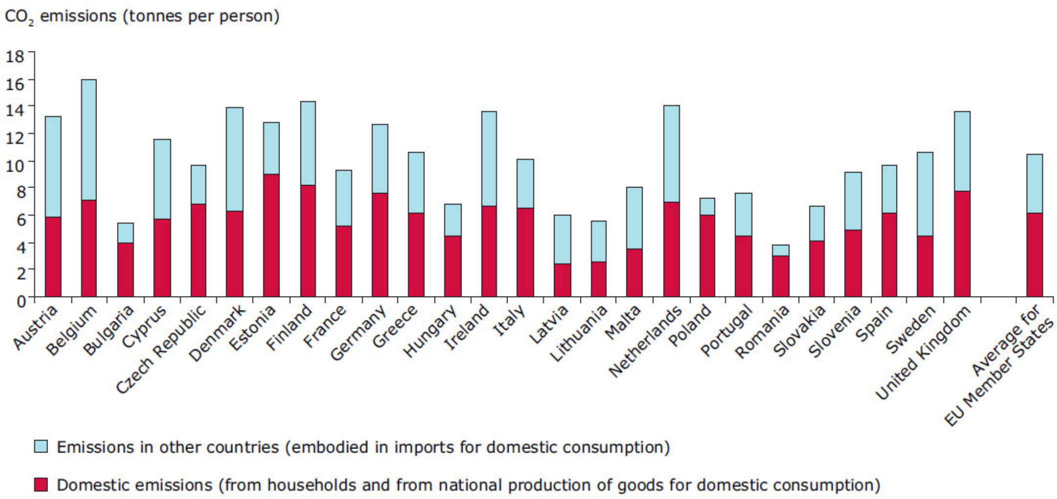


Figure 7 The figure shows emissions of carbon dioxide in tonnes per capita for 2004, based on a multi-regional environmentally extended input-output analysis. The figure comes from The European Environment, State and Outlook 2010, Consumption and the Environment, original data from Davis and Caldeira, 2010.

4.1.3 Change in greenhouse gas emissions associated with Swedish consumption

The indicator, see Figure 8, shows the change in the level of greenhouse gas emissions due to Swedish consumption, abroad and in Sweden, between 2000 and 2008. The percentage change can be read off from the diagram, with the index 100 = the year 2000.

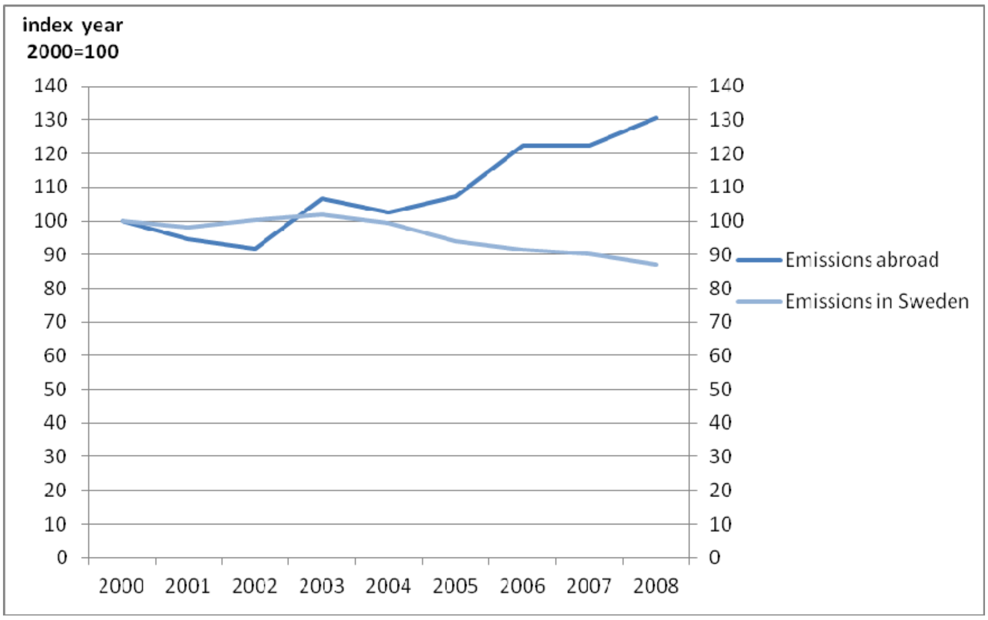


Figure 8 Change in level of greenhouse gas emissions with index 100 = the year 2000. The emissions are broken down into emissions abroad, associated with imports, and emissions in Sweden, principally Sweden's total emissions including international transport minus exports.

It can be read off from the indicator that emissions abroad increased by 30 per cent over the period 2000 to 2008, while emissions in Sweden decreased by just over 10 per cent over the same period.

The precise emission levels depend on what input data are available (for example for emissions in other countries) and model assumptions (for example how bunkering has been handled), and may therefore vary between different studies.

4.2 Other emissions associated with Swedish consumption

The indicators for other emissions to air that are proposed are: emissions of nitrogen oxides (NO_X), ammonia (NH_3) and sulphur dioxide (SO_2) abroad and in Sweden, associated with Swedish consumption.

4.2.1 Emissions of nitrogen oxides associated with Swedish consumption

The indicator, see Figure 9, shows emissions of nitrogen oxides (NO_X) in thousands of tonnes caused by Swedish consumption in 2000 to 2008, abroad and in Sweden. The emissions are added together so that the upper line shows the total quantity of emissions caused by Swedish consumption.

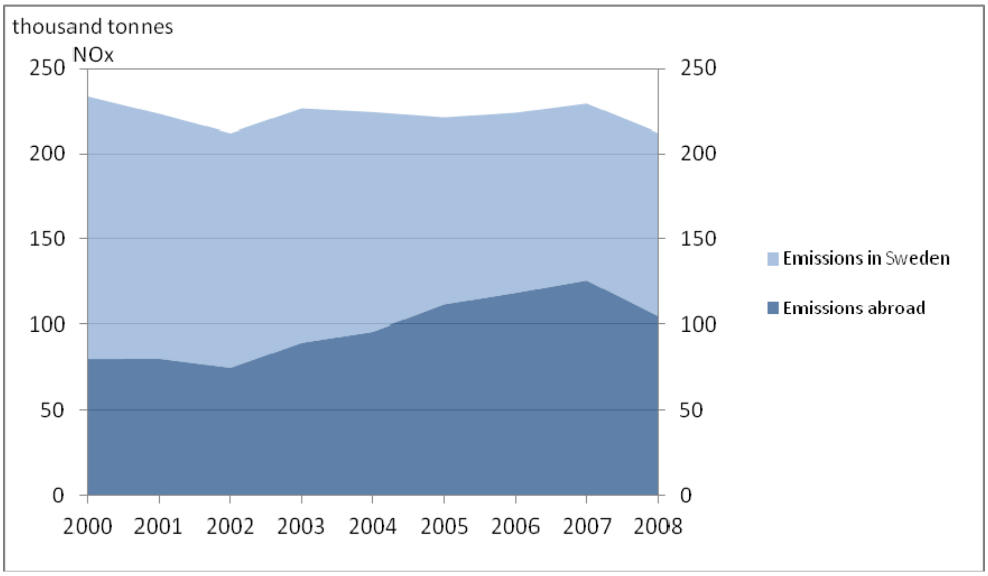


Figure 9 Model-calculated emissions of nitrogen oxides (NOX) due to Swedish consumption, thousands of tonnes, in 2000-2008. The emissions are broken down into emissions abroad, associated with imports, and emissions in Sweden, principally Sweden's total emissions including international transport minus exports.

It is possible to read from the indicator that the total sum of emissions of nitrogen oxides caused by Swedish consumption is just over 210 thousand tonnes in 2008. In 2000, the total sum of emissions caused by Swedish consumption was just over 230 thousand tonnes. Consumption-based emissions of nitrogen oxides overall decreased by 9 per cent over the period.

The indicator shows the total emissions broken down into emissions that take place in Sweden and emissions that take place in other countries due to imports. Emissions abroad increased from 80 thousand tonnes to just over 100 thousand tonnes from 2000 to 2008, which is equivalent to an increase of around 30 per cent over the period. By comparison, emissions in Sweden caused by Swedish consumption fell from just over 150 million tonnes to just over 100 million tonnes, equivalent to a decrease of around 30 per cent, over the same period. In 2008, just under 50 per cent of total emissions of nitrous oxide caused by Swedish consumption took place in other countries.

The precise emission levels depend on what input data are available (for example for emissions in other countries) and model assumptions (for example how bunkering has been handled), and may therefore vary between different studies.

4.2.2 Emissions of ammonia associated with Swedish consumption

The indicator, see Figure 10, shows emissions of ammonia (NH_3) in thousands of tonnes caused by Swedish consumption in 2000 to 2008, abroad and in Sweden.

The emissions are added together so that the upper line shows the total quantity of emissions caused by Swedish consumption from 2000 to 2008.

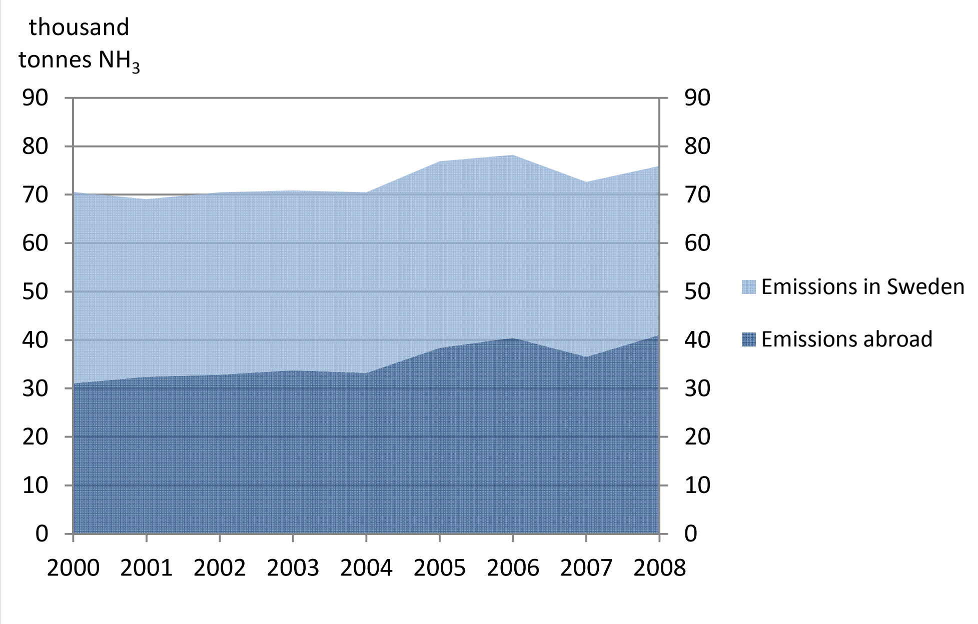


Figure 10 Model-calculated emissions of ammonia (NH_3) due to Swedish consumption, thousands of tonnes, 2000-2008. The emissions are broken down into emissions abroad, associated with imports, and emissions in Sweden, principally Sweden's total emissions including international transport minus exports.

It is possible to read from the indicator that the total sum of emissions of ammonia caused by Swedish consumption is just over 76 thousand tonnes in 2008. In 2000, the total sum of emissions caused by Swedish consumption was 71 thousand tonnes. Consumption-based emissions of ammonia overall increased by 8 per cent over the period.

The indicator shows the total emissions broken down into emissions that take place in Sweden and emissions that take place in other countries due to imports. Emissions abroad increased from just over 30 thousand tonnes to just over 40 thousand tonnes from 2000 to 2008, which is equivalent to an increase of just over 30 per cent over the period. By comparison, emissions in Sweden caused by Swedish consumption fell from just under 40 thousand tonnes to 35 thousand tonnes, equivalent to a decrease of just over 10 per cent, over the same period. In 2008, just over 50 per cent of total emissions of ammonia caused by Swedish consumption took place in other countries.

The precise emission levels depend on what input data are available (for example for emissions in other countries) and model assumptions, and may therefore vary between different studies.

4.2.3 Emissions of sulphur dioxide associated with Swedish consumption

The indicator, Figure 11, shows emissions of sulphur dioxide (SO_2) in thousands of tonnes caused by Swedish consumption in 2000 to 2008, abroad and in Sweden. The emissions are added together so that the upper line shows the total quantity of emissions caused by Swedish consumption from 2000 to 2008.

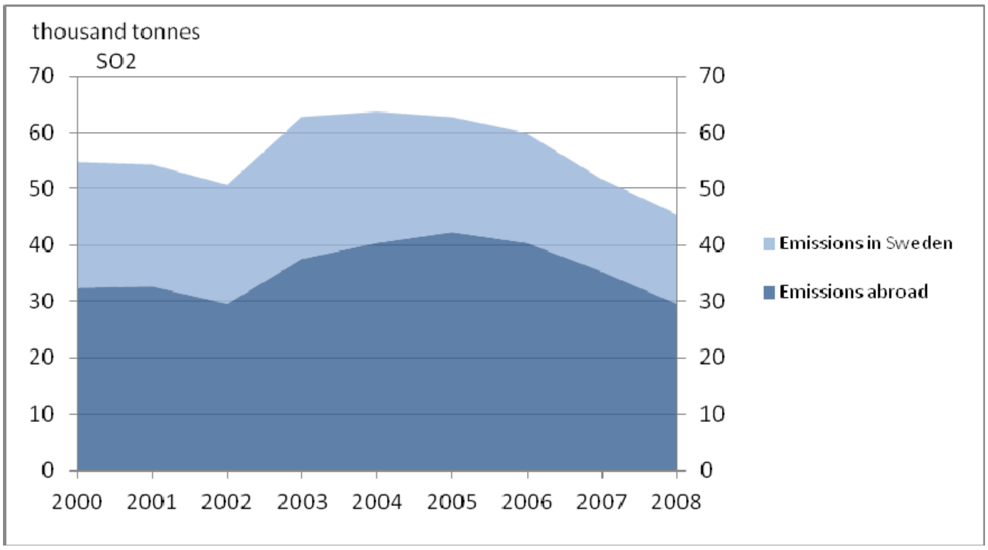


Figure 11 Model-calculated emissions of sulphur dioxide (SO2) due to Swedish consumption, thousands of tonnes, 2000-2008. The emissions are broken down into emissions abroad, due to imports, and emissions in Sweden, principally Sweden's total emissions including international transport minus exports.

It is possible to read from the indicator that the total sum of emissions of sulphur dioxide caused by Swedish consumption is just over 45 tonnes in 2008. In 2000, the total sum of emissions caused by Swedish consumption was 55 thousand tonnes. Consumption-based emissions of sulphur dioxide overall decreased by 17 per cent over the period.

The indicator shows the total emissions broken down into emissions that take place in Sweden and emissions that take place in other countries due to imports. Emissions abroad decreased from 32 thousand tonnes to 30 thousand tonnes from 2000 to 2008, which is equivalent to a decrease of 9 per cent over the period. By comparison, emissions in Sweden caused by Swedish consumption fell from 22 thousand tonnes to 16 thousand tonnes, equivalent to a decrease of just over 30 per cent, over the same period. In 2008, just over 65 per cent of total emissions of sulphur dioxide caused by Swedish consumption took place in other countries.

The precise emission levels depend on what input data are available (for example for emissions in other countries) and model assumptions (for example how bunkering has been handled), and may therefore vary between different studies.

4.3 Emissions of chemical substances associated with Swedish consumption

No ready-made indicator is presented in this area, but rather the result of the work that has taken place under this project. The result shown is based on reported emissions from point sources. Reporting takes place annually from units with emissions above specified limits in E-PRTR. The result does not include any other emissions, i.e. it does not include diffuse emissions from articles or from the use of chemical products. A discussion is presented together with the result.

E-PRTR data from 2008 were downloaded, and input-output analysis was performed on these data. After the substances had been weighted using LCA methodology, contributions to potential toxicity from emissions caused by total final demand in Sweden were obtained. Contributions to toxicity are broken down into the activities of the individual companies according to the Swedish Standard Industrial Classification SNI 2007. The product classification follows SNI, so that articles made for example in the sector of manufacture of paper and paper products (SNI 17) correspond to the product group of paper and paper products (Statistics Sweden, 2009b).

The contribution to potential aquatic ecotoxicity is shown in Figure 12. The pie chart is equivalent to 100 per cent. Based on reported emissions in E-PRTR, environmentally extended input-output analysis and taking account of the toxicity of the emitted substances, the total final demand in Sweden of the following product groups (grouping according to SNI 2007 [10], simplified designations) makes the greatest contribution to potential aquatic ecotoxicity: paper and paper products and steel and metal products. Note that the result shows the contribution associated with total final demand in Sweden (see 3.1.1), i.e. emissions that take place in production of the goods and services that go for export are included here). It is also important to emphasise that no emissions that take place in use are included in the analysis, i.e diffuse emissions are not included. Emissions in other countries caused by imported articles are not included in the analysis.

[10] http://www.sni2007.scb.se/

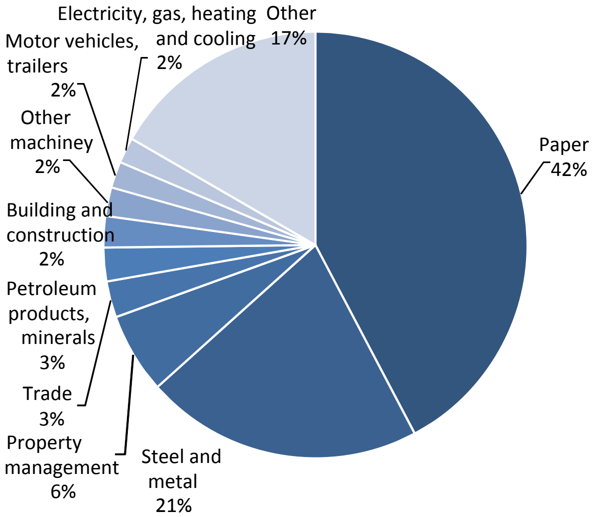


Figure 12 Percentage contribution to potential aquatic ecotoxicity in Sweden from the whole final demand of products in different product groups (including exports), in 2008 based on point sources (E-PRTR) in Sweden.

Of the substances included in the E-PRTR database, it is zinc (emission to water) in the “paper” group (SNI 17) that contributes most to potential ecotoxicity. In the group of “steel and metal” (SNI 24) it is fluoranthene[11] and zinc and zinc compounds (emission to both air and water) that contribute most to potential ecotoxicity. The quantity in kg of these substances reported to E-PRTR as emissions in 2008 is shown in Table 1.

[11] A polycyclic aromatic hydrocarbon

Table 1

Contributions to potential human toxicity, broken down into cancer-related toxicity and non-cancer-related toxicity, are shown in Figure 13.

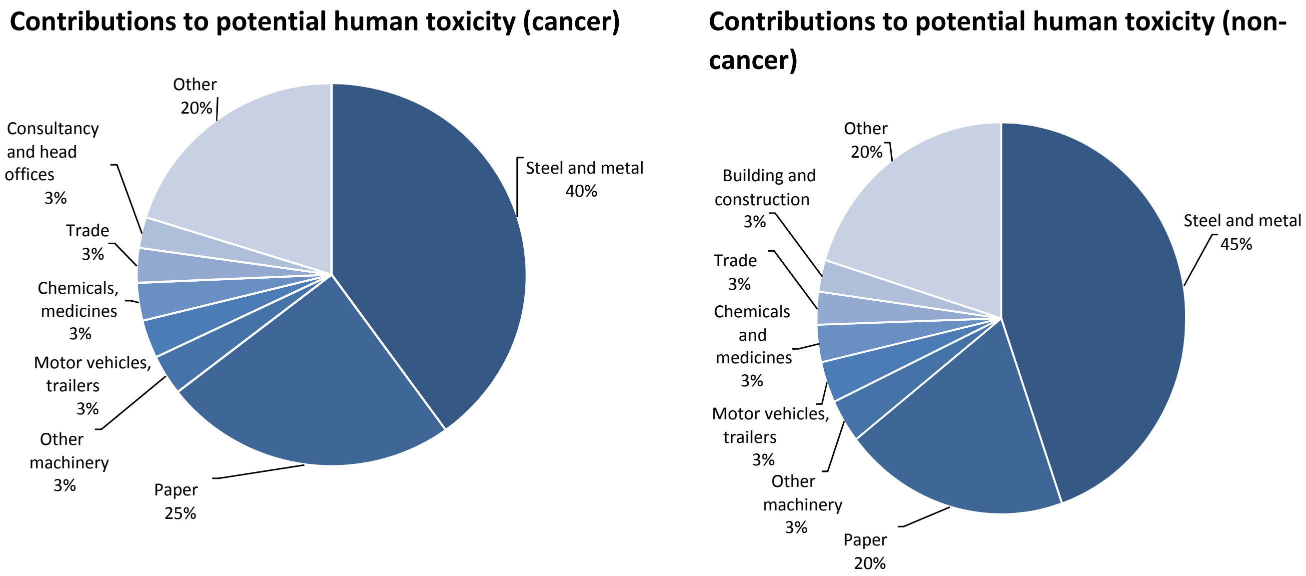


Figure 13 Contributions to potential human toxicity (cancer) on the left and potential human toxicity (non-cancer) on the right associated with total final demand of products in different product groups (excluding exports) in 2008 based on point sources in Sweden (E-PRTR).

Based on reported emissions in E-PRTR, environmentally extended input-output analysis and taking account of the toxicity of the emitted substances, the total final demand in Sweden of the following product groups makes the greatest contribution to potential human toxicity (both cancer and non-cancer): steel and metal products and paper and paper products. Note that the result shows the contribution associated with total final demand in Sweden (see 3.1.1), i.e. emissions from the production of goods that go for export are also included here. It is also important to emphasise that no emissions that take place in use are included in the analysis, i.e. diffuse emissions are not included. Emissions caused by imported goods are not included in the analysis.

Of the substances included in the E-PRTR database, it is chromium emissions to air that contribute most to potential human toxicity caused by the final demand of steel and metal products. It is chromium emissions to water that contribute most to potential human toxicity caused by the final demand of paper and paper products.

The volumes (in kg) of emissions of the substances that are reported in E-PRTR for Sweden in 2008 and that contribute most to potential toxicity are listed in Table 1.

Table 1 Reported emissions in E-PRTR in 2008 in kg of the substances that contribute most to potential toxicity according to the Usetox method.

Substance (medium)	Emissions (kg)*
Zinc and zinc compounds (water)	90 000
Zinc and zinc compounds (air)	20 000
Fluoranthene (water)	8 000
Chromium and chromium compounds (water)	2 000
Chromium and chromium compounds (air)	8 000

* Rounded values

With regard to chromium, Usetox distinguishes between different forms of chromium. But as information on precisely which form of chromium has been emitted is lacking in E-PRTR, an average has been used to calculate the toxicity of chromium.

Certain substances included in E-PRTR are not included in Usetox (see Annex 3). To examine whether these substances may be of significance for either ecotoxicity or human toxicity, another method, ReCipe was used to run the material. The result from ReCipe was that hydrogen fluoride contributed most to potential human toxicity, while cyanide made a large contribution to potential ecotoxicity; both these substances are lacking in Usetox.

The results from Usetox indicate that metals are of great significance to potential toxicity. The significance of metals has also been noted in earlier studies (Pizzo et al., 2011a and b). There may be several explanations for this. One is that metals quite simply are of great significance to the potential toxicity of the substances contained in the database. Another is that metals are easier to analyse than other substances, so that a more comprehensive picture is obtained of these emissions. A further explanation may have to do with the time perspective. Metals are persistent – they can only disappear from ecosystems through slow geological processes. This means that a metal emission will have a toxic effect over a long period of time. A long time perspective is used in Usetox, which is significant for the relative contribution of metals and other persistent substances compared with more readily degradable substances. If a shorter time perspective had been chosen, the relative significance of metals would have decreased. Another explanation may be that the bioavailability of metals is overestimated because of the way in which the speciation of the metals (i.e. the dissolved forms in which the metals occur) is modelled. In continued work on developing indicators for emissions of chemical substances, there is reason to separate metals and organic substances into different indicators. In addition, Sweden has an ore industry, and as exports are also included in the run in Usetox, this has probably also been a significant factor in the results.

5 Discussion and continued work

5.1 Greenhouse gases

When emissions are linked to the whole economy with environmentally extended input-output analysis, this entails a substantial number of generalisations and simplifications. The strength of using environmentally extended input-output analysis is that the whole economy is included. The precise emission levels in the result of the modelling depend on what input data are available and model assumptions, and may therefore vary from one study to another. The results are, for example, heavily dependent on how emissions abroad are estimated, in cases where emissions intensities are used instead of reported emissions. In addition, assumptions are made on how emissions are to be allocated to different activities, which may also have an impact on the results.

The following sections describe the most important underlying conditions and limitations for the environmentally extended input-output analysis that applies to this project. These limitations vary in nature – some are concerned with input-output analysis, while others are related to availability of data.

The greenhouse gas emissions studied in this report are the greenhouse gas emissions caused by domestic final demand, i.e. by Swedish consumption. The calculation of the emissions caused by consumption is based on the emissions reported to UNFCCC, but differs from these on some points.

- The greatest difference is that emissions caused by consumption are not included in the emissions caused by production of goods and services that go for export.
- Another important difference is that emissions caused by consumption include the Swedish share of international transport, e.g. cargo transport and international travel purchased in Sweden. This is possible because the consumption-based emissions are linked to the Swedish economy and are not limited to taking place within the borders of Sweden.
- Another difference compared with emissions reported to UNFCCC is that fluorinated greenhouse gases, F-gases, are not included in the consumption-based emissions. This simplification is due to the fact that at present these emissions are not broken down by industry, which is essential if they are to be included in the environmentally extended input-output analysis. The simplification ought not, however, to affect the results to such a great extent, as the proportion of F-gases among total greenhouse emissions is small.

Like the emissions reported to UNFCCC, emissions caused by land use change are not included, as there no methods as yet for linking emissions of this type to consumption. Emissions from land use change are, for example, related to livestock production and palm oil; these emissions can vary in size depending on where the production takes place. With regard to international transport, emissions that arise from foreign passenger travel abroad starting in another country are not included (Swedish Environmental Protection Agency, 2008), and neither do these form part of the emissions reported to UNFCCC.

Bunkering of oil is also included in the calculations. Emissions from bunkering are calculated on the assumption that Sweden bunkers in other countries to the same extent that other countries bunker in Sweden. Emissions from bunkering in other countries are not, however, multiplied by country-specific emission intensities. The investments have been allocated to domestic final demand and exports in the emission calculations. Investments made to produce goods that go for export are therefore not included in the consumption-based emissions. Annex 1 describes how bunkering and investments are handled in the input-output analysis.

An item that may be of significance for consumption-based emissions is electricity. The calculation of emissions from the imported electricity is made in the same way as other products, i.e. emissions are based on how much is imported and the emissions are scaled up with emissions intensities for the country concerned.

A limitation of the method is that the product categories are relatively imprecise, which makes it difficult to break the results down to product level and make comparisons between them.

Another limitation is estimation of the emissions that take place in other countries. Estimation for carbon dioxide emissions in the EU is relatively good, as there are data reported to Eurostat for these countries. Emissions intensities (tonnes of carbon dioxide per GDP dollar) from WRI[12]are used outside the EU. The WRI emission intensities are the best available data source for emissions intensities from other countries. However, these are not updated so often, and the most recent data are from 2005. It is possible to develop emissions intensities based on data from the International Energy Agency (IEA) and the World Bank to obtain more updated and detailed data for emissions in other countries. Emission intensities in other countries are generally higher than in Sweden, but the trend is towards falling or stagnating emission intensities over time (Wadeskog, verbal communication). Emissions intensities in other countries generally being higher than in Sweden or in the EU does not, however, alter the fact that there is leading-edge technology in other countries that is making production with less environmental impact possible.

[12] World Resources Institute

Wishes have been expressed to break the results down into emissions caused by imports from EU Member States and from outside the EU. This project has not looked more closely at such a breakdown, as such a breakdown is associated with certain problems:

- The EU has not been constant over the period (the EU-15 became the EU-27 in 2007).
- Import statistics may be misleading due to the Rotterdam problem. The significance of this problem is that if goods are shipped from Asia to Sweden via the Netherlands (Rotterdam is a large port in the Netherlands), the import is registered as if it takes place from an EU Member State.

According to the import statistics (Statistics Sweden trade statistics), Sweden imports goods to the value of 70 per cent of its imports from the countries that belonged to the EU-27 in 2008, see Annex 2. There is little uncertainty for carbon dioxide emissions caused within the EU, and data on carbon dioxide emissions reported to Eurostat are used in the calculation. The availability of data broken down by industry for emissions caused in countries outside the EU is extremely low. Emissions caused by imported products are calculated in the model as if they had been produced by the Swedish economy (i.e. with the same structure for the composition of trade and industry), but with the emissions intensity of the country concerned. The result is usable at total level, but the results for each individual country are not presented.

The calculation of emissions of methane and nitrous oxide is more uncertain than for carbon dioxide emissions, as the former depend to a great extent on biological processes, for example in the agricultural and waste sectors, and the latter are closely associated with the use of fossil fuels (Naturvårdsverket 2008). The "as if" assumption is used for emissions of methane and nitrous oxide, where there is additionally the uncertainty in Swedish emissions, raising the level of doubt. This has the consequence that emissions of methane and nitrous oxide in other countries are highly uncertain. Because of these uncertainties, the estimation of greenhouse gas emissions contains components with various uncertainties. For this reason, the components are not presented individually. A high degree of detail may invite conclusions to be drawn from the data material that are not warranted. As the contributions of methane and nitrous oxide to the total greenhouse effect are limited, however, the uncertainty of these figures is of limited significance to the overall result.

With regard to the interpretation of results, the indicators for greenhouse gas emissions abroad point to increasing emissions over time. Total emissions increased by 9 per cent between 2000 and 2008, while emissions abroad increased by 30 per cent over the same period. The increase shown by the indicator can be principally explained in the model by increased consumption satisfied by greater imports. The fact that the value of imports increased by just over 40 per cent, calculated in fixed prices, from 2000 to 2008 supports this explanation. An increase may also be caused by the composition of consumption changing, i.e. other types of products are imported, those which for various reasons cause higher emissions, or by production of the imported goods taking place in countries that cause greater emissions in producing identical goods. Almost half the increase in emissions, or almost 4 million tonnes of carbon dioxide equivalents, can be explained by the increase in population during the period studied if an assumption is made that the increased population has caused the same emissions as the level of emissions per person in 2000 (10.1 tonnes of carbon dioxide equivalents). The population of Sweden increased by just over 370 000 between 2000 and 2008 (population statistics from Statistics Sweden). Supplementary studies beyond the scope of this project are required to further investigate what factors underlie the increase in emissions.

More qualified analyses can be made for domestic emissions, through what is known as decomposition analysis. Such an analysis shows what driving forces underlie changes in levels of emissions (Statistics Sweden, 2003). But emissions abroad should also be studied more closely in continued work; examples of analyses that can be done are to link emissions to what type of product is consumed or activity is carried out. It would also be interesting to study more closely imports into Sweden over the same period as that for which the emissions are calculated, in order to see how imports have developed over time.

In a continued analysis it would be of interest to study more closely:

- To what extent the increased levels of emissions are due to increased volumes of imports or to the imported products coming from countries with high emissions intensities.
- From which countries the imports take place and how this has changed over the period, in order to study whether a change in the countries Sweden imports from has any significance for emissions levels.

5.2 Other emissions to air

Emissions in other countries for nitrogen oxides, sulphur dioxide and ammonia are calculated using the “as if” assumption, which means that the change in level only reflects a change in imports and in Sweden’s emissions intensity. A previous study (Statistics Sweden, 2002) has shown that emissions of nitrogen oxides in Sweden are on a par with other countries. The same study showed that Sweden has relatively low emissions of sulphur dioxide. The “as if” assumption can thus lead to an underestimate of the emissions that take place in other countries for sulphur dioxide.

Other emissions to air are reported to Eurostat according to a standardised method[13] linked to the environmental accounts system. This means that the emissions are broken down by industry and can be included in an environmentally extended input-output analysis. The emissions reported are nitrogen oxides, sulphur oxides, ammonia and emissions related to local air quality, such as volatile organic compounds (not methane), carbon dioxide and particulates. When these data are available, the indicators should be calculated with Eurostat data.

5.3 Chemical substances

The area of chemicals is an area with large knowledge gaps, with regard both to the use of chemicals in society, emissions and the dispersal and conversion of the substances in ecosystems and to their toxic properties. This, taken together, means that it is barely possible to obtain a meaningful picture of the whole area using one indicator or a small number of indicators. An analysis has been made in the project as a first step in assessing the data situation for emissions of chemical substances, with the aim of being able to include the area of chemicals in the analysis of the environmental impact of Swedish consumption in the longer term. Swedish data are used in this first step, in order to try the method out and to assess the relevance of the results. The next step should be to make a similar calculation with data from countries that contribute to Swedish imports.

The study has shown that the E-PRTR database is usable. It is possible to break the data down by industry and use them in input-output analyses. The study has also shown that emissions data in E-PRTR can be combined with methods for life-cycle assessment for a calculation of potential environmental effects.

It is of interest to continue to work on the E-PRTR database. What would be principally of interest to develop is:

- An examination of how great a proportion of emissions is included in E-PRTR in order to gain an idea of how high the total industrial emissions are
- An attempt to include data from other sources to quantify emissions of chemical substances for imported goods

A thesis project is currently in progress at Statistics Sweden aimed at examining whether it is possible to statistically “scale up” the emissions included in E-PRTR to obtain an idea of how large a proportion of the total industrial emissions is covered by E-PRTR. With regard to emissions in other countries, it would be desirable to test the data sources E-PRTR for the EU and TRI (Toxic Release Index) for the United States. Another way of “scaling up” the results based on

[13] Manual for Air Emissions Accounts, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-09-004/EN/KS-RA-09-004-EN.PDF

PRTR might be to utilise the information on carbon dioxide emissions in E-PRTR to compare with other data sources for the total emissions of carbon dioxide per industry, and consequently to say something about how large a proportion the emissions reported to E-PRTR generally account for in total industrial emissions. Such a scale-up necessitates an assumption that the emissions take place in a linear relationship to each other, an assumption that must first be investigated.

The Usetox method contains data for many of the substances contained in E-PRTR, but not all. The supplementary analysis made with the ReCipe method suggests that these data gaps may be significant. However, there are options for expanding the USetox database, as the model is generally available. A conceivable continuation project may therefore be to calculate data for additional relevant substances.

To supplement the area of chemicals, it would be relevant to make an equivalent quantification and calculation of contributions to potential toxicity of other emissions sources, that is to say including emissions that take place in use in order to relate them to the emissions caused by industrial processes calculated in this report. Continuing with emission factors or the Commodity Guide (Varuguiden) combined with trade statistics might be a way of approaching this quantification. SMED[14] (the Swedish Environmental Emissions Data consortium) has studied for which diffuse emissions there are data on behalf of the Swedish Environmental Protection Agency (Sörme et al., 2011). The study contains proposals on what substances and data sources can be used to broaden this type of toxicity to also include diffuse emissions. A project is currently in progress with the aim of developing data for some of these sources, and this too is being carried out by SMED on behalf of the Swedish Environmental Protection Agency (Ricklund, verbal communication).

In previous projects the use of chemical products has served as an indicator of the environmental impact of Swedish consumption (e.g. Palm et al., 2006) and in sector analyses (e.g. Toller et al., 2011). One such indicator is a D indicator in what is known as the DPSIR framework, see Annex 4, i.e. one that says something about driving forces in society.

An indicator based on emissions is a P indicator, i.e. one that says something about the pressure on the environment. By combining emissions statistics with methods for environmental impact assessment, which has been done under this project, many emissions are weighted together for potential harm to the environment and health. It can be noted on the basis of the DPSIR framework that different indicators complement one another. Work in the area of chemicals should be

[14] http://www.smed.se/

focused on several different indicators. The various indicators can then both reflect different parts of the DPSIR framework and reflect different parts of the total emissions and uses of chemicals.

6 References

Carlsson-Kanyama, A., Assefa, G. Peters, G and Wadeskog, A., 2007. Koldioxidutsläpp till följd av Sveriges import och konsumtion: beräkningar med olika metoder (Carbon dioxide emissions associated with Swedish imports and consumption: calculations by various methods).. KTH (Royal Institute of Technology). Stockholm.

EEA, 2010. The European Environment, State and Outlook 2010, Consumption and the Environment

Engström, R., Wadeskog, A. and Finnveden, G. (2007): Environmental assessment of Swedish agriculture. *Ecological Economics*, 60, 550-563.

European Commission (2011): Recommendations for Life Cycle Impact Assessment in the European context – Based on existing environmental impact assessment models and factors. EUR 24571 EN-2011. Joint Research Centre, Ispra, Italy.

Goedkopp M.J., Heijungs R,. Huijbregts M., de Schryver A.; Struijs J.,; van Zelm R, ReCiPe 2008. A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level; First edition Report I: Characterisation; Available at http://www.lcia-recipe.net

Handbook of National Accounting System of Integrated Environmental and Economic Accounting 2003, UN, EC, IMF, OECD and World Bank. United Nations, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank http://unstats.un.org/unsd/envaccounting/seea2003.pdf

Hauschild, M.Z., Huijbregts, M., Jolliet, O., MacLeod, M., Margni, M., van de Meent, D., Rosenbaum, R.K., McKone, T., 2008a. Building a consensus model for life cycle impact assessment of chemicals: the search for harmony and parsimony. Environ. Sci. Technol. 42, 7032–7037.

IPCC, 1996. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reporting Instructions (Volume 1). Available at http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

KemI (Swedish Chemicals Agency), 2005. Fischer, Stellan, Å. Almkvist, E. Karlsson and M. Åkerblom: Slutrapport från projektet: Framtagande av produktregisterbaserat ExponeringsIndex, Kemikalieinspektionen (Development of products register-based Exposure Index, Swedish Chemicals Agency)

KemI (Swedish Chemicals Agency), 2011. Kemikalier i varor. Strategier och styrmedel för att minska riskerna med farliga ämnen i vardagen (Chemicals in articles. Strategies and instruments for reducing the risks posed by hazardous substances in everyday life). Report No 3/11.

KemI (Swedish Chemicals Agency), 2011. Information from the website. www.kemi.se

Larsson et al, 2007. Effluent from drug manufactures contains extremely high levels of pharmaceuticals. Journal of Hazardous Materials. 148, 751-755. D.G.J. Larsson, C. de Pedro, N. Paxeus.

Naturvårdsverket (Swedish Environmental Protection Agency) 2008. Konsumtionens miljöpåverkan (Environmental impact of consumption). Report 5903.

Naturvårdsverket (Swedish Environmental Protection Agency), 2010a. Att följa den svenska konsumtionens globala miljöpåverkan i miljömålssystemet – en förstudie (Monitoring the global environmental impact of Swedish consumption in the system of environmental objectives – a preliminary study).

Naturvårdsverket (Swedish Environmental Protection Agency) 2010b. Den svenska konsumtionens globala miljöpåverkan (The global environmental impact of Swedish consumption). Swedish Environmental Protection Agency and Swedish Chemicals Agency

Naturvårdsverket (Swedish Environmental Protection Agency) 2010c. Miljömålen – svensk konsumtion och global miljöpåverkan de Facto 2010 (The environmental objectives – Swedish consumption and global environmental impact de Facto 2010).

Naturvårdsverket (Swedish Environmental Protection Agency) 2010d. Methods to assess global environmental impacts from Swedish consumption.

Naturvårdsverket (Swedish Environmental Protection Agency) 2011. Sweden's Informative Inventory Report 2011

Palm, V., Wadeskog, A. and Finnveden, G. (2006): Swedish experiences of using environmental accounts data for integrated product policy (IPP) issues. Journal of Industrial Ecology, 10 (3), 57-72.

Pizzol, M., Christensen, P., Schmidt, J., and Thomsen, M. (2011a): Impacts of "metals" on human health: a comparison between nine different methodologies for

Life Cycle Impact Assessment (LCIA). Journal of Cleaner Production, 19, 646-656.

Pizzol, M., Christensen, P., Schmidt, J., and Thomsen, M. (2011b): Eco-toxicological impacts of “metals” on the aquatic and terrestrial ecosystem: a comparison between eight different methodologies for Life Cycle Impact Assessment (LCIA). Journal of Cleaner Production, 19, 687-698.

Rockström, J.; Steffen, W.; Noone, K.; Persson, Å.; Chapin, F. S.; Lambin, E. F.; Lenton, T. M.; Scheffer, M.; Folke, C. (24 September 2009), “A safe operating space for humanity”, Nature 461 (7263): 472-475

Rosenbaum, R.K., Bachmann, T.M., Hauschild, M.Z., Huijbregts, M.A.J., Jolliet, O., Juraske, R., Kohler, A., Larsen, H.F., MacLeod, M., Margni, M., McKone, T.E., Payet, J., Schumacher, M., Russel, A., van de Meent, D., 2007. USEtox – the UNEP/SETAC toxicity model: recommended characterisation factors for human toxicity and freshwater ecotoxicity in Life Cycle Impact Assessment. Int. J. Life Cycle Assess. 13, 532–546.

Statistics Sweden, 2002 Environmental impact of Swedish trade.

Statistics Sweden, 2003 Structural decomposition of environmental accounts data – the Swedish case.

Statistics Sweden, 2008 Beräkningsunderlag till rapporten Konsumtionens klimatpåverkan (Basis of calculation for the report Climate Impact of Consumption), ref. No U-2008/3813, Statistics Sweden.

Statistics Sweden, 2009a. Läkemedel samt kosmetika och hygienprodukter i Sverige. Metodutveckling för försäljningsstatistik och flödesstudier (Medicines and cosmetics and hygiene products in Sweden. Method development for sales statistics and flow studies).

Statistics Sweden 2009b. SPIN 2007, Swedish Standard Classification of Products by Activity 2007 (MIS 2009:1). Available at www.scb.se

SSB (Statistics Norway), 2011. Indikatorer for bærekraftig utvikling 2011 (Indicators of sustainable development 2011). Available at www.ssb.no

Sörme L., Hansson K., Ek M., (2010) Förstudie över möjlig presentation av diffusa emissioner på UTIS (Preliminary study on possible presentation of diffuse emissions in UTIS (Emissions in Figures)). SMED report 55. Available at www.smed.se

Toller, S., Wadeskog, A., Finnveden, G., Malmqvist, T. and Carlsson, A. (2011): Environmental Impacts of the Swedish Building and Real Estate Management Sectors. *Journal of Industrial Ecology*, 15, 394-404.

Verbal reference:
Anders Wadeskog, Statistics Sweden +46 (0)8-506 94 000
Member of the project group.

Margareta Östman, Swedish Chemicals Agency +46 (0)8-519 41 100
Member of the reference group.

Nicklas Ricklund, Swedish Environmental Protection Agency. +46 (0)8-698 10 99.
Commissioner of work performed by SMED in 2011-2012.

Annex 1

A more detailed description is given here of the method for bunkering and investments in the environmentally extended input-output analysis.

Bunkering
Bunkering means that ships refuel in one country but use the fuel in another country. Shipping and aviation are included in the system of national accounts, and so therefore is bunkering, when it is registered as use of fuel. Emissions from shipping are broken down into domestic and international emissions. It has been assumed in the environmentally extended input-output analysis on which results in this report are based that bunkering is done by other countries in Sweden to the sane extent as it is by Sweden in other countries. However, emissions from bunkering in other countries are handled by not adjusting them with emissions intensities. This procedure avoids the unreasonable effect that bunkering would cause far larger emissions because it happens in China compared with Europe.

Investments
Final demand is broken down into private consumption, public consumption, stock changes, investments and exports. Investments are made to expand production capacity and to replace worn-out production capital. As the focus here is on domestic consumption, i.e. final demand minus exports, the emissions to produce the investment goods end up solely in domestic consumption, despite the replaced or expanded capital also being used to produce what goes for export. To compensate for this, the portion of the year’s investments that covers depreciation has been reclassified as input materials. The emissions from the production of these investment goods are consequently allocated to both domestic consumption and export. Residual investments remain in final demand and are counted as domestic consumption.

Annex 2

Tables relating to diagrams in the report

Model-based greenhouse gas emissions caused by Swedish consumption, millions of tonnes of carbon dioxide equivalents. Emissions abroad (from imports) and emissions in Sweden (total final demand minus exports) (Figure 5)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions abroad	44,4	42,1	40,8	47,4	45,5	47,7	54,4	54,3	57,9
Emissions in Sweden	45,6	44,7	45,7	46,4	45,3	42,8	41,7	41,2	39,8
Total	**90,0**	**86,8**	**86,5**	**93,8**	**90,8**	**90,5**	**96,1**	**95,5**	**97,7**

Population of Sweden Number of people in Sweden from 2000 to 2008. (from Statistics Sweden statistical database)

2000	2001	2002	2003	2004	2005	2006	2007	2008
8 882 792	8 909 128	8 940 788	8 975 670	9 011 392	9 047 752	9 113 257	9 182 927	9 256 347

Model-based greenhouse gas emissions caused by Swedish consumption, millions of tonnes of carbon dioxide equivalents per person. Emissions abroad (from imports) and emissions in Sweden (total final demand minus exports) (Figure 6)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions abroad	5,0	4,7	4,6	5,3	5,1	5,3	6,0	5,9	6,3
Emissions in Sweden	5,1	5,0	5,1	5,2	5,0	4,7	4,6	4,5	4,3
Total	**10,1**	**9,7**	**9,7**	**10,5**	**10,1**	**10,0**	**10,5**	**10,4**	**10,6**

Model-based nitrogen oxide emissions caused by Swedish consumption, thousands of tonnes of nitrogen oxides. Emissions abroad (from imports) and emissions in Sweden (total final demand minus exports) (Figure 9)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions in Sweden	153,4	143,1	137,3	136,9	128,1	109,3	105,2	103,3	107,4
Emissions abroad	80,1	80,3	74,9	89,7	96,2	111,9	118,8	126,1	105,1
Total	**233,5**	**223,3**	**212,2**	**226,6**	**224,3**	**221,2**	**224,0**	**229,4**	**212,5**

Model-based ammonia emissions caused by Swedish consumption, thousands of tonnes of ammonia. Emissions abroad (from imports) and emissions in Sweden (total final demand minus exports) (Figure 10)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions in Sweden	39,5	36,7	37,6	37,1	37,3	38,5	37,7	36,1	34,9
Emissions abroad	31,1	32,4	32,8	33,7	33,2	38,4	40,5	36,5	41,1
Total	**70,6**	**69,1**	**70,5**	**70,9**	**70,5**	**76,9**	**78,2**	**72,7**	**76,0**

Model-based sulphur dioxide emissions caused by Swedish consumption, thousands of tonnes of sulphur dioxide. Emissions abroad (from imports) and emissions in Sweden (total final demand minus exports) (Figure 11)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions in Sweden	22,3	21,6	21,1	25,1	23,2	20,3	19,4	16,4	15,9
Emissions abroad	32,5	32,8	29,6	37,6	40,5	42,5	40,5	35,4	29,7
Total	**54,8**	**54,3**	**50,7**	**62,8**	**63,7**	**62,7**	**59,9**	**51,8**	**45,5**

Good imports from country of consignment from EU-27 and all countries, and share from EU-27 out of total. SEK million and per cent.

	2000	2001	2002	2003	2004	2005	2006	2007	2008
From EU-27	470 753	469 838	472 903	497 509	540 176	594 969	662 024	743 491	768 046
From all countries	672 412	662 746	656 664	679 329	739 203	833 757	939 730	1 034 450	1 097 903
Proportion from EU-27 out of total	70%	71%	72%	73%	73%	71%	70%	72%	70%

The EU-27 comprises Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark,, Estonia, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and the United Kingdom. However, not all these countries were members throughout the period.

The trade statistics come from the statistical database of Statistics Sweden and can be downloaded under Trade in goods and services, Foreign trade – exports and imports of goods by trading partner. Note that because of the Rotterdam problem the country of consignment is not always the same as the country of manufacture.

Annex 3

Substances included in reported emissions in E-PRTR but not included in Usetox.

Carbon dioxide (CO_2) excluding biomass
Carbon monoxide (CO)
Chlorides (as total Cl)
Chlorine and inorganic compounds (as HCl)
Chlorofluorocarbons (CFCs)
Cyanides (as total CN)
Fluorides (as total F)
Fluorine and inorganic compounds (as HF)
Halogenated organic compounds (as AOX)
Halons
Hydrochlorofluorocarbons(HCFCs)
Hydro-fluorocarbons (HFCs)
Methane (CH_4)
Nitrogen oxides (NO_x/NO_2)
Non-methane volatile organic compounds (NMVOC)
Perfluorocarbons (PFCs)
Polycyclic aromatic hydrocarbons (PAHs)
Sulphur hexafluoride (SF_6)
Sulphur oxides (SO_x/SO_2)
Total nitrogen
Total organic carbon (TOC) (as total C or COD/3)
Total phosphorus

Annex 4

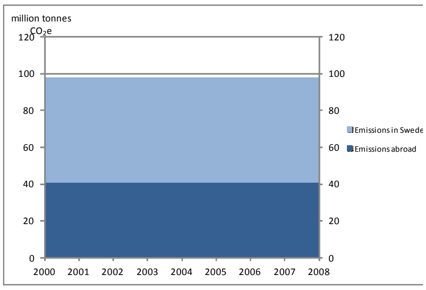
DPSIR is the EEA's expansion of the OECD's PSR model, and stands for:

D – Driving force, which describes the driving forces in society that lead to environmental problems, for example use of chemicals
P – Pressure, which describes the pressure we subject the environment to, for example emissions of chemical substances
S – State, which describes the state of the environment, for example through the concentration of different chemical substances in nature
I – Impact, which describes the effects on the environment and health, for example impact on biodiversity or health effects
R – Response, which describes the measures society takes, for example newly built houses that fulfil requirements for use of chemicals in building materials.

Annex 5

Example of what a presentation of an indicator can look like:

Greenhouse gas emissions associated with Swedish consumption



Definition:

Model-based emissions of greenhouse gases caused by Swedish consumption in millions of tonnes of carbon dioxide equivalents (carbon dioxide, methane and nitrous oxide weighted together) in 2000 to 2008 The emissions are broken down into emissions abroad (associated with imports) and emissions in Sweden (associated with total final demand minus exports).

Question I: How do emissions of greenhouse gases abroad caused by Swedish consumption change over time?

Total emissions caused by Swedish consumption increased from 90 million tonnes of carbon dioxide equivalents to 98 million tonnes of carbon dioxide equivalents in 2008. This signifies an increase of nearly 10 per cent. Emissions abroad increased from 44 million tonnes to 58 million tonnes, signifying a 30 per cent increase between 2000 and 2008. By comparison, emissions in Sweden caused by Swedish consumption decreased from 46 million to 40 million tonnes, which is equivalent to a decrease of 13 per cent over the same period.

Question II: What is behind the changed levels of emissions abroad caused by Swedish consumption?

The increase shown by the indicator can be principally explained in the model by increased consumption satisfied by greater imports. The fact that the value of imports increased by just over 40 per cent, calculated in fixed prices, from 2000 to 2008 supports this explanation. An increase may also be caused by the composition of consumption changing, i.e. other types of products are imported, those which for various reasons cause higher emissions, or by production of the imported goods taking place in countries that cause greater emissions in producing identical goods. Nearly half the increase in emissions can be explained by the increase in population over the period.

Data sources and method: Emissions associated with consumption are calculated by environmentally extended input-output analysis. Emissions that take place in Sweden, associated with consumption, are based on the official statistics on emissions prepared for climate reporting to UNFCCC, the UN convention on climate change. Emissions abroad, associated with imports, are calculated with emissions intensities from WRI (www.wri.org) or with data from Eurostat for EU Member States. The precise levels depend on what input data are available and the model assumptions, and may therefore vary from one study to another.

Consumption-based indicators in Swedish environmental policy

REPORT 6508

SWEDISH EPA
ISBN 978-91-620-6508-9
ISSN 0282-7298

The generational goal, which sets the direction for Sweden's environmental policy, was reformulated and decided upon in 2010 by the Riksdag. The changes from the previous generational goal imply among other things that environmental policy in Sweden must not lead to increased environmental and health problems outside of Sweden.

The environmental impact that Sweden causes in other countries is due among other things to the importing of products. How can this impact be quantified and followed?

In this report consumption-based indicators are proposed for the first time, for the following-up of greenhouse gas emissions and other emissions to air. The indicators are aimed at following the trend in emissions in Sweden and abroad, over time. The indicators enable the assessment of global environmental impacts caused by Swedish consumption. The method used is an environmentally extended input-output analysis which links data on emissions to the consumption in a region.

Furthermore, an attempt to include the emissions of chemical substances in an environmentally extended input-output analysis has been carried out. The method needs to be further developed before an indicator can be presented.

The report is an outcome of a project carried out by Statistics Sweden) in cooperation with the Royal Institute of Technology (KTH).

Swedish EPA SE-106 48 Stockholm. Visiting address: Stockholm - Valhallavägen 195, Östersund - Forskarens väg 5 hus Ub
Tel: +46 10 698 10 00, fax: +46 10 698 10 99, e-mail: registrator@swedishepa.se Internet: www.swedishepa.se **Orders** Ordertel: +46 8 505 933 40, orderfax: +46 8 505 933 99, e-mail: natur@cm.se Address: CM Gruppen, Box 110 93, SE-161 11 Bromma. Internet: www.swedishepa.se/publications