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Extension of a Disaggregated Input-Output Table with Environmental Data for the Year 2008

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Abbreviations and Glossary

a	annum (year)
ARA	Abwasserreinigungsanlage; engl. wastewater treatment
CH	Switzerland
CH_4	methane
CLRTAP	Convention on Long-range Transboundary Air Pollution
CO	carbon monoxide
CO_2	carbon dioxide
EE-IOT	environmentally extended input-output table
FTE	full-time equivalent
GHG	greenhouse gas
GLO	global average
GVE	Grossvieheinheit; engl. livestock unit
GWP	global warming potential
HFC	hydrofluorocarbon
IIR	Informative Inventory Report
IOT	input-output table
KVA	Kehrichtverbrennungsanlage; engl. municipal waste incineration
LCA	life cycle assessment
LCI	life cycle inventory analysis
NMVOC	non-methane volatile organic compounds
N_2O	nitrous oxide / dinitrogen monoxide
NO_x	nitrogen oxides
ODS	ozone depleting substance
PAH	polycyclic aromatic hydrocarbon
PFC	perfluorocarbon
PM	particulate matter (index gives size range in µm)
POP	persistent organic pollutant
PRTR	pollutant release and transfer register
SF_6	sulphur hexafluoride
SIOT	symmetric input-output table
SITC	Standard International Trade Classification
SNF	Swiss National Science Foundation
TOC	total organic carbon
UN-ECE	United Nations Economic Commission for Europe

Summary

An input-output table (IOT) with sectoral disaggregation in agriculture, food processing industry, energy industry, transport, public administration as well as waste and wastewater management industry is extended by detailed data on the pollutant emissions and resource use of the industries and the private households. A total of 96 industries and 20 final consumption categories are distinguished in the present environmentally extended input-output table (EE-IOT). The use of imported goods and services by industries and final consumption is taken into account separately from the use of domestic goods and services. The EE-IOT follows a mixed-units approach: the use of domestic goods and services and of imported services is recorded in monetary units, whereas the use of imported goods is recorded in physical units.

The total domestic environmental impacts according to the residence principle are taken from Frischknecht et al. (2014) and allocated to the industries and to household consumption. Data from environmental statistics, industry information and scientific studies are considered for the allocation of the domestic emissions and resource use. Where specific data is not available, auxiliary variables (i.e., direct energy consumption, numer of employees, output) are employed for the allocation of environmental burdens to the different industries and to final demand categories.

The specific environmental impacts per kg of commodity imports are taken from Frischknecht et al. (2014). The service imports are linked to environmental intensity data per CHF from the Swiss EE-IOT of the year 2005 by assuming price differences until 2008 to be negligible (Jungbluth et al. 2011). Some adjustments in certain categories of goods and service imports are made.

The uncertainty of the EE-IOT is not systematically assessed in this study. It varies depending on the quality of the data used for the allocation of pollutant emissions or resource use to the economic sectors and to final demand categories. The uncertainty is expected to be lower for environmental impacts and economic sectors with good data availability than for cases in which auxiliary variables are employed for the allocation of environmental impacts. The procedure applied for the allocation of environmental impacts to the economic sectors and to final demand categories is described in detail in the present report.

The EE-IOT compiled in this study is published in an electronic format (EcoSpold v1) readable by common life cycle assessment software and can be used by interested parties for futher analyses.

The three midpoint indicators greenhouse gas emissions, eutrophication potential and biodiversity damage potential are evaluated with the EE-IOT. From the consumption perspective, the environmental impacts according to the three indicators are strongly influenced by imports of goods and services. Between 51 % (eutrophication potential) and 66 % (biodiversity damage potential due to land use) of the total environmental impacts caused by Swiss consumption in 2008 occur abroad.

The final demand categories “housing and energy” and “transport” are responsible for a significant share of the domestic greenhouse gas emissions and the biodiversity damage potential. The waste and wastewater management sector is identified as an important direct contributor to the eutrophication potential. Agriculture causes an important share of the domestic environmental impacts in all three indicators analysed.This finding is in line with a previous study (Jungbluth et al. 2011). The disaggregation of the agricultural sector into 17 subsectors in the EE-IOT 2008 allows the differentiation between agricultural product groups. According to the midpoint indicators analysed, farming of dairy and non-dairy cattle as well as the production of food cereals and feed crops cause the highest environmental impacts (in absolute terms) among the agricultural subsectors from the production perspective.

Possible future improvements of the EE-IOT may include a more detailed data basis for the allocation of pollutant emissions to water and the disaggregation of the food processing industry with regard to energy consumption. The quantification of the environmental impacts of commodity imports could be improved if the imports and exports of platinum and palladium for monetary purposes were distinguished from other uses such as the manufacture of watches. Furthermore, the life cycle inventory data underlying the different categories of commodity imports could be regionally differentiated. This measure would make it possible to take differences in the environmental intensity of the manufacturing of products into account.

The degree of disaggregation of the economic sectors chosen in this study is deemed appropriate for the identification of the most important contributors to different environmental midpoint indicators. A more detailed disaggregation does not seem to be practical because of the lack of a corresponding level of detail in the available data. One exception where a future disaggregation may be useful and possible is the category hotels and restaurants, which could be represented as two separate sectors, because separate statistical data are available since the transition of national accounts to the NOGA 2008 classification.

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1 Introduction

An environmentally extended input-output table (EE-IOT) is a tool from environmental accounting that combines economic and environmental information in a common framework that follows concepts and definitions from national and environmental accounting. It allows to analyse various research questions regarding the interdependence of economic activities and environmental impacts.

In Switzerland input-output tables have until recently not been part of the publication program of Swiss Statistics, but were estimated from the available Swiss national accounts data and information from IOT of other European countries when Swiss data was not available (e.g. input structures, trade and transport margins). Such IOTs are available for 2001, 2005 and 2008 (Nathani et al. 2008; Nathani et al. 2011b) In order to increase the quality of the Swiss IOT for energy and environmental analysis, an energy oriented IOT of the year 2008 with a disaggregated energy and transport sector was estimated and combined with data on energy use and greenhouse gas emissions of industries and private households (Nathani et al. 2013; Nathani et al. 2011a). In a more recent project a new version of the IOT 2008 was estimated in which domestic and imported goods were separated. This allows for a better representation of the use of imported goods as intermediate goods in Swiss industries and goods for final demand (Nathani et al. 2014).

A first EE-IOT of Switzerland based on the standard IOT 2005 was published in 2011 (Jungbluth et al. 2011). In a current project funded by the Swiss National Science Foundation (SNF) an EE-IOT is developed that will be used to analyse the economic and environmental impact of nutrition in Switzerland and serve as a basis for scenarios of a sustainable development of the Swiss agri-food sector. This EE-IOT integrates and extends the work from previous years, since it

- disaggregates agriculture, food industry, the energy and the transport sector into subsectors, thus improving the economic representation of the environmentally most relevant sectors. In total the new IOT comprises 96 industries;
- separates the use of domestic from imported goods. This also improves the allocation of import-related emissions and resource use to Swiss industries and households;
- extends the disaggregated IOT with data on emissions and resource use of the Swiss industries and households as well as import-related emissions and resource use.

In this context the Swiss Federal Office for the Environment has funded an additional project that significantly extends the range of emissions and resource use included in the new EE-IOT and analyses the most important economic drivers in three environmental domains.

This report starts with the goal and scope in Chapter 2. It then contains a description of the EE-IOT (Chapter 3) and the total domestic emissions and resource use by

Switzerland in 2008 (Chapter 4). Detailed explanations of the attribution of emissions and resource consumption to the economic sectors and final consumption categories are given in Chapter 5. The methodology to quantify the environmental impacts of imports of goods and services is explained in Chapter 6. The midpoint indicators greenhouse gas emissions, eutrophication potential and biodiversity damage potential due to land use are assessed in Chapter 7. The final Chapter 8 draws some conclusions of this study and gives an outlook on the future development and improvement of the EE-IOT.

2 Goal and scope

The goal of this project was to

- extend the disaggregated IOT with data on various emissions of pollutants and consumption of resources;
- allocate the domestic pollutant emissions and resource use to the economic sectors and to final demand by using the disaggregation level of the IOT;
- calculate the environmental impacts of imports of commodities and services;
- analyse the most important drivers for environmental impacts in three selected environmental domains, namely greenhouse gas emissions, eutrophication potential and biodiversity potential due to land use, and to document the results in factsheets;
- prepare the EE-IOT in the EcoSpold v1 format so that it can be used with common LCA software.

This report gives a short overview of the concept of an EE-IOT and describes the level of disaggregation[1]. It contains a documentation of the allocation of all the emissions and resource uses considered in the EE-IOT. A special focus is on the disaggregation of agriculture and the food processing industry as well as on the energy and transport sectors.

[1] A detailed documentation of the compilation of the current IOT can be found in Nathani et al. (2015a)

3 Environmentally extended Input-Output Table

3.1 Overview

In this chapter, the general structure of an EE-IOT is briefly explained. More detailed information on the new input-output table and its environmental extension can be found in Nathani et al. (2015a).

It is important to mention that the data on resource use and emissions collected in this project follow as far as feasible the concepts and definitions of national and environmental accounting[2]. The following concepts and definitions are applied in the present study:

- Residence principle: the Swiss national economy consists of the economic units (enterprises and households) resident in Switzerland. In the EE-IOT their direct resource use and emissions are recorded. The residence principle differs to some extent from the territorial and the point-of-sales[3] principles mainly used in national environmental statistics, especially with regard to emissions from transport and mobility (see e.g. Frischknecht et al. (2014) for further explanations).
- Only emissions and resource use caused by economic actors are included. Thus e.g. emissions from nature are not recorded (e.g. volcanic eruptions, decomposing of organic matter in alpine regions). Cultivated land, such as agricultural land or forests, is considered as part of the economic system, as are for instance controlled landfills.
- Emissions remaining in the economic system are not recorded, for example waste destined for treatment.
- In the IOT, the treatment of waste is treated as a service offered by the waste treatment plants to the waste producers (enterprises or households).

3.2 Structure of the detailed input-output table

An EE-IOT consists of two parts: an economic input-output table and data on emissions and resource use by industries and households. The economic IOT records inputs and outputs of industries in monetary units and thus depicts the interrelations between the sectors of an economy (upper part of Fig. 3.1). The inputs relate to purchases from other

[2] This EE-IOT follows the European System of National Accounts (ESA) 1995 (Eurostat 1995) as does the standard IOT 2008. For further details on environmental accounting see United Nations et al. (2003) and Eurostat (2009).

[3] sales principle: Absatzprinzip, used for motor fuels

industries and the gross value added. The outputs relate to deliveries of intermediate goods to other industries and of goods to final demand. The latter comprises private households, government consumption, capital formation and exports. In this study, twelve household consumption categories are distinguished (e.g. nutrition, housing and energy or mobility).

As mentioned above, the use of domestic and of imported goods are recorded seperately. The use of imported commodities is additionally recorded in physical units because imported goods are linked to life cycle inventory (LCI) data, which refer to the mass of the products. The use of imported services and of domestic goods are kept in monetary units (middle parts of Fig. 3.1).

The environmental part of the EE-IOT contains data on resource use and emissions by industries and households in physical units (lower part of Fig. 3.1). Each row of the environmental matrix contains the use of a resource or the emission of a harmful substance by an industry or household category.

The linkage of commodity and service imports (second and third levels in Fig. 3.1) with environmental data is illustrated in Fig. 3.2. The calculation of the coefficients of total environmental impacts per mass unit of commodity imports or per monetary unit of service imports is described in Subchapter 6.2 and 6.3, respectively.

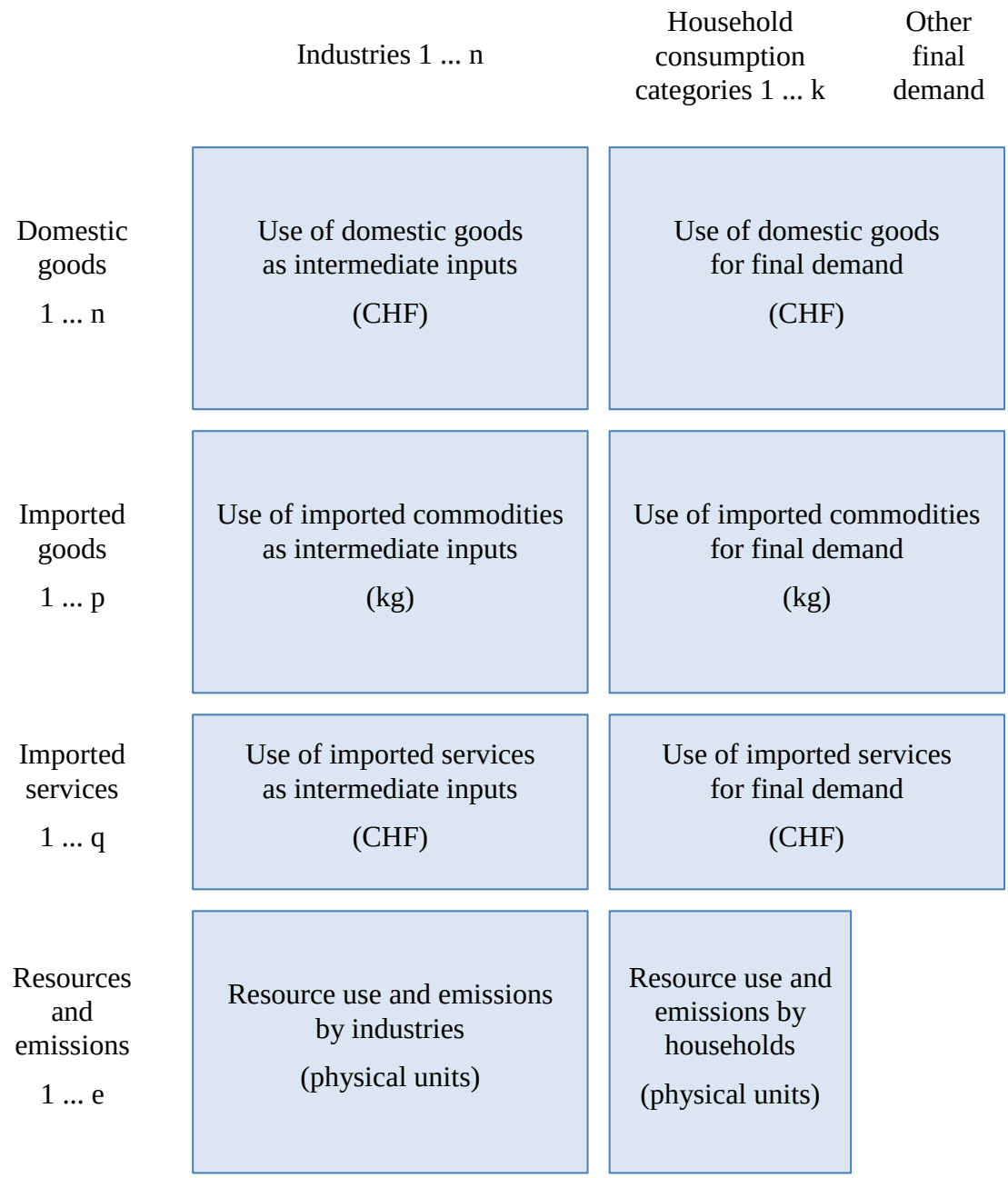

Fig. 3.1 Structure of the EE-IOT 2008

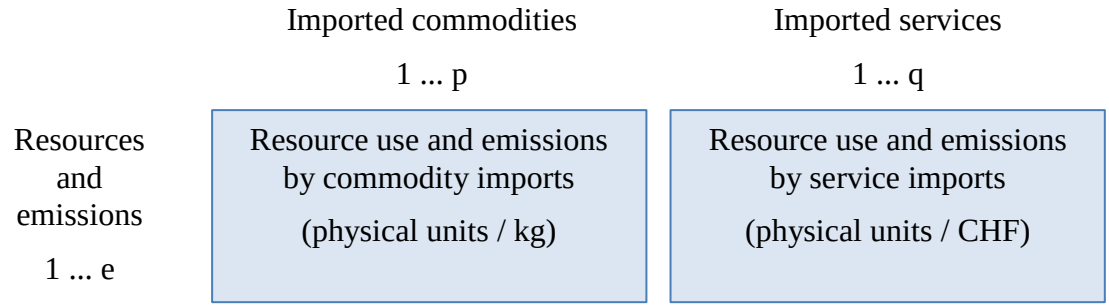

Fig. 3.2 Linkage of imported commodities and services with resource use and emissions in the EE-IOT 2008

As mentioned above, the economic part of the new Swiss EE-IOT is constructed in the context of an SNF project and the details will be presented in a forthcoming publication (Nathani et al. 2015a). The construction of the economic part of the EE-IOT basically followed the approach for estimating the revised version of the IOT 2008 (Nathani et al. 2015b). Starting points were this IOT 2008 and the existing energy IOT 2008 (Nathani et al. 2013).The approach comprised the following steps:

- determination of the output of the industries;
- estimation of the supply table, output and value added by product groups;
- estimation and balancing of the symmetric IOT (SIOT)[4];
- separation of domestic and imported goods and services in the SIOT;
- reclassification of the imported goods matrix from the CPA into the SITC classification by using a correspondence table generated from Swiss trade statistics;
- conversion of the commodity import matrix from monetary units into physical units: totals in physical units by product group were taken from the trade statistics and adapted to the national accounts totals. The totals were then distributed to the using industries and final demand categories by adopting the distribution from the commodity import matrix in monetary units. Due to missing data, the assumption is made that all users pay the same price for imported commodities (of a particular SITC category);
- aggregation of imported services to the aggregation level used for the environmental data.

[4] national accounts revision of 2012 by Swiss Statistics

With regard to sectoral disaggregation, the new EE-IOT distinguishes 96 industries. Starting from the published Swiss IOT, it contains the following disaggregation of industries:

- 17 subsectors of the agricultural sector,
- 12 subsectors of the food industry,
- 13 subsectors of the energy industry,
- 12 subsectors of the transport sector,
- 2 subsectors of public administration,
- 3 subsectors of the waste and wastewater management industry.

A list of the industries and final demand categories and of imported product groups included in the EE-IOT can be found in Tab. A.1 and Tab. A.2 in the Annex.

Unlike the EE-IOT developed in a previous study (Jungbluth et al. 2011), the final demand data are not modified. In the previous study investment expenditures were further allocated to the investing industries and households. Public expenditures were partly allocated to household consumption categories. Hence, the results of the present study are not fully comparable to the results calculated in the previous study.

A large variety of data sources was used to disaggregate the agricultural and food processing industry sectors as well as the energy and the transport sector. They include[5]:

- the revised IOT 2008 as a primary basis,
- the energy IOT 2008 as a basis for disaggregating the energy and the transport sector,
- data from Swiss Statistics' energy accounts and energy price information to calculate energy costs of industries,
- national account statistics, value added statistics from Swiss statistics,
- detailed data from Swiss Statistics' agricultural accounts, market data from the Federal Office for Agriculture
- foreign trade data from the Swiss Customs Administation and from the OECD,
- diverse data from industry associations, e.g. the Swiss Farmers' Union, the Swiss food industry federation FIAL,
- structural coefficients from the Danish and the British input-output tables 2007 and 2008 to close data gaps for the agri-food sector.

[5] see Nathani et al. (2015a) for details

3.3 Resource consumption and pollutant emissions

The pollutant emissions and resource consumptions include those which allow an assessment with the ecological scarcity method 2013 and it additionally covers three midpoint indicators (Tab. 3.1 and factsheets).

Tab. 3.1 Scope of the domestic pollutant emissions and resource consumption covered by the Swiss EE-IOT 2008 and midpoint indicators used for the analyses

Resource consumption
Water consumption
Primary energy demand (renewable)
Gravel consumption, further abiotic resources
Land use (differentiated according to use types)
Greenhouse gas emissions
CO2 (fossil)
CO2 (biogenic)
CH4
N2O
HFCs (reported as HFC-134a)
PFCs (reported as CFC-14)
SF6
Other air pollutants
SO2
NOx
PM10, PM2.5
NMVOC
Ammonia
Benzene, Dioxin, PAH, Benzo(a)pyrene
Heavy metals
Ozone depleting substances
Water pollutants
Heavy metals (individual elements) and arsenic
Phosphate
Nitrogen
Organic substances (reported as COD)
PAH, Benzo(a)Pyrene
AOX
Endocrine disruptors
Persistent organic pollutants (five most important substances)
Wastes
Radioactive wastes
Landfilled non-radioactive waste (carbon content)
Hazardous wastes to underground deposits
Soil pollutants
Heavy metals (individual elements)
Nitrate
Pesticides (reported as glyphosate)
Non-material emissions
(Traffic) noise
Midpoint indicators
Greenhouse gas emissions
Biodiversity damage potential caused by land use [1)]
Nitrogen (eutrophication potential)

1) no regional differentiation related to imports

3.4 Documentation

The EE-IOT for Switzerland in the year 2008 is published in an electronic format (EcoSpold v1) readable by common life cycle assessment (LCA) software.

4 Total domestic emissions and resource use

The total emissions and resource use are based on the figures calculated by Frischknecht et al. (2014) for the year 2008. Data according to the residence principle are used, which leads to some deviations of the emissions and resource use from national environmental statistics that are usually based on the territorial principle (see also Subchapter 3.1). A number of substance flows are adjusted to revised or different data or newly included:

- The energy consumption is now based on the Swiss Statistics' energy accounts.
- The amount of water extracted from nature and the water emissions to air are updated and now includes also cooling water for nuclear power plants.
- The land use for the main land use types is taken from the Swiss land use statistics. Several land use categories are newly added and the areas covered by the different land use categories are revised.
- The emissions of GHGs (CO_2 fossil, CH_4, N_2O, HFCs, PFCs) are now based on the Swiss Statistics' emission accounts data. Biogenic CO_2 emissions are also taken into account. Methane emissions from agriculture and forestry sectors (NOGA categories g01a to g01r and g02) are reported as biogenic methane and subtracted from the fossil CH_4 emissions.
- The emissions of some air pollutants (NO_x, NMVOC, NH_3, SO_2, CO, $PM_{2.5}$, PM_{10}) are now based on the Swiss Statistics' emission accounts data.
- The emissions of estradiol, anthracene, dichloromethane, dichloroethane, ethylbenzene, and the five POPs described in Subchapter 5.9.9 to water are newly added.
- The pesticide emissions, which were represented by a pesticide mix in the previous study (Frischknecht et al. 2014), are now reported as glyphosate. The amounts of pesticide used are converted to glyphosate-equivalents based on characterization factors for different classes of plant protection products (see also Subchapter 5.10.2 and Tab. 5.36).
- The emissions of some radioactive substances to air (cobalt-58, cobalt-60, xenon-133, iodine-131, iodine-133, krypton 85m) and water (antimony-124, cobalt-58, manganese-54, silver-110, uranium-238, carbon-14) are now considered and allocated to the NOGA categories.
- Noise emissions are considered in the present EE-IOT but have not been analysed in the study by Frischknecht et al. (2014).

5 Allocation of domestic emissions and resource use to economic sectors and final demand

5.1 Overview

The allocation of the total pollutant emissions and resource use of Switzerland in the year 2008 to the economic sectors and the final demand categories is described in this chapter. Different data sources are used for the allocation, including environmental statistics, industry data and scientific reports. Where specific data is not available, auxiliary variables are employed for the allocation of environmental burdens to the different industries and to final demand categories (Subchapter 5.2).

In the allocation of the total domestic emissions and resource consumption, it is distinguished between direct and indirect emitters of pollutants or users of resources. The direct economic actor responsible for an environmental impact is the industry sector or final consumption category emitting a pollutant to an environmental compartment (e.g., wastewater treatment plants) or extracting a resource from nature (e.g., mining companies). In most cases, the environmental impacts are assigned to the direct emitter of a pollutant or consumer of a resource in the present study.

An indirect pollutant emitter or resource user is the actor ultimately causing the environmental impact. An example may include households releasing chemicals to water, which is then treated by a wastewater treatment plant. A few cases exist in this EE-IOT, where the emissions of pollutants (e.g., endocrine disruptors and some persistent organic pollutants emitted to water) or the consumption of resources (e.g., water) are assigned to the indirect economic actor responsible for the emission or the resource consumption. This procedure results in a lower distortion due to aggregation or economic interrelations of the industry sectors and the final demand categories.

The Subchapters 5.3 to 5.12 contain a detailed description of the procedure followed to allocate the pollutant emissions and resource use to the economic sectors and to final demand.

5.2 Auxiliary variables

Auxiliary variables are used for the allocation of resource consumption and emissions to industry sectors and households when no other data are available. These variables are:

- direct energy consumption by energy carrier,
- number of employed persons (in fulltime equivalents, FTE),
- gross output („Bruttoproduktionswert“).

Data on the gross output and the number of employed persons by industry sector are compiled in Tab. A.1 in the Annex. The gross output of each sector is taken from the IOT and corrected by the own consumption of the respective industry sector in order to avoid feedback loops (i.e., the diagonal of the SIOT is set equal to zero). The number of employed persons by industry was mainly derived from the Swiss business census with various adaptations to national accounting principles. Employment data for agricultural and food subsectors also stem from the Swiss business census in the industry and the primary sector.

The consumption expenditures in the individual categories of final consumption are compiled in Tab. A.2 in the Annex.

The allocation of the direct energy consumption to the industry sectors and to household consumption is explained in Subchapter 5.3.

5.3 Direct energy consumption

5.3.1 Overview

Data on energy consumption is based on Swiss Statistics' energy accounts as a primary data source. Detailed data for 81 industries in the NOGA 2008 classification were supplied by Swiss Statistics. In order to be in line with the harvested energy approach, the total energy consumption data were multiplied by the technology-dependent energy factor reported by Frischknecht et al. (2015).

The data were reclassified into the NOGA 2002 classification using the correspondence table (for establishments) from Swiss Statistics. In some cases adjustments were necessary to avoid aggregation error and to be compatible with the concepts of the energy IOT 2008. Energy use in the energy and transport subsectors were taken from data used in the construction of the existing energy IOT 2008 and adjusted to the new totals. Energy use in the pharmaceutical industry was estimated from German energy accounts data (Destatis 2009) by assuming the same energy use per employed person in the Swiss pharmaceutical industry.

The energy consumption of agriculture and the food industry is further divided into the different subsectors. The allocation procedure is described in Subchapter 5.3.2 for agriculture and in Subchapter 5.3.3 for the food industry.

5.3.2 Agriculture

Energy use in agriculture comprises motor fuels for tractors and other machines, heating energy for greenhouses and studs and electricity. The energy use of agriculture is further allocated to the different subsectors.

The amounts of petrol and diesel fuel used in agriculture and in horticulture and landscaping are reported by Schäffeler and Keller (2008a). The fuel consumption of horticulture and landscaping is assigned to the NOGA category g01r. For the

agricultural sector, it is differentiated between tractors, mowers and other machines, for which the fuel use is known. Since the intensity of tillage is not the same for all crops, a specific fuel demand of the tractor per land area is applied as determined by Hersener and Meier (2001). This fuel demand is multiplied by the land area of the respective crop to obtain the total fuel consumption of the agricultural subsectors. Tab. 5.1 compiles the specific fuel demand, the land area and the total fuel consumption of the most important crops grown in Switzerland. The land use category meadows and pastures in BFS (2014e) encompasses 78 % meadows and 22 % pastures (BFS 2013). Only meadows are taken into account for the determination of the fuel demand. It is assumed that no machinery is employed on pastures. The fuel demand for the cultivation of meadows and artificial meadows is allocated to the NOGA categories g01k (non-dairy cattle), g01o (dairy cattle and raw milk) and g01p (other animal products) according to the number of livestock units of hay-eating animals as listed in Tab. 5.2 (Schweizerischer Bauernverband 2010a). The same allocation is used for the use of diesel fuel in mowers. The category other machines encompass a variety of vehicles used for different purposes. Since it is difficult to assign each type of machine to a specific NOGA category, the allocation procedure of tractors is also applied to the fuel consumption of other machines (Tab. 5.1). The total fuel demand of the agricultural sector according to Swiss Statistics' energy accounts does not completely agree with the fuel consumption determined based on literature data as described above. The calculated fuel consumption is therefore scaled to the total fuel use according to Swiss Statistics' energy accounts. The same allocation is used for the energy carriers petrol, diesel, biofuels and non-energy use oil products.

Tab. 5.1 Specific diesel demand of tractors and land area for the different crops (Hersener & Meier 2001; BFS 2014e).

	Land area	Specific diesel demand	Total diesel demand
	ha	L / (ha*a)	TJ / a
Meadows	481'635	110	1'905
Artificial meadows	127'259	200	915
Wheat	88'433	140	445
Barley	32'958	140	166
Oats	1'861	140	9
Maize	17'593	200	126
Silo maize	44'735	190	306
Other cereals	15'260	140	77
Potatoes	11'058	300	119
Sugar beets	20'469	500	368
Fodder beets	1'072	300	12
Vegetables	9'676	120	42
Oil-bearing crops	25'914	120	112
Pulses	4'291	120	19
Grapes	12'922	120	56
Fruits	7'333	120	32
Other vegetal products	4'910	120	21
Total	**907'379**		**4'728**

Tab. 5.2 Number of livestock units of hay-eating animal species (Schweizerischer Bauernverband 2010a).

Animal species	Livestock units (GVE)
Non-dairy cattle	242'287
Dairy cattle	726'875
Other animals	97'780

Heating energy in agriculture is mainly used for greenhouses and studs. Other agricultural buildings are not taken into account since they are either not heated or belong to private households and are thus included in the final consumption category c07 (housing and energy). The total heating energy demand is taken from Latsch et al. (2014). The same allocation is applied to all energy carriers used for heating in agriculture, namely light fuel oil, natural gas, biogas, wood, other renewable energy and distance heat.

Studs are only heated for the farming of pigs and broiler chickens but not for other animals. The space demand per animal as well as the range of the specific heating energy demand per animal place is reported by Latsch et al. (2014). The actual heating energy demand per place is determined as the arithmetic mean of the minimum and maximum values. The number of animals is taken from Erdin (2009). The heating energy consumption of porkers, piglets and breeding sows is assigned to the NOGA category g01l (pigs) and the energy used to heat the studs of broiler chickens is assigned to the NOGA category g01m (poultry).

Tab. 5.3 Number of animals as well as their space and heating energy demand used to calculate the total heating energy consumption of studs (Erdin 2009; Latsch et al. 2014).

	Number of animals	Space demand per animal	Specific heating energy demand	Total heating energy demand
	animals	place / animal	MJ / (place*a)	TJ / a
Porkers	763'233	0.90	472	324
Piglets	336'148	0.35	396	47
Breeding sows	138'008	2.50	4'770	1'646
Broiler chickens	5'300'356	0.13	60	40
Total				**2'056**

Greenhouses in Switzerland are predominantly used to grow vegetables, for horticulture and to produce other vegetal products. The greenhouse areas of these agricultural products are made available by Swiss Statistics[6]. The specific heating energy demand per greenhouse area is estimated based on a French study (Grisey et al. 2007). The mean value for France is taken for the calculation of the heating energy demand of greenhouses in Switzerland. The heating energy demand of vegetables and other vegetal

[6] https://www.pxweb.bfs.admin.ch/ (accessed on 10th June 2015)

products is twice as high as that of products of horticulture (Tab. 5.4). Heating energy for the production of vegetables is assigned to the NOGA category g01e whereas the heating energy used for other vegetal products and products of horticulture is assigned to the NOGA category g01j. The total heating energy demand obtained with these figures is higher than the actual consumption of heating energy in greenhouses. The calculated heating energy consumption is therefore scaled to the difference of the total heating energy demand reported by Latsch et al. (2014) and the heating energy demand of the studs as calculated in Tab. 5.4.

Since the heating energy consumption according to Latsch et al. (2014) does not fully agree with the sum of the use of light fuel oil, natural gas, biogas, wood, other renewable energy and distance heat of the agricultural sector according to Swiss Statistics' energy accounts, the total heating energy consumption is scaled to the total of the energy accounts.

Tab. 5.4 Specific heating energy demand and land area for the different crops grown in greenhouses (Grisey et al. 2007).

	Land area	Specific heating energy demand	Total heating energy demand
	ha	TJ / (ha*a)	TJ / a
Vegetables	486	11.5	5'598
Horticulture	231	5.8	1'328
Other vegetal products	54	11.5	617
Total	**770**		**7'543**

In agriculture, electricity is used for greenhouses, studs and general applications (e.g. hot water, lighting). The electricity demand of greenhouses is independent of the crop. It is calculated based on the land area of agricultural products grown in greenhouses and the specific electricity demand per land area reported by Grisey et al. (2007) (Tab. 5.5). Hersener and Meier (2001) compiled a detailed list of the relevant contributors to electricity consumption in an average Swiss farm. The electricity consumption associated with livestock farming is used to calculate specific demand figures for different animal species. These electricity intensities are multiplied with the number of livestock units to obtain the total electricity demand (Tab. 5.6). The electricity used for various applications on an average farm is approximately 12.3 GJ/a. Multiplication with the number of farms in Switzerland, which is about 76'000, yields a total electricity consumption of 935 TJ/a (Hersener & Meier 2001). This general electricity demand is allocated to all agricultural subsectors (g01a to g01p) based on the number of employed persons in each subsector. The total electricity demand calculated for greenhouses, livestock farming and general applications is scaled up to the total reported in the Swiss Statistics' energy accounts.

Tab. 5.5 Specific electricity demand and land area for the different crops grown in greenhouses (Grisey et al. 2007).

	Land area	Specific electricity demand	Total heating energy demand
	ha	TJ / (ha*a)	TJ / a
Vegetables	486	0.32	156
Horticulture	231	0.32	74
Other vegetal products	54	0.32	17
Total	**770**		**247**

Tab. 5.6 Livestock units and specific electricity demand for different animal species used to calculate total electricity consumption of livestock farming (Hersener & Meier 2001).

	Livestock units	Specific electricity demand	Total electricity demand
	GVE	GJ / GVE	TJ / a
Dairy cattle	726'875	1.3	973
Non-dairy cattle	242'287	0.6	156
Pigs	196'248	1.5	290
Laying hens	22'549	10.5	237
Poultry	24'877	10.5	262
Other animals	97'780	0.6	63
Total			**1'980**

5.3.3 Food industry

The consumption of electricity and heating energy of the food industry subsectors is calculated with energy intensities per ton of product and the production volumes of the subsectors. The parameters used for the calculation of the total heating energy and electricity demand of the subsectors of the food industry are compiled in Tab. 5.7 and Tab. 5.8, respectively.

The production volumes were estimated based on national statistics and data from food industry associations. Additionally, production volumes of large producers were taken from annual reports and other publications. As another information source, industry experts were asked for estimations of the production volumes of specific product groups.

Three main data sources were used to determine the energy intensities of food production. First, publicly available annual and sustainability reports of food industry companies, life cycle assessments and other studies and reports about food products were collected. Second, two big food industry companies of Switzerland made confidential data on the production volumes and energy use of production available for a number of different product groups. Third, statistical data from the German food industry were used to calculate energy intensities per employed person, which were then multiplied by the number of employees of each subsector of the Swiss food industry and

divided by the production volume of the respective subsector. This procedure yields at least three values for the energy intensity of production of the food industry subsectors. The only exception is the NOGA category g15k (prepared animal feeds), for which two independent figures are available. The arithmetic mean of the individual energy intensities is used for the calculation of the total heating energy and electricity demand of the food industry. Since the total energy consumption obtained by this procedure is little below the total reported in the Swiss Statistics' energy accounts, the calculated heating energy and electricity consumption is scaled up to the actual energy use.

Tab. 5.7 Production volumes and specific heating energy demand for the subsectors of the food industry (n.a.: not available).

	Production volume	**Specific heating energy demand**	**Total heating energy demand**
	t / a	**GJ / t**	**TJ / a**
Processed meat	418'338	3.3	1'371
Processed fish	n.a.	0.6	n.a.
Fruit and vegetable products	277'678	1.9	539
Oils and fats	139'399	7.9	1'103
Dairy products	1'148'715	3.4	3'923
Grain mill and starch products	524'572	0.6	296
Bakery and farinaceous products	466'294	3.0	1'415
Sugar	251'238	7.6	1'919
Chocolate and confectionery	193'059	3.8	728
Other food and tobacco products	270'864	10.2	2'764
Prepared animal feeds	1'685'720	0.5	807
Beverages	1'690'013	0.4	725
Total			**15'590**

Tab. 5.8 Production volumes and specific electricity demand for the subsectors of the food industry.

	Production volume	**Specific electricity demand**	**Total electricity demand**
	t / a	**GJ / t**	**TJ / a**
Processed meat	418'338	2.8	1'160
Processed fish	n.a.	1.1	n.a.
Fruit and vegetable products	277'678	0.9	254
Oils and fats	139'399	1.1	148
Dairy products	1'148'715	1.5	1'750
Grain mill and starch products	524'572	0.6	341
Bakery and farinaceous products	466'294	2.1	967
Sugar	251'238	0.7	188
Chocolate and confectionery	193'059	3.9	744
Other food and tobacco products	270'864	3.8	1'034
Prepared animal feeds	1'685'720	0.3	469
Beverages	1'690'013	0.3	567
Total			**7'621**

5.4 Water consumption

The total water consumption of Switzerland is allocated to the different production sectors based on data published by Freiburghaus (2009). The allocation procedure of water use to the different sectors is described in the following. As recommended in the ecological scarcity method 2013, it is distinguished between water extraction from nature and water consumption (i.e. water that is evaporated to air or embodied in a product). Only the amount of water consumed by industries and final demand is considered. The default assumption is that a share of 10 % of the total water extraction is used consumptively (Frischknecht & Büsser Knöpfel 2013a). Deviations from this assumption for specific sectors are described in the respective paragraphs.

The consumption of drinking water by households is assigned to the sector c04 of the final demand (housing and energy). The water demand for public purposes and the losses in the distribution system are assigned to the NOGA category g41 (collection, distribution and purification of water). The water demand of the gravel and concrete industry is assigned to the NOGA category g26 (manufacture of other non-metallic mineral products).

The water demand of the food processing industry is assigned to the NOGA categories g15a to g15l. The distribution of water consumption in the subsectors of the food industry is assumed to correspond to the masses of food that are processed in the individual NOGA categories (see Tab. 5.7).

The water demand of the textile industry and the paper industry are assigned to the NOGA categories g17 (manufacture of textiles) and g21 (manufacture of pulp, paper and paper products), respectively. The water demand of the chemical industry is allocated to the NOGA categories g24a (chemicals and chemical products) and g24b (pharmaceutical products) based on the number of employed people in each sector. The water consumed by the metal industry is assigned to the NOGA category g27 (manufacture of basic metals). The water demand of other industry sectors is assigned to the NOGA categories g18 to g37 excluding g17, g21, g24a, g24b, g26 and g27. The water demand is distributed to the different categories according to the number of employees in each category.

The water demand of the artificial production of snow is assigned to the NOGA category g91p92 (membership organizations, recreation, culture and sports). A share of 40 % consumptive water use is applied to the water extraction for artificial snow production. The water use of waste management is assigned to the NOGA category g90c (disposal services).

The water demand of other service sectors are assigned to the NOGA categories g50 to g85, g90a, g90b and g93p95, excluding the categories g90c and g91p92. The water demand is distributed to the different categories according to the number of employees in each NOGA category.

The water demand of the energy sector is fully assigned to the NOGA category g40c (nuclear power plants). The demand of cooling water of nuclear power plants is also assigned to the NOGA category g40c. For the cooling water, the share of consumptive

water use is 31 % of the water extracted from nature. This figure is based on data of the Swiss nuclear power plant Gösgen (BWG 2003).

The water demand of agriculture is assigned to the NOGA categories g01a to g01r. According to Freiburghaus (2009), the total water demand of agriculture is first divided between the following purposes: water consumption for the cultivation of vegetal products (NOGA categories g01a to g01j), water use for livestock farming (NOGA categories g01k to g01r) and for horticulture and landscaping (NOGA category g01r). The water used for the operation of running fountains is not assigned to any NOGA category since this water is not consumed. The water demand of individual crops is then calculated by multiplying the production volumes in the year 2008 (BFS 2014f) by the expected blue water consumption as reported by Pfister (2011). The water consumption of animals is determined by the number of animals (BLW 2011) and the daily water demand per animal (Tab. 5.9). The average water demand per day is estimated for the relevant animal species based on different literature sources and life cycle inventories (Nemecek et al. 2007). The share of consumptive water use is assumed to be 90 % for both vegetal and animal products.

Tab. 5.9 Number of animals, estimated daily water consumption and total water demand of different animal species (BLW 2011; Nemecek et al. 2007).

	Number of animals	Estimated daily water demand	Total water demand
	animals	L / (animal*d)	mio. m^3 / a
Non-dairy cattle [1)]	877'412	50	16.0
Dairy cattle [1)]	726'875	50	13.3
Pigs [2)]	1'540'129	8	4.5
Poultry [3)]	6'219'364	0.2	0.5
Laying hens [3)]	2'254'875	0.2	0.2
Horses [4)]	58'969	40	0.9
Sheep [5)]	446'153	5	0.8
Goats [5)]	81'445	5	0.1
Total			**36.2**

[1)] http://www.blv.admin.ch/themen/tierschutz/05466/05669/05674/index.html?lang=de (accessed on 10th June 2015)

[2)] http://www.blv.admin.ch/themen/tierschutz/05466/05705/05710/index.html?lang=de&download=NHzLpZeg7t,lnp6I0NTU042l2Z6ln1acy4Zn4Z2qZpnO2Yuq2Z6gpJCEeIJ3gWym162epYbg2c_JjKbNoKSn6A-- (accessed on 10th June 2015)

[3)] http://www.ign-nutztierhaltung.ch/huehnerhaltung/anspruche/anspruche_16.php (accessed on 10th June 2015)

[4)] http://www.blv.admin.ch/themen/tierschutz/05466/05642/05647/index.html?lang=de (accessed on 10th June 2015)

[5)] Own assumption

The allocation of total water use and the shares of water consumption are compiled in Tab. 5.10.

Tab. 5.10 Water demand of the different sectors assessed in Freiburghaus (2009) including qualified estimates of the consumptive water use of each sector and the calculated consumptive water use.

	Total water demand	**Share of consumptive use**	**Consumptive water use**
	mio. m^3 / a	**MJ / (place*a)**	**mio. m^3 / a**
Household	490	10%	49.0
Public purpose	84	10%	8.4
Distribution losses	115	10%	11.5
Gravel and concrete	16	10%	1.6
Food processing	62	10%	6.2
Textiles	3	10%	0.3
Paper	68	10%	6.8
Chemistry	358	10%	35.8
Metals	52	10%	5.2
Other industries	7	10%	0.7
Artificial snow production	17	40%	6.7
Disposal	185	10%	18.5
Other services	189	10%	18.9
Energy supply	40	10%	4.0
Cooling of nuclear power plants	1'643	31%	516.4
Agricultural production	206	90%	185.1
Running fountains	206	0%	0.0
Total			**875**

5.5 Primary mineral resources

According to the STAT-TAB database[7] six different groups of non-metallic mineral resources are mined within the borders of Switzerland. Three of these resources are in the focus of the present study, namely gravel, gypsum and sodium chloride. The extraction of these mineral resources is assigned to the NOGA category g10b14 (mining and quarrying).

5.6 Land use statistics

The data on the land use is based on information of the Swiss land use statistics 2004/09 (Arealstatistik 2004/09) using the standard nomenclature NOAS04 (BFS 2014a). The standard nomenclature NOAS04 is a structure with four levels consisting of four principal domains (settlement and urban areas, agricultural areas, wooded areas and unproductive areas), which are divided into 17 land use classes, 27 sub classes and 72

[7] http://www.pxweb.bfs.admin.ch (accessed on 05.09.2014)

basic categories. The four principal domains including a description of the land uses of the classes and subclasses are shown in Tab. 5.11.

Tab. 5.11 Principal domains of the Swiss land use statistics 2004/09 (Arealstatistik 2004/09)

4 Principal domains			Description
1	Siedlungsflächen	Settlement and urban areas	Industrial and commercial building, housing area, public buildings, agricultural buildings, not specified buildings, roads, rails, airports, special settlement areas (dump, construction and extraction sites), recreational and green areas
2	Landwirtschaftsflächen	Agricultural areas	Orchards, vineyards, horticulture, arable land, pasture and meadows,
3	Bestockte Flächen	Wooded areas	Continuous forest, discontinous forest, shrub land
4	Unproduktive Flächen	Unproductive areas	Lakes, rivers, unproductive vegetation, areas without vegetation, glaciers

A detailed description of the corresponding basic categories of each principal domain is shown in Tab. 5.12 to Tab. 5.15.

Tab. 5.12 36 basic categories of the principal domain settlement and urban areas including classification number according to NOAS04 nomenclature

No.	NOAS04	Siedlungsflächen	Settlement and urban areas
1	1	Industrie- und Gewerbegebäude	Industrial and commercial buildings
2	2	Umschwung von Industrie- und Gewerbegebäuden	Surroundings of industrial and commercial buildings
3	3	Ein- und Zweifamilienhäuser	One- and two-family houses
4	4	Umschwung von Ein- und Zweifamilienhäusern	Surroundings of one- and two-family houses
5	5	Reihen- und Terrassenhäuser	Terraced houses
6	6	Umschwung von Reihen- und Terrassenhäusern	Surroundings of terraced houses
7	7	Mehrfamilienhäuser	Blocks of flats
8	8	Umschwung von Mehrfamilienhäusern	Surroundings of blocks of flats
9	9	Öffentliche Gebäude	Public buildings
10	10	Umschwung von öffentlichen Gebäuden	Surroundings of public buildings
11	11	Landwirtschaftliche Gebäude	Agricultural buildings
12	12	Umschwung von landwirtschaftlichen Gebäuden	Surroundings of agricultural buildings
13	13	Nicht spezifizierte Gebäude	Unspecified buildings
14	14	Umschwung von nicht spezifizierten Gebäuden	Surroundings of unspecified buildings
15	15	Autobahnen	Motorways
16	16	Autobahngrün	Green motorway environs
17	17	Strassen, Wege	Roads and paths
18	18	Strassengrün	Green road environs
19	19	Parkplatzareal	Parking areas
20	20	Befestigtes Bahnareal	Sealed railway areas
21	21	Bahngrün	Green railway environs
22	22	Flugplätze	Airports
23	23	Graspisten, Flugplatzgrün	Airfields, green airport environs
24	24	Energieversorgungsanlagen	Energy supply plants
25	25	Abwasserreinigungsanlagen	Waste water treatment plants
26	26	Übrige Ver- und Entsorgungsanlagen	Other supply or waste treatment plants
27	27	Deponien	Dumps
28	28	Abbau	Quarries, mines
29	29	Baustellen	Construction sites
30	30	Bau- und Siedlungsbrachen	Unexploited urban areas
31	31	Öffentliche Parkanlagen	Public parks
32	32	Sportanlagen	Sports facilities
33	33	Golfplätze	Golf courses
34	34	Campingplätze	Camping areas
35	35	Schrebergärten	Garden allotments
36	36	Friedhöfe	Cemeteries

Tab. 5.13 13 basic categories of the principal domain agricultural areas including classification number according to NOAS04 nomenclature

No.	NOAS04	Landwirtschaftsflächen	Agricultural areas
1	37	Obstanlagen	Intensive orchards
2	38	Feldobst	Field fruit trees
3	39	Rebbauflächen	Vineyards
4	40	Gartenbauflächen	Horticulture
5	41	Ackerland	Arable land
6	42	Naturwiesen	Meadows
7	43	Heimweiden	Farm pastures
8	44	Verbuschte Wiesen und Heimweiden	Brush meadows and farm pastures
9	45	Alpwiesen	Alpine meadows
10	46	Günstige Alp- und Juraweiden	Favorable alpine pastures
11	47	Verbuschte Alp- und Juraweiden	Brush alpine pastures
12	48	Versteinte Alp- und Juraweiden	Rocky alpine pastures
13	49	Schafalpen	Sheep pastures

Tab. 5.14 11 basic categories of the principal domain wooded areas including classification number according to NOAS04 nomenclature

No.	NOAS04	Bestockte Flächen	Wooded areas
1	50	Normalwald	Normal dense forest
2	51	Schmaler Wald	Forest strips
3	52	Aufforstungen	Afforestations
4	53	Holzschläge	Felling areas
5	54	Waldschäden	Damaged forest areas
6	55	Aufgelöster Wald (auf Landwirtschaftsflächen)	Open forest (on agricultural areas)
7	56	Aufgelöster Wald (auf unproduktiven Flächen)	Open forest (on unproductive areas)
8	57	Gebüschwald	Brush forest
9	58	Feldgehölze, Hecken	Groves, hedges
10	59	Baumgruppen (auf Landwirtschaftsflächen)	Clusters of trees (on agricultural areas)
11	60	Baumgruppen (auf unproduktiven Flächen)	Clusters of trees (on unproductive areas)

Tab. 5.15 12 basic categories of the principal domain unproductive areas including classification number according to NOAS04 nomenclature

No.	NOAS04	Unproduktive Flächen	Unproductive areas
1	61	Stehende Gewässer	Lakes
2	62	Wasserläufe	Rivers
3	63	Hochwasserverbauungen	Flood protection structures
4	64	Gebüsch, Strauchvegetation	Scrub vegetation
5	65	Unproduktive Gras- und Krautvegetation	Unproductive grass und shrubs
6	66	Lawinen- und Steinschlagverbauungen	Avalanche and rockfall barriers
7	67	Feuchtgebiete	Wetlands
8	68	Alpine Sportinfrastruktur	Alpine sports facilities
9	69	Fels	Rocks
10	70	Geröll, Sand	Screes, sand
11	71	Landschaftseingriffe	Landscape interventions
12	72	Gletscher, Firn	Glaciers, perpetual snow

The 72 basic categories of the Swiss land use statistics according to the NOAS04 nomenclature are assigned to the different economic activities according to NOGA (2002).

The basic categories 1 and 2 (industrial and commercial buildings, surroundings of industrial and commercial builings) are assigned to the NOGA categories g15 to g37, g50 to g55, g64 to g85, g91p92 and g93p95. The area of the basic categories 1 and 2 is divided according to the number of employed people in the corresponding sectors. The underlying assumption is a constant average area per working place and employed person.

The basic categories 3 to 8 (one- and two-family houses, surroundings of one- and two family houses, terraced houses, surroundings of terraced houses, block flats, surroundings of block flats) are assigned to the final demand sector c04 (housing and energy).

The basic categories 9 and 10 (public buildings, surroundings of public buildings) are assigned to the NOGA categories g75 (public administration and defence), g80 (education) and g85 (health and social work). The area of the basic categories 9 and 10 is divided according to the number of employed people in the corresponding sectors.

The underlying assumption is a constant average area per working place and employed person.

The basic categories 11 and 12 (agricultural buildings, surroundings of agricultural buildings) are assigned to the agricultural subsectors (NOGA category g01a to g01r). The area of the basic categories 11 and 12 is divided according to the number of employed people in the corresponding sectors. The underlying assumption is a constant average area per working place and employed person.

The basic categories 13 and 14 (unspecified buildings, surroundings of unspecified buildings) are assigned to the NOGA categories g50 (vehicles and fuels trade), g51p52 (wholesale and retail trade), g55 (hotels and restaurants), g64 (post and telecommunications), g65 (financial services), g66 (insurance services), g70p97 (real estate services), g71p74 (renting and other business services), g72 (computer services) and g73 (research and development). The area of the basic categories 13 and 14 is divided according to the number of employed people in the corresponding sectors. The underlying assumption is a constant average area per working place and employed person.

The basic categories 15 to 19 (motorways, green motorway environs, roads and paths, green road environs and parking areas) are assigned to the NOGA categories c07 (transport), g60f (freight transport by road) and g60d (other scheduled passenger land transport). The areas of the basic categories 15 to 19 are divided according to the use of road infrastructure by the different users of the road (individual mobility, freight transport services and other land transport services). The demand of the total road network of the different users is taken from Spielmann et al. (2007, Table 5-117). The use of the roads and motorways for business travel is neglected due to the small share of the business travel distance compared to the total daily distance (below 7 %).

The basic categories 20 and 21 (sealed railway areas, green railway environs) are assigned to the NOGA category g60c (rail infrastructure). The basic categories 22 and 23 (airports and green airport environs) are assigned to the NOGA category g63b air transport infrastructure.

The basic category 24 (energy supply plants) is assigned to the NOGA categories g40a, g40b, g40c, g40d3, g40e, and g40g (running hydropower plants, storage hydropower plants, nuclear power plants, wind power and PV plants, electricity distribution and trade, gas supply). The use of industrial area per kilowatt hour electicity produced by hydropower plants is reported by Flury and Frischknecht (2012). The reservoir area of storage hydropower plants is classified as a lake and included in the basic category 61. The total area occupied by hydropower plants is obtained by multiplying the specific land use by the electricity produced in 2008 (BFE 2009). The area used by the pressurised water reactor in Gösgen and the boiling water reactor in Leibstadt is reported by Dones et al. (2009). The total land use by nuclear power plants is then calculated from the specific land occupation per megawatt and the installed capacities of each technology (Dones et al. 2009). The only open ground solar power plant in Switzerland is installed on Mont Soleil and occupies an area of two hectares (Gesellschaft Mont-Soleil 2014). The land use of wind power plants is calculated from

the specific area per kilowatt hour and the electricity produced in 2008 (Rigassi & Horbaty 2009). The parameters used for the calculation of land use by hydraulic, nuclear and wind power plants are compiled in Tab. 5.16.

The land occupied by the electricity grid is reported by Itten et al. (2014) and the land use by the gas distribution system is calculated by multiplying the specific area per kilometer by the length of the distribution and transmission network (Schori et al. 2012). Since the total land use obtained for the NOGA categories mentioned above is lower than the area covered by energy supply plants according to the Swiss land use statistics (BFS 2014a), the areas occupied by the electricity grid (NOGA category g40e) and the gas distribution system (NOGA category g40g) are scaled to yield the remaining land area.

Tab. 5.16 Calculation of the land use by hydraulic, nuclear, wind and solar power plants.

Technology	Specific land use	Activity data	Total land use
Running hydropower plants	4.5E-05 m^2·a/kWh	16'686 GWh	75 ha·a
Storage hydropower plants	3.6E-05 m^2·a/kWh	20'873 GWh	76 ha·a
Pressurized water reactors	1.5E+02 m^2/MW	1'700 MW	26 ha·a
Boiling water reactors	1.6E+02 m^2/MW	1'520 MW	25 ha·a
Wind power plants	2.4E-03 m^2·a/kWh	19 GWh	4 ha·a
Solar power plants			2 ha·a

The basic categories 25 to 27 (waste water treatment plants, other supply or waste treatment plants, dumps) are assigned to the NOGA category g90c (disposal services). The basic category 28 (quarries and mines) is assigned to the NOGA category g10b14 (mining and quarrying). The basic category 29 (construction sites) is assigned to the NOGA category g45 (construction).

The basic category 30 (unexploited urban areas) is assigned to the final demand category c04 (housing and energy). This basic category includes development area and ruins. Therefore, it is assigned to the sector c04 because it is expected to be used for housing or was used for housing before.

The basic categories 31 to 33 (public parks, sports facilities, golf courses) are assigned to the NOGA category g91p92 (membership organizations, recreation, culture, sports). The basic category 34 (camping areas) is assigned to the NOGA category g55 (hotels and restaurants). The basic categories 35 and 36 (garden allotments, cemeteries) are assigned to the NOGA category g93p95 (personal services).

The basic categories 37 and 38 (intensive orchards, field fruit trees) are assigned to the NOGA category g01f (fruits). The basic category 39 (vineyards) is assigned to the NOGA category g01g (grapes). The basic category 40 (horticulture) is assigned to the NOGA cateogry g01j (other vegetal products).

The area of the basic category 41 (arable land) is divided between the agricultural subsecteors (g01a to g01r) according to the shares of different crops as compiled in Tab. 5.17 (BFS 2014e). The area of artificial meadows is thereby assigned to the NOGA

categories g01k (non-dairy cattle), g01o (dairy cattle and raw milk) and g01p (other animal products) according to the number of hay-eating livestock units (Grossvieheinheiten; GVE) (Schweizerischer Bauernverband 2010b). The amount of hay consumed is assumed to be proportional to the number of livestock units, which make the number of different animal species comparable to each other by relating them to the weight of adult cattle. The livestock units of the sectors of cattle farming are compiled in Tab. 5.2.

Tab. 5.17 Land area used to grow different crops according to BFS (2014e) and Schweizerischer Bauernverband (2010b).

Crop	Land area (ha)
Artificial meadows	127'259
Wheat	88'433
Barley	32'958
Oats	1'861
Maize	17'593
Silo maize	44'735
Other cereals	15'260
Potatoes	11'058
Sugar beets	20'469
Fodder beets	1'072
Vegetables	9'676
Oil-bearing crops	25'914
Pulses	4'291
Other vegetal products	4'910

The basic categories 42 (meadows) and 45 (alpine meadows) are allocated to the NOGA categories g01k (non-dairy cattle), g01o (dairy cattle and raw milk) and g01p (other animal products) according to the number of livestock units as listed in Tab. 5.2 (Schweizerischer Bauernverband 2010a).

The area of the basic categories 43 (farm pastures) and 44 (brush meadows and farm pastures) is divided among NOGA categories g01k (non-dairy cattle), g01l (pigs), g01m (poultry), g01n (laying hens and eggs), g01o (dairy cattle and raw milk), and g01p (other animal products) based on the number of animals participating in the RAUS-programme (RAUS: Regelmässiger Auslauf im Freien) (BLW 2011). This programme supports farmers to put their animals out to pasture. The underlying assumption is that the space requirement is proportional to the number of livestock units of each animal species (Tab. 5.18).

Tab. 5.18 Number of livestock units of different animal species participating in the RAUS-programme (BLW 2011).

Animal species	Livestock units (GVE)
Non-dairy cattle	242'983
Dairy cattle	484'219
Pigs	99'358
Poultry	3'911
Laying hens	13'583
Other animals	72'430

The area of the basic categories 46 to 48 (favourable alpine pastures, brush alpine pastures, rocky alpine pastures) are divided between the NOGA categories g01k (non-dairy cattle), g01o (dairy cattle and raw milk) and g01p (other animal products) according to the Sömmerungsstatistik as shown in Tab. 5.19 (BLW 2011).

Tab. 5.19 Number of livestock units of different animal species going to alpine pastures during the summer according to the Sömmerungsstatistik (BLW 2011).

Animal species	Livestock units (GVE)
Non-dairy cattle	142'187
Dairy cattle	114'579
Other animals	36'661

The basic category 49 (sheep pastures) is assigned to the NOGA category g01p (other animal products).

The whole principal domain 3 (wooded areas) encompassing the basic categories 50 to 60 (normal dense forest, forest strips, afforestations, felling areas, damaged forest areas, open forest on agricultural areas, open forest on unproductive areas, brush forest, groves & hedges, clusters of trees on agricultural areas, clusters of trees on unproductive areas) is assigned to the NOGA category g02 (forestry).

The basic category 68 (alpine sports facilities) is assigned to the NOGA category g91p92 (membership organizations, recreation, culture and sports).

The remaining basic categories (61 to 67 and 69 to 72) of the principal domain 4 (unproductive areas) remain unassigned, since these areas are unused.

5.7 Greenhouse gas emissions

5.7.1 Overview

The starting point for the allocation of greenhouse gas (GHG) emissions to industries and households are the emission accounts by Swiss Statistics for the year 2008[8]. In these emission accounts, the GHGs carbon dioxide (CO_2) from fossil energy sources, CO_2 from biomass, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) are allocated to industries (following the NOGA 2008 classification) and to households. The data were reclassified to the NOGA 2002 classification using the correspondence table from Swiss Statistics.

The emissions of GHGs considered in this chapter are regulated under the Kyoto Protocol (United Nations 1998). Additional substances such as ozone depleting substances or carbon monoxide also exert an effect on the climate system and therefore contribute to the total GHG emissions. The allocation of emissions of GHGs not regulated under the Kyoto Protocol to industry sectors and to households is described in Chapter 5.8.

For the separation of emissions caused by the pharmaceutical industry from chemical industry emissions, energy related CO_2, CH_4 and N_2O emissions were calculated from energy use. Other CO_2, CH_4 and N_2O emissions were taken from background data used in the estimation of the 2008 NAMEA Air. HFC, PFC and SF_6 emissions were allocated using employment as an auxiliary variable due to missing data.

For the energy and transport subsectors the CO_2 emissions were calculated from energy use and then adjusted to Swiss Statistics' totals. For the energy sector CH_4 and N_2O emissions were taken from background data used in the estimation of the 2008 NAMEA Air and then adjusted to Swiss Statistics' totals. For the transport sectors CH_4 and N_2O emissions were allocated according to the fossil CO_2 emissions breakdown. HFC, PFC and SF_6 emissions were allocated using the employment key due to missing data.

For the government subsectors emissions were allocated by using the employment key. For the waste management subsectors emissions were taken from the above mentioned 2008 NAMEA Air.

The allocation of households' emissions to consumption categories follows Swiss Statistics' emissions accounts and makes use of background data used in the estimation of the 2008 NAMEA Air.

[8] The GHG emissions in 2008 by substance and by economic actor were supplied by Florian Kohler, Swiss Statistics, according to the commodity perspective that is largely compatible with the functional classification of the EE-IOT.

The GHG emissions of agriculture and the food industry are further divided into the different subsectors. The allocation procedure is described in Subchapter 5.7.2 for agriculture and in Subchapter 5.7.3 for the food industry.

5.7.2 Agriculture

Agricultural GHG emissions occur in a variety of processes such as combustion of fossil and biogenic energy carriers (CO_2 fossil, CO_2 biogenic), cattle farming (CH_4 biogenic, N_2O) and agricultural soils (N_2O) (BAFU 2010c). Energy related emissions of fossil CH_4 and N_2O are assumed to be very small compared to other sources of these GHGs in agriculture. Hence, CH_4 and N_2O emissions from the combustion of energy carriers are neglected.

The emissions of CO_2 from fossil sources are allocated to the agricultural subsectors (g01a to g01r) based on the use of fossil energy carriers (light fuel oil, gas, diesel oil, gasoline, other oil products, non-energy use oil products) by the different subsectors and the emission factors for the respective energy carrier reported by BAFU (2010c). Biogenic CO_2 emissions of the agricultural subsectors are calculated by the same procedure by considering the energy carriers wood, biogas and biofuels. The energy related emissions calculated are then scaled to the total according to Swiss Statistics' emission accounts.

The emissions of synthetic GHGs, namely HFCs, PFCs and SF_6, are allocated to the agricultural subsectors based on the number of employees in each subsector. This approximation is necessary since no specific data on the emissions of HFCs, PFCs and SF_6 of the agricultural production are available.

The direct non-energy related methane and nitrous oxide emissions by agriculture are reported under classification item 4 (agriculture) of Switzerland's Greenhouse Gas Inventory (BAFU 2010c). These data and further information are used to allocate the biogenic CH_4 and N_2O emissions to the agricultural subsectors.

The methane emissions from enteric fermentation of the different animal species (classification item 4A) are assigned to the respective NOGA categories g01k to g01p. The emissions by poultry are divided between NOGA categories g01m (poultry) and g01n (laying hens and eggs) according to the number of animals (BLW 2011).

The biogenic CH_4 emissions from manure management (classification item 4B) are assigned to the NOGA categories g01k to g01p based on the amount of manure produced by the different animal species. The N_2O emissions reported under the classificaton items 4B12 (liquid systems) and 4B13 (solid storage and dry lot) in Switzerland's Greenhouse Gas Inventory are assigned to the NOGA categories g01k to g01p according to the amount of nitrogen excreted by the animals in the respective animal waste management systems (BAFU 2010c). The emissions by poultry are divided between NOGA categories g01m (poultry) and g01n (laying hens and eggs) according to the number of animals (BLW 2011).

The classification item 4D of Switzerland's Greenhouse Gas Inventory comprises N_2O emissions from agricultural soils. The N_2O emissions from the use of synthetic fertilizers (classification item 4D1.1) are assigned to NOGA categories g01a to g01h and g01j to g01p. The total emissions are distributed according to the Swiss recommendations of fertilizer application to different crops (GRUDAF 2009; Neuweiler 2011; Bertschinger et al. 2003; Siegfried & Jüstrich 2012). The recommended amount of synthetic N-fertilizer is multiplied by the land area covered by the respective crop (BFS 2014e). The amount of synthetic fertilizers applied on meadows is allocated to the NOGA categories g01k, g01o and g01p based on the consumption of hay of the different animal species (Tab. 5.2). The figures used for the calculations are compiled in Tab. 5.20.

The classification item 4D1.2 (animal manure applied to soils) is assigned to the NOGA categories g01a to g01d, g01h, g01k, g01o and g01p. The total N_2O emissions under this classification item are distributed according to the amount of dung and liquid manure applied to wheat, sugar beet, maize and meadows (Bosshard & Richner 2013). The amount of manure applied to barley and oats is assumed to be the same as for wheat. Manure is also applied to potatoes and rapeseed, but data on the usual dosage are missing (Finanzdepartement Abteilung Landwirtschaft 1997). It is therefore assumed that the amount of manure applied to potatoes and rapeseed is the same as for sugar beet. The emissions caused by manure applied on meadows are assigned to the NOGA categories g01k, g01o and g01p based on the amount of hay consumed by the different animal species (Tab. 5.2). The nitrogen input to soils from the application of dung and liquid manure is multiplied by the land area covered by the respective crop to determine the shares of N_2O emissions (BFS 2014e). It is assumed that no manure is used for the other crops. The figures used for the calculations are compiled in Tab. 5.21.

Tab. 5.20 Estimated amount of N-fertilizer applied to different crops and their agricultural area in 2008 used to calculate N_2O emissions under classification item 4 D 1.1 of Switzerland's Greenhouse Gas Inventory (GRUDAF 2009; Neuweiler 2011; Bertschinger et al. 2003; Siegfried & Jüstrich 2012; BFS 2014e).

	Land area	Fertilizing recommendation	Total fertilizer use
	ha	kgN/(ha*a)	tN/a
Meadows	608'894	40	24'356
Wheat	88'433	130	11'496
Barley	32'958	100	3'296
Oats	1'861	90	168
Maize	17'593	110	1'935
Silo maize	44'735	110	4'921
Other cereals	15'260	130	1'984
Potatoes	11'058	110	1'216
Sugar beets	20'469	100	2'047
Fodder beets	1'072	100	107
Vegetables	9'676	120	1'161
Oil-bearing crops	25'914	120	3'110
Grapes	12'922	50	646
Fruits	7'333	50	367
Other vegetal products	4'910	100	491
Total	**903'088**		**57'300**

Tab. 5.21 Estimated amount of dung and liquid manure applied to different crops and their agricultural area in 2008 used to calculate N_2O emissions under classification item 4 D 1.2 of Switzerland's Greenhouse Gas Inventory (Bosshard & Richner 2013; BFS 2014e).

	Land area	Amount of dung applied	Amount of liquid manure applied	Total amount of manure applied
	ha	kgN/(ha*a)	kgN/(ha*a)	tN/a
Meadows	608'894	12.9	39.7	32'028
Winter wheat	88'433	9.9	15.2	2'220
Barley [1)]	32'958	9.9	15.2	827
Oats [1)]	1'861	9.9	15.2	47
Maize	17'593	21.8	9.2	545
Silo maize	44'735	30.3	12.2	1'901
Other cereals	15'260	9.9	15.2	383
Potatoes [1)]	11'058	19.4	4.3	262
Sugar beets	20'469	19.4	4.3	485
Fodder beets [1)]	1'072	19.4	4.3	25
Oil-bearing crops [1)]	25'914	19.4	4.3	614
Total	**868'247**			**39'338**

[1)] Amounts of dung and liquid manure estimated based on the figures for other crops.

The N_2O emissions from N-fixing crops (classificaton item 4D1.3) are assigned to NOGA categories g01i, g01k, g01o and g01p based on the amount of nitrogen fixed by clover in meadows and pastures as well as by leguminous crops (Bretscher 2010; ART 2010). The emissions caused by N-fixing crops on meadows are assigned to the NOGA categories g01k, g01o and g01p based on the amount of hay consumed by the different animal species (Tab. 5.2).

The N_2O emissions under classification item 4D1.4 (crop residue) are assigned to the NOGA categories g01a to g01p. The nitrogen input into soil from crop residues has been estimated for different crops by Bretscher (2010) and ART (2010) and is used to assign the GHG emissions to the subsectors of agricultural production. The emissions from meadows are assigned to the NOGA categories g01k, g01o and g01p based on the number of livestock units of different animal species (Tab. 5.2) and the emissions from pastures are assigned to the NOGA categories g01k to g01p based on the number of livestock units grazing on pastures (Tab. 5.18).

The cultivation of histosols (classification item 4D1.5) is treated in the same way as meadows and pastures (BAFU 2007). It is assumed that 78 % of moorlands are used as meadows and that the remaining 22 % are pastures (BFS 2013). The emissions from meadows are allocated to the NOGA categories g01k, g01o and g01p based on the amount of hay consumed by the different animal species (Tab. 5.2) and the emissions from pastures are assigned to the NOGA categories g01k to g01p based on the number of livestock units grazing on pastures (Tab. 5.18).

The GHG emissions under classification item 4D2 (pasture, range and paddock manure) are assigned to the NOGA categories g01k to g01p according to the amount of nitrogen excreted on pastures of the different animal species (Bretscher 2010; ART 2010).

The indirect N_2O emissions from atmospheric deposition (classification item 4D3.1) are caused by volatilization of NO_x from manure and synthetic nitrogen fertilizer applied to agricultural soils. The indirect emissions from nitrogen leaching and run-off (classification item 4D3.2) occur as diffuse nitrate emissions from manure and synthetic nitrogen fertilizer applied to agricultural soils (Bretscher 2010; ART 2010). For both classificaton items, the emissions from manure by different animal species are reported by ART (2010) and assigned to the respective NOGA categories g01k to g01p. The share of poultry is divided between the NOGA categories 01m (poultry) and g01n (laying hens and eggs) according to the number of animals (BLW 2011). The indirect N_2O emissions from synthetic fertilizers are divided between the NOGA categories g01a to g01h, g01j, g01k, g01o and g01p based on the shares of fertilizer used as determined under classification item 4D1.1 of Switzerland's Greenhouse Gas Inventory (Tab. 5.20).

The N_2O emissions under classification item 4D4 include the use of sewage sludge and compost as organic fertilizers. Since sewage sludge must not be used as a fertilizer any more, the emissions are completely associated with the application of compost on agricultural fields. Data on the amounts of compost used is scarce, but the use of compost is recommended for the cultivation of cereals, maize, sugar and fodder beet, vegetables, fruits, rapeseed and artificial meadows (Amt für Umweltschutz 2013). The N_2O emissions from the use of compost are assigned to the NOGA categories g01a to g01f, g01h, g01k, g01o and g01p based on the land area covered by the respective crops. It is assumed that the amount of compost applied to a unit area of agricultural land does not depend on the crop. The N_2O emissions from the use of compost are low, which justifies this assumption. The emissions from compost applied on meadows are allocated to the NOGA categories g01k, g01o and g01p based on the amount of hay consumed by the different animal species (Tab. 5.2).

5.7.3 Food industry

The GHG emissions of the food processing industry are mainly associated with the combustion of fossil and biogenic energy carriers (CO_2 fossil, CO_2 biogenic, CH_4 fossil, N_2O) and refrigeration of food products (HFCs and PFCs).

The emissions of CO_2 from fossil sources are allocated to the food industry subsectors (g15a to g15l) based on the use of fossil energy carriers (light fuel oil, gas, diesel oil, gasoline, other oil products, non-energy use oil products) by the different subsectors and the emission factors for the respective energy carrier reported by BAFU (2010c). Biogenic CO_2 emissions of the food industry subsectors are calculated by the same procedure by considering the energy carriers wood, biogas and biofuels. The calculated energy related emissions are then scaled to the total according to Swiss Statistics' emission accounts.

The emissions of HFCs and PFCs are mainly caused by refrigeration. Since data on refrigerant emissions by subsector of the food industry is very scarce, the emissions of these substances are allocated to the different subsectors based on the production volumes of food products (Tab. 5.7). It is assumed that refrigerant emissions are proportional to the weight of food processed.

Emissions of SF_6 are allocated to the food industry subsectors based on the number of employees in each subsector. This approximation is necessary since no specific data on the emissions of SF_6 of the food processing industry are available.

5.8 Emissions to air

5.8.1 Overview

The emissions of main air pollutants, carbon monoxide, particulate matter, priority heavy metals and persistent organic pollutants (POPs) are reported annually based on the UN-ECE Convention on Long-range Transboundary Air Pollution (CLRTAP). The allocation of the emissions of these air pollutants to the different NOGA categories is documented in Subchapter 5.8.2. The emissions of ozone depleting substances are allocated to the NOGA categories based on scientific studies (Subchapter 5.8.3). The allocation procedure of benzene emissions by the economic sectors and by final consumption in Switzerland is described in Subchapter 5.8.4.

5.8.2 Air pollutants based on UN-ECE CLRTAP

The starting point for the allocation of emissions of selected air pollutants (NO_x, SO_2, NH_3, NMVOC, CO, PM_{10}, $PM_{2.5}$) to industries and households are the emission accounts by Swiss Statistics for the year 2008[9]. The data were reclassified from the NOGA 2008 to the NOGA 2002 classification using the correspondence table from Swiss Statistics. An additional data source is the Informative Inventory Report (IIR) under the UN-ECE Convention on Long-range Transboundary Air Pollution (CLRTAP), in which the emissions of many air pollutants from Switzerland are reported (BAFU 2011).

The Swiss IIR for the year 2008 is mainly used for the further disaggregation of emissions of air pollutants covered by the Swiss Statistics' emission accounts. These sectors are agriculture (NOGA categories g01a to g01r), the food processing industry (g15a to g15l), the chemical and pharmaceutical industry (g24a and g24b), the energy

[9] The emissions of air pollutants in 2008 by economic actor were supplied by Florian Kohler, Swiss Statistics, according to the commodity perspective that is largely compatible with the functional classification of the EE-IOT.

industry (g40a to g40g), the transport sector (g60a to g60g, g63a to g63c), public administration (g75a and g75b) and the waste sector (g90a to g90c).

The IIR also serves as a basis for the allocation of the air emissions of $PM_{>10}$, lead, cadmium, mercury, polychlorinated dioxins and furans (PCDD / PCDF) as well as polycyclic aromatic hydrocarbons (PAHs) to all NOGA categories distinguished in the EE-IOT. The total emissions of these substances are taken from the IIR without an adjustment to the residence principle due to missing data.

The CLRTAP inventory uses the UN-ECE National Format for Reporting (NFR) as classification. The allocation of the emissions of air pollutants is described here following the classification items of the IIR. However, this allocation is in many cases only relevant for the pollutants not covered by the Swiss Statistics' emission accounts. The allocation based on the IIR is used for the disaggregation of all emissions of air pollutants for selected sectors (e.g. agriculture, which is contained in classification item 4).

The classification item 1A1a (public electricity and heat production) is assigned to the energy industry (NOGA categories g40a to g40g) and the waste and wastewater management sectors (g90a to g90c). The emissions reported under the classification item 1A1a are divided according to the detailed activity data and emission factors reported in the IIR (BAFU 2011).

The classification item 1A1b (petroleum refining) is assigned to the NOGA category g23a (manufacture of coke and refined petroleum products).

The classification items 1A2a (stationary combustion in manufacturing industries and construction: iron and steel) and 1A2b (stationary Combustion in manufacturing industries and construction: non-ferrous metals) are assigned to the NOGA categories g27 (manufacture of basic metals).

The classification item 1A2c (stationary combustion in manufacturing industries and construction: chemicals) is assigned to the NOGA categories g24a (chemicals and chemical products) and g24b (pharmaceutical products) based on the number of employed people in each sector.

The classification item 1A2d (stationary combustion in manufacturing industries and construction: pulp, paper and print) is assigned to the NOGA category g21 (manufacture of pulp, paper and paper products).

The classification item 1A2e (stationary combustion in manufacturing industries and construction: food processing, beverages and tobacco) is assigned to the NOGA categories g15a to g15l (food processing and tobacco industry). The emissions reported under the classification item 1A2e are divided according to the fuel consumption for stationary combustion (light fuel oil, heavy fuel oil, coal, natural gas) of the different subsectors and the emission factors for the corresponding fuels for stationary combustion reported in the IIR (BAFU 2011).

The classification item 1A2fi (stationary combustion in manufacturing industries and construction: other) is assigned to the NOGA categories g17 (manufacture of textiles),

g18 (manufacture of wearing apparel), g19 (tanning and dressing of leather), g20 (manufacture of wood products), g22 (publishing and printing), g25 (manufacture of rubber and plastic products), g26 (manufactur of other non-metallic mineral products), g28 (manufacture of fabricated metal products), g29 (manufacture of machinery and equipment), g30p31 (manufacture of computers and electrical machinery), g32 (manufacture of radio, television and communication equipment), g33 (manufacture of medical, precision and optical instruments), g34 (manufacture of motor vehicles), g35 (manufacture of other transport equipment) and g36 (manufacture of furniture). The emissions reported under the classification item 1A2fi are divided according to the fuel consumption for stationary combustion (light fuel oil, heavy fuel oil, coal, and natural gas) of the different subsectors and the emission factors for the corresponding fuels for stationary combustion reported in the IIR (BAFU 2011).

The classification item 1A2fii (mobile combustion in manufacturing industries and construction) is assigned to the NOGA categories g15a to g15l and g17 to g45. The emissions reported under the classification item 1A2fii are divided according to the fuels for mobile combustion (gasoline, diesel and natural gas) used in the different subsectors and the emission factors for the corresponding fuels for mobile combustion reported in the IIR (BAFU 2011) and in the public part of the off-road database[10].

The classification items 1A3ai (international aviation) and 1A3aii (civil aviation) are assigned to the NOGA category g62 (air transport). The classification items 1A3bi (road transport: passenger cars), 1A3biv (road transport: mopeds & motorcycles), 1A3bv (road transport: gasoline evaporation) and 1A3bvi (road transport: automobile tyre and brake wear) are assigned to the category c07 (transport) of the final demand. The classification items 1A3bii (road transport: light duty vehicles) and 1A3biii (road transport: heavy duty vehicles) are assigned to the NOGA category g60f (freight transport by road). The classification item 1A3c (railways) is assigned to the NOGA category g60b (goods rail transport). The classification item 1A3dii (national navigation) is assigned to the NOGA category g61 (water transport). The classification item 1A3e (pipeline compressors) is assigned to the NOGA category g60g (transport via pipeline).

The classification items 1A4ai (commercial / institutional: stationary) and 1A4aii (commercial / institutional: mobile) are assigned to the NOGA categories g50 to g55, g64 to g85, g91p92 and g93p95. The emissions reported under the classification item 1A4ai are divided according to the fuels for stationary combustion (light fuel oil, coal, biomass and natural gas) used in the different economic sectors and emission factors for the corresponding fuels for stationary combustion reported in the IIR (BAFU 2011). The fraction of the individual NOGA categories in total emissions under classification item 1A4aii is calculated by the amount of petrol, diesel and natural gas consumed by

[10] http://www.bafu.admin.ch/luft/00596/06906/offroad-daten/index.html?lang=de, accessed 21.08.2014

each sector and fuel-specific emission factors as reported in the IIR (BAFU 2011) and in the public part of the off-road database.[10]

The classification items 1A4bi (residential: stationary plants) and 1A4bii (residential: household and gardening (mobile)) are assigned to the category c04 (housing, water, electricity, gas and other fuels) of the final demand.

The classification item 1A4ci (agriculture / forestry / fishing: stationary) is assigned to the agricultural subsectors (NOGA categories g01a to g01r) and to forestry (NOGA category g02). The share of emissions assigned to the NOGA category g05 is zero because the fishing industry in Switzerland is negligible (BAFU 2011). The emissions reported under the classification item 1A4cii are divided according to the fuels for stationary combustion (biomass and wood) used in the different categories. Specific emission factors are not available.

The classification item 1A4cii (agriculture / forestry / fishing: off-road vehicles and other machinery) is assigned to the agricultural subsectors (NOGA categories g01a to g01r) and to forestry (NOGA category g02). The share of emissions assigned to the NOGA category g05 is zero because the fishing industry in Switzerland is negligible (BAFU 2011). The emissions reported under the classification item 1A4cii are divided according to the fuels for mobile combustion (gasoline and diesel) used in the different categories and emission factors for the corresponding fuels for mobile combustion of the public part of the off-road database.[10]

The classification item 1A5b (other, mobile (including military, land based and recreational boats)) is assigned to the NOGA category g75b (other public administration and defence).

The classification items 1B1a (fugitive emission from solid fuels: coal mining and handling), 1B2aiv (refining / storage) and 1B2av (distribution of oil products) are assigned to the NOGA category g23a (manufacture of coke and refined petroleum products).

The classification item 1B2c (venting and flaring) is assigned to the NOGA category g40g (Gas supply).

The classification items 2A1 (cement production), 2A2 (lime production) and 2A3 (limestone and dolomite use) are assigned to the NOGA category g26 (manufacture of other non-metallic mineral products).

The classification items 2A5 (asphalt roofing) and 2A6 (road paving with asphalt) are assigned to the NOGA category g45 (construction).

The classification item 2A7a (quarrying and mining of minerals other than coal) is assigned to the NOGA category g10b14 (mining and quarrying).

The classification items 2B1 (ammonia production), 2B2 (nitric acid production), 2B4 (carbide production) and 2B5a (other chemical industry) are assigned to the NOGA category g24a (chemicals and chemical products).

The classification items 2C1 (iron and steel production), 2C5d (zinc production) and 2C5e (other metal production) are assigned to the NOGA category g27 (manufacture of basic metals).

The classification item 2D1 (Pulp and paper) is assigned to the NOGA category g21 (manufacture of pulp, paper and paper products).

The classification item 2D2 (food and drink) is assigned to the subsectors of the food processing industry (NOGA categories g15a to g15l). The emissions reported under the classification item 2D2 include emissions from breweries, spirits production, bread production, meat smokehouses, roasting facilities, milling companies, wine production and sugar production. The emissions of breweries, spirit production and wine production are assigned to the NOGA category g15l (beverages). The emissions of milling companies are assigned to the NOGA category g15f (grain mill and starch products). The emissions of bread production are assigned to the NOGA category g15g (bakery and farinaceous products). The emissions of meat smokehouses are assigned to the NOGA category g15a (processed meat). The emissions of the roasting facilities are assigned to the NOGA category g15jp16 (other food and tobacco products). The emissions of sugar production are assigned to the NOGA category g15h (sugar). The activity data and the corresponding emission factors are reported in the IIR (BAFU 2011).

The classification item 2D3 (wood processing) is assigned to the NOGA category g20 (Manufacture of wood and of products of wood).

The classification item 2G (other production, consumption, storage, transportation or handling of bulk products) includes emissions from claus-units and from blasting and shooting. The emissions of claus-units are assigned to the NOGA category g23a (manufacture of coke and refined petroleum products) and the emissions from blasting and shooting are assigned to the NOGA category g10b14 (mining and quarrying). The activity data and the corresponding emission factors are reported in the IIR (BAFU 2011).

The NMVOC emissions reported under the classification item 3C (chemical products) are assigned to the NOGA category g24a (chemicals and chemical products). The classification item 3D3 (other product use) is assigned to the final demand category c12 (miscellaneous goods and services).

The emissions under the classification item 4B1a (cattle dairy) are assigned to the NOGA category g01o (dairy cattle and raw milk). The emissions under the classification item 4B1b (cattle non-dairy) are assigned to the NOGA category g01k (non-dairy cattle). The classification items 4B3 (sheep), 4B4 (goats), 4B6 (horses) and 4B7 (mules and asses) are assigned to the NOGA category g01p (other animal products). The emissions under the classification item 4B8 (swine) are assigned to the NOGA category g01l (pigs). The emissions under the classification item 4B9a (laying hens) are assigned to the NOGA category g01n (laying hens and eggs). The classification items 4B9b (broilers), 4B9c (turkeys) and 4B9d (other poultry) are assigned to the NOGA category g01m (poultry).

The classification item 4D1a (synthetic N-fertilizers) is assigned to the NOGA categories g01a to g01h, g01j, g01k, g01o and g01p (food cereals, feed crops, sugar crops, root and tuber crops, vegetables, fruits, grapes, oil-bearing crops, other vegetal products, non-dairy cattle, dairy cattle and raw milk, other animal products). The amount of synthetic N-fertilizers applied on meadows is allocated to the NOGA categories g01k, g01o and g01p based on the consumption of hay of the different animal species (Tab. 5.2). The total emissions are distributed according to the Swiss recommendations of fertilizer application to different crops (GRUDAF 2009; Neuweiler 2011; Bertschinger et al. 2003; Siegfried & Jüstrich 2012). The recommended amount of synthetic N-fertilizer is multiplied by the land area covered by the respective crop (BFS 2014e) in order to assign the total NO_x and NH_3 emissions to the different subcatecories of agricultural production. The figures used for the calculations are compiled in Tab. 5.20.

The classification item 4D2a (farm-level agricultural operations) is assigned to the NOGA categories g01a to g01d, g01h, g01k, g01o and g01p (food cereals, feed crops, sugar crops, root and tuber crops, oil-bearing crops, non-dairy cattle, dairy cattle and raw milk, other animal products). The total emissions are distributed according to the amount of dung and liquid manure applied to wheat, sugar beet, maize, and meadows (Bosshard & Richner 2013). The amount of manure applied to barley and oats is assumed to be the same as for wheat. Manure is also applied to potatoes and rapeseed, but data on the usual amounts applied are missing (Finanzdepartement Abteilung Landwirtschaft 1997). It is therefore assumed that the amount of manure applied to potatoes and rapeseed is the same as for sugar beet. The emissions caused by manure applied on meadows are assigned to the NOGA categories g01k, g01o and g01p based on the amount of hay consumed by the different animal species (Tab. 5.2). The nitrogen input from manure is multiplied by the land area covered by the respective crop to determine the shares of NO_x, NMVOC, and NH_3 emissions (BFS 2014e). It is assumed that no manure is used for the other crops. The figures used for the calculations are compiled in Tab. 5.21.

The classification item 4D2c (N-excretion on pasture range and paddock) is assigned to the NOGA categories g01k to g01p (non-dairy cattle, pigs, poultry, laying hens and eggs, dairy cattle and raw milk, other animal products). The annual NO_2 and NH_3 emissions per animal are calculated using the emission factors reported by BAFU (2011). The total emissions per category are then determined by multiplying the emissions per animal by the number of respective animals participating in the RAUS-programme (BLW 2011). The livestock units reported in the statistical data to the RAUS-programme are converted to the number of animals by conversion factors determined by Schweizerischer Bauernverband (2010a). The figures used for the calculations of NO_x and NH_3 emissions are compiled in Tab. 5.22 and Tab. 5.23, respectively. The emissions calculated by this procedure are lower than the actual emissions in the IIR. The NO_x and NH_3 emissions of each agricultural subsector are therefore scaled up by the same factor in order to obtain the total emissions according to the IIR (BAFU 2011).

Tab. 5.22 Emission factors and number of animals used to calculate the NO_x emissions under UN-ECE classification item 4D2c (N-excretion on pasture range and paddock) (BAFU 2011; BLW 2011).

Animal species	Number of animals on pastures (animals)	Emission factor ($gNO_x/(animal*a)$)	NO_x emissions (tNO_x/a)
Dairy cattle	484'219	459	222
Non-dairy cattle	318'192	560	178
Young cattle	221'150	201	44
Sheep	205'451	74	15
Goats	42'351	17	1
Horses	30'647	218	7
Swine	506'530	2.5	1
Layers	1'358'291	1.3	2
Broilers	542'511	0.12	0
Turkey	65'654	0.99	0
Growers and other poultry	165'038	0.11	0
Total	**3'940'033**		**471**

Tab. 5.23 Emission factors and number of animals used to calculate the NH_3 emissions under UN-ECE classification item 4D2c (N-excretion on pasture range and paddock) (BAFU 2011; BLW 2011).

Animal species	Number of animals on pastures (animals)	Emission factor ($gNH_3/(animal*a)$)	NH_3 emissions (tNH_3/a)
Dairy cattle	484'219	1'163	563
Non-dairy cattle	318'192	1'472	468
Young cattle	221'150	528	117
Sheep	205'451	195	40
Goats	42'351	45	2
Horses	30'647	576	18
Swine	506'530	19	9
Layers	1'358'291	30	40
Broilers	542'511	3	1
Turkey	65'654	22	1
Growers and other poultry	165'038	3	0
Total	**3'940'033**		**1'261**

The classification item 4F (field burning of agricultural wastes) is assigned to the NOGA category g02 (products of forestry). According to BAFU (2010c), the agricultural wastes burnt consist only of branches, which are predominantly produced in the forestry sector.

The emissions of air pollutants under the classification items 6A (solid waste disposal on land), 6B (waste-water handling), 6Cb (industrial waste incineration), 6Cc

(municipal waste incineration), 6Cd (cremation) and 6D (other waste) are assigned to the NOGA category g90c (other sewage and refuse disposal, sanitation and similar activities).

The classification item 7A (other) is assigned to the final demand category c12 (miscellaneous goods and services).

5.8.3 Ozone depleting substances

Ozone depleting substances (ODSs) have been primarily used as refrigerants, solvents, and as blowing agents in the production of insulating materials for buildings. The emissions and the main applications of the individual ozone depleting substances have been reported by Frischknecht and Büsser Knöpfel (2013b). The figures for the year 2011 are used for the allocation of the emissions to the different NOGA categories since no data are avaialable for 2008.

The emissions of all substances used as extinguishing agents and solvents are assigned to the NOGA category g24a (chemicals and chemical products). For the refrigerants, it is assumed that 50 % of the ODS emissions are caused by the chemical industry (NOGA category g24a) and 50 % stem from buildings. The emissions of HCFC-22, which is used both as a blowing agent and as a refrigerant, are assigned to 25 % to the chemical industry (NOGA category g24a) and the remaining 75 % of the emissions are assigned to buildings.

The emissions of refrigerants and blowing agents used in insulating materials in the buildings sector are further divided between residential, industrial, and service uses according to the total volume of buildings in each category (Schneider 2009). Emissions of ODSs from residential buildings are assigned to the final consumption category c04 (housing, water, electricity, gas and other fuels). The share of emissions caused by industrial buildings is divided between the NOGA categories g15a to g15l and g17 to g45 based on the number of employees in each sector. The same procedure was applied to the buildings used by the service sectors, which include NOGA categories g50 to 85, g90a to g90c, g91p92 and g93p95.

5.8.4 Benzene

The emissions of benzene to air are reported by Heldstab et al. (2013) for the years 1990 and 2010. These data are taken as a basis for the allocation of benzene emissions to the different economic sectors. The emissions in 2008 are obtained by a linear interpolation of the emissions in 1990 and 2010. Heldstab et al. (2013) distinguish different emission sources of benzene, which serve as a starting point for the allocation of the total emissions to the NOGA categories.

The benzene emissions from road transportation are further divided into passenger cars, lorries, and buses according to Keller (2010) and assigned to the NOGA categories c07 (transport), g60f (freight transport by road) and g60d (other scheduled passenger land transport), respectively. The emissions from railway transportation are mainly caused by

the transport of petroleum products (Heldstab et al. 2013) and are therefore assigned to the NOGA category g60b (goods rail transport). The benzene emissions from navigation are assigned to the NOGA category g61 (water transport).

The emission source encompassing households and the service sector is futher divided into emissions from oil and gas heatings including gardening tools and wood firings (Heldstab et al. 2013). The benzene emissions from the wood firings are fully assigned to the final consumption category housing and energy (c04) since it is assumed that wood firings are predominantly present in residential buildings. The emissions from oil or gas heatings and gardening tools are divided between the final consumption category c04 (housing and energy) and the service sectors according to their cumulated building volumes (Schneider 2009). The benzene emissions caused by service activities are allocated to the NOGA categories g50 to g85, g90a to g90c, g91p92 and g93p95 proportional to the number of employees in each sector.

Only little information is available on the amounts of benzene emitted by the different industrial sectors. The emissions from construction vehicles as reported by Heldstab et al. (2013) are assigned to the NOGA category g45. Furthermore, the benzene emissions by companies exceeding a certain load threshold are published in the Swiss Pollutants Release and Transfer Register (PRTR). The benzene emissions of companies from the energy, chemical, and cement sectors are reported in the PRTR and assigned to the NOGA categories g23a (manufacture of coke and refined petroleum products), g24a (chemicals and chemical products) and g26 (manufacture of non-metallic mineral products), respectively (BAFU 2010a). The remaining benzene emissions are allocated to the NOGA categories g15a to g15l and g17 to g45 based on the number of employed people in each sector.

The benzene emissions from agriculture and forestry are mainly caused by vehicles and machines (Heldstab et al. 2013). The fraction of emissions occurring in the agricultural and forestry sectors is determined by the emissions of hydrocarbons from offroad vehicles, which amount to 2’570 t/a and 643 t/a, respectively (Schäffeler & Keller 2008b). The benzene emissions from forestry are assigned to the NOGA category g02. The emissions from agriculture are allocated to the NOGA categories g01a to g01k, g01o and g01p based on the land areas covered by the different crops as listed in Tab. 5.1 (BFS 2014e). The land use category meadows and pastures in BFS (2014e) encompasses 78 % meadows and 22 % pastures (BFS 2013). Only meadows are taken into account for the determination of benzene emissions. It is assumed that no machinery is employed on pastures. The benzene emissions from the cultivation of meadows are allocated to the NOGA categories g01k, g01o and g01p according to the amount of hay consumed by the different animal species (Tab. 5.2).

5.9 Emissions to water

5.9.1 Overview

The pollutant emissions into water are either caused by point or by diffuse sources. For many substances, the loads emitted by the most important point sources are registered in the Swiss Pollutants Release and Transfer Register (PRTR). These data are used for the assignment of emissions of water pollutants to the NOGA categories (Subchapter 5.9.2). A number of substances mainly enter the aquatic environment via diffuse sources such as transportation or buildings. The diffuse share of the emissions, which is also listed in the PRTR, is further divided into the industries and final demand categories causing these emissions. The allocation procedure for nitrogen, phosphorus and some heavy metals is described in the Subchapters 5.9.3 to 5.9.7. The assignment of the diffuse emissions of other substances, persistent organic pollutants (POPs) and of radioactive substances into water to the NOGA categories is documented in the Subchapters 5.9.8 to 5.9.10.

5.9.2 Emissions based on the Swiss Pollution and Transfer Register (PRTR)

The Swiss Pollutants Release and Transfer Register (PRTR) is a publicly available data base, which provides information on releases of pollutants to air, water and soil and transfers of pollutants to wastewater and wastes. The Swiss PRTR allows searching for specific facilities, pollutants and pollutant releases. The Swiss PRTR contains data on 125 different facilities in the year 2008 including dairy companies, manufacturers of construction materials, chemical and pharmaceutical industry as well as wastewater treatment and municipal waste incineration plants. Emissions of 48 different pollutants or pollutant categories are covered in the year 2008.

The different facilities listed in the Swiss PRTR are assigned to the corresponding NOGA category. The emissions caused by Schweizer Rheinsalinen AG are assigned to the NOGA category g10b14 (mining and quarrying). The emissions caused by Papierfabrik Utzensdorf AG and Perlen Papier AG are assigned to the NOGA category g21 (manufacture of pulp, paper and paper products). The emissions caused by Tamoil SA Raffinerie de Collombey and Varo Refining Cressier SA are assigned to the NOGA category g23a (manufacture of coke and refined petroleum products).

The emissions caused by Borregaard Schweiz AG, CABB AG, Cimo SA, DSM Nutritional Products – Werk Lalden, DSM Nutritional Products – Werk Sisseln, Givaudan Suisse SA (site de Vernier) and Lonza AG are assigned to the NOGA category g24a (chemicals and chemical products).

The emissions caused by Stahl Gerlafingen AG, Swiss Steel Stahlwerk, Swiss Steel Walzwerk and vonRoll Casting Pipesystems SA are assigened to the NOGA category g27 (manufacture of basic metals).

The emissions caused by ARA Neuhausen, ARA REAL, AIB ARA Birs , ARA Chur, ARA Worblental, Consorzio depurazione acque Lugano e dintorni, Entsorgungszentrum

Tännlimoos, GVRZ Kläranlage Schönau, Kläranlage Bibertal-Hegau, Kläranlage Hard, Les Cheneviers, ProRheno AG, ERZ Entsorgung + Recycling Zürich, Station d'épuration d'Aïre, STEP de Vidy (Lausanne), Zweckverband der Abwasserreinigung Solothurn-Emme are assigned to the NOGA category g90c (other sewage and refuse disposal).

Tab. 5.24 shows an aggregated overview of the distribution of the releases of the different production sectors assessed in the PRTR including an estimation of the share of the diffuse emissions according to Zobrist et al. (2004). The diffuse emissions account for a high share of the total release in the case of cadmium, chlorides, copper, lead, TOC, nitrogen, phosphorus and zinc.

Tab. 5.24 Relative distribution of the releases of the different production sectors according to the PRTR and diffuse sources according to Zobrist et al. (2004).

	Mineral industry	Energy industries	Waste- and waste water management	Chemical industry	Production and processing of metals	Other industral activities	Paper and wood production and processing	Animal and vegetable products from the food- and beverage sector	Diffuse sources, whole Switzerland (not assigned)	Total releases
1,2-EDC	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Anthracene	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
AOX	0.00%	8.93%	25.79%	0.51%	0.00%	0.00%	64.77%	0.00%	0.00%	100.00%
Arsenic & comp.	0.00%	80.00%	7.83%	12.17%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Benzene	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Cadmium & comp.	0.00%	22.00%	36.00%	0.00%	0.00%	0.00%	0.00%	0.00%	42.00%	100.00%
Chlorides	1.65%	0.08%	9.96%	3.81%	0.00%	0.00%	0.00%	0.00%	84.50%	100.00%
Chromium & comp.	0.00%	0.92%	99.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Copper & comp.	0.00%	0.01%	1.68%	0.09%	0.14%	0.00%	0.00%	0.00%	98.07%	100.00%
Cyanides	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Dichloromethane	0.00%	1.67%	0.00%	98.33%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Ethyl benzene	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Fluorides	0.00%	0.65%	68.37%	30.98%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Lead & comp.	0.00%	0.06%	1.50%	1.46%	0.08%	0.00%	0.00%	0.00%	96.90%	100.00%
Mercury & comp.	0.00%	8.33%	45.83%	45.83%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Naphthalene	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Nickel & comp.	0.00%	2.05%	65.64%	32.31%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
PAHs	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Phenols	0.00%	95.34%	4.66%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
TOC	0.00%	0.04%	2.90%	0.31%	0.00%	0.00%	3.70%	0.00%	93.05%	100.00%
Total nitrogen	0.00%	0.03%	9.85%	0.79%	0.00%	0.00%	0.37%	0.00%	88.97%	100.00%
Total phosphorus	0.00%	0.01%	13.03%	0.11%	0.00%	0.00%	2.67%	0.00%	84.19%	100.00%
Xylenes	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Zinc & comp.	0.00%	0.08%	2.91%	0.87%	0.51%	0.00%	0.00%	0.00%	95.62%	100.00%

5.9.3 Diffuse nitrogen emissions

The diffuse nitrogen emissions are assigned to the different NOGA categories based on a material flow analysis of nitrogen in Switzerland for the year 2005 (BAFU 2010b). The diffuse nitrogen emissions from atmospheric deposition are set to zero in order to avoid double counting of emissions occurring into the air, which are quantified in Subchapter 5.8.2. Nitrogen emissions to water from the elusion from forest and other natural soils is not taken into account either, because these emissions are not caused by human activities.

The diffuse nitrogen emissions from sewage treatment plants reported in BAFU (2010b) are assigned to the NOGA category g90c (other sewage and refuse disposal, sanitation and similar activities), whereby the emissions already allocated to this sector based on the PRTR (see Subchapter 5.9.2) are subtracted. The diffuse nitrogen inputs into Swiss waters by untreated wastewater from product manufacturing are assigned to the NOGA category g19 (leather products).

The diffuse nitrogen emissions from agriculture are further divided between the different subsectors (NOGA categories g01a to g01r) according to the elusion of nitrate from agricultural soils as reported by Prasuhn and Mohni (2003). For the category of other vegetal products (NOGA category g01j), the nitrogen elusion rate is determined as the arithmetic mean of the elusion rates of all other crops because specific data for these products are not available. The amount of nitrate leaching from one hectare agricultural land is multiplied by the area covered by the respective crop (BFS 2014e) to determine the share of the subsectors in total diffuse nitrogen emissions to water. The fraction of nitrogen eluting from meadows is divided between the NOGA categories g01k (non-dairy cattle), g01o (dairy cattle) and g01p (other animal products) based on the amount of hay consumed by the different animal species (Tab. 5.2). The diffuse nitrogen emissions from pastures are assigned to the NOGA categories g01k (non-dairy cattle), g01l (pigs), g01m (poultry), g01n (laying hens and eggs), g01o (dairy cattle), and g01p (other animal products) based on the number of respective animals participating in the RAUS-programme (Tab. 5.18; BLW 2011). Since there are different eco-factors for nitrate emissions to surface waters and to groundwater (Frischknecht & Büsser Knöpfel 2013b), the total nitrate flow is divided between these two compartments based on their shares in the Swiss net runoff. It is assumed that the input into surface waters is 55 % of the total nitrate emissions while the remaining 45 % enter the groundwater bodies (Sinreich et al. 2012). The parameters used for the calculation of the nitrate emissions to water are compiled in Tab. 5.25. Since the diffuse nitrogen emissions by the agricultural subsectors are somewhat higher than the emissions according to the material flow analysis (BAFU 2010b), the emissions by agriculture are scaled down proportionally.

Tab. 5.25 Calculation of the amount of nitrate eluting from agricultural soils. The total nitrate emissions are divided into surface waters (55 %) and groundwater (45 %) based on the relative shares in net runoff (Sinreich et al. 2012). The nitrate elusion rates are estimated based on Prasuhn and Mohni (2003) and the land areas covered by the crops are taken from BFS (2014e).

	Land area	Nitrate elusion rate	Nitrate elusion to surface waters	Nitrate elusion to groundwater	Total nitrate elusion
	ha	kg N / (ha*a)	t N / a	t N / a	t N / a
Meadows	481'635	13	3'444	2'818	6'261
Artificial meadows	127'259	50	3'500	2'863	6'363
Pastures	135'846	13	971	795	1'766
Wheat	88'433	90	4'377	3'582	7'959
Barley	32'958	90	1'631	1'335	2'966
Oats	1'861	90	92	75	168
Maize	17'593	50	484	396	880
Silo maize	44'735	60	1'476	1'208	2'684
Other cereals	15'260	90	755	618	1'373
Potatoes	11'058	150	912	746	1'659
Sugar beets	20'469	40	450	368	819
Fodder beets	1'072	40	24	19	43
Vegetables	9'676	150	798	653	1'451
Oil-bearing crops	25'914	30	428	350	777
Pulses	4'291	130	307	251	558
Grapes	12'922	30	213	174	388
Fruits	7'333	13	52	43	95
Other vegetal products	4'910	60	162	133	295
Total	**1'043'224**		**20'078**	**16'427**	**36'505**

5.9.4 Diffuse phosphorus emissions

The diffuse phosphorus emissions are assigned to the different NOGA categories based on a material flow analysis of phosphorus for Switzerland in the year 2006 (Binder et al. 2009). The diffuse emissions from the waste management sector are assigned to the NOGA category g90c (other sewage and refuse disposal, sanitation and similar activities). The phosphorus emissions already reported in the PRTR are subtracted from the diffuse emissions from waste management according to Binder et al. (2009) in order to avoid double counting of phosphorus emissions.

Phosphorus emissions from agricultural production are caused by soil erosion and by effluents of animal excreta. The phosphorus emissions from livestock effluents are quantified analogously to the water consumption by the number of animals (BLW 2011). The amount of excreta is assumed to be proportional to the water volume used per animal (Tab. 5.9). The phosphorus emissions from livestock farming are assigned to the NOGA categories g01k to g01p.

Diffuse emissions of phosphorus from agriculture mainly occur by soil erosion since phosphorus strongly binds onto particles. An average soil loss of 1 t/(ha·a) is assumed and the phosphorus concentration in soil is approximately 1 gP/kg (Prasuhn & Mohni

2003). The diffuse phosphorus emissions from agricultural soils calculated with these parameters are little below the corresponding phosphorus flow reported by Binder et al. (2009). A constant scaling factor is applied to the phosphorus emissions of all agricultural subsectors in order to attain the phosphorus flow to water according to the material flow analysis. The allocation of the total phosphorus emissions to the agricultural subsectors is done by weighting the land areas of the individual crops with the cropping management factor (C factor) in the universal soil loss equation. This factor describes differences in the erosion depending on the respective crop (Prasuhn & Mohni 2003). The fraction of phosphorus emitted from meadows is divided between the NOGA categories g01k (non-dairy cattle), g01o (dairy cattle) and g01p (other animal products) based on the amount of hay consumed by the different animal species (Tab. 5.2). The diffuse phosphorus emissions from pastures are assigned to the subcategories of livestock farming (g01k to g01p) based on the number of respective animals participating in the RAUS-programme (Tab. 5.18; BLW 2011).

Tab. 5.26 Allocation of the agricultural phosphorus emissions to water to the different crops. The C factor describes the susceptibility of different agricultural soil types to erosion. The phosphorus output is calculated by weighting the land area by the C factor and an average phosphorus erosion rate of 1 kgP/(ha·a) (Prasuhn & Mohni 2003). The land areas covered by the crops are taken from BFS (2014e).

	Land area	C factor	Total phosphorus output
	ha	-	t P / a
Meadows	481'635	0.003	40
Artificial meadows	127'259	0.008	28
Pastures	135'846	0.003	11
Wheat	88'433	0.093	229
Barley	32'958	0.028	26
Oats	1'861	0.115	6
Maize	17'593	0.186	91
Silo maize	44'735	0.186	231
Other cereals	15'260	0.054	23
Potatoes	11'058	0.115	35
Sugar beets	20'469	0.160	91
Fodder beets	1'072	0.160	5
Vegetables	9'676	0.245	66
Oil-bearing crops	25'914	0.060	43
Pulses	4'291	0.100	12
Grapes	12'922	0.200	72
Fruits	7'333	0.100	20
Other vegetal products	4'910	0.100	14
Total	**1'043'224**		**1'043**

5.9.5 Diffuse copper emissions

The diffuse copper emissions are assigned to the different NOGA categories based on a material flow analysis of copper (von Arx 2006). Diffuse emissions of copper are caused by agriculture, transportation, building materials, households, and navigation. The diffuse copper emissions to water from the direct input via the atmosphere are not taken into account in order to avoid double counting of copper emitted to air.

The agricultural copper emissions mainly occur by soil erosion (von Arx 2006) and are therefore assigned to the different subsectors by the same procedure as applied to the diffuse phosphorus emissions. The C factor of the different crops is taken from Prasuhn and Mohni (2003) and the average copper concentration in soil is 20 mgCu/kg according to von Arx (2006). The fraction of copper emitted from meadows is divided between the NOGA categories g01k (non-dairy cattle), g01o (dairy cattle) and g01p (other animal products) based on the amount of hay consumed by the different animal species (Tab. 5.2). The diffuse copper emissions from pastures are assigned to subcategories of livestock farming (g01k to g01p) based on the number of respective animals participating in the RAUS-programme (Tab. 5.18; BLW 2011). The parameters used for the calculations are compiled in Tab. 5.27. The diffuse copper emissions from agricultural soils calculated with these parameters are higher than the corresponding copper flow reported by von Arx et al. (2006). A constant scaling factor is applied to the copper emissions of the different agricultural subsectors in order to attain the copper flow to water according to the material flow analysis.

Tab. 5.27 Allocation of the agricultural copper emissions to water to the different crops. The C factor describes the susceptibility of different agricultural soil types to erosion. The copper output is calculated by weighting the land area by the C factor and an assumed phosphorus erosion rate of 0.02 kgCu/(ha·a) (Prasuhn & Mohni 2003). The land areas covered by the crops are taken from BFS (2014e).

	Land area	C factor	Total copper output
	ha	-	kg Cu / a
Meadows	481'635	0.003	803
Artificial meadows	127'259	0.008	566
Pastures	135'846	0.003	227
Wheat	88'433	0.093	4'572
Barley	32'958	0.028	513
Oats	1'861	0.115	119
Maize	17'593	0.186	1'819
Silo maize	44'735	0.186	4'626
Other cereals	15'260	0.054	458
Potatoes	11'058	0.115	707
Sugar beets	20'469	0.160	1'821
Fodder beets	1'072	0.160	95
Vegetables	9'676	0.245	1'318
Oil-bearing crops	25'914	0.060	864
Pulses	4'291	0.100	239
Grapes	12'922	0.200	1'437
Fruits	7'333	0.100	408
Other vegetal products	4'910	0.100	273
Total	**1'043'224**		**20'864**

The emission category transportation and building materials reported by von Arx (2006) for the diffuse copper emissions into water is further divided into the final consumption category transport (c07), freight transport by road (NOGA category g60f), and the emissions from the corrosion of copper surfaces used in buildings.

Copper emissions from road transport are calculated with the emission factors for break pad and road abrasion for passenger cars and lorries (Hillenbrand et al. 2005) and the respective vehicle distance travelled in 2008 (BFS 2014d; BFS 2014c). Additional copper emissions occur from the abrasion of catenary wires in railway transportation. These emissions are quantified by the length of the rail network (BFS 2014b) and emission factors reported by Hillenbrand et al. (2005). The diffuse copper emissions from railway transportation are assigned to the NOGA category c07 (transport). The fraction of emissions going into water is assumed to be 12 % for both road and railway transportation (Hillenbrand et al. 2005). The parameters used for the calculations of the diffuse copper emissions from the transportation sector are compiled in Tab. 5.28 and Tab. 5.29.

Tab. 5.28 Calculation of the diffuse copper emissions by road transportation. It is assumed that 12 % of the total emissions go to water (Hillenbrand et al. 2005). The emission factors are taken from Hillenbrand et al. (2005) and the travelling distances are reported by BFS (2014d; 2014c).

		Passenger transport	Freight transport
Travelling distance	km/a	5.14E+10	5.70E+09
EF break pad abrasion	mgCu/km	1.50	1.53
EF road abrasion	mgCu/km	0.007	0.007
Total copper emissions	kgCu/a	77'460	8'761
Copper emissions to water	**kgCu/a**	**9'295**	**1'051**

Tab. 5.29 Calculation of the diffuse copper emissions by rail transportation. It is assumed that 12 % of the total emissions go to water (Hillenbrand et al. 2005). The emission factors are taken from Hillenbrand et al. (2005) and length of the rail network is reported by BFS (BFS 2014b).

		Rail transport
Length rail network	km	5'860
Cross section catenary wires	mm2	120
Abrasion rate	m3/a	4
Copper density	kgCu/m3	8'920
Total copper emissions	kgCu/a	39'203
Copper emissions to water	**kgCu/a**	**4'704**

The diffuse emissions from copper sheets used for roofs and facades is calculated with data reported by von Arx (2006). The fraction of emissions going to water is assumed to be 70 % (Hillenbrand et al. 2005). The calculations are shown in Tab. 5.30. These emissions are assigned to residential (c04, housing and energy), industrial and service activities according to information on the total metal use in buildings reported by Schneider (2009). The diffuse copper emissions from industrial buildings are further assigned to NOGA categories g17 to g45 based on the number of employees. The amount of copper emitted to water by buildings used for service activities is divided between the NOGA categories g50 to g85, g90a to g90c, g91p92 and g93p95 based on the number of employed people in each NOGA category.

Tab. 5.30 Calculation of the diffuse copper emissions from buildings. It is assumed that 70 % of the total emissions go to water (Hillenbrand et al. 2005). The area and the erosion rate are taken from von Arx (2006) and the division of emissions between the building types is done according to Schneider (2009).

		Residential	Services	Industry
Area copper sheets	m2	1.40E+07	7.00E+06	1.40E+07
Area exposed to water	-	53%	53%	53%
Erosion rate	gCu/(m2*a)	1.8	1.8	1.8
Total copper emissions	kgCu/a	13'356	6'678	13'356
Copper emissions to water	**kgCu/a**	**9'349**	**4'675**	**9'349**

The diffuse copper emissions from transportation and building reported by von Arx (2006) are lower than the calculated emissions based on the procedure described above. The copper emissions of all sectors are therefore scaled down proportionally to obtain the total emissions according to the material flow analysis (von Arx 2006).

5.9.6 Diffuse zinc emissions

The main sources of diffuse zinc emissions into water are the water supply network, the corrosion of galvanized products, transportation, and building materials (Hillenbrand et al. 2005). The total zinc emissions to water are reported in the Swiss PRTR.

The emissions from the German drinking water supply network reported by Hillenbrand et al. (2005) are converted to zinc emissions per capita (1.9 gZn/(inhabitant·a) and then multiplied by the Swiss population (7.7 million inhabitants in 2008). These emissions are assigned to the NOGA category 41 (collection, purification and distribution of water).

The diffuse zinc emissions from road transportation are calculated based on emission factors for tyre, break pad, and road abrasion (Hillenbrand et al. 2005) and the vehicle distance travelled (BFS 2014d; BFS 2014c). The fraction of emissions going into water is estimated at 12 % (Hillenbrand et al. 2005). The emissions are assigned to the final demand category c07 (transport) and the NOGA category g60f (freight transport by road). The parameters used for the calculation are listed in Tab. 5.31.

Tab. 5.31 Calculation of the diffuse zinc emissions from road transport. It is assumed that 12 % of the total emissions go to water (Hillenbrand et al. 2005). The emission factors are taken from Hillenbrand et al. (2005) and the travelling distances are reported by BFS (2014d; 2014c).

		Passenger transport	**Freight transport**
Travelling distance	km/a	5.14E+10	5.70E+09
EF tyre abrasion	mgZn/km	0.93	12.46
EF break pad abrasion	mgZn/km	0.48	0.61
EF road abrasion	mgZn/km	0.24	0.24
Total zinc emissions	kgZn/a	84'810	75'867
Zinc emissions to water	**kgZn/a**	**10'177**	**9'104**

The area of zinc coated sheets used for roofs and facades is estimated from the volume of galvanized iron used in residential, industrial, and service buildings (Schneider 2009) The parameters used for the calculation of diffuse zinc emissions from buildings are compiled in Tab. 5.32. It is assumed that 70 % of the zinc emissions from building materials go into water (Hillenbrand et al. 2005). The emissions from residential buildings are assigned to the final demand category c04 (housing and energy). The emissions from industrial buildings are divided between the NOGA categories g17 to g45 based on the number of employees. The amount of zinc emitted to water by service buildings is assigned to the NOGA categories g50 to g85, g90a to g90c, g91p92 and g93p95 based on the number of employed people in each sector.

Tab. 5.32 Calculation of the diffuse zinc emissions from buildings. It is assumed that 70 % of the total emissions go to water (Hillenbrand et al. 2005). The metal volume and the fraction of zinc coated sheets is taken from Schneider (2009), the zinc content in the sheets is reported by Daxbeck et al. (1998) and the thickness, the area fraction exposed to water and the erosion rate are reported by Hillenbrand et al. (2005).

		Residential	Services	Industry
Metal volume in buildings	m3	2.00E+06	1.00E+06	2.00E+06
Fraction zinc coated sheets	-	10%	10%	10%
Thickness zinc coated sheets	mm	0.7	0.7	0.7
Area zinc coated sheets	m2	2.86E+08	1.43E+08	2.86E+08
Zinc content in sheets	-	3%	3%	3%
Area exposed to water	-	50%	50%	50%
Erosion rate	gZn/(m2*a)	3.0	3.0	3.0
Total zinc emissions	kgZn/a	12'857	6'429	12'857
Zinc emissions to water	**kgZn/a**	**9'000**	**4'500**	**9'000**

Due to the fact that only limited information is available on the amount of zinc emitted by the corrosion of galvanized products, these emissions are assumed to be approximately two thirds of the water emissions from traffic (12’854 kgZn/a) as it was found in the case of Germany (Hillenbrand et al. 2005). Zinc emissions from galvanized products are assigned to the construction (NOGA category g45), transportation (assigned to the categories c07 (transport) and g60f (freight transport by road) according to the vehicle distances), and industrial sectors (NOGA category g28, manufacture of fabricated metal products, except machinery and equipment) based on the emission shares of different galvanized products given in Hillenbrand et al. (2005).

The diffuse zinc emissions to water calculated by the procedure described above are lower than the total diffuse emissions reported in the Swiss PRTR. A constant scaling factor is therefore applied to all sectors in order to obtain the total zinc emissions according to the Swiss PRTR.

5.9.7 Diffuse lead emissions

The diffuse lead emissions into water are mainly caused by transportation and building materials, whereas the fraction of the drinking water supply network is assumed to be negligible. The total lead emissions to water are reported in the Swiss PRTR.

Diffuse lead emissions from road transportation are calculated based on emission factors for tyre, break pad, and road abrasion (Hillenbrand et al. 2005) and the vehicle distance travelled (BFS 2014d; BFS 2014c). The fraction of emissions going into water is estimated at 12 % (Hillenbrand et al. 2005). The calculations are shown in Tab. 5.33. The emissions are assigned to the final demand category c07 (transport) and the NOGA category g60f (freight transport by road).

Tab. 5.33 Calculation of the diffuse lead emissions from road transport. It is assumed that 12 % of the total emissions go to water (Hillenbrand et al. 2005). The emission factors are taken from Hillenbrand et al. (2005) and the travelling distances are reported by BFS (2014d; 2014c).

		Passenger transpo	Freight transport
Travelling distance	km/a	5.14E+10	5.70E+09
EF tyre abrasion	mgPb/km	0.0015	0.0207
EF break pad abrasion	mgPb/km	0.11	0.01
EF road abrasion	mgPb/km	0.011	0.011
Total lead emissions	kgPb/a	6'451	249
Lead emissions to water	kgPb/a	**774**	**30**

The total volume of lead sheets is calculated by the annual use of lead for building materials and the average lifetime as reported by KBOB by assuming steady state conditions (2001). The parameters used for the calculation of the diffuse lead emissions from buildings are listed in Tab. 5.34. These emissions are assigned to residential (final demand category c04, housing and energy), industrial and service activities according to information on the total metal use in buildings reported by Schneider (2009). The diffuse lead emissions from industrial buildings are further assigned to NOGA categories g17 to g45 based on the number of employees. The amount of lead emitted to water by service buildings is assigned to the NOGA categories g50 to g85, g90a to g90c, g91p92 and g93p95 based on the number of employed people in each sector.

Tab. 5.34 Calculation of the diffuse lead emissions from buildings. It is assumed that 70 % of the total emissions go to water (Hillenbrand et al. 2005). The yearly lead use and the life time of the lead sheets is taken from KBOB (2001), the division between the building types is done according to Schneider (2009) and the remaining parameters are reported by Hillenbrand et al. (2005).

		Residential	Services	Industry
Lead use	t/a	200	100	200
Life time	a	40	40	40
Lead density	kgPb/m3	11'400	11'400	11'400
Volume lead sheets	m3	702	351	702
Thickness lead sheets	mm	1.4	1.4	1.4
Area lead sheets	m2	5.01E+05	2.51E+05	5.01E+05
Area exposed to water	-	70%	70%	70%
Erosion rate	gPb/(m2*a)	4.3	4.3	4.3
Total lead emissions	kgPb/a	1'498	749	1'498
Lead emissions to water	**kgPb/a**	**1'049**	**524**	**1'049**

The diffuse lead emissions to water calculated by the procedure described above are lower than the total diffuse emissions reported in the Swiss PRTR. A constant scaling factor is therefore applied to all sectors in order to obtain the total lead emissions according to the Swiss PRTR.

5.9.8 Diffuse emissions of other substances

The diffuse water emissions of cadmium listed in the Swiss PRTR are fully assigned to the NOGA category g90c (other sewage and refuse disposal, sanitation and similar activities) due to scarce information on the sectors emitting cadmium.

The diffuse water emissions of TOC listed in the Swiss PRTR are fully assigned to the NOGA category g90c (other sewage and refuse disposal, sanitation and similar activities) due to scarce information on the sectors emitting pollutants.

The emissions of endocrine disruptors are assigned to the NOGA category c06 (health). The total emissions of endocrine disruptors have been reported by Frischknecht and Büsser Knöpfel (2013b).

5.9.9 Emissions of persistent organic pollutants

Persistent organic pollutants (POPs) encompass a wide range of substances emitted by various activities. For this reason, the five most relevant substances in terms of characterised annual flows into water are selected for the allocation of POP emissions to the different NOGA categories. Together, these substances make up a share of 65 % in the total annual emissions (Frischknecht & Büsser Knöpfel 2013b). The emissions of the following substances are analysed in some more detail: 2,2'-(1,4-naphthalenediyl)bis-benzoxazole (also referred to as fluorescent brightener 367), 1,1'-oxybis-pentabromo-benzene (also referred to as pentabromodiphenyl ether (PBDE) 99), 2,2'-(1,2-ethenediyldi-4,1-phenylene)bis-benzoxazole (also referred to as fluorescent brightener 393), 4,4'-(1-methylethylidene)bis[2,6-dibromo-phenol (also referred to as tetrabromobisphenol A (TBBPA)), pentabromomethyl-benzene (also referred to as pentabromotoluene (PBT)).

The two selected fluorescent brighteners are used for plastic products and textiles[11]. The emissions of the fluorescent brighteners 367 and 393 are therefore assigned to the NOGA categories g25 (manufacture of rubber and plastic products) and g17 (manufacture of textiles) according to the number of employees in each sector. This approximation is necessary because specific data on the use of fluorescent brighteners in the two sectors is not available.

PBDE-99, TBBPA, and PBT are brominated flame retardants. The production, use and trade of PBDE-99 are prohibited by the Stockholm Convention on Persistent Organic Pollutants (UNEP 2009). The emissions of PBDE-99 into the hydrosphere mainly occur via landfills and wastewater treatment plants and are therefore assigned to NOGA category g90c (other sewage and refuse disposal, sanitation and similar activities) (Morf et al. 2002; Morf et al. 2007). TBBPA is mainly used in electric and electronic devices, building materials and motor vehicles. The total TBBPA emissions are assigned to the

[11] http://www.dyestuffintermediates.com/fluorescent-brightener (accessed on 15th October 2014)

NOGA categories g30p31 (manufacture of computers and electrical machinery) and g90c (other sewage and refuse disposal, sanitation and similar activities) based on the annual emissions from the production and disposal of TBBPA-containing products as estimated by Morf et al. (2002). PBT is used as a flame retardant in plastics and is assumed to enter the hydrosphere primarily via landfills and wastewater treatment plants (European Food Safety Authority (EFSA) 2012). The emissions of PBT are therefore assigned to NOGA category g90c (other sewage and refuse disposal, sanitation and similar activities).

The allocation of the emissions of the remaining POPs considered in this study is done based on the characterised flows of the five most important POPs. It is thereby assumed that the substances analysed in more detail are representative of the other POPs.

5.9.10 Radioactive emissions

The water emissions of different radioactive isotopes of hospitals, research and nuclear power plants (including intermediate storage) based on data of ENSI (2010) and BAG (2010) assessed in Frischknecht and Büsser (2013b) are assigned to the NOGA categories g85 (health and social work), g73 (research and development) and g40c (nuclear power plants).

5.10 Emissions to soil

5.10.1 Overview

The main classes of soil pollutants are plant protection products and heavy metals. The allocation of the emissions of plant protection products to the different NOGA categories is described in Chapter 5.10.2, whereas the allocation procedure for heavy metals is documented in Chapter 5.10.3.

5.10.2 Plant protection products

The emissions of plant protection products to soil by the agricultural sector are calculated from the typical doses of pesticides applied to different crops, which are reported by Spycher and Daniel (2013). The dose is multiplied by the agricultural area covered by the respective crop to determine the total amount of pesticides applied in the different agricultural subsectors (NOGA categories g01a to g01j) (BFS 2014e). The land areas and the pesticide dose used for the different crops are compiled in Tab. 5.35. The fraction of plant protection products applied on meadows is divided between the NOGA categories g01k (non-dairy cattle), g01o (dairy cattle) and g01p (other animal products) based on the number of livestock units of hay consuming animal species (Tab. 5.2). The emissions onto pastures are assigned to subsectors of livestock farming (NOGA categories g01k to g01p) based on the number of respective animals participating in the RAUS-programme (Tab. 5.18; BLW 2011).

Tab. 5.35 Pesticide dose and land area for the different crops (Spycher & Daniel 2013; BFS 2014e). AS: active substance in the pesticide formulation.

	Land area	Herbicides	Fugicides	Insecticides	Other pesticides
	ha	kgAS / (ha*a)	kgAS / (ha*a)	kgAS / (ha*a)	kgAS / (ha*a)
Meadows	481'635	0.06	0.00	0.00	0.00
Artificial	127'259	0.06	0.00	0.00	0.00
Pastures	135'846	0.06	0.00	0.00	0.00
Wheat	88'433	1.00	0.90	0.01	0.44
Barley	32'958	1.90	1.00	0.00	0.53
Oats	1'861	1.10	0.20	0.00	0.20
Maize	17'593	1.40	0.00	0.00	0.03
Silo maize	44'735	1.40	0.00	0.00	0.03
Other cereals	15'260	1.10	0.20	0.00	0.20
Potatoes	11'058	3.00	7.10	0.01	5.00
Sugar beets	20'469	5.00	0.30	0.10	0.51
Fodder beets	1'072	4.80	0.20	0.30	0.45
Vegetables	9'676	1.40	3.70	0.20	0.12
Oil-bearing crops	25'914	1.60	0.30	0.10	0.17
Pulses	4'291	1.90	0.10	0.10	0.02
Grapes	12'922	1.30	20.80	0.03	0.14
Fruits	7'333	1.56	24.28	1.94	12.88
Other vegetal products	4'910	1.80	0.50	0.03	0.10

The amount of herbicides, fungicides, and insecticides applied in horticulture and landscaping (NOGA category g01r) is interpolated for the year 2008 from figures reported by Krebs et al. (2011). The amount of the eight most common herbicides used in private gardens has been estimated by Wittwer and Gubser (2010) and is assigned to NOGA category c04 (housing and energy). It is assumed that the amount of other plant protection products applied in private gardens is negligible. The herbicide emissions to soil along the railway network are reported in SBB (2013) and assigned to NOGA category g60c (rail infrastructure).

The total amount of pesticides estimated for the NOGA categories obtained by this procedure is lower than the figure reported by Frischknecht and Büsser Knöpfel (2013b). The emissions of plant protection agents of the different sectors of arable farming (NOGA categories g01a to g01j) are therefore scaled, while the emissions of the other NOGA categories are kept constant. The total emissions finally correspond to the emissions of plant protection products calculated in the mentioned study (Frischknecht & Büsser Knöpfel 2013b).

The product groups herbicides, fungicides, insecticides and other pesticides are distinguished. The characterization factors used for the pesticide groups are listed in Tab. 5.36. The total emissions of plant protection products are determined from the sum of the characterized emissions of the individual groups and reported in glyphosate-equivalents (Frischknecht & Büsser Knöpfel 2013b).

Tab. 5.36 Characterization factors of the different groups of plant protection products for the year 2010.

Pesticide Group	Characterization Factor
	g Glyphosate-eq / g
Herbicides	3.52
Fungizides	4.84
Insecticides	3.89
Other pesticides	1.63

Source: Norbert Egli, FOEN, personal communication 08.10.2014.

5.10.3 Heavy metals

The emissions of heavy metals to soil by the agricultural sector has been investigated by Keller et al. (2005b). The relevant sources of heavy metal emissions into soil are the application of manure and mineral fertilizer as well as, for copper and zinc, the use of fungicides for certain crops (Keller et al. 2005a). Sewage sludge is not applied onto agricultural fields any more and atmospheric deposition is not taken into account here in order to avoid double counting of heavy metals emitted to air. The input of cadmium, lead, copper, and zinc from the different sources reported by Keller et al. (2005b) is used to calculate the total emissions of these heavy metals into agricultural soils. For the category of other vegetal products (NOGA category g01j), the heavy metal input is determined by calculating the arithmetic mean of the inputs per hectare of all other crops. The emission factors for the individual crops are multiplied by the land area covered by each crop (BFS 2014e). It is assumed that 39 % of the meadows and pastures are used intensively, 39 % medium intensively and 22 % extensively (Baur 2013). The heavy metal emissions from arable farming are assigned to NOGA categories g01a to g01j. The fraction of heavy metals emitted onto meadows is divided between the NOGA categories g01k (non-dairy cattle), g01o (dairy cattle) and g01p (other animal products) based on the amount of hay consumed by the different animal species (Tab. 5.2). The emissions onto pastures are assigned to the subcategories of livestock farming (NOGA categories g01k to g01p) based on the number of respective animals participating in the RAUS-programme (Tab. 5.18; BLW 2011).

Tab. 5.37 Heavy metal emission factors and land area for the different crops (Keller et al. 2005a; BFS 2014e).

	Land area	Cadmium	Lead	Copper	Zinc
	ha	g / (ha*a)	g / (ha*a)	g / (ha*a)	g / (ha*a)
Meadows	481'635	0.6	8.9	92	511
Artificial meadows	127'259	0.6	8.9	92	511
Pastures	135'846	0.5	9.4	80	431
Wheat	88'433	1.4	3.7	32	185
Barley	32'958	1.5	5.0	59	318
Oats	1'861	3.5	5.9	41	279
Maize	17'593	1.8	12.4	155	953
Silo maize	44'735	1.9	17.7	135	695
Other cereals	15'260	0.8	4.8	34	197
Potatoes	11'058	1.8	12.7	534	718
Sugar beets	20'469	2.5	10.1	107	623
Fodder beets	1'072	3.1	10.3	55	281
Vegetables	9'676	0.4	2.2	66	484
Oil-bearing crops	25'914	2.9	13.4	74	448
Pulses	4'291	5.1	2.3	18	138
Grapes	12'922	0.7	3.5	2'055	57
Fruits	7'333	1.2	2.5	50	101
Other vegetal products	4'910	1.9	7.8	224	401

Copper is also emitted to soil by the wash-out of wood preservatives from power poles. These emissions are estimated based on the wash-out rate of copper, which is 0.11 kg/(km·a), and the length of the medium voltage electricity grid of 29’629 km (Itten et al. 2014). The copper emissions from the wash-out of wood-preservatives from power poles are assigned to NOGA category g40e (electricity distribution and trade).

5.11 Wastes

The volume in the final repository occupied by low-active radioactive waste and radioactive waste are assigned to the NOGA category g40c (nuclear power plants).

The TOC emissions into groundwater caused by inert material and sanitary landfills are completely assigned to the NOGA category g90c (other sewage and refuse disposal, sanitation and similar activities).

The export of hazardous wastes and wastes disposed in underground deposits are modelled as a physical import of disposal services (see Subchapter 6.2). This service import (g90 GLO (global average)) is assigned to the NOGA category g90c (other sewage and refuse disposal, sanitation and similar activities).

5.12 Noise

The noise emissions of the different means of transport according to Frischknecht and Büsser Knöpfel (2013b) are assigned to the corresponding NOGA categories. The noise emissions of road traffic are assigned to the NOGA category g60f (freight transport by road) and the sector c07 of the final consumption (transport). The noise emissions of the road traffic by passenger cars are completely assigned to the sector c07 of the final consumption, because the share of business travel of the daily distance covered by cars in Switzerland is only about 7 % (BFS/ARE 2012).

The noise emissions of rail traffic are assigned to the NOGA categories g60a (passenger rail transport) and g60b (freight rail transport) based on the respective number of disturbed persons.

The noise emissions of air traffic are assigned to the NOGA category g62 (air transport).

Tab. 5.38 Number of persons disturbed by noise caused by transport of passengers and freight of road, rail and air traffic according to Frischknecht and Büsser (2013b) and assigned NOGA category.

	Road traffic			Rail traffic			Air traffic		
	Persons	Freight	Total	Persons	Freight	Total	Persons	Freight	Total
Number of disturbed persons	349'080	366'674	715'754	23'087	37'847	60'934	22'280	4'914	27'194
Share of disturbed persons	49%	51%	100%	38%	62%	100%	82%	18%	100%
vehicle kilometers travelled	5.59E+10	5.87E+09	6.18E+10	1.83E+08	3.00E+07	6.18E+10	6.57E+09	1.45E+09	6.18E+10
NOGA category	c07	g60f		g60a	g60b		g62	g62	

6 Environmental impacts of imports

6.1 Overview

In addition to the domestic interrelations of the economic sectors and the final demand categories, the IOT contains the use of imports of goods and services in the different industries and by final demand. These economic data are linked to environmental data in order to quantify the environmental impacts of imports. The methodology to compile environmental data of imports of goods and services is described in the Subchapters 6.2 and 6.3, respectively.

6.2 Imports of goods

The calculation of the environmental impacts of imported goods generally follows the approach developed by Frischknecht et al. (2014). Data on the imports of goods in physical units (mass or energy content) are linked with LCI data and standard transport distances to quantify the environmental intensities of the commodity imports.

Starting point for the quantification of the amounts of imported goods are data from the Swiss foreign trade statistics classified according to the Standard International Trade Classification rev. 3 (SITC). These data are then adjusted to be compatible with the national accounts data on commodity imports and to include expenditures of resident economic units (e.g. tourists) for goods abroad[12]. Differences between imports according to the foreign trade statistics and imports according to national accounts include various items, e.g. the import of non-monetary gold and silver for industrial purposes, purchases in ports and airports or uncontrolled imports such as drugs.

The adjustment of the SITC import data includes the following steps:

- Imports in monetary units that are compatible with national accounts totals following the CPA[13] classification are taken from the IOT. Tourism imports of commodities are added.

[12] Expenditures of resident units abroad count as service imports in national accounting. Part of these expenditures relate to commodities that are included here and not under import of services, so that their environmental impact can be calculated with appropriate LCI data.

[13] CPA 2002: Statistical classification of products by activity in the European Economic Community, 2002 version. This classification is a product classification used in the EU input-output tables that is largely compatible with the Swiss NOGA classification.

- The values are transformed into the SITC classification by using a correspondence table derived from the foreign trade statistics.
- Adjustment factors for each SITC category are calculated by dividing the import values compatible with national accounts by the import values from the foreign trade statistics.
- The adjustment factors are then applied to SITC imports in physical units to derive imports compatible with national accounts. This calculation thus assumes that for each SITC category the goods added to the foreign trade statistics data in national accounting have the same prices as the goods included in the foreign trade statistics.

These adjustments lead to an increase of total commodity imports in physical units by 7%.

The environmental impacts of commodity imports are calculated with environmental intensities determined by Frischknecht et al. (2014) for the year 2008. A few adjustments made in specific categories of commodity imports are described in the following.

In the category SITC-35 (electric current) in the study carried out by Frischknecht et al. (2014), two errors were noticed. The amount of imported elctricity in the year 2008 was lower than the actual electricity import and the environmental impacts erroneously did not include radioactive wastes from nuclear power plants. The specific environmental burden of electricity imports has been corrected in the present study and the amount of imported electricity has been adjusted according to BFE (2009). This results in higher environmental impacts of electricity imports in the current EE-IOT as compared to the study by Frischknecht et al. (2014).

The uranium products are now separated from other inorganic chemicals contained in SITC-52. Two individual categories of commodity imports, namely SITC-52 (inorganic chemicals, excluding uranium products) and SITC-52 U (uranium products), are distinguished and modelled with specific LCI data based on the Swiss trade statistics in 2008. The import of uranium products (SITC-52 U) is determined based on the electricity production in nuclear power plants in 2008 in order to take account of the fluctuating trade and the temporary storage of nuclear fuel elements. Exports of used fuel elements for reprocessing are counted as a service import (Frischknecht et al. 2014).

The imports of non-ferrous metals (SITC-68) are modelled analogously to the previous study (Frischknecht et al. 2014). The amounts of platinum and palladium, which are imported to or exported from Switzerland, are balanced in order to avoid a high impact due to precious metal trade that is only done for monetary purposes. In the study carried out by Frischknecht et al. (2014), the amount of imported goods under SITC-68 was incorrect and has been adjusted in the present study.

6.3 Imports of services

The environmental impacts of service imports have been quantified by Jungbluth et al. (2011) who compiled an EE-IOT for Switzerland in the year 2005. They estimated the environmental impacts of service imports by linking them to the corresponding industry sectors in the Swiss EE-IOT. The assumption was made that imported services have the same environmental intensity as the services provided in Switzerland. The environmental impacts of the service import categories hotels and restaurants (g55 GLO), transport services (g60 GLO) and health and social work (g85 GLO) were estimated with LCI data based on assumptions of their average composition (Jungbluth et al. 2011).

In the present study, data on the environmental intensities of service imports per monetary unit (CHF) from Jungbluth et al. (2011) are used since more detailed data are not available. They are linked with data on service imports from the new IOT after subtraction of tourist expenditures for commodities. A correction for the price changes between 2005 and 2008 was not feasible due to missing data regarding the service trade partners of Switzerland as well as their relevant currency exchange and inflation rates. The environmental intensities of the service imports in the year 2005 are thus applied by assuming price changes until 2008 to be negligible. This assumption can be justified by the minor importance of service imports as compared to the environmental impacts of commodity imports or domestic production.

The service imports from industry sectors (g01p05 GLO to g45 GLO) mainly comprise earnings from patents and licences. These imports are modelled by the service import category g71p74 GLO (renting and other business services) because otherwise the environmental impacts of service imports from industry sectors would be overestimated.

The export of hazardous wastes for underground deposition or incineration is modelled as a physical import of disposal services (g90 GLO). The import category g90 GLO is taken from a previous study (Frischknecht et al. 2014) and includes the mass of hazardous waste disposed of in underground deposits and hazardous waste incineration in foreign countries in the year 2008.

7 Results

7.1 Overview

The disaggregated EE-IOT compiled in this study can be employed for the analysis of a variety of different questions. For instance, the EE-IOT allows:

- the identification of key sectors and activities responsible for environmental impacts,
- the assessment of the economic and environmental impacts of a certain consumption pattern and
- the development of policies to proceed towards a more sustainable economy.

The EE-IOT is made available to the public in the EcoSpold v1 format and can be used for further analyses. The midpoint indicators greenhouse gas emissions, eutrophication potential and biodiversity damage potential are evaluated in this study. The results are presented in the Subchapters 7.2 to 7.4 and are also published in separate factsheets.

7.2 Greenhouse gas emissions (carbon footprint)

7.2.1 Midpoint indicator

The global increase in temperature of 0.85 °C observed between 1880 and 2012 is mainly caused by anthropogenic greenhouse gas (GHG) emissions (IPCC 2013). GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). In addition to their direct warming effect, GHGs have a number of indirect effects such as changes in precipitation patterns, an increase in the frequency of extreme weather events and a rise in sea level (IPCC 2013). That is why climate change was identified by Rockström et al. (2009) as one of the planetary boundaries that has already been exceeded.

Switzerland has committed itself to reduce its domestic GHG emissions by 20 % until 2020 in comparison to the emission level of 1990 (Schweizerischer Bundesrat 2011) and states the need for a reduction by between 50 % and 85 % until 2050 (Schweizerischer Bundesrat 2012). The potency of different GHGs in terms of their warming effect is characterized by the global warming potential (GWP, calculated for a period of 100 years), and CO_2 is used as the reference substance.

7.2.2 Domestic and foreign GHG emissions

An overview of the total domestic and foreign GHG emissions caused by Switzerland is given in Tab. 7.1. The Swiss domestic GHG emissions amount to 60.5 Mt CO_2-eq. A

fraction of 27 % (16.1 Mt CO_2-eq) thereof is related to the production of exported goods and services. The Swiss domestic final demand, i.e. consumption of private households, the government, non-profit institutions and capital formation, results in GHG emissions of 103 Mt CO_2-eq in Switzerland and abroad. This means that a fraction of 57 % (58.7 Mt CO_2-eq) of the total GHG emissions ultimately caused by Swiss consumption occurs abroad. The net traded emissions, defined as the difference between emissions abroad caused by domestic final demand and domestic emissions caused by exports, are 42.6 Mt CO_2-eq.

Tab. 7.1 Domestic and foreign GHG emissions caused by Swiss domestic final demand and by exports.

			Greenhouse gas emissions		
			Domestic emissions	Emissions abroad	Total emissions
			t CO2-eq.	t CO2-eq.	t CO2-eq.
Emissions caused by domestic final demand			*44'401'697*	*58'749'043*	*103'150'740*
Emissions caused by exports			*16'127'362*		
Total			*60'529'059*		
Net traded emissions					*42'621'681*

7.2.3 Important contributors to domestic GHG emissions

The ten most important contributors to total domestic GHG emissions are listed in Tab. 7.2. Only direct emissions by households and industry sectors are considered for the identification of the ten most important contributors to GHG emissions. It becomes evident that the ten most important contributors cause more than two thirds of Switzerland's total GHG emissions. The two dominant contributors, namely the household consumption categories housing and energy (c04) and transportation (c07), are responsible for more than one third (21.7 Mt CO2-eq) of the total domestic GHG emissions.

The remaining eight economic sectors of the ten most important contributors cause together about one third of the total domestic GHG emissions. Air transport (g62) and freight transport by road (g60f) are responsible for approximately 10 % of domestic GHG emissions. Cattle farming (dairy (g01o) and non-dairy (g01k)) causes roughly 9 % of Switzerland's GHG emissions. Further important contributors to GHG emissions are the cement industry (g26), the chemical and pharmaceutical industry (g24) and heat generation in waste incineration plants (g90b). With the exception of wholesale, retail, vehicles and fuels trade, which has a high economic relevance, service sectors are not among the ten most important contributors to total domestic GHG emissions.

Tab. 7.2 The ten most important contributors to total domestic GHG emissions. Only direct emissions by households and sectors are taken into account.

			Greenhouse gas emissions	Share in total
			t CO2-eq.	
1.	c04	Housing and energy	11'762'002	*19%*
2.	c07	Transport	9'942'569	*16%*
3.	g62	Air transport	4'996'949	*8%*
4.	g01o	Dairy cattle and raw milk	3'786'380	*6%*
5.	g26	Manufacture of other non-metallic mineral products	3'480'168	*6%*
6.	g24	Chemicals, chemical and pharmaceutical products	1'998'393	*3%*
7.	g50b52	Wholesale, retail, vehicles and fuels trade, repair	1'932'689	*3%*
8.	g01k	Non-dairy cattle	1'770'735	*3%*
9.	g90b	Heat from waste incineration	1'358'710	*2%*
10.	g60f	Freight transport by road	1'211'514	*2%*
	Remaining contributors		18'288'951	*30%*
	Total		*60'529'059*	*100%*

7.2.4 Carbon footprint: GHG emissions due to final consumption

Domestic and foreign GHG emissions attributable to Switzerland from the consumption perspective (carbon footprint) can be shown by final consumption category and by product group.

The carbon footprint by final consumption category is shown in Tab. 7.3. The consumption of private households causes 74 % of the total GHG emissions related to Swiss consumption. The most important categories of household consumption with respect to GHG emissions are housing and energy (c04, 21 %), transport (c07, 17 %) and food and non-alcoholic beverage (c01, 12 %). Capital formation is responsible for 21 % of the consumption related GHG emissions and the consumption of the government and of non-profit institutions causes 5 %.

The major share of consumption related GHG emissions (57 %) are caused by imports outside Switzerland, the remaining 43 % of emissions occur domestically. Consumption categories with particularly high shares of GHG emissions caused abroad are clothing and footwear (c03) with 95% of total emissions, household equipment and maintenance (c05) with 89% as well as alcoholic beverages, tobacco and narcotics (c02) with 81%.

Tab. 7.3 Disaggregation of the carbon footprint by consumption category: GHG emissions in Switzerland and abroad caused by consumption of private households, the government and non-profit institutions as well as by capital formation. The consumption of private households is further divided into twelve categories (c01 to c12).

			Greenhouse gas emissions			
			Domestic emissions	Emissions abroad	Total emissions	Share in total
			t CO2-eq.	t CO2-eq.	t CO2-eq.	
Consumption of private households			37'422'092	38'965'482	76'387'574	*74%*
	c01	Food and non-alcoholic beverage	4'987'236	7'078'558	12'065'793	*12%*
	c02	Alcoholic beverages, tobacco and narcotics	233'995	926'319	1'160'315	*1%*
	c03	Clothing and footwear	121'565	2'222'571	2'344'136	*2%*
	c04	Housing and energy	14'294'963	7'451'076	21'746'039	*21%*
	c05	Household equipment and maintenance	315'982	2'550'979	2'866'961	*3%*
	c06	Health	1'716'838	2'302'799	4'019'637	*4%*
	c07	Transport	11'880'413	5'406'940	17'287'353	*17%*
	c08	Communications	169'787	527'239	697'025	*1%*
	c09	Recreation and culture	1'436'135	4'118'561	5'554'696	*5%*
	c10	Education	74'806	78'894	153'700	*0%*
	c11	Restaurants and hotels	1'449'068	3'558'316	5'007'384	*5%*
	c12	Misc. goods and services	741'305	2'743'231	3'484'536	*3%*
Consumption of the government and non-profit institutions			2'611'656	2'959'310	5'570'966	*5%*
Capital formation			4'367'949	16'824'251	21'192'200	*21%*
Total domestic final consumption (excl. exports)			44'401'697	58'749'043	*103'150'740*	*100%*

In a second analysis the contribution of the most important product groups to the consumption related GHG emissions is shown. Tab. 7.4 shows the ten product groups, that cause the highest total GHG emissions with a disaggregation into domestic emissions and emissions abroad. They cover a share of 60 % of the total GHG emissions caused by Swiss consumption.

The direct GHG emissions by private households (HH) account for 21 % of the total consumption related GHG emissions. Construction services (g45) have the second-highest share in GHG emissions with 8%. Hotel and restaurant services (g55) and health services (g85) follow next with 5% and 4% of total emissions, respectively. These services have a large share in household consumption expenditure. Product groups with a particularly high share of emissions abroad are machinery (g29), electricity (g40e), petroleum products (g23a) as well as hotel and restaurant services (g55). One explanation for the large share in the last case is that these services are partly used by Swiss residents travelling abroad.

Tab. 7.4 Disaggregation of the carbon footprint by product group: GHG emissions in Switzerland and abroad caused by Swiss consumption.

			Greenhouse gas emissions			
			Domestic emissions	Emissions abroad	Total emissions	Share in total
			t CO2-eq.	t CO2-eq.	t CO2-eq.	
1.	HH	Direct emissions by households	21'827'794	0	21'827'794	*21%*
2.	g45	Construction services	3'135'404	5'294'806	8'430'209	*8%*
3.	g55	Serv. of hotels and restaurants	1'582'417	3'875'397	5'457'814	*5%*
4.	g85	Health and social work services	2'109'748	2'490'702	4'600'451	*4%*
5.	g23a	Refined petroleum products	318'750	3'823'762	4'142'512	*4%*
6.	g50b52	Automobile, wholesale and retail trade	1'500'573	2'403'331	3'903'903	*4%*
7.	g29	Machinery	236'743	3'598'343	3'835'086	*4%*
8.	g15a	Processed meat	2'057'008	1'739'986	3'796'994	*4%*
9.	g40e	Distributed electricity	222'931	3'200'336	3'423'268	*3%*
10.	g62	Air transport	1'625'246	1'341'767	2'967'013	*3%*
	Remaining product groups		9'785'084	30'980'612	40'765'697	*40%*
	Total		44'401'697	58'749'043	*103'150'740*	*100%*

7.2.5 Conclusion and outlook

The comparison of the domestic emissions occurring in Switzerland (60.5 Mt CO_2-eq) with the GHG emissions ultimately caused by Swiss consumption (103 Mt CO_2-eq) makes clear that the GHG emissions associated with imported goods and services cannot be disregarded when Switzerland's responsibility for global climate change is assessed. However, the high share of GHG emissions related to Swiss consumption occurring abroad makes it difficult to effectively develop and implement policies to reduce the total emissions. A life cycle approach can be employed to identify the key product groups and consumption categories responsible for the domestic and foreign GHG emissions caused by Swiss consumption.

7.3 Eutrophication potential (nitrogen footprint)

7.3.1 Midpoint indicator

The anthropogenic interference with the global nitrogen cycle by the industrial (Haber-Bosch process) and agricultural (leguminous crops) fixation of atmospheric nitrogen was identified as one of the planetary boundaries that has been already clearly transgressed (Rockström et al. 2009). The fraction of reactive nitrogen, which enters the environment, may affect water quality and the composition of aquatic and terrestrial ecosystems.

Marine eutrophication is caused by emissions of nitrogen compounds to air, water and soil and typically results in algal blooms, which are followed by oxygen depletion in the water and other adverse ecological effects. The fraction of the total nitrogen emissions ending up in the marine environment (i.e., the fate factor in units of year/km^3) is estimated by the CARMEN model. The eutrophication potential, as defined in the ReCiPe 2008 impact assessment method, is then determined by the sum of all nitrogen

fluxes to the environmental compartments multiplied by their respective fate factor (Goedkoop et al. 2009).

The eutrophication potential can be used to estimate the amount of algal biomass produced by the additional nitrogen input. This is an upper boundary since the growth of algae also depends on the season and other factors. The extent of oxygen depletion in the seawater can be derived from the mass of algae, but it is not possible to make a prediction about the consequences on other species (Goedkoop et al. 2009).

7.3.2 Domestic and foreign eutrophication potential

An overview of the total domestic and foreign eutrophication potential caused by Switzerland is given in Tab. 7.5. The Swiss domestic eutrophication potential amounts to 80.1 kt N-eq. A fraction of 29 % (23.0 kt N-eq) thereof is related to the production of exported goods and services. The Swiss domestic final demand, i.e. consumption of private households, the government, non-profit institutions and capital formation, results in a eutrophication potential of 116 kt N-eq in Switzerland and abroad. Hence, a fraction of 51 % (59.1 kt N-eq) of the total eutrophication potential ultimately related to Swiss consumption is caused abroad. The net traded eutrophication potential, defined as the difference between emissions of nitrogen compounds abroad caused by domestic final demand and domestic emissions caused by exports, is 36.1 kt N-eq.

Tab. 7.5 Domestic and foreign eutrophication potential caused by Swiss domestic final demand and by exports.

	Eutrophication potential		
	Domestic emissions	Emissions abroad	Total emissions
	t N-eq	t N-eq	t N-eq
Emissions caused by domestic final demand	*57'110*	*59'093*	*116'203*
Emissions caused by exports	*23'022*		
Total	*80'132*		
Net traded emissions			*36'072*

7.3.3 Important contributors to domestic eutrophication potential

The ten most important contributors to the total domestic eutrophication potential are listed in Tab. 7.6. Only direct emissions of nitrogen compounds by households and industry sectors are considered for the identification of the ten most important contributors to the eutrophication potential. A share of 89 % of the domestic emissions of nitrogen compounds is caused by the ten economic sectors with the highest contribution.

The sector sewage and refuse disposal (g90c), which encompasses the wastewater treatment plants, is responsible for 24 % of the domestic eutrophication potential. Eight of the remaining sectors in the ten most important contributors to the eutrophication potential are agricultural subsectors. Livestock farming (g01o, g01k and g01p) is responsible for almost one third of the total domestic eutrophication potential, with dairy cattle being of particular importance with a share of 20 %. The production of food

cereals (g01a) and feed crops (g01b) causes 15 % and 12 % of the total domestic eutrophication potential, respectively.

Industry and service sectors are not among the ten most important contributors to Switzerland's total domestic eutrophication potential, with the exception of the leather industry (g19).

Tab. 7.6 The ten most important contributors to the total domestic eutrophication potential. Only direct emissions by households and economic sectors are taken into account.

			Eutrophication potential	Share in total
			t N-eq	
1.	g90c	Other sewage and refuse disposal, sanitation, similar activities	19'362	*24%*
2.	g01o	Dairy cattle and raw milk	15'676	*20%*
3.	g01a	Food cereals	11'917	*15%*
4.	g01b	Feed cereals	9'761	*12%*
5.	g01k	Non-dairy cattle	5'991	*7%*
6.	g01d	Root and tuber crops	2'229	*3%*
7.	g01p	Other animal products	1'952	*2%*
8.	g01e	Vegetables	1'949	*2%*
9.	g19	Tanning and dressing of leather and manufactures thereof	1'518	*2%*
10.	g01c	Sugar crops	1'118	*1%*
	Remaining contributors		8'658	*11%*
	Total		*80'132*	*100%*

7.3.4 Nitrogen footprint: Eutrophication potential due to final consumption

The domestic and foreign eutrophication potential attributable to Switzerland from the consumption perspective (nitrogen footprint) can be shown by final consumption category and by product group.

The nitrogen footprint by consumption category is shown in Tab. 7.7. The consumption of private households causes 83 % of the total eutrophication potential related to Swiss consumption. The dominant category of household consumption with respect to the emissions of nitrogen compounds is food and non-alcoholic beverage (c01) with a share of 50 %. Capital formation is responsible for 10 % of the consumption related eutrophication potential and the consumption of the government and of non-profit institutions causes 8 %.

Domestic emissions and emissions abroad have a similar share in total eutrophication potential from the consumption perspective. Consumption categories with particularly high shares of eutrophication potential caused abroad are clothing and footwear (c03) with 89% of total emissions, household equipment and maintenance (c05) with 85% as well as alcoholic beverages, tobacco and narcotics (c02) with 80%.

Tab. 7.7 Disaggregation of the nitrogen footprint by consumption category: Eutrophication potential in Switzerland and abroad caused by consumption of private households, the government and non-profit institutions as well as by capital formation. The consumption of private households is further divided into twelve categories (c01 to c12).

			Eutrophication potential			
			Domestic emissions	Emissions abroad	Total emissions	Share in total
			t N-eq	t N-eq	t N-eq	
Consumption of private households			45'655	50'398	96'053	*83%*
	c01	Food and non-alcoholic beverage	28'605	29'064	57'668	*50%*
	c02	Alcoholic beverages, tobacco and narcotics	511	1'902	2'413	*2%*
	c03	Clothing and footwear	193	1'607	1'800	*2%*
	c04	Housing and energy	4'775	2'163	6'938	*6%*
	c05	Household equipment and maintenance	240	1'337	1'577	*1%*
	c06	Health	2'769	2'356	5'124	*4%*
	c07	Transport	1'439	1'319	2'758	*2%*
	c08	Communications	122	215	336	*0%*
	c09	Recreation and culture	1'679	4'823	6'501	*6%*
	c10	Education	103	79	182	*0%*
	c11	Restaurants and hotels	4'439	4'073	8'512	*7%*
	c12	Misc. goods and services	782	1'461	2'243	*2%*
Consumption of the government and non-profit institutions			6'310	2'478	8'788	*8%*
Capital formation			5'145	6'217	11'362	*10%*
Total domestic final consumption (excl. exports)			57'110	59'093	*116'203*	*100%*

In a second analysis the contribution of the most important product groups to the consumption related eutrophication potential is shown. Tab. 7.8 shows the ten product groups, which cause the highest total eutrophication potential with a disaggregation into domestic emissions and emissions abroad. They cover a share of 58 % of the total eutrophication potential caused by Swiss consumption.

Eutrophying emissions hardly occur during final consumption. This is mainly due to the fact that all households are linked to sewage treatment plants. In general food products cause a large share of emissions. Processed meat (g15a) is the product group with the highest share of the eutrophication potential (15% of the total). Dairy products (g15e) follow with a share of 11%. In both cases emissions mainly stem from agriculture and domestic emissions dominate. Hotel and restaurant services (g55) then follow with a share of 8%. Product groups with a particular large share of emissions abroad are bakery and farinaceous products (g15g) and other food and tobacco products (g15jp16) with a share of 85 % of the total eutrophication potential occurring abroad.

Tab. 7.8 Disaggregation of the nitrogen footprint by product group: Eutrophication potential in Switzerland and abroad caused by Swiss consumption.

			Eutrophication potential			
			Domestic emissions	Emissions abroad	Total emissions	Share in total
			t N-eq	t N-eq	t N-eq	
1.	g15a	Processed meat	10'595	7'145	17'741	*15%*
2.	g15e	Dairy products	9'929	3'019	12'948	*11%*
3.	g55	Serv. of hotels and restaurants	4'847	4'426	9'273	*8%*
4.	g15g	Bakery and farinaceous products	1'107	6'375	7'481	*6%*
5.	g85	Health and social work services	3'442	2'576	6'018	*5%*
6.	g90c	Disposal services	5'722	61	5'783	*5%*
7.	g45	Construction services	3'228	1'969	5'197	*4%*
8.	g15jp16	Other food products, tobacco products	646	3'578	4'224	*4%*
9.	g15f	Grain mill and starch products	2'393	1'772	4'165	*4%*
10.	g80	Education services	1'733	1'328	3'061	*3%*
	Remaining product groups		13'468	26'844	40'312	*35%*
	Total		57'110	59'093	*116'203*	*100%*

7.3.5 Conclusions and outlook

The consumption of Switzerland results in a eutrophication potential of 116 kt N-eq in 2008, of which 59.1 kt N-eq (51 %) are caused abroad and associated with imported goods and services. Agriculture is the most important direct contributor to the total eutrophication potential caused in Switzerland. Food products have a high share in the total nitrogen footprint from the consumption perspective. The sector sewage and refuse disposal is of high importance from the production perspective (domestic emissions of nitrogen compounds) but much less from the consumption perspective (domestic and foreign emission). The environmentally-extended input-output table makes it possible to identify the key economic sectors and products ultimately responsible for the domestic and foreign eutrophication potential caused by Swiss consumption.

7.4 Biodiversity damage potential due to land use (biodiversity footprint)

7.4.1 Midpoint indicator

Biodiversity loss was identified by Rockström et al. (2009) as one of the planetary boundaries that has already been clearly transgressed. The main causes of biodiversity loss are land use and land use change, i.e., the conversion of natural ecosystems into cultivated and urban areas. The use of land area leads to land competition and may additionally result in changes in the biotic production potential, soil organic matter content, biodiversity and other ecosystem services (Frischknecht et al. 2013).

The biodiversity damage potential (BDP) proposed by de Baan et al. (2012) is the selected metric to quantify the environmental impacts of land use in the ecological scarcity method. The BDP evaluates different land use types based on global data on their biodiversity. Characterisation factors are derived by comparing the observed species richness of a land use type in a given biome to the expected biodiversity of that

biome. Natural forests and settlement areas are used as the reference biomes with BDPs of 0 and 1, respectively (Frischknecht & Büsser Knöpfel 2013b). The total BDP (in km^2a settlement area-equivalents; km^2a SA-eq) is determined by the sum of all land uses weighted by their characterisation factor.

The BDP quantifies the impacts of land use on plant and animal diversity. However, it is not able to take land competition or effects on ecosystem services into account.

7.4.2 Domestic and foreign BDP

An overview of the total domestic and foreign BDP caused by Switzerland is given in Tab. 7.9.

The Swiss domestic BDP is 12'704 km^2a SA-eq. A fraction of 29 % (3'710 km^2a SA-eq) thereof is related to the production of exported goods and services. The Swiss domestic final demand, i.e. consumption of private households, the government, non-profit institutions and by capital formation results in a BDP of 26'755 km^2a SA-eq in Switzerland and abroad. Hence, a fraction of 66 % (17'761 km^2a SA-eq) of the total BDP ultimately related to Swiss consumption is caused abroad. The net traded BDP, defined as the difference between land occupation abroad caused by domestic final demand and domestic BDP caused by exports, is 14'051 km^2a SA-eq.

Tab. 7.9 Domestic and foreign BDP caused by Swiss domestic final demand and by exports.

			Biodiversity damage potential		
			Domestic land use	Land use abroad	Total land use
			km^2a settlement area-eq	km^2a settlement area-eq	km^2a settlement area-eq
Land use caused by domestic final demand			*8'994*	*17'761*	*26'755*
Land use caused by exports			*3'710*		
Total			*12'704*		
Net traded land use					*14'051*

7.4.3 Important contributors to domestic BDP

The ten most important contributors to the total domestic BDP are listed in Tab. 7.10. Only direct land use by households and industry sectors is considered for the identification of the ten most important contributors to the BDP. A share of 85 % of the total domestic BDP is caused by the ten most important contributors, which are strongly dominated by the agricultural subsectors.

Livestock farming (g01o, g01k and g01p) is responsible for more than one third of the total domestic BDP, with dairy and non-dairy cattle being of particular importance. The production of food cereals (g01a) and feed crops (g01b) causes 11 % and 10 % of the total domestic BDP, respectively. The forestry sector (g02) is the second most important contributor to the total BDP with a share of 13 %.

The direct BDP caused by the final demand of households contributes 6 % in the category housing and energy (c04) and 4 % in the category transport (c07). Neither industry nor service sectors are among the ten most important contributors to Switzerland's total domestic BDP.

Tab. 7.10 The ten most important contributors to the total domestic BDP. Only direct land use by households and sectors is taken into account.

			Biodiversity damage potential	Share in total
			km^2a settlement area-eq	
1.	g01o	Dairy cattle and raw milk	2'626	*21%*
2.	g02	Products of forestry	1'607	*13%*
3.	g01a	Food cereals	1'451	*11%*
4.	g01b	Feed cereals	1'313	*10%*
5.	g01k	Non-dairy cattle	1'304	*10%*
6.	c04	Housing and energy	721	*6%*
7.	g01p	Other animal products	594	*5%*
8.	c07	Transport	452	*4%*
9.	g60f	Freight transport by road	356	*3%*
10.	g01h	Oil-bearing crops	355	*3%*
	Remaining contributors		1'926	*15%*
	Total		*12'704*	*100%*

7.4.4 Biodiversity footprint: BDP due to final consumption

The domestic and foreign BDP attributable to Switzerland from the consumption perspective (biodiversity footprint) can be shown by final consumption category and by product group.

The biodiversity footprint by consumption category is shown in Tab. 7.11. The consumption of private households causes 87 % of the total BDP related to Swiss consumption. By far the most important category of household consumption with respect to the BDP is food and non-alcoholic beverage with a share of 51 % in the total BDP ultimately caused by Swiss consumption. Further important categories of final consumption are recreation and culture (c09, 8 %) as well as restaurants and hotels (c11, 7 %). Capital formation is responsible for 7 % of the consumption related BDP and the consumption of the government and of non-profit institutions causes 5 %.

The major share of the consumption related biodiversity footprint (66 %) is caused by imports outside Switzerland, the remaining 34 % of BDP occur domestically. Consumption categories with particularly high shares of BDP caused abroad are clothing and footwear (c03) with 98% of total impacts, household equipment and maintenance (c05) with 94%, alcoholic beverages, tobacco and narcotics (c02) with 88 % as well as recreation and culture (c09) with 85%.

Tab. 7.11 Disaggregation of the biodiversity footprint by consumption category: BDP in Switzerland and abroad caused by consumption of private households, the government and non-profit institutions as well as by capital formation. The consumption of private households is further divided into twelve categories (c01 to c12).

			Biodiversity damage potential			
			Domestic land use	Land use abroad	Total land use	Share in total
			km^2a settlement area-eq	km^2a settlement area-eq	km^2a settlement area-eq	
Consumption of private households			7'758	15'620	23'379	*87%*
	c01	Food and non-alcoholic beverage	4'501	9'107	13'608	*51%*
	c02	Alcoholic beverages, tobacco and narcotics	100	723	823	*3%*
	c03	Clothing and footwear	18	817	835	*3%*
	c04	Housing and energy	1'068	295	1'363	*5%*
	c05	Household equipment and maintenance	37	541	578	*2%*
	c06	Health	400	636	1'036	*4%*
	c07	Transport	565	106	672	*3%*
	c08	Communications	12	33	45	*0%*
	c09	Recreation and culture	308	1'818	2'127	*8%*
	c10	Education	15	27	43	*0%*
	c11	Restaurants and hotels	658	1'113	1'771	*7%*
	c12	Misc. goods and services	77	403	480	*2%*
Consumption of the government and non-profit institutions			568	831	1'399	*5%*
Capital formation			668	1'309	1'977	*7%*
Total domestic final consumption (excl. exports)			8'994	17'761	*26'755*	*100%*

In a second analysis the contribution of the most important product groups to the consumption related BDP is shown. Tab. 7.12 shows the ten product groups, which cause the highest total BDP with a disaggregation into domestic land use and land used abroad. They cover a share of 67 % of the total BDP caused by Swiss consumption.

The biodiversity footprint is dominated by food products: three food product groups, namely processed meat (g15a), dairy products (g15e) and other food and tobacco products (g15jp16), account for a total of 30 % of the BDP caused by Swiss consumption. Hotel and restaurant services (g55) follow as the first non-food product group with 7% of the total, yet they need agricultural and food products as intermediate inputs. Product groups with a particularly high share of land use abroad are chocolate and confectionary (g15i), other food and tobacco products (g15jp16), grain mill and starch products (g15f) as well as bakery and farinaceous products (g15g). These product groups rely on agriculture that is mainly responsible for BDP.

Tab. 7.12 Disaggregation of the biodiversity footprint by product group: BDP in Switzerland and abroad caused by Swiss consumption.

			Biodiversity damage potential			
			Domestic land use	Land use abroad	Total land use	Share in total
			km^2a settlement area-eq	km^2a settlement area-eq	km^2a settlement area-eq	
1.	g15a	Processed meat	1'759	1'857	3'616	*14%*
2.	g15e	Dairy products	1'562	838	2'400	*9%*
3.	g15jp16	Other food products, tobacco products	110	1'859	1'970	*7%*
4.	g55	Serv. of hotels and restaurants	718	1'206	1'925	*7%*
5.	g15i	Chocolate and confectionery	79	1'682	1'761	*7%*
6.	g15g	Bakery and farinaceous products	168	1'481	1'649	*6%*
7.	g85	Health and social work services	494	777	1'271	*5%*
8.	g45	Construction services	1'173	0	1'173	*4%*
9.	g01j	Other vegetal products	398	715	1'113	*4%*
10.	g15f	Grain mill and starch products	54	867	921	*3%*
	Remaining product groups		2'478	6'478	8'956	*33%*
	Total		8'994	17'761	*26'755*	*100%*

7.4.5 Conclusions and outlook

A fraction of two thirds of the total BDP ultimately caused by Swiss consumption, which is 26'755 km^2a SA-eq in 2008, can be attributed to imported goods and services. Agriculture is by far the most important direct contributor to the BDP caused in Switzerland. The production of animal products accounts for a high share in the total biodiversity footprint from the consumption perspective (domestic and foreign land use). The environmentally-extended input-output table makes it possible to identify the key economic sectors and products ultimately responsible for the domestic and foreign BDP caused by Swiss consumption.

8 Conclusions and outlook

An input-output table (IOT) with sectoral disaggregation in agriculture, food processing industry, energy industry, transport, public administration as well as waste and wastewater management industry is extended by detailed data on the pollutant emissions and resource use of the individual sectors and the categories of final consumption. A total of 96 industry sectors and 20 final consumption categories are distinguished in the present EE-IOT. The use of imported goods and services by industries and households is taken into account separately from the use of domestic goods and services.

The uncertainty of the EE-IOT is not systematically assessed in this study. It varies depending on the quality of the data used for the allocation of pollutant emissions or resource use to the economic sectors and to final demand categories. The uncertainty is expected to be lower for environmental impacts and economic sectors with good data availability than for cases in which auxiliary variables are employed for the allocation of environmental impacts.

The three midpoint indicators GHG emissions, eutrophication potential and BDP are evaluated with the EE-IOT. From the consumption perspective, the environmental impacts according to the three indicators are strongly influenced by imports of goods and services. Between 51 % (eutrophication potential) and 66 % (BDP) of the total environmental impacts caused by Swiss consumption in 2008 occur abroad.

The final demand categories housing and energy and transport are responsible for a significant share of the domestic greenhouse gas emissions and the biodiversity damage potential. The waste and wastewater management sector is identified as an important direct contributor to the eutrophication potential. Agriculture causes an important share of the domestic environmental impacts in all three indicators analysed.This finding is in line with a previous study (Jungbluth et al. 2011). The disaggregation of the agricultural sector into 17 subsectors in the EE-IOT 2008 allows the differentiation between agricultural product groups. According to the midpoint indicators analysed, farming of dairy and non-dairy cattle as well as the production of food cereals and feed crops cause the highest environmental impacts (in absolute terms) among the agricultural subsectors from the production perspective.

Several recommendations for future improvements of the EE-IOT can be formulated. Regarding the allocation of domestic emissions and resource use to the economic sectors and to final demand categories, the data basis is considered not very robust for many water pollutants, particularly for diffuse emissions and POPs. The allocation of the energy consumption of the food processing industry to the subsectors could be improved if more data on the specific energy consumption and the production volumes of the subsectors were available. Hence, more detailed national environmental statistics and industry data are desirable to improve the allocation of domestic environmental impacts to the economic sectors and to final demand.

The quantification of the environmental impacts of commodity imports could be improved if the imports and exports of platinum and palladium for monetary purposes were distinguished from other uses such as the manufacture of watches. This differentiation is already being made for gold and could also be implemented for platinum and palladium in the trade statistics in order to take account of the potentially high environmental impacts of these metals. Furthermore, the LCI data underlying the different categories of commodity imports could be regionally differentiated. This measure would make it possible to take differences in the environmental intensity of the manufacturing of products into account.

The degree of disaggregation of the economic sectors chosen in this study is deemed appropriate for the identification of the most important contributors to different environmental midpoint indicators. A more detailed disaggregation does not seem to be practical because of the lack of a corresponding level of detail in the available data. One exception where a future disaggregation may be useful and possible is the category hotels and restaurants, which could be represented as two separate sectors, because separate statistical data are available since the transition of national accounts to the NOGA 2008 classification.

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Annex: Industry, consumption and import codes

Tab. A.1 Overview of the industry sectors distinguished in the Swiss EE-IOT 2008 as well as their output (without own consumption of the respective sector) and their number of employees (FTE: full-time equivalents)

Code	Name	Output (Mio. CHF)	Employees (FTE)
g01a	Food cereals	360	2'111
g01b	Feed cereals	416	2'335
g01c	Sugar crops	179	1'364
g01d	Root and tuber crops	187	1'501
g01e	Vegetables	647	9'278
g01f	Fruits	327	2'895
g01g	Grapes	755	7'967
g01h	Oil-bearing crops	117	971
g01i	Pulses	13	82
g01j	Other vegetal products	818	1'901
g01k	Non-dairy cattle	876	8'191
g01l	Pigs	1'155	4'118
g01m	Poultry	228	896
g01n	Laying hens and eggs	184	722
g01o	Dairy cattle and raw milk	3'103	58'312
g01p	Other animal products	146	7'966
g01r	Horticulture and landscaping	2'115	17'812
g02	Products of forestry	717	4'882
g05	Fish, fishing products and services	38	359
g10b14	Mining and quarrying	2'072	4'607
g15a	Processed meat	4'803	10'436
g15b	Processed fish	78	206
g15c	Fruit and vegetable products	319	1'388
g15d	Oils and fats	503	386
g15e	Dairy products	4'658	10'834
g15f	Grain mill and starch products	683	1'227
g15g	Bakery and farinaceous products	2'068	8'996
g15h	Sugar	338	341
g15i	Chocolate and confectionery	2'155	5'649
g15jp16	Other food and tobacco products	6'114	11'595
g15k	Prepared animal feeds	1'502	1'662
g15l	Beverages	2'599	5'465
g17	Textiles	2'159	9'491
g18	Clothing	1'185	4'678
g19	Leather products	607	1'751
g20	Wood and wood products	6'011	35'900
g21	Pulp, paper and paper products	4'329	11'691
g22	Publishing and printing products	10'225	39'112
g23a	Refined petroleum products	4'738	761
g23b	Nuclear fuels	0	0
g24a	Chemicals and chemical products	17'072	39'818
g24b	Pharmaceutical products	46'064	26'150

Tab. A.1 Overview of the industry sectors distinguished in the Swiss EE-IOT 2008 as well as their output (without own consumption of the respective sector) and their number of employees (FTE: full-time equivalents) (continued)

Code	Name	Output (Mio. CHF)	Employees (FTE)
g25	Rubber and plastic products	8'885	24'127
g26	Other non-metallic mineral products	5'737	18'027
g27	Basic metals	7'632	15'092
g28	Fabricated metal products	20'856	86'517
g29	Machinery	36'200	99'087
g30p31	Computer and electrical industry	19'424	38'142
g32	Communication equipment	8'306	25'166
g33	Precision instruments, watches	40'166	89'903
g34	Motor vehicles	1'988	5'177
g35	Other transport equipment	5'820	15'566
g36	Furniture; other products	5'548	22'544
g37	Recycling services	1'605	3'592
g40a	Running hydro power plants	938	843
g40b	Storage hydro power plants	1'474	1'212
g40c	Nuclear power plants	1'238	1'711
g40d1	Other fossil public power plants (incl. CHP)	11	3
g40d2	Wood power plants (incl. CHP)	5	11
g40d3	Wind power and PV plants	7	4
g40e	Electricity distribution and trade	14'252	16'296
g40f	Public heat supply	315	339
g40g	Gas supply	2'398	817
g41	Collection, purification and distribution of water	1'376	2'611
g45	Construction	56'717	292'667
g50	Vehicles and fuels trade	12'625	81'726
g51p52	Wholesale and retail trade, repair	117'434	437'596
g55	Hotels and restaurants	23'469	185'574
g60a	Passenger rail transport	4'415	15'217
g60b	Goods rail transport	1'535	4'165
g60c	Rail infrastructure	2'341	11'472
g60d	Other scheduled passenger land transport	2'366	16'474
g60e	Taxi operation, other land passenger transport	1'024	7'119
g60f	Freight transport by road	8'919	33'666
g60g	Transport via pipelines	149	140
g61	Water transport	5'520	2'449
g62	Air transport	7'071	8'672
g63a	Water transport infrastructure	19	36
g63b	Air transport infrastructure / Airports	1'100	3'434
g63c	Other transport services	7'272	53'560
g64	Post and telecommunications	17'862	60'716
g65	Financial services	56'467	139'170
g66	Insurance services	31'335	46'441
g70p97	Real estate activities	69'683	51'268
g71p74	Renting and other business services	61'151	302'683
g72	Computer services	15'615	64'658
g73	Research and development	11'156	18'413
g75a	Road infrastructure	6'237	9'164
g75b	Public administration services	20'330	118'197
g80	Education	32'864	178'378
g85	Health and social work	52'643	372'248

Tab. A.1 Overview of the industry sectors distinguished in the Swiss EE-IOT 2008 as well as their output (without own consumption of the respective sector) and their number of employees (FTE: full-time equivalents) (continued)

Code	Name	Output (Mio. CHF)	Employees (FTE)
g90a	Electricity from waste incineration	157	218
g90b	Heat from waste incineration	120	121
g90c	Other sewage and refuse disposal, sanitation, similar activities	6'350	18'724
g91p92	Membership organizations, recreation, culture, sports	15'559	79'247
g93p95	Personal services	5'124	67'420

Tab. A.2 Overview of the final consumption categories distinguished in the Swiss EE-IOT 2008 and the consumption expenditures in each category

Code	Name	Final consumption (Mio. CHF)
c01	Food and non-alcoholic beverage	29'319
c02	Alcoholic beverages, tobacco and narcotics	10'992
c03	Clothing and footwear	10'394
c04	Housing and energy	77'175
c05	Household equipment and maintenance	13'144
c06	Health	44'292
c07	Transport	28'521
c08	Communications	7'579
c09	Recreation and culture	25'957
c10	Education	1'742
c11	Restaurants and hotels	21'836
c12	Miscellaneous goods and services	39'159
c_npish	Consumption expenditure of non-profit institutions	10'581
c_gov	Consumption expenditure of government	55'888
c_socsec	Consumption expenditure of social security	2'992
inv_eq	Equipment investments	71'653
inv_bld	Building investments	49'109
d_inv	Changes in inventories	3'535
n_acq	Net acquisition of valuables	983
exp	Exports	308'162

Tab. A.3 Overview of the categories of commodity imports distinguished in the Swiss EE-IOT 2008

Code	Name
SITC-00	Live animals other than animals of division 03
SITC-01	Meat and meat preparations
SITC-02	Dairy products and birds' eggs
SITC-03	Fish, crustaceans, molluscs and aquatic invertebrates, and preparations thereof
SITC-04	Cereals and cereal preparations
SITC-05	Vegetables and fruit
SITC-06	Sugars, sugar preparations and honey
SITC-07	Coffee, tea, cocoa, spices, and manufactures thereof
SITC-08	Feeding stuff for animals (not including unmilled cereals)
SITC-09	Miscellaneous edible products and preparations
SITC-11	Beverages
SITC-12	Tobacco and tobacco manufactures
SITC-21	Hides, skins and furskins, raw
SITC-22	Oil-seeds and oleaginous fruits
SITC-23	Crude rubber (including synthetic and reclaimed)
SITC-24	Cork and wood
SITC-25	Pulp and waste paper
SITC-26	Textile fibres (other than combed wool) and their wastes
SITC-27	Crude fertilizers and crude minerals
SITC-28	Metalliferous ores and metal scrap
SITC-29	Crude animal and vegetable materials, n.e.s.
SITC-32	Coal, coke and briquettes
SITC-33	Petroleum, petroleum products and related materials
SITC-34	Gas, natural and manufactured
SITC-35	Electric current
SITC-41	Animal oils and fats
SITC-42	Fixed vegetable fats and oils, crude, refined or fractionated
SITC-43	Animal or vegetable fats and oils, processed
SITC-51	Organic chemicals
SITC-52	Inorganic chemicals, excluding uranium products
SITC-52 U	Uranium products
SITC-53	Dyeing, tanning and colouring materials
SITC-54	Medicinal and pharmaceutical products
SITC-55	Essential oils, resinoids, perfume materials, and cleansing preparations
SITC-56	Fertilizers (other than those of group 272)
SITC-57	Plastics in primary forms
SITC-58	Plastics in non-primary forms
SITC-59	Chemical materials and products, n.e.s.
SITC-61	Leather, leather manufactures, n.e.s., and dressed furskins
SITC-62	Rubber manufactures, n.e.s.
SITC-63	Cork and wood manufactures (excluding furniture)
SITC-64	Paper, paperboard and articles of paper pulp, of paper or of paperboard
SITC-65	Textile yarn, fabrics, made-up articles, n.e.s., and related products
SITC-66	Non-metallic mineral manufactures, n.e.s.
SITC-67	Iron and steel
SITC-68	Non-ferrous metals
SITC-69	Manufactures of metals, n.e.s.

Tab. A.3 Overview of the categories of commodity imports distinguished in the Swiss EE-IOT 2008 (continued)

Code	Name
SITC-71	Power-generating machinery and equipment
SITC-72	Machinery specialized for particular industries
SITC-73	Metalworking machinery
SITC-74	General industrial machinery and equipment, n.e.s., and machine parts, n.e.s.
SITC-75	Office machines and automatic data-processing machines
SITC-76	Telecommunications and sound-recording and reproducing apparatus and equipment
SITC-77	Electrical machinery, apparatus and appliances
SITC-78	Road vehicles (including air-cushion vehicles)
SITC-79	Other transport equipment
SITC-81	Prefabricated buildings; sanitary, plumbing, heating and lighting fittings
SITC-82	Furniture, and parts thereof; bedding, mattresses, mattress supports, cushions
SITC-83	Travel goods, handbags and similar containers
SITC-84	Articles of apparel and clothing accessories
SITC-85	Footwear
SITC-87	Professional, scientific and controlling instruments and apparatus, n.e.s.
SITC-88	Photographic apparatus, equipment and supplies and optical goods; watches and clocks
SITC-89	Miscellaneous manufactured articles, n.e.s.
SITC-93	Specific trade incidents
SITC-97	Gold, non-monetary (excluding gold ores and concentrates)

Tab. A.4 Overview of the categories of service imports distinguished in the Swiss EE-IOT 2008 (GLO: global average)

Code	Name
g01b05 GLO	Primary sector
g10b14 GLO	Mining and quarrying
g15b16 GLO	Food and tobacco products
g17 GLO	Textiles
g18 GLO	Clothing
g19 GLO	Leather products
g20 GLO	Wood and wood products
g21 GLO	Pulp, paper and paper products
g22 GLO	Publishing and printing products
g23 GLO	Refined petroleum products
g24 GLO	Chemical and pharmaceutical products
g25 GLO	Rubber and plastic products
g26 GLO	Other non-metallic mineral products
g27 GLO	Basic metals
g28 GLO	Fabricated metal products
g29 GLO	Machinery
g30b31 GLO	Computers and electrical equipment
g32 GLO	Communication equipment
g33 GLO	Medical and optical instruments, watches
g34 GLO	Motor vehicles
g35 GLO	Other transport equipment
g36 GLO	Other manufacturing
g37 GLO	Recycling services
g40b41 GLO	Energy and water
g45 GLO	Construction
g50 GLO	Vehicles and fuels trade
g51b52 GLO	Wholesale and retail trade
g55 GLO	Hotels and restaurants
g60b62 GLO	Transport
g63 GLO	Auxiliary transport
g64 GLO	Post and telecommunications
g65 GLO	Financial intermediation
g66 GLO	Insurance and pension funding
g70 GLO	Real estate activities
g71u74 GLO	Renting and other business services
g72 GLO	Informatics
g73 GLO	Research and development
g75 GLO	Public administration
g80 GLO	Education
g85 GLO	Health and social work
g90 GLO	Disposal services
g91b92 GLO	Membership organizations, recreation, culture, sports
g93b95 GLO	Personal services