Economy-wide Material Flow Accounts (EW-MFA)

Compilation Guide 2013

10 September 2013

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Preface

The European Strategy for Environmental Accounting (ESEA) identifies Economy-wide Material Flow Accounts (EW-MFA) as one core module of Environmental Accounts to be produced regularly and in a timely fashion in order to support policy making.

EW-MFA has been included as one of three modules in Regulation (EU) No 691/2011 on European Environmental Economic Accounts which will enter into force with the 2013 data collection.

By providing this 2013 version of the EW-MFA Compilation Guide Eurostat is attempting to further improve the methodological foundation for harmonised EW-MFA across Europe. The primary objective is to facilitate and support the compilation of the 2013 questionnaire.

Acknowledgements

The 2013 version of EW-MFA Compilation Guide is based on earlier versions and has been drafted by Eurostat's contractors (Karl Schoer in cooperation with Jan Kovanda and Christoph Lauwigi). We would like to thank the following members of the MFA Task Force for their review of the draft and their valuable contributions: Florian Kohler, Sacha Baud, Ursula Lauber, and Sven Kaumanns. We further would like to thank our colleagues Johan Selenius and Annemiek Kremer for their comments.

Introduction: 2013 Compilation Guide for Economy-wide Material Flow Accounts (EW-MFA)

Summary

The first version of Eurostat's "Economy Wide Material Flow Accounts: Compilation Guidelines" was released in draft form in 2007. It has been used by national statistical offices to support the collection of EW-MFA data and to complete the EW-MFA questionnaire sent out by Eurostat in 2007. Revised versions of the compilation guide were prepared for supporting the data collections via the 2009, 2011, and the 2012 questionnaire.

This 2013 version of the Compilation Guidelines refers to the 2013 EW-MFA Questionnaire. The revisions in the 2013 version are minor and a result of feedbacks from and discussions with experts from national statistical offices. The changes compared to the previous 2012-version can be summarized as following:

- Table 14 has been changed
- Some PRODCOM codes from Annex 2 were changed or removed respectively (see minutes of the meeting of the Task Force on Material Flows June 2013)
- Chapter 8 on Domestic Processed Output (Table F) has been inserted (it originates from the earlier Compilation Guide 2009 and has not been improved)
- Formula after Table 6 on "grazed biomass" has been changed
- Section 7.3 on residence adjustments has been revised

The 2013 EW-MFA Questionnaire has seen the following revisions:

- Annex 1: adjusted to changes in crop statistics
- Annex 3 and 4 of EW-MFA-Questionnaire have been up-dated towards CN2012 and CN2013

Major changes already introduced in the 2012 version of the EW-MFA Compilation Guide (compared to 2011 version) had been the following:

- More supporting information was added as Annexes to the questionnaire. The revision work focussed on improving the chapters on domestic extraction of metal ores and non-metallic minerals. Here some effort was put on explaining the quality and the relationship of the data sources in some more detail.
- Hunting: The conversion table for the weight of hunted animals was amended and includes now about 150 animals.
- Metal ores: The default conversion factors from metal content and from concentrate to gross ore (Table 12) have been revised by using the results of a Eurostat project on calculating raw material equivalents of product flows.
- Non-metallic minerals: The section of non-metallic minerals was restructured. Reference was made to approaches for detecting underreporting by crosschecking with monetary information. It was tried to assign the materials which are reported by USGS and BGS to the classifications which are used for EW-MFA and for PRODCOM.

- External trade: Tables with EU-level conversion factors were added to the compilation manual for imported or exported goods which might not be reported in tonnes for all countries but only in other physical units, like pieces.

Purpose of EW-MFA

The general purpose of economy-wide material flow accounts (EW-MFA) is to describe the interaction of the domestic economy with the natural environment and the rest of the world economy (ROW) in terms of flows of materials (excluding water and air). The economy is demarcated by the conventions of the national accounting system (resident units).

In Eurostat's EW-MFA material inputs to the economy cover extractions of materials (excluding water and air) from the natural environment and imports of material products (goods) from the ROW. Material outputs are disposals of materials to the natural environment and exports of material products and waste to the ROW.

Only flows crossing the system boundary (between the environment and the economy) on the input-side or on the output-side are counted. Material flows within the economy are not represented in EW-MFA.

Relationship of EW-MFA to other accounting systems

EW-MFA can be regarded as a sub-module to the System of Integrated Environmental and Economic Accounting (SEEA[1]). This implies a close conceptual relationship to the System of National Accounts (SNA[2]) and its European version (ESA[3]). The ESA is the European standard system for the compilation of economic statistics and derivation of economic indicators in monetary terms, among which the gross domestic product (GDP) is most established. This system is expanded by different environmental physical accounts, among them EW-MFA, supplementing the monetary economic accounting system with information in mass units on physical flows between the economy and the environment and other economies.

The EW-MFA is also closely related to the Economic Accounts for Agriculture (EAA) and the Integrated System of Environmental and Economic Forestry Accounts (IEEAF), which are elaborations of the ESA for the agricultural and the forestry sector. Further, EW-MFA is related to other physical flow modules of the European environmental accounting system, like the Air Emissions Accounts and Physical Energy Flow Accounts. The concepts, accounting rules, and classifications of EW-MFA are harmonized as far as possible with ESA95 and SEEA and the above mentioned sub-modules to ESA and SEEA. The harmonization of EW-MFA with ESA and the other parts of the accounting system has the advantage that those data – beyond being used for establishing general environmental indicators such as Domestic Extraction Used (DEU), Direct Material Input (DMI) and Domestic Material Consumption (DMC) – can be applied in hybrid environmental-economic analyses which combines physical data on environmental pressures with the monetary data on the economic driving forces (e.g. Input-Output Tables).

Data sources

[1] http://unstats.un.org/unsd/envaccounting/default.asp
[2] http://unstats.un.org/unsd/nationalaccount/sna.asp
[3] http://epp.eurostat.ec.europa.eu/portal/page/portal/esa_2010/introduction

EW-MFA is a systematic and comprehensive conceptual framework which consists of accounting rules, definitions, and classifications. For populating the EW-MFA framework with data various statistical sources have to be used. Those original sources have to be reformatted and amended in order to comply with the concepts of the EW-MFA accounting system.

In principal all available sources should be regarded for establishing the accounting estimates. There are three principal categories of data sources: specific national sources, EU-wide harmonized sources and some important international sources, like FAO, BGS, and USGS.

As a general rule priority should be given to national data sources.

In this compilation guide, however, the specific national data sources could only be addressed in a general manner due to their diversity. Therefore much focus is put on describing how EU-wide harmonised sources and some international sources could be used for filling the conceptual framework of the accounting system.

Notwithstanding it is recommended as a general rule to use national data sources. National sources include besides specific national data also EU-wide harmonised statistics, like production statistics (PRODCOM), external trade statistics (COMEXT), energy and agricultural statistics. But sometimes the national version of the EU-wide harmonised sources may provide some more detailed information.

International sources should preferably be consulted for crosschecking and for filling gaps which are not covered by national sources or in cases where the quality of the national sources is considered not to be sufficient.

Eurostat's 2013 EW-MFA questionnaire

Eurostat's EW-MFA questionnaire is designed to facilitate data organisation and provide an important tool in the process of EW-MFA compilation. It is an EXCEL workbook comprising:

- eight sheets (data tables A to H) where the material flow data are to be filled in; the data tables have a hierarchical classification structure differentiating four levels of detail;
- five sheets with so called compilation tools supporting a harmonised estimation of various items of the accounts where statistical sources are likely lacking;
- nine Annexes (see last page) with various listings such as correspondence keys between different classifications aiming at facilitating the actual compilation.

Table A

Data on **domestic extraction used (DEU)** of biomass, metal ores, non-metallic minerals, and of fossil energy carriers have to be entered into **Table A**.

Tables B to E

Tables B to **E** are designed for the organisation of data on **trade flows (imports and exports)**.

In **Table B** (total imports) and **Table D** (total exports) data on *total* trade flows are requested. In the case of EU Member States this is the sum of intra and extra EU trade flows.

Table C (imports extra-EU27) and **Table E** (exports extra-EU27) request data on extra-EU27 trade. This is only applicable to EU Member States and refers to the trade volume which occurs with non EU27 states.

All trade data employ a classification of material flows similar to the classification employed for domestic extraction used (Table A). The major difference is that the traded goods constitute not only primary but also processed material. The latter may consist of *biomass*, *metal ores and concentrates*, *non-metallic minerals*, *fossil energy carriers*, or *waste imported for final treatment and disposal*. Products which cannot be clearly identified as belonging to one of the four material categories should be included under *other products*.

In 2011 an additional (voluntary) dimension has been introduced into the trade tables B to E: stage of manufacturing. This dimension distinguishes three broad groupings of traded goods: raw products, semi-manufactured products, and finished products.

Data on discharges from the economy into the environment are organised in **Table F** as **domestic processed output (DPO).** It may consist of *emissions to air* (F.1.) or *water* (F.3.), *waste* (F.2.) or *discharges that result from the dissipative use of products*[4] (F.4.) as would be the case in the application of fertilizer, for example. Additionally, data on *dissipative losses*[5] (F.5.) are entered into this table.

Balancing items are represented in **Table G**. These data are organised according to whether they comprise those gases required on the input side (G.1.) to balance a given output which is already accounted for, or gases which must be considered on the output side (G.2.) to balance a given input.

Data collected and organised in Tables A to G are used to derive/aggregate various **indicators** which are reported in **Table H**. Based on known volumes of *domestic extraction used* (H.1.), *imports* (H.2.), and *exports* (H.3.), the *direct material input DMI* (H.4.), *domestic material consumption DMC* (H.5.), and the *physical trade balance* (H.6.) can be calculated. By additionally considering *domestic processed output* DPO (H.7.) and *balancing items* (Table G), *net additions to stock* (H.8.) may be determined.

[4] I.e. dispersion of materials as a consequence of product use on agricultural land or roads
(e.g. fertilizers and manure spread on fields, or salt, sand and other thawing materials spread on roads).
[5] I.e. dispersion of materials as a consequence of the corrosion and abrasion of products
and infrastructures, leakages, etc. (e.g. rubber worn away from car tires, particles worn from friction products such as brakes, abrasion from roads, losses due to evaporation of e.g. water or other solvents used in paints or other coatings).

Table A – Domestic Extraction Used

Material inputs from the natural environment to the economy are called ***domestic extraction***. The extraction of materials from the environment is a specific type of economic production process. This refers to the purposeful extraction or movement of natural materials by humans or human-controlled means of technology. Not all materials that are deliberately extracted or moved in the extraction process ultimately enter the economy; and not all materials are moved with the intention of using them in the economy. Therefore one distinguishes between ***used*** and ***unused extraction***.

Eurostat's EW-MFA questionnaire – and hence this compilation guide – does not include *unused* extraction.

"*Used* refers to an input for use in any economy, i.e. whether a material acquires the status of a product. […] *Unused* flows are materials that are extracted from the environment without the intention of using them, i.e. materials moved at the system boundary of economy-wide EW-MFA on purpose and by means of technology but not for use" (Eurostat 2001: 20). Examples of unused extraction are soil and rock excavated during construction or overburden from mining, the unused parts of felling in forestry, the unused by-catch in fishery, the unused parts of the straw harvest in agriculture or natural gas flared or vented.

1 Biomass

1.1 Concepts and classification

Cultivated and non-cultivated biomass:

Biomass in general comprises organic non-fossil material of biological origin. Not all generated biomass is regarded to be domestic extraction in Eurostat's EW-MFA. Two major types of creation of biomass can be identified:

- Biomass is generated within the environment by a natural process which is outside human control, such like non-cultivated forests, the growth of wild animals, wild fish, wild mushrooms, or wild berries.
- Biomass is generated by a cultivation process which takes place more or less under human control, like production of agricultural crops and plants, timber, firewood, cultivated animals and their products, like milk, eggs, wool, honey, cultivated fish, and other cultivated aquatic products.

For the purpose of Eurostat's EW-MFA certain accounting conventions have been established that clarify whether a certain generation of biomass is assigned to domestic extraction or not. These conventions reflect specific requirements of accounting for physical flows from the environment to the economy, the availability of data, as well as the specific European production conditions. The elements of the accounting convention are presented in Table 1.

Please note that in Eurostat's EW-MFA the treatment of cultivated crops (A.1.1), their residuals (A.1.2) and cultivated tress (A.1.3) differ from the treatment in the Physical Supply Use Tables framework of the SEEA Central Framework (see SEEA 2012, chapter 3). For these three cases, in EW-MFA, the flow from the environment to the economy is recognised at the point of harvest. In the SEEA this point is recognised earlier at the nutrient, water and air input to cultivated plants as the latter already belong to the economy. EW-MFA assumes that the quantities harvested embody all of the different natural inputs and hence can be used as a proxy. The harvested amount can be more easily measured at macro-economic level (e.g. agricultural and forestry statistics).

Table 1: Treatment of generation of biomass in Eurostat's EW-MFA

EW-MFA category	Biomass from…
Domestic extraction of non- cultivated (wild) biomass	Hunting of wild animals other than aquatic animals
	Gathering of wild crops and plants
	Catch of wild fish
	Catch of all other wild aquatic animals and plants
	Extraction from non-cultivated forests
Domestic extraction of cultivated biomass	Cultivation of agricultural crops and plants
	Cultivation of trees (excluding change in inventories of standing timber)
Not regarded as domestic extraction	Cultivation of animals other than aquatic animals (live animals and animal products)
	Cultivation of fish (aquaculture)
	Cultivation of all other aquatic animals and plants

Classification:

The classification of material flows for domestic extraction of biomass is based on that fundamental demarcation. Table 2 presents the classification. Annex 1 of the 2013 EW-MFA questionnaire shows the correspondences between EW-MFA codes for biomass and various Eurostat statistics (such as e.g. agricultural crop statistics, forestry statistics, fishery statistics etc.).

The classification of material flows for domestic extraction of biomass has four sections at the two digit level: A.1.1 *Crops (excluding fodder crops)*, A.1.2 *Crop residues (used), fodder crops and grazed biomass*, A.1.3 *Wood*, and A.1.4 *Fish catch, aquatic plants/animals, hunting and gathering*.

The items A.1.1 and A.1.2 cover the biomass from agricultural crop and plant cultivation, item A.1.3 represents biomass from cultivated forests, and item A.1.4 comprises all biomass extraction from non-cultivated (wild) biomass.

Agricultural biomass:

(A.1.1) Crops (excluding fodder crops): include primary harvest of all crops from arable land and permanent cultures (excluding fodder crops). This includes major staple foods from crop and garden land such as cereals, roots and tubers, pulses, vegetables as well as commercial feed crops, industrial crops and all fruits and nuts from permanent cultures.

(A.1.2) Crop residues (used), fodder crops and grazed biomass: In most cases, primary crop harvest is only a fraction of total plant biomass of the respective cultivar. The residual biomass, such as straw, leaves, stover etc., often is subject to further economic use. A large fraction of crop residues is used as bedding material in livestock husbandry but crop residues may also be used as feed, for energy production, or as industrial raw material. In EW-MFA used crop residues are regarded as domestic extraction, disregarding whether they are sold or used for intra-unit consumption. Residues which are left in the field and ploughed into the soil or burned in the field are not accounted for as used extraction. EW-MFA distinguishes between two types of crop-residues:

- A.1.2.1.1 *Straw of cereals (all harvested straw of cereals including maize)*, and
- A.1.2.1.2 *all other crop-residues*.

For most European countries *other crop residues* will refer to tops and leaves of sugar beets and only occasionally to residues from other crops (e.g. sugar cane, etc.).

Table 2: Classification of material flows for domestic extraction used – biomass

A.1 Biomass			
	A.1.1 Crops (excluding fodder crops)		
		A.1.1.1 Cereals	
		A.1.1.2 Roots, tubers	
		A.1.1.3 Sugar crops	
		A.1.1.4 Pulses	
		A.1.1.5 Nuts	
		A.1.1.6 Oil-bearing crops	
		A.1.1.7 Vegetables	
		A.1.1.8 Fruits	
		A.1.1.9 Fibres	
		A.1.1.10 Other crops n.e.c.	
	A.1.2 Crop residues (used), fodder crops and grazed biomass		
		A.1.2.1 Crop residues (used)	
			A.1.2.1.1 Straw
			A.1.2.1.2 Other crop residues (sugar and fodder beet leaves, other)
		A.1.2.2 Fodder crops and grazed biomass	
			A.1.2.2.1 Fodder crops (including biomass harvest from grassland)
			A.1.2.2.2 Grazed biomass
	A.1.3 Wood (in addition, optional reporting of the net increment of timber stock.)		
		A.1.3.1 Timber (industrial round-wood)	
		A.1.3.2 Wood fuel and other extraction	
		A.1.3.M Net increment of timber stock (memo item)	
	A.1.4 Wild fish catch, aquatic plants/animals, hunting and gathering		
		A.1.4.1 Wild fish catch	
		A.1.4.2 All other aquatic animals and plants	

A.1.4.3 Hunting and gathering

(refers to Table A.1 of the EW-MFA questionnaire)

For most classification entries for agricultural biomass corresponding items can be identified in the classification of agricultural crop statistics (see Annex 1). Exemptions are other crops (A.1.1.10) and used crop residues (A.1.2.1) like straw and sugar and fodder beet leaves.

For *other crops* the sub-items *tobacco* (C1550), *hops* (C1560), *other industrial crops* (C1570), and *other permanent crops n.e.c.* (C2980) are included in the classification of the agricultural crop statistics. The remaining items of *other crops* which are not covered by crop statistics (like *outdoor flowers and ornamental plants, under glass flowers and ornamental plants, wooded area with short rotation*, and *seeds and seedlings*) can be found in the classification of agricultural land use in the Farm Structure Survey data set (see Table 3) as well as in the classification of the Economic Accounts for Agriculture.

The items for *crop residues* are not covered by any other European statistics; currently some data for some countries are available in the Gross Nutrient Balances.

(A.1.3) Wood: This item records the biomass from cultivated and non-cultivated forests, whereby the latter is quantitatively less important in Europe.

As far as the classification entries for wooded biomass are concerned (A.1.3), the items A.1.3.1 timber (industrial round-wood) and part of A.1.3.2 wood fuel and other extraction is covered by the classification of the forestry statistics. However the remaining part (other forest extraction) of item A.1.3.2 which refers to items such as cork and other forestry products is only reported in the classification for the Environmental and Economic Accounts for Forestry.

Net increment of timber stock: The classification entry A.1.3.M *Net increment of timber stock* is a memorandum item which refers to a specific borderline issue. That item is indirectly represented in the classification of the forestry statistics as INC_FAWS “Increment in forests available for wood supply”. This item denotes the total annual increment whereas the EW-MFA classification refers to stock change (totals increment minus felling).

As the EW-MFA data have to serve different analytical purposes item 1.3.M is required for bridging different concepts regarding the output of timber cultivation. For the purpose of establishing the central EW-MFA indicators, like DMI and DMC, only the harvested timber is regarded as domestic extraction and not the total growth of trees. This is different from the conventions in the IEEAF and ESA 95. There, the total natural growth (annual increment) of cultivated timber is always considered to be economic output of cultivation of trees, which accumulates in inventories (work in progress) until timber is harvested, and the difference between total economic output (i.e. annual increment) and felling is the change in inventories of standing timber. In the IEEAF, the change in inventories of standing timber (work in progress) is regarded as stock change.

The approach of EW-MFA follows the perception that environmental pressures related to the extraction of timber are well represented by the harvest of timber, whereas adding to the stock of standing timber should be regarded as a rather positive effect from an environmental viewpoint.

For most member countries the annual net increment of timber is substantially higher than the annual felling. For a hybrid analysis, like combining these physical data with monetary data, e.g. in environmental economic input-output analysis, it is necessary to demarcate the monetary and the corresponding flows in a uniform manner. Therefore EW-MFA reports the change in inventories of standing timber additionally as a memorandum item.

(A.1.4) Non-cultivated biomass: The entries for the extraction of **wild aquatic biomass** (A.1.4.1 and A.1.4.2) are reported in the European fishery statistics. It has to be noted that data are reported separately for cultivated and non-cultivated aquatic biomass. According to the above mentioned convention for demarcating the extraction of biomass only non-cultivated fish and other aquatic animal and plants have to be included in EW-MFA. Out of the entry *hunting and gathering* (A.1.4.3) only gathering is covered by the classification of the agricultural crop statistics (C3718 *Wild products (truffles, other mushrooms, grape hyacinth-bulbs = volvos (GR), etc..*.) and C3719 *Wild products*). However, hunting is not covered by the classification of any other European statistical source. (For details on how to deal with this see 1.3.4.2)

Biomass waste from management of parks, infrastructure areas, gardens etc.:

A significant amount of biomass is generated as a by-product of management of home gardens, infrastructure areas, public parks, and sports facilities etc. A certain fraction of this biomass flow, which comprises mown grass, woody biomass, residues from pruning and foliage etc., may be subject to further economic use, e.g. for energy generation or the production of compost or it may appear in waste statistics. According to EW-MFA system boundaries, these fractions are regarded as domestic extraction of biomass (domestic processed output, respectively). However, due to lack of reliable data and estimation procedures they are currently not accounted for. Recently, this biomass flow has received increasing attention in the context of strategies for sustainable resource use and might be included at a later stage of EW-MFA method development.

1.2 Data sources

Statistical reporting of biomass extraction has a long tradition. Most fractions of biomass harvest are reported by national statistical offices (or national offices concerned with agriculture and forestry) in their series of agricultural, forestry, and fishery statistics. Additional information useful for biomass accounts may be provided by national food, feed, and wood balances. The accounting frameworks are well established and show a high degree of international standardisation and accuracy.

The collection of many data on biomass is harmonized at the European level. The most important harmonized basic data for the calculation of domestic extraction of biomass at the national and the European level are:

- Agricultural crop statistics
- Forestry statistics
- Fishery statistics

Those sources provide data in mass units.

Supplementary sources for closing gaps and for cross-checking are:

- land use statistics from the Farm Structure Survey (FSS);
- Economic Accounts for Agriculture (EAA);
- Integrated Environmental and Economic Accounts for Forestry (IEEAF).

The FSS provide data on area use. The EAA primarily report in monetary units, but internally the monetary estimates are usually based on physical statistical data or estimates. The IEEAF publish data in mass unit as well as in monetary units. However IEEAF results are only available for a few member countries so far.

Another rather comprehensive international source of data on biomass extraction is the statistical database provided by the United Nations Food and Agricultural Organization. The FAO database covers a huge range of data concerning agriculture, forestry, and fishery, and the food system on the level of nation states in time series since 1961.

1.3 Data compilation

1.3.1 General approach

Primary sources: Generally it can be stated that most part of extraction of biomass is covered well by national and European data from harmonised statistical sources as:

- agricultural crop statistics,
- forestry statistics, and
- fishery statistics.

Those data are reported in mass units and can usually be used for the compilation without further processing. An exception is the issue of standardisation of moisture content of fodder crops (see below).

It is recommended using those data as primary source for compilation. However, whenever possible, the results should be cross-checked with other national (e.g. EAA of IEEAF data) or international sources.

Data gaps: It has to be noted that if the above mentioned primary sources are applied, there may remain typical data gaps which have to be closed by additional statistical information or by estimation models.

Some entries of EW-MFA are outside the scope of the above primary statistics, i.e. they are not covered by the classification of that statistical source (see previous section 1.1 on classification). In other cases data for existing classification items may not be reported at the national level (missing data), data may be inaccurate or reporting could be systematically biased (e.g. under-reporting).

As far as agricultural crop production is concerned, it is recommended to refer to the respective results of **the EAA system as a general source for closing data gaps**. The EAA results are published in monetary terms. However, usually the compilation of the monetary results is internally based on physical data and estimates. Note that the EW-MFA is designed as a physical satellite system to the economic accounting system. Therefore it should be anyway taken care that the results of both systems are harmonised at the conceptual and at the data level.

Standard estimation procedures for closing typical data gaps of a considerable quantitative significance are described in the following sections.

1.3.2 Cultivated agricultural biomass

The domestic extraction of cultivated crops and plants are widely covered by the agricultural crop statistic. Major gaps refer to some individual crops under the entry *other crops n.e.c.* (A1.1.10) and to *crop residues (used)* (A1.2.1).

1.3.2.1 Conversion to standard moisture content

A characteristic feature of all types of biomass is its considerable moisture content (mc), which may account for more than 95% in the case of fresh living plant biomass. However, the moisture content is very variable across plant parts and species and vegetation periods. In many cases, biomass is harvested at low moisture content (e.g., cereals) or dried during the harvesting process (e.g., hay making). In accordance with agricultural statistics, biomass is accounted for at its weight at the time of harvest. A few crops may be harvested at different water contents (fresh weight (80-95% mc) or air dry (15% mc); in those cases, moisture content has to be standardised according to EW-MFA conventions. This applies only for the categories A.1.2.2.1 fodder crops and A.1.2.2.2 grazed biomass.

1.3.2.2 Data gap other crops n.e.c.

As already mentioned, some specific crops like flowers, Christmas trees and seeds and short rotation wood which are to be reported under the item other crops n.e.c. (A.1.1.10) are not covered by crop statistics. Alternative information on those items can be obtained from monetary reporting of EAA and from the agricultural land use statistics. Land use statistics reports the area under crops. The area information has to be converted into tonnes by employing yield factors. Preferably specific national information on average yields should be used.

If no national yield factors are available Table 3 presents approximate yield factors compiled by ifeu-Institute Heidelberg which may be applied.

Table 3: Average yield factors for selected agricultural crops and plants

Code FSS 1990-2007	Code FSS 2010	Crop/plant		Yield (t/hectare)
G05	B 45 HA	Nurseries	Average: expert estimate	51.3
D16	B 181 HA	Outdoor-flowers and ornamental plants	Aster	22.0
D17	B 182 HA	Under glass-flowers and ornamental plants	Rose	123.19
H02G	B 521 HA	Wooded area - with short rotation	Habitat of medium quality	9.1
			Habitat of good quality	12.9
D19	B 110 HA	Seeds and seedlings	Beet seeds	2.43 - 4.86
			Sugar beet seeds	0.9 - 1.8

Source: Compilation ifeu-Institut Heidelberg based on sources for Germany

In many cases, primary harvest is only a fraction of total plant biomass. The remaining crop-residues may be subject to further economic use. Used crop residues are regarded as domestic extraction (used) in EW-MFA. The most prominent example for this is (cereal) straw, which may either be used as bedding material for livestock, feed stuff, for energy generation or as raw material. Crop residues which are ploughed into the field or burnt are not accounted for as domestic extraction used.

However, those used crop residues which are usually used within the establishment are not reported by the agricultural crop statistics. If used crops residues are also not reported by other national sources[6] an estimation procedure has to be applied for the purpose of EW-MFA.

The following estimation approach is suggested:

Step 1: Identification of crops which provide residues for further socio-economic use.

In most cases this will include all types of cereals, sugar crops, and oil bearing crops. Only in exceptional cases do other crops need to be considered.

Step 2: Estimation of available crop residues via harvest factors

The procedure to estimate the amount of crop residues available is based on assumptions on the relation between primary harvest and residues of specific crops. In agronomics, different measures for this relation are used: the most prominent is the harvest index, which denotes the share of primary crop harvest of total aboveground plant biomass, and the grain to straw ratio. This relation is typical for each cultivar, however, subject to breeding efforts and therefore variable over time. Based on this, one can calculate a harvest factor, which allows for the extrapolation of total residue biomass from primary crop harvest. Typical harvest factors, which can be used in absence of national information, are provided in Table 4.

Available crop residues [t (as is weight)] = primary crop harvest [t (as is weight)] * harvest factor

Table 4: Standard values for harvest factors and recovery rates for the most common crop residues used in Europe

	Harvest factor	Recovery rate
Wheat	1	0.7
Barley	1.2	0.7
Oats	1.2	0.7
Rye	1.2	0.7
Maize	1.2	0.9
Rice	1.2	0.7
All other cereals	1.2	0.7
Rape seed	1.9	0.7
Soy bean	1.2	0.7
Sugar beet	0.7	0.9
Sugar cane	0.5	0.9

Source: Wirsenius 2000

[6] These amounts, at least in terms of monetary values (also for the intra-consumption) should be included in the background data of the Economic Accounts for Agriculture (EAA) as part of the intermediate consumption: - position 19063 Animal feedingstuffs – feedingstuffs produced and consumed by the same holding and 19900 other goods and services (for example for bedding materials). Both mentioned positions also include off course other flows so their total cannot be directly used but normally these crops residues are a part of it and should appear in the calculations of the EAA.

Step 3: Estimation of fraction of used residues

In most cases, only a certain fraction of the totally available crop-residue will be harvested and further used. The actual used fraction of residues (recovery rate) can be estimated based on expert knowledge or specific studies, but it should be noted that it may vary considerably between regions, countries, and over time. In cases in which no information on the country-specific share of used residues is available, recovery rates provided in Table 4 can be applied for European countries.

Used crop-residues [t (as is weight)] = available crop-residues [t (as is weight)] * recovery rate

1.3.2.3 Under-reporting of fodder crops and grazed biomass

The classification item A.1.2.2 fodder crops and grazed biomass subsumes different types of roughage including fodder crops, biomass harvested from grassland, and biomass directly grazed by livestock. Not included are commercial feed crops such as barley, grain maize, soy bean etc. the harvest of which has been counted elsewhere.

Reporting on fodder crops and grazed biomass can be voluntarily reported in crop statistics, but in practice many data gaps appear in national as well as in Eurostat’s crop production database in particular for grazed biomass.

If no complete and reliable data for both fodder crops and grazed biomass exist, estimation approaches have to be applied.

Two main estimation methods are possible, a supply-side approach or a demand-side approach. The supply-side approach attempts at closing gaps in production data for individual fodder crop categories. The demand-side approach takes the annual fodder requirement of the existing livestock as the starting point for estimating the total production of fodder crops. Ideally both approaches should be combined to crosscheck the results.

Supply-side approach:

Fodder crops: If data for item A.1.2.2.1 fodder crops (incl. biomass harvested from grassland) are missing in the crop statistics one should try to refer to internal estimates of EAA where fodder crops (including harvest from grassland) have to be completely covered in monetary terms. The underlying physical data or models of the EAA calculations could also be used for closing those gaps. As far as grass type fodder crops are concerned it has to be noted that data have to be reported in dry weight (15 % moisture). If data from the original sources (like national agricultural statistics, data from Eurostat’s reference database, or from other sources) are reported in wet weight they have to be converted accordingly.

Grazed biomass: A significant amount of fodder is directly taken up by animals from pastures (grazed biomass). Grazed biomass is regarded as domestic extraction according to the EW-MFA conventions.

However, in Eurostat’s crop production database data on the uptake of biomass from pasture[7]s is reported only for some few countries, as Estonia, France, Italy, Latvia, Lithuania, Luxemburg,

[7] Like for crop residues, the grazing biomass (except the one grazed in “wild” pastures (like e.g. Alpine pastures)) is included in the intermediate consumption of the EAA in the position 19063 *Animal feedingstuffs – feedingstuffs produced and consumed by the same holding*.

Netherlands, Poland, Romania, Croatia and Macedonia.

Information on grazing might be available from national **gross nutrient balances** or from agricultural experts. These data can be used for EW-MFA. If necessary, quantities given in other units (e.g. dry weight or specific feed units) have to be converted into air dry weight (15% mc) with the support of expert knowledge. Eurostat is currently looking at possibilities to improve the data on grassland and other grazing areas output as it is one of the main outputs in the gross nutrient balances.

Another source – if it exists on national level – may be animal feed balances.

For countries with no or with incomplete direct data on extraction of grazed biomass supply-side estimate via grazed area and information on area yield can possibly be applied. Often, statistical offices and Eurostat's reference database provide data on the extent of grazing land (often differentiated by quality or intensity) in their agricultural or land use statistics. Based on information on the extent of pastures and typical area yields, the biomass taken up by grazing can be calculated.

Country or region specific area yields of pastures and rangelands can be estimated based on different sources. As mentioned above, Eurostat's reference database reports for some countries the actual uptake of grass per hectare. For countries with no direct data it could be considered to estimate the uptake of grazed biomass by utilizing information on area yields (kg per hectare) from other countries or a mix of other countries with similar natural conditions.

Grazing potential [t at 15% mc] = pasture area [ha] * pasture yield [t at 15% mc / ha]

Those calculation results should be cross-checked as far as possible with expert knowledge and literature data. Further, Table 5 provides information on typical grazing yields potential for different quality types of pastures in Central Europe (based on data for Austria).

Table 5: Typical area yield of permanent pastures

	Yield range [t at 15%mc / ha]	**Average yield [t at 15%mc / ha]**
Rough grazing, alpine pasture	<1	0.5
Extensive pasture	1-5	2.5
Improved pasture	5-10	7.0

Source: The values are derived from data for Austrian grassland systems given in Buchgraber et al. (1994) and can be assumed typical for Central Europe.

Demand-side approach:

The demand for grazed biomass can be estimated based on typical roughage requirements of ruminants and other grazing animals and information on livestock numbers. Daily biomass intake by grazing depends on the live weight of the animal, animal productivity (e.g., weight gain, milk yield), and the feeding system (e.g., share of concentrate), and may vary considerably within one species. This method is based on European average values and allows a rough estimation of biomass uptake by grazing.

Roughage requirement = livestock [number] * annual feed intake [t per head and year]

European average factors for roughage uptake by livestock species are provided in Table 6. The values are given in air dry weight (i.e. at a moisture content of 15%) and take into consideration that the share of market feed in feed ratios ranges between 5 and 20% (dry matter basis, average across all species).

Table 6: Typical roughage intake by grazing animals in Europe

	Daily intake (range) [kg/head and day]	Annual intake (range)[t/head and year]	Annual intake (average)[t/head and year]
Cattle (and buffalo)	10-15	3.6-5.5	4.5
Sheep and goats	1-2	0.35-0.7	0.5
Horses	8-12	2.9-4.4	3.7
Mules and asses	5-7	1.8-2.6	2.2

Sources: The values are typical for industrialised livestock production systems and derived from national feed balances and literature (Wirsenius 2000; Hohenecker 1981; Wheeler et al. 1981; BMVEL 2001).

Roughage uptake may be covered from grass type fodder crops, hay or silage, or from grazing. To estimate biomass uptake by grazing, total roughage uptake has to be reduced by the amount of available fodder crops and biomass harvest from grassland (item A.1.2.2.1[8]).

Demand for grazed biomass = roughage requirement [t at 15% mc]
– fodder crops incl. biomass harvest from grassland, A.1.2.2.1 [t at 15% mc]
– industrial fodder products

If results from the supply-side approach for grazed biomass are available they should be used for crosschecking the outcome of the demand-side approach. If the results do not match, the underlying assumptions should be reviewed, which may after expert consultation lead to an adaptation of the estimates. Reasons for differences may be an exceptionally high share of market feed and feed concentrate in feed ratios, overgrazing of pasture resources or significant grazing on areas other than those reported as pasture in land use statistics (woodlands, waste lands etc.).

1.3.2.4 Biomass production by households for own consumption

Following the rules of ESA and SNA respectively which are also applicable to EW-MFA, own account production of agricultural goods has to be regarded as domestic extraction. However, there are only few reliable data or estimation procedures available for quantifying those items in physical terms. In Eurostat's reference data base the production of fruits and vegetables in kitchen garden of agricultural households is included in the list of crop production items (kitchen gardens), which however would only be a fraction of total agricultural own account production in home gardens. But only some few countries report estimates for even those items. However, as far as data are reported that information should be included into domestic extraction estimate.

[8] And also by part of the crops under 1.1 (barley, grain, maize etc.) to avoid an over-estimation. This should not be neglected. E.g. Swiss animal feed balance reveal that this represent 4% of the intake of cattle. This can be probably higher in countries with for example beef meat production where animals don't go so much in the pastures.

1.3.2.5 Biomass harvest from set aside agricultural land

A significant amount of agricultural land in the European Union is set-aside[9]. In many cases, this land, however, does not remain uncultivated but is used for the production of renewable resources, such as oil crops or short rotation forests etc. Usually, the biomass from these areas will be considered in national agricultural statistics, in some cases it might be recorded in separate statistical accounts or sources. In any case, it has to be accounted for as domestic extraction and subsumed under the respective item (e.g. under A.1.1.6 *oil bearing crops* or A.1.3.2 *wood fuel*).

1.3.3 Cultivated wooded biomass

The following items are related to the domestic extraction of wood: *timber (industrial round-wood)* (A.1.3.1) and *fuel wood and other extractions* (A.1.3.2).

Wood harvest under bark (without bark): Extraction of wood and fuel wood is reported in forestry statistics (Eurostat's reference database) and in National Statistics. Wood output is usually reported in solid cubic metres. For EW-MFA, cubic metres have to be converted into tonnes. The conversion factors differ by tree species. If no national conversion factors are available the international default factors as given in Table 7 can be applied.

Table 7: Conversion factors from cubic metres to metric tonnes for coniferous and non-coniferous harvested round wood

	Density [t at 15% moisture content / m^3]
Coniferous	0.52
Non-coniferous	0.64

The standard density factors of table 7 are taken from the "Good Practice Guidance for Land Use, Land-Use, Change and Forestry, IPCC National Greenhouse Gas Inventories Programme" (Penman et al. 2003, Table 3a.1.1). Those density factors which are reported by IPCC refer to oven dry mass of wood, as for the purpose of IPCC a conversion from m^3 to tonnes is required as an interim step for estimating carbon content of wooded biomass. But according to the conventions of EW-MFA (see section 1.3.2.1) biomass has to be reported in air dry weight (moisture content of 15 %). Therefore the original density factors of the IPCC publication were transformed into factors which convert solid cubic metres into metric tonnes at 15 % moisture content.

Wood harvest over bark (including the bark): Special care must be taken concerning the issue of bark, which accounts for approximately 10% of stem wood weight. Wood felling is reported in solid cubic metres (m^3) in Eurostat's reference database under bark (i.e. without bark) for almost all member countries. For recent years also data for over bark are reported for most countries. Significant fraction of the bark is subject to further economic use (e.g., energy production). The part of the bark which is used has to be regarded as domestic extraction for the purpose of EW-MFA. All biomass which remains in the forest and is not used (branches, root-stock etc.), is not accounted as domestic extraction in EW-MFA. It should be assumed that all harvested wood over bark which is statistically reported is used economically.

It is suggested to use the empirical relation between harvests over bark to harvest under bark (other

[9] In fact, after the mid-term change of the CAP a few years ago, the set-aside went down. However, it is expected to go up with the new CAP 2013.

years or other countries for which are data reported) for estimating missing values for over bark production.

Other extractions from forest: The item “other extractions” comprises according to the European Framework for Integrated Environmental and Economic Accounting (IEEAF) (see Eurostat (2002) Table 3a) natural gum, cork and other forest products. Other wild products which are related to wooded land like wild mushrooms, truffles, berries, nuts, wild animals and products from wild animals etc. are reported under the item A.1.4.3 hunting and gathering. Short rotation wood, like Christmas trees and poplars, are reported under classification item A.1.1.10.

Extraction of other forest products is included in the IEEAF database. But that database is only available in monetary terms and not for all countries. If monetary data on extraction of other forest products are available in the forestry accounts for a country this may indicate whether that item is of some quantitative significance. Therefore it should be tried to use those monetary data as a basis for roughly estimating tonnes. It should be checked whether internal physical data (as an interim step for estimating monetary values) from the forest accounts can be used. As far as physical values are not available unit values derived from external trade data could be used. However, it should be noted that the accuracy of the results obtained by converting monetary values to quantities by price information from external trade statistics may be rather limited, among others due to heterogeneity of the aggregate which is converted.

Net increment of timber stock: Data on “increment in forests available for wood supply” and of “felling available for wood supply” are reported in Eurostat’s reference database for member countries in a periodicity of five years. Those data should also be available from national forest inventories. Further information on this item can be obtained from the database of the European Forest Institute (http://www.efi.int/portal/virtual_library/databases/). Data reported in volume [m³] should be converted into mass [t at 15% moisture content] by using the factors provided in Table 7.

A further source for estimating the change in inventories of standing timber could be internal physical or monetary estimates from national accounts and IEEAF.

1.3.4 Non cultivated biomass

1.3.4.1 Fish catch, aquatic animals/plants

The items A.1.4.1 and A.1.2.2 comprise the extraction of all wild (non-cultivated) aquatic biomass. Cultivated aquatic resources (aquaculture) are, as explained above, not regarded as domestic extraction in EW-MFA. Fish capture and extraction of other aquatic animals and plants is reported in national fishery statistics and in a comprehensive manner in Eurostat’s reference database. For all items the Eurostat database differentiates between catch of wild resources and production from aquaculture. The production data from the fishery statistics in mass units can be directly used for EW-MFA. In accordance with the residence principle, all landings of national vessels should be included, regardless of the geographic location of landings.

1.3.4.2 Hunting and gathering

Item A.1.4.3 hunting and gathering refers to extraction of wild non-aquatic animals, wild animal products and of wild crops and plants. Hunting comprises the hunting and trapping of animals for food, for their pelt or hide, for research purposes, zoos, or for use as pets. But breeding of game on holdings, which should be recorded as part of animal cultivation is excluded. Gathering includes the collection of non-cultivated mushrooms, truffles, berries, nuts egg etc.

Hunting and gathering is quantitatively of minor significance and is only accounted for if data are available in national statistics. Eurostat's reference database provides data on gathering in the agricultural crop statistics only for some few countries. Hunting is not reported there at all. However there may be some data available at the national level. For example data from the hunters' association could be used[10].

A conversion of hunting data from pieces into tonnes might be necessary by referring to information on average weight per piece (see Table 8). But it should be considered that determining the average life weight might be burdened with considerable inaccuracy, as that weight is usually only reported as a range.

Conceptually the weight of the bowels has to be deducted from the life weight, as hunted animals are usually disembowelled directly after hunting and the bowels are left behind in the forest[11]. Therefore those parts of the animals have to be regarded as unused extraction. The used extraction comprises the disembowelled bodies including skins, head, and antlers. Usually estimated average life weight per piece is reported as the primary information. The share of the bowels differs considerably from species to species and usually no comprehensive information is available on that item.

If that specific information on unused extraction is not available it is recommend to use a simplified approach[12].

Table 8: Weight of European hunted animals

Animal species		Souce		Life weight in kg								
English	Latin	Burnand[1]	Wikipedia	Total			Male			Female		
				min	max	aver-rage	min	max	aver-rage	min	max	aver-rage
Mammals												
Rabbit	Oryctolagus cuniculus	X		2.0	3.0							
Hare or brown hare	Lepus europaeus	X		4.0	5.0							
Variable hare	Lepus timidus varronis	X				3.0						
Red deer or Stag	Cervus elaphus	X		100	200.0							
Roedeer	Capreolus capreolus	X		14.0	20.0							
Fallow deer	Dama dama	X				65.0						
Sika (deer)	Cervus nippon		X		80.0							

[10] See: Deutscher Jagdschutz-Verband e.V. (Hrsg.): Jahresjagdstrecken Bundesrepublik Deutschland http://www.jagd-online.de and Schweinert (2004), p 61.
For Switzerland see: http://www.wild.uzh.ch/jagdst/index.php?la=2
[11] And also part of the blood.
[12] E.g. 20% for big animals; one may assume that small animals (rabbits, birds etc.) are not disembowelled in the forest.

Animal species		Souce		Life weight in kg								
English	Latin			Total			Male			Female		
		Burnand[1]	Wikipedia	min	max	aver-rage	min	max	aver-rage	min	max	aver-rage
Wildbear	Sus scrofa	X		50.0	120.0							
Wolf	Canis lupus	X		35.0	45.0							
Lynx	Lynx lynx	X				30.0						
Wild cat	Felis sylvestris	X		6.0	10.0							
Badger	Meles meles	X		20.0	25.0							
Fox	Vulpes vulpes	X		6.0	12.0							
Beech marten	Martes foina		X	1.1	2.3							
Pine marten	Martes martes		X	0.8	1.8							
Polecat	Mustela putorius		X				0.4	1.7		0.2	0.9	
Raccoon dog	Nyctereutes procyonoides		X	6.5	7.0							
Raccoon	Procyon lotor		X	3.5	9.0							
Nurek vison	Mustela lutreola		X	0.4	0.8							
Weasel	Mustela nivalis		X	0.0	0.3							
Stoat	Mustela erminea		X	0.0	0.4							
Genet	Genetta genetta		X	1.0	3.0							
Mangoose	Herpestes ichneumon		X	0.2	5.0							
Squirrel	Sciurus vulgaris		X	0.2	0.4							
Chamois	Rupicapra rupicapra	X		50.0	65.0							
Bouquetin	capra ibex	X		75.0	100.0							
Mufflon	Ovis orientalis musimon	X		20.0	40.0							
Brown bear	Ursus arctos	X		250.0	300.0							
Elk	Alces alces		X						320.0			225.0
Reindeer	Rangifer		X				159.0	182		80.0	120.	

Animal species		Souce		Life weight in kg								
English	Latin	Burnand[1]	Wikipedia	Total			Male			Female		
				min	max	average	min	max	average	min	max	average
	tarandus										0	
Marmot	Marmota marmota	X		5.0	8.0							
Otter	Lutra lutra	X		15.0	16.0							
Common seal	Phoca vitulina	X				75.0						
Birds												
Common partridge	Perdix perdix	X					0.40	0.45				0.38
Red legged partridge	Alectoris rufa	X					0.40	0.65		0.35	0.45	
Rock partridge	Alectoris graeca	X		0.60	0.80							
Pintailed sandgrouse	Pterocles alchata	X										
Blackbellied sandgrouse	Pterocles orientalis	X										
Pallas' sandgrouse	Syrrhaptus paradoxus	X										
Quail	Coturnix coturnix	X		0.08	0.13							
Song trush	Turbus philomelos	X		0.07	0.08							
Fieldfare	Turbus pilaris	X		0.09	0.11							
Mistletrush	Turbus viscivorus		X			0.14						
Redwing	Turbus iliacus	X				0.06						
Blackbird	Turbus mercula	X				0.10						
Ring ouzel	Turbus torquatus	X										
Great bustard	Otis tarda	X					4.00	11.00		4.00	5.00	
Little bustard	Tetrax tetrax	X		0.75	1.00							

Animal species		Souce		Life weight in kg								
English	Latin			Total			Male			Female		
		Burnand[1]	Wikipedia	min	max	aver-rage	min	max	aver-rage	min	max	aver-rage
Stone curlew	Burhinus oedicnemus	X		0.38	0.48							
Pratincole	Glareola pratincola	X										
Sky lark	Alauba arvensis	X										
Wood lark	Lullula arborea	X										
Crested lark	Galerida cristata	X										
Calandra lark	Melanocoryph a calandra	X										
Short toed lark	Calandrella brachydactyla	X										
Pheasant	Phasianus colchicus	X					1.35	1.55		1.00	1.15	
Woodcock	Scolopax rusticola	X		0.30	0.40							
Woodpigeon or Ringdove	Columba palumbus	X				0.50						
Stock dove	Columba oenas	X				0.30						
Rock dove	Columba livia	X				0.30						
Turtle dove	Streptopelia turtur	X		0.12	0.16							
Hazel grouse	Tetrastes bonasia	X		0.40	0.48							
Black grouse	Lyrurus tetrix	X					1.00	1.70		0.70	1.00	
Capercaillie	Tetrao urogallus	X					3.00	4.50		1.80	2.30	
Ptarmigan	Lagopus mutus	X		0.40	0.50							
Red grouse	Lagopus scoticus	X				0.60						
Mallard	Anas	X		0.90	1.40							

Animal species		Souce		Life weight in kg								
English	Latin			Total			Male			Female		
		Burnand[1]	Wikipedia	min	max	aver-rage	min	max	aver-rage	min	max	aver-rage
	platyrhynchos											
Gadwall	Anas strepera	X		0.70	0.85							
Shoveler	Spatula clypeata	X		0.55	0.75							
Pintail	Anas acuta	X					0.80	1.20		0.70	0.90	
Widgeon	Anas penelope	X		0.70	0.90							
Garganey	Anas querquedula	X		0.30	0.45							
Teal	Anas crecca	X		0.27	0.45							
Marbled duck	Marmaronetta angustiroistris	X										
Grey lag goose	Anser anser	X		3.00	4.00							
White fronted goose	Anser albifrons	X		2.00	3.00							
Pinkfooted goose	Anser brachyrhynchus	X		2.00	2.50							
Bean goose	Anser fabalis	X		2.50	4.00							
Brentgoose	Branta bernicla	X		1.20	1.70							
Barnacle goose	Branta leucopsis	X				1.20						
Shelduck	Tadorna tadorna	X		0.90	1.20							
Redcrested pochard	Netta rufina	X		1.00	1.20							
Pochard	Aythya ferina	X		0.80	1.10							
Ferruginous duck	Aythya nyroca	X		0.50	0.70							
Scaup duck	Aythya marila	X		0.80	1.30							
Tufted duck	Aythya fuligula	X		0.70	1.00							

Animal species		Souce		Life weight in kg								
English	Latin			Total			Male			Female		
		Burnand[1]	Wikipedia	min	max	aver-rage	min	max	aver-rage	min	max	aver-rage
Goldeneye	Bucephala clangula	X		0.80	1.10							
Harlequin	Histrionicus histrionicus	X		0.25	0.45							
Velvet scoter	Melanitta fusca	X		1.20	2.00							
Common scoter	Melanitta nigra	X		0.80	1.20							
Common eider	Somateria molissima	X		1.50	2.50							
Common snipe	Gallinago gallinago	X		0.10	0.15							
Great snipe	Gallinago media	X		0.18	0.25							
Jack snipe	Lymnocryptes minimus	X		0.06	0.07							
Golden plover	Pluvialis apricaria	X		0.13	0.18							
Grey plover	Pluvialis squatarola	X		0.17	0.24							
Dotterel	Charadrius morinellus	X				0.12						
Ringed plover	Charadrius hiaticula	X				0.06						
Little ring plover	Charadrius dubius	X		0.04	0.05							
Kentish plover	Charadrius alexandrius	X				0.04						
Lapwing	Vanellus vanellus	X				0.20						
Moorhen	Gallinula chloropus	X		0.25	0.30							
Purple gallinule	Porphyrio porphyrio	X										
Coot	Fulica atra	X		0.60	0.80							

Animal species		Souce		Life weight in kg								
English	Latin			Total			Male			Female		
		Burnand[1]	Wikipedia	min	max	aver-rage	min	max	aver-rage	min	max	aver-rage
Corn crake or Land rail	Crex crex	X		0.12	0.18							
Water rail	Rallus aquaticus	X		0.10	0.13							
Spotted crake	Porzana porzana	X		0.08	0.12							
Little crake	Porzana parva	X		0.05	0.05							
Baillon's crake	Porzana pusilla		X				0.02	0.05		0.02	0.06	
Common heron	Ardea cinerea	X		1.50	2.00							
Purple heron	Ardea purpurea	X		1.00	1.50							
Night heron	Nycticorax nycticorax	X				0.75						
Little bittern	Ixobrychus minutus	X		0.13	0.16							
Bittern	Botaurus stellaris	X		1.00	1.30							
Squacco heron	Ardeola ralloides	X		0.25	0.35							
Little egret	Egretta garzetta	X				0.50						
Spoonbill	Platalea leucorodia	X				1.70						
Glossy ibis	Plegadis falcinellus	X				0.75						
Common crane	Grus grus	X		4.00	6.00							
Common curlew	Numenius arquata	X		0.70	1.10							
Whimbrel	Numenius phaeopus	X		0.35	0.40							
Bar-tailed godwit	Limosa lapponica	X					0.16	0.25		0.25	0.29	

Animal species		Souce		Life weight in kg								
English	Latin			Total			Male			Female		
		Burnand[1]	Wikipedia	min	max	aver-rage	min	max	aver-rage	min	max	aver-rage
Black-tailed godwit	Limosa limosa	X		0.24	0.34							
Blackwinged stilt	Himantopus himantopus	X		0.14	0.18							
Avocet	Recurvirostra avosetta	X		0.30	0.40							
Ruff (male), Reeve (female)	Philomachus pugnax	X							0.20	0.12	0.15	
Common red shank	Tringa totanus	X				0.13						
Greenshank	Tringa nebularia	X		0.15	0.17							
Spotted redshank	Tringa erythropus	X				0.14						
Marsh sandpiper	Tringa stagnatilis	X				0.08						
Green sandpiper	Tringa ochropus	X		0.08	0.10							
Common sandpiper	Actitis hypoleucos	X		0.05								
Wood sandpiper	Tringa glareola	X		0.05	0.08							
Rednecked phalarope	Phalaropus lobatus	X		0.04	0.05							
Grey phalarope	Phalaropus fulicarius	X		0.05	0.05							
Dunlin	Calidris alpina	X		0.05	0.05							
Curlew sandpiper	Calidris feruginea	X				0.05						
Little stint	Calidris minuta		X	0.02	0.03							
Temminck stint	Calidris temminckii		X	0.02	0.04							
Purple	Calidris		X				0.05	0.09		0.06	0.11	

Animal species		Souce		Life weight in kg								
English	Latin			Total			Male			Female		
		Burnand[1]	Wikipedia	min	max	aver-rage	min	max	aver-rage	min	max	aver-rage
sandpiper	maritima											
Broadbilled sandpiper	Limicola falcinellus		X	0.03	0.05							
Knot	Calidris canutus		X	0.12	0.17							
sanderling	Calibris alba		X	0.05	0.07							
Turnstone	Arenaria interpres	X				0.11						
Oystercatch er	Haematopus ostralegus	X				0.50						
Rook	Corvus frugileus	X										
Carrion crow	Corvus corone	X										
Hooded crow	Corvus cornix	X										
Jay	Garrulus glandarius		X			0.17						
Magpie	Pica pica	X				0.20						

1) Tony Burnand: Wild, Europäische Jagdtiere, Stutgart and Zürich 1964

2 Metal Ores

2.1 Concepts and classification

A metal is a chemical element. All metals are listed in the Periodic Table of the Elements. The statistical classification of metal ores is based on the chemical characteristics.

Classification:

Table 9 shows the classification of material flows for domestic extraction of metal ores. On a first level (2-digit) metal ores are distinguished into iron and non-ferrous metals. The latter are further broken down into 9 sub-groupings. The 2013 EW-MFA questionnaire includes this 3-digit level. Due to the high importance of certain non-ferrous metals (critical raw materials) one may consider in future questionnaires to detail further down to a 4-digit level (as already indicated in Table 9).

Annex 2 of the EW-MFA questionnaire presents the correspondences to PRODCOM.

Table 2: Classification of material flows for domestic extraction used – metal ores

A.2 Metal ores			
	A.2.1 Iron		
	A.2.2 Non-ferrous metal		
		A.2.2.1 Copper - gross ore	
		M.2.2.1 Copper - metal content (optional reporting)	
		A.2.2.2 Nickel - gross ore	
		M.2.2.2 Nickel - metal content (optional reporting)	
		A.2.2.3 Lead - gross ore	
		M.2.2.3 Lead - metal content (optional reporting)	
		A.2.2.4 Zinc - gross ore	
		M.2.2.4 Zinc - metal content (optional reporting)	
		A.2.2.5 Tin - gross ore	
		M.2.2.5 Tin - metal content (optional reporting)	
		A.2.2.6 Gold, silver, platinum and other precious metal – gross ore	
			A.2.2.6.1 Gold – gross ore (optional reporting)
			A.2.2.6.2 Silver – gross ore (optional reporting)
			A.2.2.6.3 Platinum group metals – gross ore (optional reporting)
		A.2.2.7 Bauxite and other aluminium - gross ore	
		A.2.2.8 Uranium and thorium - gross ore	
		A.2.2.9 Other n.e.c.- gross ore	
			A.2.2.9.1 Antimony – gross ore (optional reporting)

A.2.2.9.2 Beryllium – gross ore (optional reporting)
A.2.2.9.3 Bismuth – gross ore (optional reporting)
A.2.2.9.4 Cadmium – gross ore (optional reporting)
A.2.2.9.5 Chromium – gross ore (optional reporting)
A.2.2.9.6 Cobalt – gross ore (optional reporting)
A.2.2.9.7 Germanium – gross ore (optional reporting)
A.2.2.9.8 Magnesium – gross ore (optional reporting)
A.2.2.9.9 Manganese – gross ore (optional reporting)
A.2.2.9.10 Mercury – gross ore (optional reporting)
A.2.2.9.11 Strontium – gross ore (optional reporting)
A.2.2.9.12 Titanium – gross ore (optional reporting)
A.2.2.9.13 Tungsten – gross ore (optional reporting)
A.2.2.9.14 Further others n.e.c – gross ore (optional reporting)

Platinum group metals (abbreviated as the PGMs) are a term used sometimes to collectively refer to six metallic elements clustered together in the periodic table. The six platinum group metals are ruthenium, rhodium, palladium, osmium, iridium, and platinum. They have similar physical and chemical properties, and tend to occur together in the same mineral deposits.

Reporting units:

For the purpose of EW-MFA extraction of metal ores is measured as gross ore. Table 10 gives an overview over the terminology used in EW-MFA with regard to the different flows involved in the extraction of metals.

Table 10: Different system boundaries in metal mining

Description of the material	Common terminology	EW-MFA terminology
Materials removed to get access to reserve, i.e. metal containing ores	Overburden, interburden	*Unused* extraction
The metal containing material	Run of mine, gross ore, crude ore	*Used* extraction
Concentrated ore	Ore concentrate	
The pure metal	Net ore or metal content	Metal component of used extraction not specifically considered in the EW-MFA indicators, but reported in EW-MFA questionnaire as memorandum item

Metal mining involves the mobilisation of huge amounts of materials. For the compilation of comparable data sets and indicators it is instrumental that the same system boundary is applied.

Accounting for domestic extraction of metals and also of non-metallic minerals always refers to the run-of-mine production. Run-of-mine production means that the total amount of extracted crude mineral that is submitted to the first processing step is counted.

Material extracted but not used as an input for subsequent processing is termed "unused domestic extraction" and is not recorded in the EW-MFA questionnaire. Unused extraction may, for example, include overburden removed and deposited or interburden removed and filled.

Concentrate denotes an interim step between extraction of the gross ore and the production of the metal. Usually the ores are converted into concentrates within the mining industry before they are sold to other industries.

Statistics on extraction of metals may report the run-of-mine production, the mass of a concentrate, or the metal content. Table A of the EW-MFA questionnaire asks for the extracted metals in gross ore (i.e. run-of-mine). Additionally metal content is to be reported as a memo item. The mass weight of actual metal content is important for further analysis of the EW-MFA data and this information is also helpful for cross checking. However, it is the gross ore figure which is used for calculating aggregated EW-MFA indicators.

If extraction of a metal is only reported for one of the two categories - gross ore and metal content - or only as ore concentrate appropriate conversion factors (see below) have to be applied for estimating gross ore and/or metal content.

It may also be the case that two or even more metals are obtained from the same crude ore, this is called coupled production. If this is the case, the total amount of ore has to be allocated to the different metals. The respective calculation procedure is explained below.

2.2 Data sources

Data on the physical output of the metal mining can be obtained from various sources at the national and the international level.

PRODCOM: Eurostat's production statistics (PRODCOM) provide comparable data at the national and the European level on the production of metal ores. The output is usually measured as ore concentrate and not as gross ore. Further, the completeness of the data varies considerably across countries and years.

PRODCOM report the products which are sold on the market whereas the concept of domestic extraction in EW-MFA does not refer to a market transaction but to the act of extraction of natural resources from the natural environment. PRODCOM reports both, physical data for volume sold and total volume. Data on total volume are more comprehensive as they comprise also extracted materials which are not sold but used for intermediate consumption within the extracting establishment. Therefore, as far as PRODCOM data are used, the data on total volume and not on sold volume should be used for the purpose of compiling figures on domestic extraction.

Geological surveys, ministries, and industrial associations: Further information may be available from specific national sources on mining, like statistics from geological surveys, ministries and industrial associations.

Individual Mining companies: Annual business reports of individual mining companies or other direct information from mining companies can be a very important source, especially for estimating ore grades or for identifying coupled production.

International sources: Apart from national mining statistics, especially the following international sources can be useful also for compilations at the national level:

- British Geological Survey (BGS): European Mineral Statistics
  http://www.bgs.ac.uk/mineralsuk/statistics/europeanStatistics.html
- United States Geological Survey (USGS): Minerals Yearbook (Volume III: Area Reports: International
  http://minerals.usgs.gov/minerals/pubs/country/index.html#pubs

The mining output is predominantly reported as metal content by BGS and USGS data bases.

Those sources use as far as possible official statistical data of the countries concerned. “Where official data are not available or where there is reasonable cause to doubt the accuracy or completeness of such data information is sought from other sources such as geological survey organizations, chambers of mines, universities, trade associations and primary producers themselves” (British Geological Survey (2011), p. iii).

The USGS additionally provides detailed information on the mineral industry within the studied country, in particular about the structure of the mineral industry in terms of commodity, major operating companies, and major equity owners, location of main facilities, and annual capacity.

The data which are published by BGS and USGS represent estimates which are the results of comprehensive cross checking of various sources.

2.3 Data compilation

2.3.1 General approach

Quite frequently the country level information on the mining output of individual metals differs substantially from source to source. Therefore it is highly advisably to consult and evaluate not only one but all available data sources for arriving at balanced and realistic estimates.

PRODCOM: The national and the EUROSTAT production statistics basically report the products which are sold in the market. As metal ores are usually sold as concentrates, PRODCOM data on production of metal ores in weight units are provided as weight of “metal ores and concentrates”. An exception is iron which is partly reported also as gross ore. As far as only data on ore concentrates are available, conversion factors have to be established for estimating gross ore as well as metal content (see below). Special attention has also to be put on the issue of coupled production of ores (i.e., one ore contains more than one metal). In case of coupled production the ore concentrate reported in PRODCOM under a specific metal may also contain other metals which are going to be separated only at the smelter level. A further problem is that the PRODCOM classification is not detailed enough for tracking each individual metal.

Individual mining companies: It is highly recommended to refer to the annual business reports of individual mining companies. The number of those companies is rather limited per country. Usually they publish annual financial reports which should provide information on value and quantities of the metals ores that are mined, and especially on the ores grades and the occurrence of coupled production of ores.

International sources: It is also recommended to pay special attention to BGS and USGS at least for cross-checking and, if necessary for gap filling.

Table 11 gives an overview on mining of metal ores in European countries according to USGS and BGS sources. This overview may be incomplete, as the situation in the different countries can vary over time.

Table 11: Mining of metals in Europe by country and type of metal

	Aluminium	Antimony	Beryllium	Bismuth	Cadmium	Chromium	Cobalt	Copper	Germanium	Gold	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Silver	Strontium	Tin	Titanium	Tungsten	Uranium	Zinc
Austria											X			X							X		
Bulgaria				X				X		X	X	X		X			X						X
Czech Republic																						X	
Spain								X	X	X	X	X	X		X		X	X				X	X
Finland						X	X	X		X		X			X	X	X						X
France	X									X	X						X					X	
Germany											X											X	
Greece	X											X	X			X	X						X
Hungary	X													X									
Ireland												X					X						X
Italy										X		X		X			X						
Poland								X		X		X	X				X						X
Portugal			X					X			X						X		X		X	X	X
Romania				X				X		X	X	X		X			X					X	X
Slovakia										X	X		X										
Sweden								X		X	X	X					X						X
United Kingdom											X	X											
Cyprus								X															
Netherlands													X										
Norway					X						X					X				X			
Switzerland																							
Croatia																							
Turkey	X	X				X		X		X	X			X		X	X	X					X

Source: USGS and BGS

It is generally recommended to use national data sources (preferably mine specific or e.g. geological survey, national production statistics) as a priority source for both, metal content and gross ore. However, depending on data availability and quality it might be useful to combine different data.

In some cases national information for individual metals may not be satisfactory for different reasons:

- No information is available for a metal
- Information is not available in the required level of detail (e.g. if PRODCOM is used)
- The accuracy of the available information is assessed as being questionable due to crosschecking with alternative sources or due to other plausibility checks (e.g. consistent time series, plausibility with respect to monetary information from supply and use tables from national accounts and structural business statistics)

For cases of lack or non-satisfactory quality of national sources it is proposed to refer to the above mentioned international sources, preferably to USGS.

In some cases it may also be useful to combine USGS (or BGS) data on metal content, which cover the complete national production, with information on ore grades from annual business reports of mining companies.

2.3.2 Conversion factors

The basic data on output of metal mining are presented in different reporting units. As already mentioned, PRODCOM usually reports "ore and concentrates". Other sources like BGS and USGS usually use metal content as reporting unit. Therefore most of the basic data for the individual metal ores cannot be used directly, but have to be converted into the required EW-MFA reporting unit gross ore by using appropriate conversion factors.

Conversion factors may differ substantially from mine to mine. Therefore those factors should be derived from national sources, preferable at the basis of information from the individual mines. Partly, conversion factors can also be obtained from USGS country tables or from literature. See for example: Bureau of Mines (1987).

As far as specific national conversion factors should not be available, general conversion factors (see following Table 12) may be applied as a default setting. The estimation of those factors is predominantly based on information from annual business reports for about 160 metal mines. See: Schoer et al. (2012).

Table 12: General conversion factors between metal content, ore concentrate and gross ore

	Gross ore / metal content	Gross ore / concentrate
A.2.1 Iron	43.32	81.93
A.2.2.1 Copper	1.04	3.33
A.2.2.2 Nickel	1.83	23.45
A.2.2.3 Lead	11.86	16.52
A.2.2.4 Zinc	8.34	14.50
A.2.2.5 Tin	0.24	0.33
A.2.2.6.1 Gold	0.00021	0.06630
A.2.2.7 Aluminium	18.98	67.55
A.2.2.6.2 Silver	0.034	2.552
A.2.2.8 Uranium	0.0015	0.3744
A.2.2.9.1 Antimony	NA	NA
A.2.2.9.3 Bismuth	NA	NA
A.2.2.9.4 Cadmium	NA	NA
A.2.2.9.5 Chromium	25.70	67.79
A.2.2.9.6 Cobalt	0.77	9.90
A.2.2.9.7 Germanium	NA	NA
A.2.2.9.9 Manganese	35.88	58.52
A.2.2.9.10 Mercury	NA	NA

A.2.2.9.11 Strontium	NA	NA
A.2.2.9.12 Titanium (Ilmenite)	9.09	15.97
A.2.2.9.12 Titanium (Rutile)	1.96	2.06
A.2.2.9.13 Tungsten	0.39	1.23
A.2.2.9.14 Molybdenum	0.13	0.24

Source: ifeu Institute

The ore grade denotes the metal content (net ore) of a specific gross ore. Ore grades are variable across ores and mines. The amount of gross ore can be calculated on the basis of data on metal extraction in tonnes of ores, ore concentrates or metal content and the corresponding country specific conversion factors. If coupled production for a specific metal can be excluded (that is, only a single metal is extracted from the given ore), the amount of gross ore is obtained by dividing for example the metal content by the ore grade (conversion factor from metal content to gross ore).

- Ore grade = metal content / gross ore

Gross ore = metal content / ore grade

2.3.3 Coupled production

Coupled production of metal ores refers to the case that one specific ore can contain more than one metal. For example, lead is often associated with zinc, or tin is often associated with copper in the same deposit.

The occurrence of coupled production of ores should be identified on a mine by mine basis by referring to annual business reports. Partly that information is also reported in the country reports of USGS.

If more than one metal is extracted from the same gross ore, care must be taken to ensure that the same run-of-mine is not accounted for more than once. In the case that coupled production has been identified for two or more metals, a specific calculation model has to be applied. The calculation approach suggested in this guide is predominantly based on the value relationships of the metals which are mined in coupled production.

Calculation approach

Step 1: Calculation of the total gross ore:

As far as the direct amount of gross ore of coupled production can not be obtained from the primary source the total gross ore of a coupled production setting could be calculated by multiplying the amount of one of the metals (measured as metal content in tonnes) by the specific ore grade. However, in some cases the information on ore grades may not be really coherent (as it was assumed for example 1 of table 14), as each calculation for each metal may provide different results for the total amount of gross ores. In order to obtain an unambiguous result a rule has to be established for estimating the total gross ore. For that purpose it is suggested to identify the “main metal” by using the value criterion.

For deciding on what metal is regarded as the main metal the physical quantities of the metal output (metal content in tonnes) is converted into value terms. If no direct information on values of produced metal output is available from the primary source, the metal content in tonnes is multiplied with an external price. As the focus is not on correct absolute values but on the values in relation to the other metals, it is suggested to apply long term average prices from USGS sources.

The long term average prices for metals are shown in Table 13.

Table 13: Metal prices in the United States, average 1990-2009

Metal	USD per tonne
A.2.1 IRON	44
A.2.2.1 COPPER	3 382
A.2.2.2 NICKEL	12 362
A.2.2.3 LEAD	1 270
A.2.2.4 ZINC	1 542
A.2.2.5 TIN	9 721
A.2.2.6.1 GOLD	14 008 593
A.2.2.6.2 SILVER	230 197
A.2.2.7 ALUMINIUM	1 827
A.2.2.8 STRONTIUM	849
A.2.2.9.1 ANTIMONY	3 261
A.2.2.9.3 BISMUTH	11 801
A.2.2.9.4 CADMIUM	2 674
A.2.2.9.5 CHROMIUM	1 338
A.2.2.9.6 COBALT	37 888
A.2.2.9.7 GERMANIUM	1 110 515
A.2.2.9.9 MANGANESE	876
A.2.2.9.10 MERCURY	7 932
A.2.2.9.12 TITANIUM	11 020
A.2.2.9.13 TUNGSTEN	16 762
A.2.2.9.14 MOLYBDENUM	21 426

Source: USGS Historical Statistics for Mineral and Material Commodities in the United States

Long term averages have the advantage of widely neutralizing short term fluctuation and they are more in accordance with the economic decisions of opening or closing a mine which is also based on rather long term assessment. The total amount of gross ore is calculated by dividing the metal content of the main metal by the ore grade of that metal (see also calculation approach for single ore above).

Step 2: Allocation of gross ore to metals from coupled production:

The total amount of gross ore has to be attributed to the different metals mined in coupled production. This can be done by using the above value relationships. For example, for metal m_1, the attributed fraction of total gross ore (gm_1) should be calculated as follows:

$$\mathrm{gm_i} = \text{total gross ore in } [t] \frac{\mathrm{vm}_i}{(\mathrm{vm}_1 + \mathrm{vm}_2 + \ldots + \mathrm{vm}_n)}$$

with: gm_i is the fraction of the total gross ore attributable to the extraction of metal m_i.

vm_i is the value of the metal i

Table 14 presents two numerical examples for the suggested calculation approach.

Table 14: Coupled production: allocation of gross ores (numerical examples based on USGS data for Poland)

	Ore grade	Metal content	Specific price (average 1999-2009)	Output value (metal content x specific price)	Output value - % in total	Gross ore - total (calculated)	Gross ore - total, based on main metal (metal with the highest contribution to the total output value)	Gross ore - total, allocated by value relations
	1	2	3	4 = 2x3/1000	5	6 = 2/1x100	7 = 6 for first rank in 4	8 = 5x7
	%	1000 tonnes	USD/tonne	million USD	%	1000 tonnes	1000 tonnes	1000 tonnes
	Example 1							
Copper	1.890000000	575	3,382	*1,945*	95%	30,423	*30,423*	28,926
Lead	0.102520000	31	1,270	39	2%	30,238		586
Gold	0.000001675	0.00005	14,008,593	1	0.0%	3,045		11
Silver	0.000864165	0.26300	230,197	61	3%	30,434		901
Total		606.3		2,045	100%		30,423	30,423
	Example 2							
Lead	1.70000	69	1,270	88	16%	4,059		583
Zinc	4.20000	156	1,542	*241*	43%	3,714	*3,714*	1,600
Silver	0.02689	1	230,197	230	41%	3,719		1,531
Total		226.0		558	100%		3,714	3,714

In example 1 copper is identified as the metal with the highest output value (see column 4 = 1945 million US$). The total amount of gross ore is therefore set to 30.423 million tonnes (see column 7). That amount is allocated to the individual metals (column 8) using the value relations (see column 6) as a key.

In example 2, zinc is identified as the metal with the highest output value (see column 4). Therefore it is assumed that the total amount of gross ore is 3.714 million tonnes (see column 7). That amount is distributed over the individual metal ores (column 8) extracted using the output value relations (column 6).

3 Non-metallic minerals

3.1 Concepts and classification

Table 15 shows the classification of material flows for domestic extraction of non-metallic minerals[13].

This classification for non-metallic minerals is derived from CPA 2002. Links to CPA and other classifications are provided in several Annexes to the questionnaire (Annex2, Annex 3 and Annex 5).

The item Excavated earthen materials (A.3.10) is not covered by the CPA classification which is employed by Eurostat's production statistic data base (PRODCOM). In its EW-MFA for 1980 to 1998, the Italian Statistical Office has reported soil from excavation activities that are reused in construction as material input. So far, no standardised estimation procedures are available for this material flow. For further details, please refer to Barbiero et al. (2003).

Table 15: Classification of material flows for domestic extraction used – non-metallic minerals

A.3 Non-metallic minerals	
	A.3.1 Marble, granite, sandstone, porphyry, basalt, other ornamental or building stone (excluding slate)
	A.3.2 Chalk and dolomite
	A.3.3 Slate
	A.3.4 Chemical and fertilizer minerals
	A.3.5 Salt
	A.3.6 Limestone and gypsum
	A.3.7 Clays and kaolin
	A.3.8 Sand and gravel
	A.3.9 Other n.e.c.
	A.3.10 Excavated earthen materials (including soil), only if used (optional reporting)

(refers to Table A.3 of the EW-MFA questionnaire)

3.2 Data sources

The data sources for compilation of non-metallic minerals are rather similar to the ones for metals. As for metals, data on the physical output of the mining of non-metallic minerals can be obtained from various sources at the national and the international level.

PRODCOM: National and Eurostat's production statistics (PRODCOM) provides comparable data

[13] It is important to keep in mind that the category “domestic extraction of non-metallic minerals” does not include the extraction of gases from the atmosphere for industrial purposes, such as the extraction of nitrogen in the Haber-Bosch process. These flows, if quantitatively important, are accounted for as balancing items.

at the national and the European level on the production of non-metallic minerals. However, the completeness of the data varies considerably across countries and years.

PRODCOM report the products which are sold on the market whereas the concept of domestic extraction in EW-MFA does not refer to a market transaction but to the act of extraction of natural resources from the natural environment. PRODCOM reports both, physical data for volume sold and total volume. Data on total volume are more comprehensive as they comprise also extracted mineral materials which are not sold but used for intermediate consumption within the extracting establishment. Therefore, as far as PRODCOM data are used, the data on total volume and not on sold volume should be used for the purpose of compiling figures on domestic extraction.

PRODCOM and also other sources can typically under-report the extraction of so called bulk mineral materials, i.e. materials which are mainly used for construction purposes, like sand and gravel or crushed stones and clay for manufacturing of brick. Those statistical gaps may occur, if the extracted materials do not enter the market, but are used within the establishment for further processing (intermediate consumption e.g. in construction or brick manufacturing). The data gaps have to be closed by further information or by estimation models (see below).

Compared to bulk minerals, minerals which are predominantly used for industrial purposes are usually covered rather well by the production statistics and other sources.

Additional information useful for getting comprehensive data on domestic extraction of minerals may be provided by industrial associations (e.g. for gravel and sand industry, natural stones industry, or cement industry). These may also provide figures covering the complete field of activities involved in minerals extraction, for example also small scale enterprises not considered by other statistics. In case statistics of industrial associations or related data sources are used, it should be ensured that these report continuously on the same items. In some cases, however, data for minerals for construction will have to be estimated as described below.

Further the PRODCOM has some major conceptual gaps:

a) Suppressing of values for confidentiality reasons;

b) PRODCOM is designed for achieving a coverage for at least 90 %, i.e. small scale companies are widely excluded;

c) PRODCOM does not cover all branches, i.e. extraction of minerals by branches which are out of scope of PRODCOM, like agriculture, trade and transport are not regarded.

Statistics Austria and IFF have developed an estimation approach for filling those gaps for sand and stone (Eva Milota, Nina Eisenmenger, Anke Schaffartzik (2011)). That approach is designed for the specific data situation in Austria. The main idea of that method is to compare the monetary values of PRODCOM with the corresponding monetary values of the Structural Business Statistics (SBS) or with supply and use tables of the National Accounts, which both are characterised by a comprehensive coverage. The gaps between both approaches are used for grossing up the physical values of PRODCOM. ISTAT is testing a similar approach.

As far as comparison with SBS is concerned, it has to be noted that SBS data as published by EUROSTAT’s reference database are only available at a rather high level of aggregation. Therefore one has to be careful, if there are large differences between both sources. In those cases the results of simply grossing up with the differences at the aggregated level may be biased by structural effects.

Other national sources: Further information may be available from specific national sources on mining, like statistics from ministries, geological surveys and from industrial associations. Also annual business reports of individual mining companies should be regarded as sources for compilation of data on non-metallic minerals.

International sources: Apart from national mining statistics, important international sources are the data collections of BGS, USGS (see also chapter on metals). BGS, USGS data represent estimates which are the results of comprehensive cross checking of various sources.

A correspondence table between the EW-MFA classification for non-metallic minerals and the PRODCOM classification, and the lists of materials in BGS and USGS can be found in Annex 5 of the questionnaire. It has to be noted that the relationship between PRODCOM on the one hand and BGS and USGS on the other hand is not straightforward in all cases, as BGS and USGS do not clearly follow any established statistical product classification. An unambiguous comparison turns out to be especially difficult for bulk minerals, which are used for construction purposes and limestone.

The assignment of BGS and USGS items to PRODCOM categories for the correspondence table was done by using the detailed description of PRODCOM and the relation of PRODCOM to product classification for Eurostat's external trade statistics (CN).

With respect to USGS some problems where encountered. The portfolio of raw materials reported by USGS is quite large and it is not possible to attribute some raw materials to PRODCOM codes unambiguously. Some materials in USGS are higher aggregated than PRODCOM and the level of aggregation differs across the individual countries. Further particular raw materials are called differently for different countries and as there is no detailed description of the raw material categories at the country level, it turned out to be very difficult to judge where these names are simply synonyms and where they cover somewhat different raw materials. The correspondence table in the Annex 5 reflects the most common level of aggregation of raw material categories.

3.3 Data compilation

3.3.1 General approach

The country level information on the mining output of individual non-metallic minerals may differ substantially from source to source. Therefore it is highly advisable to consult and evaluate not only one but all available sources for arriving at balanced and realistic estimates.

National source should be applied with priority. But it is recommended to use data from BGS and USGS for crosschecking and gap filling.

3.3.2 Run of mine concept

The run-of-mine concept concerns metals in particular, but principally holds true for all minerals. For minerals other than metallic ores, it may generally be assumed that the difference between run-of-mine production and reported production is not relevant.

Minerals have specific moisture content that is usually not subject to high variability. Therefore data for the extraction of minerals are simply taken as they are reported.

3.3.3 Conversion from cubic metres to tonnes

In most sources data on mining of non-metallic minerals are reported in mass unit. However, some statistics may provide data in cubic meters (m^3). Those data have to be converted to tonnes. Table 16 provides conversion factors for selected materials.

Table 16: Specific gravities of selected non-metallic minerals

Material	**tonnes per cubic meter**
Ornamental and building stone	
Marble, solid	2.563
Granite, solid	2.691
Sandstone, solid	2.323
Porphyry, solid	2.547
Basalt, solid	3.011
Stone (default value if no other specifications are available)	2.500
Chalk and dolomite	
Chalk, lumpy	1.442
Dolomite, lumpy	1.522
Chalk and dolomite (default value if no other specifications are available)	1.500
Slate	
Slate, solid	2.691
Slate, broken	1.290-1.450
Slate, pulverized	1.362
Slate (default value if no other specifications are available)	1.400
Limestone and gypsum	
Gypsum, crushed	1.602
Limestone, broken	1.554
Limestone (default value if no other specifications are available)	1.500
Clay	
Clay, dry excavated	1.089
Clay, wet excavated	1.826
Clay, dry lump	1.073
Clay, fire	1.362
Clay, wet lump	1.602
Clay, compacted	1.746
Clay (default value if no other specifications are available)	1.500
Sand and gravel	
Gravel, loose, dry	1.522
Gravel, with sand, natural	1.922

Material	tonnes per cubic meter
Gravel, dry 1,3 to 5,1 cm	1.682
Gravel, wet 1,3 to 5,1 cm	2.002
Sand, wet	1.922
Sand, wet, packed	2.082
Sand, dry	1.602
Sand, loose	1.442
Sand, rammed	1.682
Sand, water filled	1.922
Sand with Gravel, dry	1.650
Sand with Gravel, wet	2.020
Sand and gravel (default value if no other specifications are available)	1.900

Source: SIMETRIC

3.3.4 Description of materials and specific compilation issues

3.3.4.1 Marble, granite, sandstone, porphyry, basalt, other ornamental or building stone (excluding slate) – A.3.1

This category comprises almost any competent rock type that may be used in the form of shaped and/or sized blocks for either structural or decorative purposes. It includes marble and other calcareous ornamental or building stone (e.g. travertine, ecausine, limestone and alabaster), and granite, sandstone, and other ornamental or building stone (e.g. porphyry, basalt), as well as roofing stone and may even include slate, which should, however, be counted under A.3.3.

3.3.4.2 Chalk and dolomite – A.3.2

Chalk is a soft, white, porous form of limestone composed of the mineral calcite. It is also a sedimentary rock. Uses are widespread and comprise blackboard chalk, to mark boundaries, in sports, applied to the hands or to instruments to prevent slippage, and as tailor's chalk.

Dolomite is the name of both a carbonate rock and a mineral consisting of calcium magnesium carbonate found in crystals. Dolomite rock (also dolostone) is composed predominantly of the mineral dolomite. Limestone which is partially replaced by dolomite is referred to as dolomitic limestone. Limestone and dolomite are commonly used as crushed-rock aggregate, for cement production, and for other industrial and agricultural uses. Limestone and dolomite are often combined in statistical reporting. They are, however, differentiated in statistics by CPA codes at the 5 digits level.

Please note! In case data for limestone are derived from an estimate described under 1.3.3.4.6, it should be figured out if this estimate includes use of dolomite (for cement production). Data reported for dolomite under 1.3.3.4.6 then eventually have to be corrected for double counts. It is recommended to consult a national expert for clarification of this issue.

3.3.4.3 Slate – A.3.3

Slate is a fine-grained, homogeneous, metamorphic rock derived from an original shale-type sedimentary rock composed of clay or volcanic ash through low grade regional metamorphism. Slate can be made into roofing slates, also called roofing shingles. Fine slate can also be used as a whetstone to hone knives. Because of its thermal stability and chemical inertness, slate has been used for laboratory bench tops and for billiard table tops. Slate tiles are often used for interior and exterior flooring or wall cladding.

3.3.4.4 Chemical and fertilizer minerals – A.3.4

This group of minerals mainly comprises:

Natural calcium or aluminium calcium phosphates, often combined under the heading “phosphate rock”. Most of it (over 90%) is used to produce fertiliser; the remainder is used in the production of detergents, animal feedstock, and many other minor applications.

Carnallite, sylvite, and other crude natural potassium salts are often combined under the heading “potash”. Potassium is essential in fertilisers and is widely used in the chemicals industry and in explosives. Data for potash are often reported in K2O contents. In this case, as for metals, the run-of-mine production has to be calculated to obtain the used domestic extraction. Germany is by far the biggest producer of potash in the EU and the third biggest in the world. The K2O content in run of mine production of potash in Germany is about 55%.

Unroasted iron pyrite which is an iron disulfide. Pyrite is used for the production of sulphur dioxide, e.g. for the paper industry, and in the production of sulphuric acid, though such applications are declining in importance.

Crude or unrefined sulphur is a fundamental feedstock to the chemical industry. Please note! Not all domestic sulphur production is accounted for in category A.3.4. For the purpose of EW-MFA three principle types of sulphur can be distinguished: (1) Sulphur from mining: This sulphur should be accounted for in category A.3.4. (2) Sulphur produced in the refinery through desulphurisation of petroleum resources. This sulphur is included in the amounts of extracted petroleum resources and should not be reported under A.3.4. (3) In some cases sulphur can occur as an unused by-product of the extraction of petroleum resources. This sulphur is considered unused extraction and is not accounted for in the EW-MFA questionnaire.

Other chemical minerals are mainly:

- Baryte, which is used in a variety of industries for its properties of high specific gravity.
- Witherite, a barium carbonate mineral which is the chief source of barium salts and is mined in considerable amounts in Northumberland. It is used for the preparation of rat poison, in the manufacture of glass and porcelain, and formerly for refining sugar.
- Borates, which are chemical products from borate minerals, which are e.g. used as wood preservatives. Borate minerals contain the borate anion, BO33-, the most common borate mineral is boron.
- Fluorspar (fluorite), which is a colorful mineral which is industrially used as a flux for smelting, and in the production of certain glasses and enamels.

3.3.4.5 Salt – A.3.5

This material group concerns sodium chloride. Salt may be produced from rock salt, brine or seawater. It is used for human consumption, in the chemical industry, or to 'grit' roads to prevent the formation of ice.

3.3.4.6 Limestone and gypsum – A.3.6

In Europe, limestone is mostly used for cement production, followed by its use as crushed rock aggregate. Limestone which is used for industrial purposes (e.g. production of lime or cement) is reported under EW-MFA classification item 3.6 whereas crushed limestone aggregate is allocated to item 3.8 and limestone as dimension stone is assigned to item 3.1.

Limestone requires special attention in the account for non-metallic minerals. Statistics often underreport amounts of limestone extracted for construction purposes, in particular for cement production. This position, however, commonly represents a large mass flow representing a considerable share of total domestic extraction of non-metallic minerals.

To check and if necessary correct for missing limestone extraction for cement production, the following estimation can be applied:

Estimate of limestone extraction based on (finished) cement production: The German Federal Institute for Geosciences and Natural Resources (BGR) explicitly reports limestone used for the production of Portland cement. Using corresponding production figures for cement from the BGR, a ratio of 1.19 tonnes of limestone for the production of 1 tonne of cement can be identified. The extraction of limestone can be calculated based on data for cement production in tonnes and the ratio of limestone to cement:

- Limestone for cement production [t] = cement production [t] * 1.19

Data for cement production can be obtained from production statistics (see Table 17 for respective PRODCOM codes).

Table 17: Cement production

PRODCOM 2007 code	PRODCOM 2008 code	Product
26511210	23511210	White Portland cement
26511230		Grey Portland cement (including blended cement)
26511250	23511290	Alumina cement
26511290		Other hydraulic cements

It is recommended to compare the estimated figure for limestone extraction for cement with the figure for limestone reported in production statistics. The higher number should be selected as data for the domestic extraction of limestone (with a tolerance of about 10% in favour of using the original statistics figure). If limestone for other use than for cement is clearly indicated in statistics, this figure has to be added to the estimate for limestone for cement.

Limestone may be partially replaced by dolomite which is referred to as dolomitic limestone for cement production. Please note! In case data for limestone are derived from an estimate described above it should be figured out if this estimate includes use of dolomite (for cement production). Data reported for dolomite under A 3.2, if needed, have to be corrected for double counts. It is recommended to consult a national expert for clarification of this issue.

A compilation tool is provided in the sheet “limestone v1” of the questionnaire.

3.3.4.7 Clays and kaolin – A.3.7

Kaolinite is a clay mineral. Rocks that are rich in kaolinite are known as china clay or kaolin. Other kaolinic clays are kaolin minerals such as kaolinite, dickite and nacrite, anauxite, and halloysite-endellite.

The largest use of kaolin is in the production of paper, as it is a key ingredient in creating “glossy” paper (but calcium carbonate, an alternative material, is competing in this function). Other uses of clays and kaolin are in ceramics, medicine, bricks, as a food additive, in toothpaste, in other cosmetics, and since recently also as a specially formulated spray applied to fruits, vegetables, and other vegetation to repel or deter insect damage.

In statistics, kaolin may be grouped together with other clays under the heading “industrial or special clays”. Other industrial or special clays can be: ball clay, bentonite, attapulgite, ceramic clay, fire (refractory) clay, flint clay, fuller’s earth, hectorite, illite clay, palygorskite, pottery clay, saponite, shale, special clay and slate clay.

Kaolin and other special clays are commonly well documented in statistics. Common clays and loams for construction purposes in particular for bricks and tiles are distinguished from special or industrial clays. Clay and loams for construction are often not or under-represented in statistics.

To check for this, data on the volume of production of clay products from PRODCOM database can be used to estimate the use of crude clay.

Preferably specific national sources should be used for converting the data on production of clay products into amounts of crude clay. If those national sources are not available conversion factors as shown in Table 18 could be used.

Table 18: Correspondence PRODCOM 2007 and PRODCOM 2008 codes and conversion factors for manufacture of bricks, tiles, and construction products, in baked clay

PRODCOM 2007 code	PRODCOM 2008 code	Product	Unit	Conversion factors original units to tonnes of product	Conversion factors tonnes of raw clay to tonnes of product	Conversion factor product in original units to tonnes of raw clay
26401110	23321110	Non-refractory clay building bricks (excluding siliceous fossil meals or earths)	m³	0.740	1.349	0.998
26401130	23321130	Non-refractory clay flooring blocks, support or filler tiles and the like (excluding siliceous fossil meals or earths)	kg	1000	1.349	1349
26401250	23321250	Non-refractory clay roofing tiles	p/st	421.9	1.349	569

PRODCOM 2007 code	PRODCOM 2008 code	Product	Unit	Conversion factors original units to tonnes of product	Conversion factors tonnes of raw clay to tonnes of product	Conversion factor product in original units to tonnes of raw clay
26401270	23321270	Non-refractory clay constructional products (including chimneypots, cowls, chimney liners and flue-blocks, architectural ornaments, ventilator grills, clay-lath; excluding pipes, guttering and the like)	kg	1000	1.349	1349
26401300	23321300	Ceramic pipes, conduits, guttering and pipe fittings: drain pipes and guttering with fittings	kg	1000	1.349	1349

In PRODCOM the individual clay product groups are shown in different units like m3, kg or piece. The table shows the estimated average conversion factors to tonnes of crude clay for clay products as reported in PRODCOM. The general conversion factor from kg of clay product to tonnes of crude clay was obtained by a study on 12 brick factories in Germany, Austria and Switzerland (see Bruck (1996)). See also Swiss Federal Statistical Office (Bundesamt für Statistik (2005)). According to this study 1.349 tonnes of clay are required for producing 1 tonne of clay product. PRODCOM reports bricks and roofing tiles not in kg. Hence, bricks have to be converted from cubic metres to tonnes and roofing tiles from pieces to tonnes. The conversion factor for brick has rather a wide range depending on the type of brick, ranging from clinkers over solid bricks to cellular or hollow bricks. For the purpose of the above conversion table a factor of 740 kg/m3 is suggested. That factor is an average value in an environmental declaration for brick by the Institut Bauen und Umwelt e.V. according to ISO 4025. The conversion factor for roofing tiles was derived from COMEXT. COMEXT reports roofing tiles in pieces as well as in kg. The suggested factor was estimated as an average of all imports and exports of roofing tiles during the period 2000 to 2009 for EU 27 (2.37 kg per piece).

The estimation result shall be compared with the figures for common clays and loams extraction reported in statistics (excluding industrial or special clays). The higher number should be selected as data for the domestic extraction used of common clay and loam (with an eventual tolerance of about 10% for using the original statistics figure).

A compilation tool is provided in the sheet “clay v1” of the questionnaire.

3.3.4.8 Sand and gravel – A.3.8

There are two major groups of sand and gravel (sometimes also subsumed under the notion natural aggregates) which are distinguished by their principal uses:

- **Industrial sand and gravel:** Industrial sands and gravels show specific material properties that are required for use in iron production and manufacturing including fire resistant industrial use in glass and ceramics production, in chemical production, for use as filters, and for other specific uses. Statistical sources (e.g. the USGS) often report the amount of sand and gravel in industrial production processes explicitly.

- **Sand and gravel for construction:** Sand and gravel for construction is used in structural engineering (e.g. buildings) and civil engineering (e.g. roads). Use of sand and gravel in structural engineering is mainly for the production of concrete. In civil engineering gravel is mainly used for different kinds of layers in road construction, in concrete elements and for asphalt production.

Statistics for sand and gravel may not report the total amount extracted for both industrial and construction use adequately. Often, only special sand and gravel for industrial use is included (see above). Statistics also may report numbers for sand and gravel for construction but not report total numbers due to e.g., limitations in the census. To find out if sand and gravel is not adequately reported or underestimated in statistical sources, the following checks can be performed:

The amount of sand and gravel per capita of the population in the respective year can be taken as an indicator. As a rule of thumb, if this amount is significantly below 1 tonne per capita, it can be assumed that sand and gravel for construction purposes is not adequately reported and has to be estimated. Additionally stakeholders and experts concerned with this economic activity should be consulted to clarify the significance of the reported numbers. If no adequate statistical data are available, the total amount of sand and gravel extracted for construction can be estimated.

The following simple procedure to estimate the amount of sand and gravel for construction takes into account the two most important uses of sand and gravel. It combines an estimate of sand and gravel required for the production of concrete (step 1) with an estimate of sand and gravel used in layers in road construction (step 2). In step 3 the total amount of sand and gravel is calculated as the sum of the results obtained from step 1 and step 2.

Step 1: Estimation of sand and gravel required for the production of concrete:

Concrete is a mixture of 6% air, 11% Portland cement, 41% gravel or crushed stone (coarse aggregate), 26% sand, and 16% water (PCA 2007). Thus, sand and gravel make up about 67% of the produced concrete. Based on these relations two ways for calculating sand and gravel required for concrete production are possible:

Method 1a) Estimate of sand and gravel based on concrete production data:

Sand and gravel input [t] = concrete production [t] x 0.67

Data on concrete production can be obtained from production statistics (PRODCOM 2007 item 26631000 Ready-mixed concrete and PRDCOM 2008 item 23631000); in general, method 1a) tends to underestimate the amount of sand gravel, because concrete reported in statistics commonly refers to transport concrete and does not include concrete produced directly at the construction site.

Method 1b) Estimation of sand and gravel based on the consumption of cement:

The required input of sand and gravel to produce one tonne of concrete is 6.09 times the input of cement (PCA 2007). Accordingly, sand and gravel input into concrete production can be calculated as follows:

Sand and gravel input [t] = cement consumption [t] * 6.09

Cement consumption can be derived from data on production of and trade with cement:

Apparent cement consumption = cement production + cement imports – cement exports

Data on cement flows can be obtained from statistical sources. For covering production the PRODCOM items for cement in Table 17 have to be considered. Trade flows include COMEXT HS-CN-items 252321 (White Portland cement); 252329 (Portland cement excl. white); 252330 (Aluminous Cement); 252390 (Cement weather or not coloured excl. Aluminous and Portland cement).

Step 2: Estimation of sand and gravel for road layers (freezing protection and carrying layers):

Based on information on the length of newly built roads (by type of road and year) it is possible to estimate the amount of sand and gravel used in road construction. In addition, sand and gravel required for annual maintenance of the total existing kilometres of roads should be included. Data on the length and enlargement of the road network are commonly provided by national transport or road statistics and Eurostat's reference database (Road transport infrastructure).

In addition to information on the length of the road network, data on the amount of sand and gravel required to build one kilometre of a certain road type have to be acquired. Table 19 provides data on sand and gravel requirement per km for construction and maintenance for German roads.

Table 19: Requirements of sand and gravel per km of road construction in Germany

	Tonnes sand and gravel per km		**Reference data**	
	for construction	for annual maintenance	average width in m	total length in km
Highways	28 383	518	24.4	12 531
National roads	9 692	151	8.8	40 711
Federal state roads	8 719	76	7.5	86 597
District roads	6 777	65	6.5	91 520
Local roads	5 729	67	5.5	460 000
All roads	6 886	81	6.4	691 359

Sources: Ulbricht 2006; Steger et al. 2009.

Those German coefficients can be used for estimating the sand and gravel consumption for construction and maintenance of roads also for other European countries. However, if doing so, it has to be considered that German road standards may be comparably high and German coefficients rather represent upper limits. This is mainly because German roads are dimensioned for higher speed. Therefore they have to be usually wider than in other European countries. For finding a realistic deduction from German coefficients for the purpose of other countries information on average width of roads compared to German roads (see table) could be helpful. But also other factors, like different requirements for frost protection should be considered.

Step 3:

Estimated figures for sand and gravel for concrete production (step 1) and sand and gravel for road construction (step 2) are finally added and compared with the figure for sand and gravel reported in statistics. The higher number should be selected as data for the domestic extraction of sand and gravel for construction (with an eventual tolerance of about 10% in favour of using the original statistics figure). If sand and gravel for industrial uses is given as a specific position in statistics, this figure has to be added to the estimated figure.

The use of recycled sand and gravel should also be taken into account and subtracted.

A compilation tool is provided in the sheet “sand and gravel v1” of the questionnaire.

3.3.4.9 Other n.e.c. – A.3.9

This is a diverse group that essentially comprises all minerals not covered by the previous groups. Some of the minerals that are allocated to A 3.9 are listed below.

Bitumen and asphalt, natural asphaltites and asphaltic rock: The largest use of asphalt is for making asphalt concrete for road surfaces. Only natural asphalt and bitumen is accounted for in this category. Most of the bitumen, tar and asphalt used in Europe are products of the petrochemical industry and are not considered domestic extraction.

Precious and semi-precious stones, different stones such as pumice stone, emery; natural corundum, natural garnet and other natural abrasives used for various industrial purposes. Synthetic diamonds are not reported under item 3.9 or CPA 14.5 and they are not regarded as DEU.

Graphite, a stable form of pure carbon, is mainly used in refractories.

Quartz and quartzite are special qualities of silicon used e.g. in the optical industry or in metal manufacturing.

Siliceous fossil meals like Kieselgur, Tripolite, Diatomite and other siliceous earths, used e.g. as absorption agent or material for heat insulation.

Asbestos, a fibrous mineral, is nowadays restricted in its use due to serious hazard to health.

Steatite and talc are magnesium silicate minerals, used for several industrial purposes.

Feldspar is an essential component of glass and ceramic manufacture.

3.3.4.10 Excavated earthen materials (including soil), only if used (optional reporting) – A.3.10

The item “Excavated earthen materials” denotes material such as e.g. soil which is excavated e.g. in construction. It is only counted if it is used.

This item is not a typical product and hence not covered by CPA and PRODCOM. It is difficult to measure and information needs to be derived from other, notably national data sources. In its economy-wide EW-MFA for 1980 to 1998, the Italian Statistical Office has reported soil from excavation activities that are reused in construction as material input. So far, no standardised estimation procedures for this material flow are available. For further details, please refer to Barbiero et al. (2003).

3.3.4.11 Specific issue: crushed rock

Several statistical sources use the category “crushed rock” or “crushed stone”. Crushed rock is commonly produced as broken natural stones for road-, railway-, waterway-, and buildings construction. A range of natural stone types can be used to produce crushed rock. These include the types explicitly addressed in this guide under A.3.2 (chalk and dolomite), A.3.6 (limestone and gypsum), and under A.3.9 (other non-metallic minerals n.e.c.). In addition, crushed rock may comprise other natural stones like sandstone, volcanic stones, basalt, granite, quartzite, gneiss, and others.

The EW-MFA classification of stone minerals in Table 15 is not fully consistent with classifications specifying crushed stone (or rock) in national and international mining statistics. Possible other classifications may have the following characteristics:

- statistical data include gravel under crushed rock, or vice versa, without distinction;
- statistics report building stone which may comprise, but not show separately, dimension stone and crushed rock;
- data for limestone are reported as such but also included under crushed rock, so that double counting occurs.

It is therefore difficult to assess whether the production of crushed stone reported in various statistical sources is complete and without doubles counts. In the first place, we recommend acquiring data for the domestic extraction of non-metallic minerals as described in this guide. Crushed rock should then be mainly covered by limestone, gypsum, chalk, and dolomite, and bitumen and asphalt rock.

The total of these positions may then be compared with the total number for crushed rock in national statistics or alternatively in the BGS European Mineral Statistics. In case the number for total crushed rock is considerably higher than the sum of related minerals accounted for as described in this guide, the difference may be taken as an estimate for additional domestic extraction used of crushed rock which cannot be further identified.

Please note! If this is the case please add the additional amount of crushed stones to A.3.6 and add a footnote stating what amount of additional crushed stone had been added and by which method it has been estimated.

4 Fossil energy materials/carriers

4.1 Concepts and classification

Table 20 shows the classification of material flows for domestic extraction of fossil energy materials/carriers. Annex 2 of the EW-MFA questionnaire includes correspondences to the respective codes of Eurostat's energy statistics/balances.

In Eurostat's energy statistics/balances the commodity *oil shale and tar sands* is lumped together with *lignite*. For the EW-MFA Table A, the two items are to be reported separately. Further, Eurostat energy statistics/balances do not report separately the two commodities *crude oil* and *natural gas liquids*. However, disaggregation of these items can be obtained from national or IEA (International Energy Agency) energy balances.

Table 20: Classification of material flows for domestic extraction of fossil energy materials/carriers (refers to Table A.4 of the EW-MFA questionnaire)

A.4 Fossil energy materials/carriers		
	A.4.1 Coal and other solid energy materials/carriers	
		A.4.1.1 Lignite (brown coal)
		A.4.1.2 Hard coal
		A.4.1.3 Oil shale and tar sands
		A.4.1.4 Peat
	A.4.2 Liquid and gaseous energy materials/carriers	
		A.4.2.1 Crude oil, condensate and natural gas liquids (NGL)
		A.4.2.2 Natural gas

(refers to Table A.4 of the EW-MFA questionnaire)

Whereas energy statistics/balances show a comprehensive picture of the supply and use of all energy carriers, the domestic extraction of energy materials/carriers in EW-MFA is limited to the extraction of fossil energy carriers only.

Not included are primary renewable energy carriers, like hydro, wind, solar and geothermal energy. The domestic extraction of biomass which might be used for energy purposes is reported under biomass (A.1). The domestic extraction of the energy carrier uranium is reported under metals (A.2).

Oil shale and tar sands are only of regional significance in Europe (Estonia) and small quantities in Italy and Germany.

Natural gas: Production is measured after purification and extraction of NGL and sulphur and excludes re-injected gas and quantities vented or flared (so called total dry production).

4.2 Data sources

National statistics like mining statistics and energy statistics/balances provide data on the extraction of petroleum resources and other fossil energy carriers. Data quality is usually very high for all subcategories.

International sources: Eurostat's reference database provides energy statistics/balances for all EU countries. Other prominent international data bases for fossil energy materials are provided by the International Energy Agency (IEA 2004), the United Nations Industrial Commodity Production Statistics and the data collections of the United States Geological Survey (USGS) and the British Geological Survey (BGS).

4.3 Data compilation

Primary source – energy statistics/balances:

The energy balance is an accounting system which reports the supplies and uses of energy in a detailed, comprehensive, and coherent manner. Some countries also compile energy flow tables in the framework of environmental economic accounting. Eurostat is also developing energy accounts (physical flow accounts).

It is recommended to use energy balance data on domestic production of fossil energy carriers as the primary source for compiling the EW-MFA data on domestic extraction of fossil energy materials/carriers.

All kind of peat is to be reported here under A.4. It has to be noted that the energy balance excludes peat for non-energetic use. However extraction of peat for non–energetic use (gardening) accounts for a substantial proportion of total peat extraction. Therefore the energy balance figures have to be supplemented for extraction of peat for non-energetic use. As far as no national sources are available for that purpose USGS can be utilized as a data source[14].

If peat data are reported in cubic metres the following conversion factor can be used (UN 1987):

$$1\ m^3 = 0.x\ t$$

Conversion factors for natural gas:

The energy statistics/balance data are primarily reported in calorific units like joules or tonnes of oil equivalents. Additionally, data in tonnes are provided for fossil energy carriers, with the exception of natural gas. Data in mass weight units can be integrated into the EW-MFA without further processing. But data on natural gas have to be converted from calorific values (or cubic metres) into tonnes. Preferably country specific conversion factors should be applied, as the technical characteristics of natural gas vary from region to region (see below). If that specific information is not available, general factors could be used (see Table 21).

[14] See: http://minerals.usgs.gov/minerals/pubs/commodity/peat/index.html#mybhttp://minerals.usgs.gov/minerals/pubs/commodity/peat/index.html#myb

Table 21: Calorific value and density of natural gas of fossil energy carriers

	kg / m³ (standard cubic meter at 15℃)	GCV [MJ/kg]	GCV [MJ/m³]
Natural gas (range)	0.76-0.83	36-55	30-45
Natural gas (default value)	0.8	50	40

Source: derived from OECD/IEA/Eurostat 2005

Tables B, C, D, and E – Imports and Exports

5 Concepts and classification

Tables B, C, D, and E of the EW-MFA questionnaire record the material flows of traded products and waste (imports and exports). An important distinction is made between total trade and extra-EU27 trade:

Table B	Imports - total trade (intra + extra EU trade)
Table C	Imports - extra-EU27 trade
Table D	Exports - total trade (intra + extra EU trade)
Table E	Exports - extra-EU27 trade

For the purpose of EW-MFA, the traded products are grouped into material groups which are similar to the classification of material flows for domestic extraction. The close classification is needed in order to enable the addition/aggregation of domestic extraction and trade components in order to derive indicators..

Obviously, this grouping according to the material contained in the traded products is very crude because products are composed of many different materials. In particular finished products are very heterogeneous. Therefore the traded products are grouped into those material classes which form the main component of the respective good (e.g. motor vehicles are grouped into a class termed *products mainly from metals* (B.2.3)).

In addition to domestic extraction of materials EW-MFA records the material exchange between the domestic economy and the rest of the world economy. This material exchange comprises the import and export of products (=trade) and waste.

Classification:

The classification of external trade flows for EW-MFA is presented in Table 22. Annex 3 of the EW-MFA questionnaire provides a correspondence between the EW-MFA classification and the product classification for Eurostat's external trade statistics (CN).

Table 22: Classification of trade flows (refers to Tables B, C, D, and E of the EW-MFA questionnaire)

B*.1 Biomass and biomass products
B*.1.1 Crops, raw and processed
B*.1.1.1 Cereals, raw and processed
B*.1.1.2 Roots, tubers, raw and processed
B*.1.1.3 Sugar crops, raw and processed
B*.1.1.4 Pulses, raw and processed
B*.1.1.5 Nuts, raw and processed

B*.1.1.6 Oil-bearing crops, raw and processed
B*.1.1.7 Vegetables, raw and processed
B*.1.1.8 Fruits, raw and processed
B*.1.1.9 Fibres, raw and processed
B*.1.1.10 Other crops n.e.c., raw and processed
B*.1.2 Crop residues and fodder crops
B*.1.2.1 Crop residues (used), raw and processed
B*.1.2.1.1 Straw
B*.1.2.2.2 Other crop residues
B*.1.2.2 Fodder crops
B*.1.2.2.1 Fodder crops
B*.1.3 Wood and wood products
B*.1.3.1 Timber, raw and processed
B*.1.3.2 Wood fuel and other extraction, raw and processed
B*.1.4 Fish capture and other aquatic animals and plants, raw and processed
B*.1.4.1 Fish capture
B*.1.4.2 All other aquatic animals and plants
B*.1.5 Live animals other than in 1.4, and animal products
B*. 1.5.1 Live animals other than in 1.4
B*. 1.5.2 Meat and meat preparations
B*. 1.5.3 Dairy products, birds' eggs, and honey
B*. 1.5.4 Other products from animals (animal fibres, skins, furs, leather, etc.)
B*. 1.6 Products mainly from biomass
B*.2 Metal ores and concentrates, raw and processed
B*.2.1 Iron ores and concentrates, iron and steel, raw and processed
B*.2.2 Non-ferrous metal ores and concentrates, raw and processed
B*.2.2.1 Copper
B*.2.2.2 Nickel
B*.2.2.3 Lead
B*.2.2.4 Zinc
B*.2.2.5 Tin
B*.2.2.6 Gold, silver, platinum and other precious metal
B*.2.2.7 Bauxite and other aluminium
B*.2.2.8 Uranium and thorium
B*.2.2.9 Other n.e.c.

B*.2.3	Products mainly from metals
B*.3	**Non-metallic minerals, raw and processed**
B*.3.1	Marble, granite, sandstone, porphyry, basalt and other ornamental or building stone (excluding slate)
B*.3.2	Chalk and dolomite
B*.3.3	Slate
B*.3.4	Chemical and fertilizer minerals
B*.3.5	Salt
B*.3.6	Limestone and gypsum
B*.3.7	Clays and kaolin
B*.3.8	Sand and gravel
B*.3.9	Other n.e.c.
B*.3.10	Excavated earthen materials (including soil), only if used (optional reporting)
B*.3.11	Products mainly from non-metallic minerals
B*.4	**Fossil energy materials/carriers, raw and processed**
B*.4.1	Coal and other solid energy products, raw and processed
B*.4.1.1	Lignite (brown coal)
B*.4.1.2	Hard coal
B*.4.1.3	Oil shale and tar sands
B*.4.1.4	Peat
B*. 4.2	Liquid and gaseous energy products, raw and processed
B*. 4.2.1	Crude oil, condensate and natural gas liquids (NGL)
B*.4.2.2	Natural gas
B*.4.2.3	Adjustment for residence principle: Fuel bunkered by resident units abroad (Table B); Fuel bunkered by non-resident units on the national territory (Table D)
B*.4.2.3.1	Fuel for land transport
B*.4.2.3.2	Fuel for water transport
B*.4.2.3.3	Fuel for air transport
B*.4.3	Products mainly from fossil energy products
B*.5	**Other products**
B*.6	**Waste imported for final treatment and disposal**

*Note: the codes starting with "B" are related to Table B. The other tables have codes starting with their respective letter (e.g. codes in Table D start with a "D").

The EW-MFA classification for imports and exports distinguishes six broad material categories:

- B*.1 Biomass and biomass products

- B*.2 Metal ores and concentrates, raw and processed
- B*.3 Non-metallic minerals, raw and processed
- B*.4 Fossil energy materials/carriers, raw and processed
- B*.5 Other products
- B*.6 Waste imported for final treatment and disposal

*Note: the codes starting with "B" are related to Table B. The other tables have codes starting with their respective letter (e.g. codes in Table D start with a "D").

Under B.4 the items B.4.2.3.1 to B.4.2.3.3 are introduced. Those items are needed for adjusting the original trade and/or energy statistics, which are reported according to the territory principle, to the residence principle.

It should be stressed that the allocation of foreign trade categories to the EW-MFA categories is not unambiguous because the trade classifications always distinguish between different goods, whereas the EW-MFA classification distinguishes between different types of materials. As goods are often a mixture of different materials no unequivocal correspondence between these two classification systems is possible.

Despite this conceptual incompatibility between EW-MFA and trade classifications it is possible to determine for most goods the main material component (as e.g. for most biomass goods), or the main raw materials used in the production (as e.g. for steel ingots). For others, it is only possible to classify the good as either of biomass, mineral, or fossil fuel origin. In these latter cases, the commodities are assigned to material categories such as e.g. *products mainly from biomass* (B.1.6). The remaining goods, mostly commodities that are highly processed and consist of a complex mix of materials for which it is not possible to determine a main material component, are summarized in the EW-MFA category *other products* (B.5). For details see Annex 3.

EU intra and extra trade:

The external trade flows between EU countries are called intra-EU trade. The exchange of EU countries with non EU countries is called extra-EU trade. The sum of intra-EU and extra-EU trade is termed total trade.

In the EW-MFA questionnaire separate reporting of extra-EU and total trade is requested. This implies that the intra-EU trade can be calculated by deducting the extra-EU from total trade.

Transit flows:

According to the EW-MFA concept imports and exports exclude so called transit goods. Transit goods are imports that are exported again without any processing occurring within the country and thus to which no value is added between import and re-export.

Treatment of goods sent for processing:

As far as goods sent for processing are concerned the EW-MFA follows the concept of the SEEA central framework.

It is increasingly common for goods from one country to be sent to another country for further processing before being (i) returned to the original country, (ii) sold in the processing country, or (iii) sent to other countries. In situations where the un-processed goods are sold to a processor in a second country there are no particular recording issues. However, in situations where the processing is undertaken on a fee for service basis and there is no change of ownership of the goods (i.e. the ownership remains with the original country) the financial flows are unlikely to relate directly to the physical flows of goods being processed.

In monetary accounting of SNA only the service fee is recorded as external trade flow. However the SEEA central framework follows a deviating approach for recording that transaction in physical terms. The treatment is to record the physical flows of goods, both as they enter into the country of the processing unit and as they leave that country. Tracking the physical flows in this way enables a clearer reconciliation of all physical flows in the economy and also provides a physical link to the recording of the environmental effects of the processing activity in the country in which the processing in being undertaken, including for example, emissions to air. The same considerations apply to flows of goods for repair and merchanting.

The SEEA approach for treatment of those flows is in accordance with the external trade statistics.

Unit of measurement:

The import and export flows (=products and waste) in EW-MFA are measured in mass weight units. The reporting of the mass weight refers to the traded weight of the goods (= material product in ESA95) and of waste materials for final treatment and disposal (see section 2.3.2).

Packaging materials:

From a conceptual point of view, packaging materials should be accounted for in EW-MFA. However, external trade statistics only report net weight, which usually excludes the weight of packaging material. However practically, packaging materials are often of negligible importance. A German study on traded packaging materials revealed that the amount of packaging materials in imported goods was only 0.5 % of the imported tonnes (GVM 2005). Considering the minor importance and the huge efforts an estimation of packaging materials in traded goods would take, the Eurostat Task Force on MFA recommended that no additional estimation of packaging materials needs to be performed.

Resident principle:

The demarcation of the flows follows the residence principle of the European System of National Accounts (ESA 95), that is the import and export flows refer to transactions of so called resident units with non-resident units. In the system of national accounts resident units are defined as those units whose centre of economic interest is located on the national economic territory.

6 Data sources

External trade statistics:

External trade statistics are the main data source for compiling trade flows in EW-MFA. External trade statistics cover all flows of material goods as well as waste flows as long as the latter have a monetary value. Eurostat provides a harmonized external trade statistic database (COMEXT) which distinguishes more than 10 000 product classes (CN 8-digit level). National foreign trade statistics or data bases may offer even more details.

The COMEXT data base reports the imports and exports of goods in monetary, physical units, and in supplementary units (only for some goods). In COMEXT the standard physical unit is 100 kilograms.

Supplementary sources:

For adjusting the external trade data to the concepts of EW-MFA some supplementary information is required (e.g. balance of payment accounts or energy statistics).

7 Data compilation

7.1 General approach

The principal source for compiling the data on imports and exports of goods and waste are the harmonized external trade statistics. Those data can be obtained from national sources as well as from Eurtostat’s reference database (COMEXT). The COMEXT data are reported according to the Combined Nomenclature (CN8), which first six digit codes coincide with the Harmonized Commodity Description and Coding System (HS) and as well according to the Standard International Trade Classification (SITC) and the Broad Economic Categories (BEC). Regarding the product classification the Combined Nomenclature (CN) is applied for the detailed data whereas the Standard International Trade Classification (SITC) or the Broad Economic Categories (BEC) is used for aggregated data. The correspondence between the EW-MFA classification and the CN can be applied for allocating the CN items of COMEXT to the entries of the EW-MFA classification.

Please note! The CN is subject to annual revisions that ensure that the CN is kept up to date in the light of changes in technology or in patterns in international trade.

Beside product flows, flows of *waste for final treatment and disposal* are also covered by COMEXT data base (SITC 599).

The required disaggregation between EU-intra and EU-extra trade is provided by the COMEXT data base. Transit flows are, as required by the EW-MFA concept, excluded from COMEXT data.

Crosschecking:

It is recommended to use monetary trade data and the calculated prices for cross-checking. If necessary, missing or false physical data in single years can be estimated by use of monetary trade flow data and tonne prices in adjacent years. Another possibility to cross-check or complete missing data is to refer to alternative data sources, e.g. national or international statistics on traded goods, for example the IEA or FAO.

7.2 Unit of measurement

COMEXT data report the imports and exports of goods in monetary and physical units. The standard physical unit is 100 kilograms measured at the point in time when a good crosses an administrative border. For some commodities, data are reported in other physical units such as length (metres), area (square metres), volume (cubic metres, litres), numeric units (pieces, pairs, dozens, packs), or, for electricity, in kilowatt-hours. The unit kilograms complies with the EW-MFA concept, except for the treatment of packaging material which is conceptually included to EW-MFA flows, but excluded in external trade statistics. However as that item is quantitatively insignificant and difficult to measure, it was decided to neglect that conceptual difference for the purpose of data calculation.

However, it has to be noted that from 2006 on, Member States may not collect data in kilograms if the supplementary unit (i.e. a unit other than kilograms) is requested. In those cases the other physical units have to be converted into kilograms by appropriate conversion factors. Those factors can be obtained for the same country from the years before 2006.

For some items national conversion factors from other sources may also be available, as for example information from national aircraft and ships registers.

If no appropriate national information is available EU level conversion factors for exports and imports which are provided by Eurostat could be applied. See Annexes 6 to 9 of the questionnaire.

7.3 Resident principle

In principle, the demarcation of the trade flows for EW-MFA (Tables B to E) should follow the resident principle as applied in National Accounts. The physical trade transaction between the domestic economy (resident units) and the rest of the world economy (non-resident units) needs to be reported.

Between the ESA 95/SNA 1993 and the ESA 2010/2008 SNA, there has been a fundamental change in the treatment of goods sent abroad for processing without change of ownership. In the ESA 95/SNA 1993, such goods were shown as exports on being sent abroad, and then recorded as imports on return from abroad, at a higher value as a result of the processing. This was known as the gross recording method and effectively imputes a change of ownership so that international trade figures represent an estimate of the value of the goods being traded. The ESA 2010, the 2008 SNA and the BPM6 do not impute a change of ownership, but rather show only one entry – an import of the processing service. This would be an export of the service for the country in which the processing (inward processing) takes place and an import of service for the country of the principal (outward processing). This recording is more consistent with the institutional records and associated financial transactions. It does, however, cause an inconsistency with the IMTS 2010[15]. The IMTS 2010 continues to show the gross value of the exports for process and returning imported processed goods[16].

Based on the SEEA recommendation (see SEEA-CF § 1.45[17]) the Task Force on Material Flow Accounts decided at its meeting on 11-12 June 2013 not to introduce this conceptual change into EW-MFA. This implies that international trade statistics can be used to compile Table B to E without any adjustments for "goods send for processing".

Nevertheless adjustments to trade statistics are needed with regards to goods purchases by residents

[15] International Merchandise Trade Statistics: Concepts and Definitions 2010 (see http://unstats.un.org/unsd/trade/eg-imts/IMTS2010-final-22March2011.pdf)

[16] See IMTS 2010, paragraph 1.20. It is recommended that in all cases, goods for processing and goods resulting from such processing (compensating products in customs terminology), are to be included in the merchandise exports and imports of the countries at their full (gross) value.

[17] „..in situations of goods send to other countries for processing or repair, or in cases of merchanting, the SEEA Central Framework recommends recording the actual physical flows of goods in those cases where the ownership of those goods does not change but remains with a resident of the originating country. No change to the monetary recording of these flows is recommended. This variation is particularly applicable in recording physical flows associated with the processing of raw materials (e.g. oil refining) where the physical flows may be largely invariant to the nature of the contractual relationships which are the focus of the recording of monetary flows in the SNA and the Balance of Payments."

abroad (become imports) and goods purchased on the territory by non-residents (become exports).

These two resident-adjustment-items are quantitatively relevant in the case of fuel consumption; e.g. mobile resident units (transport vessels) which operate outside the national territory.

To account for this effect the additional items B/E.4.2.3.1 to B/E.4.2.3.3 have been added to the EW-MFA questionnaire /Tables B to E). On the import side the fuels bunkered by resident units abroad have to be added as additional imports to the imports which are reported by the external trade statistics. On the export side the fuels which are bunkered on the domestic territory by non- resident economic units have to be added accordingly.

The relative size of the flows accounted for in item B/E.4.2.3 can vary largely from country to country. Some of these flows can be negligible; others can be of considerable size. In particular in countries with large airport hubs or ports on the economic territory, significantly sized shipping fleets, or important transit routes, the amount of fuel bunkered by non-resident units domestically can be considerable and adjustments may be necessary. The data required for these adjustments are, however, not readily available, as there are no corresponding items for those entries in the CN. In general three paths for obtaining the required information (or a combination of these paths) are potentially viable:

- **Energy and transport statistics:** In some countries national energy or transport statistics collect data on fuel use in international transport. Experts in energy and transport statistics should be consulted to provide a first assessment of the significance of the concerned flows and to identify potential statistical sources.
- **Other physical flow accounts such as e.g. Air Emissions Accounts (AEA) and Physical Energy Flow Accounts (PEFA):** Like EW-MFA other physical flow accounts (e.g. AEA, PEFA) follow the residence principle and require respective adjustments. In the course of the compilation of respective adjustment items for AEA or PEFA certain pieces of information might become available that can be used to approximate the fuel uses needed for EW-MFA adjustments, namely:
  - fuel purchases by resident units abroad;
  - fuel purchases by non-residents on the territory.
- **National accounts:** National accounts have a long tradition in dealing with practical difficulties resulting from a consequent implementation of the residence principle. In general, national accounts experts have a good overview on the required adjustments and monetary data on fuel use in international transport may be available from national accounts. Usually the monetary data should be based on estimates in physical terms. On the basis of national accounting data on fuel used by non-resident units domestically and fuel used by resident units abroad, the required mass flows can be estimated.

7.4 Stage of manufacturing

Traded goods can also be classified according to their level ("stage") of manufacturing. The following three levels (or stages) of manufacturing are common:

- **raw products:** raw materials alike products produced by primary industries such as agriculture, forestry, fishing, and mining;
- **semi-manufactured products:** products which are further processed raw products but do not yet constitute finished products; they obviously need to be further processed;

- **finished products:** products which are finalised, i.e. are not processed or transformed anymore; note that finished products potentially are used for final consumption by households, governments etc. but also as intermediate input to industries.

Each of the trade tables in the EW-MFA questionnaire (Tables B to E) has been amended by three additional rows asking for figures on these three broad product groupings.

That information can be helpful for assessing the resource requirements which are behind the import and export flows. In general one may assume that the degree of representation of the raw material requirement for manufacturing a product by its weight tends to decrease with the level of manufacturing. That is, whereas the weight of raw products is usually rather close to the weight of the domestic extraction, a finished product may contain only the metal content, which represent a small part of the weight of the metal ore and the energy carriers which were used for its production. Insofar the results of the "level ("stage") of manufacturing approach" can serve as a first approximation for raw material equivalents (RME). Annual material flow indicators in RME are published by Eurostat (See Karl Schoer, Jürgen Giegrich, Jan Kovanda, Christoph Lauwigi, Axel Liebich, Sarka Buyny, Josefine Matthias (2012)) and the German Statistical Office (See Sarka Buyny and Ursula Lauber (2010). Other member countries have conducted pilot studies on RME.

Annex 4 of the EW-MFA questionnaire presents a correspondence key assigning the more than 20 000 CN positions to the three product groups. The assignment of a CN code to one of the three product groups was done by a joint effort of Eurostat, Destatis, and the Swiss Federal Statistical Office. A statistical definition for the three product groups does not exist and could not be employed to develop formal criteria. In practice the assignment was mainly based on the CN labels. It is considered more important that the correspondence is harmonised and that all European NSIs use the same.

7.5 Alternative method for calculating external trade flows

Statistic Netherlands has developed an alternative method for compiling the external trade flows in EW-MFA on the basis of national accounts data. Detailed trade data using the most detailed product classification (typically national versions of CPC/CPA) is obtained from the national accounts in monetary units. These monetary values for products are then converted into mass units by using conversion factors of unit prices (e.g. euro per tonne). In this way it is possible to convert the detailed product import and export data into mass units (tonnes).

This method assures a match between the monetary national account data and the physical EW-MFA data. Also, because physical trade data is not directly used, this method is useful when the quality of physical trade data is not sufficient.

The challenge is to find a price-to-tonne relationship that reflects the heterogeneity of the CPC/CPA product groups. Price information can be obtained from the trade statistics by taking only those registrations into account that provides reliable monetary and physical data. Another challenge is to match the CPC products to the EW-MFA material categories. A few CPC products, like non-ferrous metals, are not detailed enough to match the EW-MFA classification. In these cases a breakdown of the CPC-products in more specific commodities can be made on the basis of the international trade statistics.

The EW-MFA was developed according to SNA1993/ESA1995 concepts and definitions. However, the SNA2008/ESA2010 has different guidelines with respect to goods sent for processing and merchanting. Basically, a change in ownership determines if a good is recorded gross as a trade in goods or net as a trade in services. In accordance with the revised SEEA, it has been decided for the compilation of the EW-MFA not to follow the SNA2008/ESA2010 in this respect. See section 2.1. As a consequence, if a country has implemented SNA2008/ESA2010 with respect to the processing of goods abroad, the above approach of combining national accounts commodities and prices per tonne may not be appropriate. In case of goods send for processing, the monetary value would reflect the value of the service rather than a value of the product - so a price per mass (tonne) could not be used any longer. The above method can only be applied if monetary trade values in the national accounts are recorded according to the SNA1993/ESA1995.

8 Table F - Domestic Processed Output (DPO)

The indicator Domestic Processed Output to nature (DPO) was developed and applied first by an international team of experts in a joint effort resulting in the publication "The Weight of Nations" (Matthews et al. 2000). DPO indicates the total weight of materials which are released back to the environment after having been used in the domestic economy. These flows occur at the processing, manufacturing, use, and final disposal stages of the economic production and consumption chain. Exported materials are not included in DPO because they are yet to be used in other countries.

DPO was calculated for the USA, Japan, Austria, Germany, The Netherlands (Matthews et al. 2000), for Finland (Muukkonen 2000), for the EU-15 (Bringezu and Schütz 2001), for the Czech Republic (Scasny et al. 2003) and for Italy (Barbiero et al. 2003). Table 23 shows DPO data around the year 2000 for some industrial economies.

Table 23: Selected results for DPO

tonnes per capita	Austria	Japan	Germany	Nether-lands	USA	Finland	Italy
	1996	1996	1996	1996	1996	1997	1997
Emissions to air	10.3	10.4	11.7	15.2	22.0	16.9	8.2
CO2	10.1	10.4	11.5	15.1	20.5	16.8	7.9
Waste landfilled	1.1	0.6	0.9	0.6	1.6	1.9	1.0
Municipal waste		0.10	0.15	0.5		0.4	0.4
Emissions to water	0.01	0.01	0.04	0.04	0.03	1.4	0.2
Dissipative use of products	1.1	0.10	0.6	2.4	0.5	4.2	2.5
Organic fertiliser	0.7	0.09	0.3	2.3	0.3	3.8	2.3
Dissipative losses	0.06		0.01		0.00		0.03
DPO not further defined					1.0	1.0	
DPO	12.5	11.2	13.1	18.2	25.1	25.4	11.8

Sources: Matthews et al. 2000: Austria, Japan, Germany, Netherlands, USA; Muukkonen 2000: Finland; Barbiero et al. 2003: Italy.

Note: at the time these studies were performed, DPO was defined including waste landfilled. In this Guide, waste to controlled landfills is excluded from DPO.

As can be clearly seen from table 23, emissions to air by far dominate the overall DPO level, and CO_2 emissions dominate the emissions to air. On average (measured as weighted average across all countries shown in table 23), emissions to air accounted for 85% of DPO and CO_2 accounted for 94% of emissions to air.

The DPO account comprises 5 major categories:

F.1. Emissions to air

F.2. Waste landfilled (uncontrolled)

F.3. Emissions to water

F.4. Dissipative use of products

F.5. Dissipative losses

The first three categories (F.1. to F.3.) refer to the three gateways through which materials are initially released to the environment, i.e. air, land, and water, commonly referred to as emissions and waste in official statistics. The remaining two categories (F.4. and F.5.) are residual categories which are not fully attributable to a specific gateway but are rather attributed to a type of release, dissipative or deliberate, than to an environmental gateway.

Apparently there can be overlaps between a distinction according to gateways and a distinction according to dissipative uses and losses. Mainly these potential overlaps refer to a few emissions to air. Essentially there are two practical rules that help avoiding double counting between emissions to air and other categories of DPO:

1. N_2O emissions from product use and NMVOC emissions by solvents are accounted for in “dissipative use of products” and not in “emissions to air”.
2. Emissions to air from fertiliser application, such as N_2O and NH_3 are not accounted for in DPO. The related primary output is fertiliser spread on agricultural soil. The inclusion of these emissions thus would represent double counting.

Please note! So far no fully standardised methods for the compilation of DPO from different data sources have been developed and the quality, structure and comprehensiveness of available data sources differ largely across countries. It is therefore not possible to provide default procedures in sufficient detail. The following recommendations are of a more general nature and will inevitably leave some questions unanswered. It certainly will require the judgment and creativity of the practitioner to apply these general rules to the specific national situation. It is good practise to specify clearly the assumptions made and the data sources used, so that the issue of completeness can be evaluated. In particular this applies to the estimation of CO_2 emissions, as they by far dominate both DPO and emissions to air.

8.1 F.1. Emissions to air

Table 24: Domestic processed output: emissions to air (refers to Table F1 in the EW-MFA questionnaire)

F.1 Emissions to air		
	F.1.1 Carbon dioxide (CO2)	
		F.1.1.1 Carbon dioxide (CO2) from biomass combustion
		F.1.1.2 Carbon dioxide (CO2) excluding biomass combustion
	F.1.2 Methane (CH4)	
	F.1.3 Dinitrogen oxide (N2O)	
	F.1.4 Nitrous oxides (NOx)	

	F.1.5 Hydroflourcarbons (HFCs)
	F.1.6 Perflourocarbons (PFCs)
	F.1.7 Sulfur hexaflouride
	F.1.8 Carbon monoxide (CO)
	F.1.9 Non-methane volatile organic compounds (NMVOC)
	F.1.10 Sulfur dioxide (SO2)
	F.1.11 Ammonia (NH3)
	F.1.12 Heavy metals
	F.1.13 Persistent organic pollutants POPs
	F.1.14 Particles (e.g PM10, Dust)

8.1.1 Introduction

Emissions to air are gaseous or particulate materials released to the atmosphere from production or consumption processes in the economy. In EW-MFA emissions to air comprise 14 main material categories on the 2digit level, as shown in the table 24.

8.1.2 Data sources

Statistical reporting on air emissions has a relatively short history as compared to agricultural, mining or trade statistics. As a consequence data from different sources are less harmonized and gaps in the historical record are likely to occur. As a general rule in EW-MFA it is recommend to use national data sources. The following section briefly describes three important inventories for emissions to air that are based on national data, and subsequently compiled in international data bases.

1. **National greenhouse gas inventories in the common framework of IPCC:** The national inventories cover emissions to air that have a greenhouse gas potential, i.e. contribute directly and indirectly to global warming. Countries which signed the UN Framework Convention on Climate Change (UNFCCC) are requested to compile their national greenhouse gas inventories according to the respective IPCC (International Panel on Climate Change) guidelines, i.e. in the common reporting format (CRF). The latest revision of these guidelines was published in 2006 (IPCC 2006) and covers sources and sinks of the direct greenhouse gases CO_2 (carbon dioxide), CH_4 (methane), N_2O (dinitrogen oxide), HFC (hydrofluorocarbons), PFC (perfluorocarbons) and SF_6 (sulphur hexafluoride) as well as the indirect greenhouse gases NO_x (nitrogen oxides), NMVOC (non-methane volatile organic components), CO (carbon monoxide), and SO_2 (sulphur dioxide). Country specific data are available at UNFCCC (http://unfccc.int/2860.php).

   Please note! IPCC resp. UNFCCC report data based on the territory principle, and if used as data source need to be converted to the residence principle, e.g. using “bridge tables” as described in the Eurostat Manual for Air Emissions Accounts (Eurostat 2009, 2013).

General information on the implications of the residence principle for EW-MFA accounts and required adjustments can be found in the fundamentals chapter of this guide and the chapter dealing with imports and exports.

2. **CORINAIR (CORe INventory of AIR emissions):** Air emission data are also complied under the UNECE convention on long range transboundary air pollutants (LRTAP). The focus of this convention is on classical air pollutants. For European countries air emission data for the LRTAP are collected in CORINAIR a project of the European Topic Centre on Air Emissions and the EEA. CORINAIR includes the pollutants CO, NH_3, NMVOC, NO_X, PM10, PM2.5, SO_2 and it provides cross references to the Integrated Pollution Prevention and Control (IPPC) coding formats. Data for European countries can be accessed via EEA (http://www.eea.europa.eu).

   Please note! Like UNFCCC data, CORINAIR data are based on the territory principle, and if used as data source need to be converted to the residence principle.

3. **Air emission accounts (AEA - national accounting matrices including environmental accounts)**: In AEA environmental information is compiled consistently with the way activities are represented in the supply and use framework of the national accounts. AEA provides air emission data by economic activity. In Europe AEA data are compiled at the national level by statistical offices and collected by EUROSTAT (http://epp.eurostat.ec.europa.eu). As AEA is a framework linking emissions to the input-output framework of the national accounts, the data structure and the applied conventions are somewhat different from the traditional emission inventories as e.g. the CORINAIR and the IPCC statistics, to ensure the comparability of AEA to the input output framework.

   Please note! AEA data are in line with the residence principle, and if available should be used as primary data source for EW-MFA. Please refer to the Eurostat Manual for Air Emissions Accounts (2009, 2013).

The three accounting systems serve different purposes and therefore reveal differences in coverage and accounting conventions. Often a combination of data source will be necessary to fill in F1 in table D. The most important points to consider when using data from emission inventories for EW-MFA are discussed in the next section.

8.1.3 Conventions

Terminology and classification: The terminology for emissions to air follows international harmonised standards of IPCC, CORINAIR or AEA.

System boundaries: In defining the system boundary for emissions to air it is important to ensure that this definition for the output side is consistent with the definition for the input side and with the definition of societal stocks. As a general rule the category **“**emissions to air” indicates the total weight of materials which are released to the air by national resident units on the national economic territory and abroad. There are some **exceptions** to be taken into account:

- All emissions to air listed under G.2 (**output balancing items**) are not included in DPO.
- **Emissions from fertilizer applications** are not included in DPO, as this would represent double counting with “dissipative uses”.
- **N_2O emissions from product use and NMVOC emissions by solvents** are accounted for in “dissipative use of products” and not in “emissions to air”.

- Emissions from fuel for use on ships or aircraft engaged in international transport are called **international bunkers**. The quantity of these emissions, predominantly consisting of CO_2 from fossil fuel combustion, may be negligible for some countries and very significant for others. These emissions should be included in DPO. A note containing a clear description of the used data sources and applied assumptions is instrumental here.

Please note! The EW-MFA system boundary is not necessarily identical with the system boundaries applied in the above mentioned emission inventories. There are several points to consider when using emissions inventories.

- IPCC and CORINAIR inventories are based on the territory principle and account for anthropogenic emissions from the economic territory, whereas AEA for economic activities of residents, regardless whether they are active on the national economic territory or abroad (i.e. applying the residence principle; AEA also includes CO_2 emissions from international bunkers). If IPCC and/or CORINAIR data are used, adjustments to ensure consistency with the residence principle are required. For these adjustments data reported in the “bridge tables” of air emissions accounts (cf. Eurostat’s (2009, 2013) *Manual for Air Emissions Accounts*) can be used for these adjustments. In general, it is recommended to use AEA as primary data source for all relevant emissions of greenhouse gases and air pollutants.
- IPCC reports usually totals GWP (global warming potential) measured in CO_2 equivalents and not in metric tonnes. In addition, the totals reported in the national greenhouse gas inventories are calculated according to a complex set of rules, specifying the recognition of sinks and the inclusion or exclusion of certain emissions. It is therefore necessary to use the underlying inventories rather than the totals for compiling emissions to air. It is also advisable to refer to the methodological guidelines (IPCC 2006) in order to check what is included or not in the data. IPCC recommends reporting emissions from international bunkers separately and not as part of the totals.

Estimations: Estimations are necessary if data are not available in tonnes or if emissions have to be estimated directly from input data by using coefficients. Estimations might also be necessary for longer time series. In rare cases emission data are reported without oxygen content (e.g. as carbon instead of CO_2); they have to be converted using stoichiometric equations. In this guide we do not describe any estimation procedures for emissions to air. However, some important stoichiometric equations are reported in the chapter on balancing items. Should estimations become necessary, please refer to the Eurostat Manual for Air Emissions Accounts (Eurostat 2009, 2013).

Oxygen content: Oxygen is drawn from the atmosphere during fossil fuel combustion and other industrial processes. Overall, the amount of oxygen uptake from the atmosphere during production and consumption is quite substantial and accounts for approximately 20% by weight of material inputs to industrial economies (Matthews et al. 2000). In EW-MFA, this atmospheric oxygen is not included in the totals on the input side (DE, DMC, and DMI) but it is included in the totals on the output side (DPO). The reason is that oxygen is a constituent part of the pollutants and greenhouse gases, and that these emissions are usually reported and analysed with their oxygen content. To arrive at a full mass balance, the missing oxygen on the input side is reported as input balance items (see chapter on table G).

8.1.4 Data compilation

8.1.4.1 F.1.1 Carbon dioxide (CO_2)

Carbon dioxide is a naturally occurring gas. It is a constituent part of the atmosphere and plays a decisive role for the metabolism of all living species. CO_2 serves as a nutrient for plants and is a metabolic residual for animals. Thus plant and animal metabolisms together constitute a dynamic equilibrium that is able to keep CO_2 concentrations in the atmosphere within a narrow range. The industrial metabolism, mainly by combusting huge amounts of fossil fuels, entails enormous net releases of CO_2 into the atmosphere. This CO_2 is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1.

Please note! CO_2 represented 77% of the global warming potential of all greenhouse gas emissions in 2004 (IPCC 2007), and it constituted some 90% of the weight of all emissions to air in industrial economies in the late 1990ies (Matthews et al. 2000). Apparently CO_2 is not only the most important part of DPO in terms of policy relevance. CO_2 also dominates the quantity of overall DPO: It is therefore good practise to concentrate most of the effort on the CO_2 account. Provided careful consideration of the applied system boundaries in each case, inventory data from AEA should be used. To assure correct accounting, it may be advisable to consult a national expert.

8.1.4.2 F.1.1.1 Carbon dioxide (CO_2) from biomass combustion

This subcategory includes:

- Biofuels like biodiesel and bioethanol,
- biogas (which may be used both as a biofuel and as a fuel for producing electricity and heat),
- biomass for electricity and heat, mainly wood and agricultural harvest residuals,
- biomass used in rural areas of developing countries, especially fire wood and residuals or wastes from agriculture and forestry, also referred to as traditional biomass (REN21 2005).
- **Please note!** This category **does not include**
  - CO_2 emissions form land use and land use changes: These flows cannot be accounted for with an input side equivalent. Instead, they are considered flows within the environment.
  - CO_2 emissions from human or animal respiration, they are considered as output balancing items (see chapter G).

8.1.4.3 F.1.1.2 Carbon dioxide (CO_2) excluding biomass combustion

This category includes CO_2 emissions from both energetic and non-energetic non-biotic sources.

Please note! CO_2 emissions from **international bunkers** should be included under F.1.1.2 These emissions may be estimated following the guidelines of IPCC (2006). The applied assumptions and data sources used should be described in a footnote.

8.1.4.4 F.1.2 Methane (CH_4)

Methane, a hydrocarbon, is a greenhouse gas produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and oil, coal production, and incomplete fossil-fuel combustion.

Please note! Make sure that methane emissions from uncontrolled landfills are not included in the “emissions to air” total. They may be reported as a separate memorandum item.

8.1.4.5 F.1.3 Dinitrogen oxide (N_2O)

Dinitrogen oxide is a colourless non-flammable gas, with a pleasant, slightly-sweet odour. It is used in surgery and dentistry for its anaesthetic and analgesic effects, where it is commonly known as laughing gas due to the euphoric effects of inhaling it. It is also used as an oxidizer in internal combustion engines. N_2O acts as a powerful greenhouse gas.

Please note! Make sure **not to include**:

- N_2O emissions from product use which should instead be allocated to "dissipative use of products", and
- N_2O emissions from agriculture and from wastes to uncontrolled landfills.

8.1.4.6 F.1.4 Nitrous oxides (NOx)

Nitrogen dioxide is the chemical compound NO_2. It is one of several nitrogen oxides (NOx). This orange/brown gas has a characteristic sharp, biting odour. NO_2 is one of the most prominent air pollutants and a respiratory poison.

8.1.4.7 F.1.5. Hydrofluorocarbons (HFCs)

HFCs are commercially produced gases used as a substitute for chlorofluorocarbons. HFCs largely are used in refrigeration and semiconductor manufacturing.

8.1.4.8 F.1.6. Perfluorocarbons (PFCs)

PFCs are by-products of aluminium smelting and uranium enrichment. They also replace chlorofluorocarbons in manufacturing semiconductors.

8.1.4.9 F.1.7. Sulfur hexafluoride

Sulfur hexafluoride is largely used in heavy industry to insulate high voltage equipment and to assist in the manufacturing of cable-cooling systems.

8.1.4.10 F.1.8. Carbon monoxide (CO)

CO is a colourless, odourless, and tasteless toxic gas. It is the product of the incomplete combustion of carbon-containing compounds, notably in internal-combustion engines. It still has significant fuel value, burning in air with a characteristic blue flame, producing carbon dioxide. CO is valuable in modern technology, being a precursor to myriad products.

8.1.4.11 F.1.9. Non-methane volatile organic compounds (NMVOC)

NMVOC is the abbreviation for non-methane volatile organic compounds. They easily vaporise at room temperature and most of them have no colour or smell. **Please note!** NMVOC emissions of solvents are included in "dissipative use of products" and not in “emissions to air”.

8.1.4.12 F.1.10. Sulphur dioxide (SO_2)

Sulphur dioxide is a colourless gas with a penetrating, choking odour. It dissolves readily in water to form an acidic solution (sulphurous acid) and is about 2.5 times heavier than air.

8.1.4.13 F.1.11. Ammonia (NH_3)

In its pure state and under usual environmental conditions, ammonia exists as a colourless, pungent-smelling gas. It is alkaline, caustic and an irritant. Under high pressure, ammonia can be stored as a liquid. It is highly soluble in water. It reacts with acids to form ammonium salts.

Please note! Ammonia emissions from agriculture are not included in “emissions to air”.

8.1.4.14 F.1.12. Heavy metals

There are several different definitions of which elements fall in this group: According to one definition, heavy metals are a group of elements between copper and bismuth on the periodic table of the elements having specific gravities greater than 4.0. All of the more well-known elements with the exception of bismuth and gold are toxic.

8.1.4.15 F.1.13. Persistent organic pollutants (POPs)

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of this, they have been observed to persist in the environment, to be capable of long-range transport, bio-accumulate in human and animal tissue, bio-magnify in food chains, and to have potential significant impacts on human health and the environment.

In May 1995, the UNEP Governing Council (GC) decided to begin investigating POPs, initially beginning with a short list of twelve POPs, which has been extended since then. The groups of compounds that make up POPs are also classed as PBTs (Persistent, Bioaccumulative, and Toxic) or TOMPs (Toxic Organic Micro Pollutants).

8.1.4.16 F.1.14. Particles (e.g. PM10, Dust)

PM10 are particles that vary in size and shape, have a diameter of up to 10 micronsand are made up of a complex mixture of many different species including soot (carbon), sulphate particles, metals, and inorganic salts such as sea salt.

8.2 F.2. Waste landfilled

8.2.1 Introduction

By definition, waste refers to materials that are not prime products (i.e. products produced for the market) and which are of no further use to the generator for purpose of production, transformation or consumption. The generator discards, intends or is required to discard these materials. Wastes may be generated during the extraction of raw materials, during the processing of raw materials to intermediate and final products, during the consumption of final products, and in the context of other activities.

The EW-MFA questionnaire distinguishes between municipal and industrial waste and accounts for both of these only if they are discharged to uncontrolled landfills (see table 25):

Table 25: Domestic processed output: waste landfilled (refers to Table F.2 of the EW-MFA questionnaire)

1 digit	2 digit	3 digit
F.2 Waste land filled (uncontrolled)		
	F.2.1 municipal waste (uncontrolled)	
	F.2.2 industrial waste (uncontrolled)	

A landfill is defined as a deposit of waste into or onto land, both in the form of a specially engineered landfill and of temporary storage for over one year on a disposal site. These may be either internal (i.e. the waste is generated and disposed at the same site) or external (Eurostat 2005).

A controlled landfill is one whose operation is subject to a permit system and to technical control procedures in accordance with the national legislation in force. The sites of controlled landfills are specifically modified and maintained for this purpose. For the purposes of EW-MFA, only waste disposed of outside of these controlled sites should be accounted for. This refers to so-called “wild“dumping which should be reported under F.2 if data available.

The following flows are excluded:

- Residuals directly recycled or reused at the place of generation.
- Waste materials that are directly discharged into ambient water or air. They are accounted for in emissions to air or water respectively.
- Waste that was generated by unused extraction. This refers mainly to soil excavation in constructions and to overburden from mining and quarrying.
- Waste incinerated. This flow is already accounted for in emissions to air.

8.2.2 Data sources

First and foremost, national waste statistics should be used to acquire data for waste to uncontrolled landfills.

A good overview on waste statistics data for European countries can be obtained from Eurostat’s Environmental Data Centre on Waste[18].

8.2.3 Conventions

System boundaries: There are two important system boundaries to be considered when accounting for waste as part of DPO. Only waste deposited in **uncontrolled** landfills (wild dumping) is an output to nature and therefore part of DPO. Consequently, emissions from uncontrolled landfills are not considered as this would constitute double counting.

In contrast, **controlled**, i.e. maintained, landfills must be considered part of the socio-economic system. Therefore, wastes deposited in controlled landfills should be accounted for as an addition to stock.

[18] http://epp.eurostat.ec.europa.eu/portal/page/portal/waste/introduction

While this distinction is accepted on conceptual grounds, the Eurostat EW-MFA task force admitted that it might difficult to separate controlled from uncontrolled land fill in practical terms. In addition, the direct application of this argument to other areas of material flow accounting would imply changing the definitions of DPO and NAS. We therefore recommend to show the net material additions to controlled landfills as a memorandum item and to exclude them from the indicator NAS.

Estimations: Estimations may become necessary for industrial wastes landfilled (see Data Compilation).

Water content: Wastes are commonly reported in wet weight (including water content). If this waste flow is of substantial quantity, an attempt should be made to additionally provide the dry matter value (EC 2002).

8.2.4 Data compilation

Waste statistics or other sources may report the total amounts of waste to uncontrolled landfills directly. If this is the case, these figures for waste landfilled should be taken as totals for the accounting of F.2 without further distinction between municipal waste and industrial waste. If this is the case, this information should be included in a footnote.

The current status of European data is described in Eurostat (2005). There, data for waste landfilled are provided only for non-hazardous waste from the manufacturing industry, and only sporadically for countries and years. Data for waste landfilled from energy production and water supply, from the construction sector, from agriculture, forestry and fishery, from mining and quarrying, and from the service and public sector are not included at all.

It may therefore be necessary to perform estimations if national sources do not provide better data. These estimates could concentrate on the two main positions, waste landfilled from the manufacturing industry and waste landfilled from construction.

Waste landfilled from the manufacturing industry is reported for some European countries and years by Eurostat (2005). Using data for the gross value added in the same year by the manufacturing industry (e.g. data from Eurobase), the amount of waste landfilled per unit GVA can be derived (in tonnes waste per Euro gross value added). Then, the amount of waste landfilled can be estimated by multiplying the tonnes of waste per Euro GVA with the total amount of gross value added by the manufacturing industry in a given year.

The estimate for waste landfilled from construction (construction and demolition waste excluding excavated soil – see below) can be performed in a similar way, Eurostat, however, does not provide data for construction waste landfilled so far. These data have to be derived from specific national sources. A respective database should be established.

Please note! Only waste to uncontrolled landfills should be counted under F.2. If no specific data are available, national experts should be consulted. If no reliable information can be found on waste discharged to uncontrolled landfills, for industrialized economies, the assumption can be made that only controlled landfills are used.

Construction and demolition waste includes rubble and other waste material arising from the construction, demolition, renovation or reconstruction of buildings or parts thereof, whether on the surface or underground. It consists mainly of building material and soil, including excavated soil. It includes waste from all origins and from all sectors of economic activity. For the requirements of EW- MFA, excavated soil has to be omitted from the figures for construction and demolition waste.

Excavated soil or earth represents a material flow of the unused domestic extraction type which is not part of the direct material inputs to the economy and must therefore also be excluded from the domestic processed output of the economy.

8.3 F.3 Emissions to water

8.3.1 Introduction

Emissions to water are substances and materials released to natural waters by human activities after or without passing waste water treatment. Accounting for only 1%, emissions to water represent the smallest category of DPO (Matthews et al. 2000). In the context of a full material balance of a national economy it is therefore sufficient to roughly estimate emissions to water.

Table 26: Domestic processed output: emissions to water (refers to Table F.3 of the EW-MFA questionnaire)

1 digit	2 digit	3 digit
F.3 Emissions to water		
	F.3.1 Nitrogen (N)	
	F.3.2 Phosphorus (P)	
	F.3.3 Heavy metals	
	F.3.4 Other substances and (organic) materials	
	F.3.5 Dumping of materials at sea	

8.3.2 Data sources

Air Emissions Accounts (AEA), emission inventories, and environmental reports are the main data sources for emissions to water. It should be noted that statistics on water pollution commonly use a specific reporting terminology. While the inorganic pollutants nitrogen and phosphorus as well as heavy metals are commonly reported as elements, organic pollutants are reported as compounds by using various indirect aggregate indicators. Due to the minor quantitative importance of emissions to water in the overall material flow accounts, the estimation of specific balancing items is not necessary.

8.3.3 Conventions

Terminology and classification: The EW-MFA classification for emissions to water represents an aggregation of the main categories reported in the emissions statistics.

8.3.4 System boundaries

Emissions to water are materials which cross the boundary from the economy back into the environment with water as a gateway. Therefore, emissions to water should be accounted for at the state they are in upon discharge to the environment. Where waste water treatment occurs, this refers to the post-treatment state. Otherwise, it refers to the substances or materials directly released to the environment via water. It should be noted that statistics on water pollutants traditionally focused on the concentration of the pollutants in the water bodies. Attention must therefore be paid to including only data on *flows* of pollutants into the water bodies (normally measured in quantity per year) and not data on pollutant *concentration* in the water bodies (normally measured in quantity per volume).

8.3.5 Data compilation

8.3.5.1 F.3.1 Nitrogen (N)

Total nitrogen (N) stands for the sum of all nitrogen compounds. Nitrogen from agriculture is not included in the category emissions to water because it is already included in the category "dissipative use of products" as nitrogenous fertilisers. N-emissions to water include emissions by waste water from households and industry.

8.3.5.2 F.3.2 Phosphorus (P)

As with nitrogen, total phosphorus (P) stands for the sum of all phosphorus compounds. P-emissions to water include emissions by waste water from households and industry and do not include emissions from agriculture, as these are again included in category "dissipative use of products" as phosphorus fertilisers.

8.3.5.3 F.3.3 Heavy metals

Heavy metals may come from municipal and industrial discharges. For example, for Germany the share of municipal emissions in total discharge of heavy metals is 77 % on average (between 62 % for lead and almost 93 % for mercury). The most important industrial source is the chemical industry with 40 % of the total industrial discharge (Böhm et al. 2000).

8.3.5.4 F.3.4 Other substances and (organic) materials

Organic substances are commonly reported in water emission inventories as indirect summary indicators. The most commonly used are BOD (biological oxygen demand), COD (chemical oxygen demand), TOC (total organic carbon), or AOX (adsorbable organic halogen compounds). **Please note!** All of these indicators measure organic substances in water by each using a different indirect method. The values reported for these indicators should therefore neither be included directly in EW-MFA nor should they be aggregated. It is necessary to:

(1) Make a decision as to which of the indicators to use. Our recommendation is to take TOC, if available, as it is the most comprehensive and sensitive indicator.

(2) Convert the reported quantity which indirectly indicates the amount of organic substances into the quantity of the organic substance itself by using a simplified stoichiometric equation.

8.3.5.5 F.3.5 Dumping of materials at sea

Dumping of materials at sea is not a common reporting format. If data are not available, this category may simply be left blank. **Please note!** Attention should be paid not to include materials which are part of the unused domestic extraction, like dredging, in order to be consistent with the material input side.

8.4 F.4. Dissipative use of products

8.4.1 Introduction

“Some materials are deliberately dissipated into the environment because dispersal is an inherent quality of product use or quality and cannot be avoided” (Matthews et al. 2000, p 27). Examples of dissipative use flows are inorganic and organic fertilizers such as manure, compost, or sewage sludge.

Table 27: Domestic processed output: dissipative use of products (refers to Table F.4 of the MFA questionnaire)

1 digit	**2 digit**	**3 digit**
F.4 Dissipative use of products		
	F.4.1 Organic fertiliser (manure)	
	F.4.2 Mineral fertiliser	
	F.4.3 Sewage sludge	
	F.4.4 Compost	
	F.4.5 Pesticides	
	F.4.6 Seeds	
	F.4.7 Salt and other thawing materials spread on roads (incl grit)	
	F.4.8 Solvents, laughing gas and other	

Matthews et al. (2000) were the first to make an attempt to account for these flows as part of an EW-MFA. Their results for 1996 show, for example, that applied mineral fertiliser ranged from 17 kilogram per capita and year in Japan to around 110 kg/cap in Austria and Germany, spread manure from 105 kg/cap in Japan to 2282 kg/cap in the Netherlands, sewage sludge from 4 kg/cap in the Netherlands to 13 kg/cap in Germany, pesticides from 0.4 kg/cap in Germany to 3 kg/cap in Austria, and grit materials from 26 kg/cap in Germany to 134 kg/cap in Austria.

8.4.2 Data sources

Data on dissipative use of products are rarely reported in official statistics. Data on the consumption and use of mineral fertiliser, pesticides, or seeds may be found in agricultural statistics. Data for organic fertiliser usually have to be estimated. Data for sewage sludge, compost, and salt and other thawing materials on roads may be reported in statistics or reports on the environment or in specific studies. National air emission inventories commonly include data for emissions from the use of solvents and N_2O as a product.

8.4.3 Conventions

Water content: Organic fertiliser (manure) spread on agricultural land should be reported in dry weight. If reported with water content, an attempt should be made to convert the data to dry matter. The same holds true for sewage sludge and compost.

8.4.4 Data compilation

8.4.4.1 F.4.1 Organic fertiliser (manure)

Manure is organic matter, excreted by animals, which is used as a soil amendment and fertilizer.

Manure spread on agricultural land is usually not or not sufficiently reported in agricultural statistics and has to be estimated (see e.g. Matthews et al. 2000). An estimate could be based on the number of livestock by type multiplied with the manure production per animal per year and a coefficient to correct for dry matter. Examples for required coefficients are given in table 28.

Table 28: Daily manure production coefficients

	Manure production per animal per day in kg	Dry matter of manure 1= Wet weight
Dairy cows	70	0.085
Calves	17	0.05
Other bovine	28	0.085
Pigs for slaughtering	7	0.071
Pigs for breeding	26	0.028
Other pigs	8	0.071
Sheep	7	0.07
Horses	7	0.07
Poultry	0.2	0.15

Source: Meissner 1994

8.4.4.2 F.4.2 Mineral fertiliser

The fertiliser industry is essentially concerned with the provision of three major plant nutrients - nitrogen, phosphorus and potassium - in plant-available forms. Nitrogen is expressed in the elemental form, N, but phosphorus and potassium may be expressed either as the oxide (P_2O_5, K_2O) or as the element (P, K). Sulphur is also supplied in large amounts, partly through the sulphates present in such products as superphosphate and ammonium sulphate.

Accordingly, agricultural statistics commonly report domestic consumption in agriculture of specified nitrogenous fertilizers, phospate fertilizers, and potash fertilizers, and multi-nutrient fertilizers (NP/NPK/NK/PK). FAOSTAT e.g. reports nitrogenous fertilizers, phosphate fertilizers, and potash fertilizers for the EU. Data mostly refer to nutrient content of fertilisers. A fertiliser often not reported is lime (e.g. in forestry) for which specific sources should be checked.

In principle, the accounting of fertilisers and pesticides would have to be for the total masses. Statistics, however, commonly report fertilisers in nutrient contents (e.g. N,P,K) and pesticides in active ingredients contents. In case multipliers to total weight are known, the account should be based on total weights.

8.4.4.3 F.4.3 Sewage sludge

Sewage sludge refers to any solid, semi-solid, or liquid residue removed during the treatment of municipal waste water or domestic sewage. Although it is useful as a fertiliser and soil conditioner, sewage sludge, if applied inappropriately can also be potentially harmful to the water and soil environment and human and animal health. The application of sludge on agricultural land is therefore subject to strict regulations in many countries.

Sewage sludge spread on agricultural land may be reported in environment statistics or in specific studies. Sewage sludge should be reported in dry weight. If reported in wet weight, a water content of 85% may be assumed for conversion to dry weight.

8.4.4.4 F.4.4 Compost

Composting refers to a solid waste management technique that uses natural processes to convert organic materials to humus through the action of microorganisms. Compost is a mixture that consists largely of decayed organic matter and is used for fertilizing and conditioning land.

Compost may be reported in agricultural statistics, in environment statistics, or in specific studies. Compost should be reported in dry weight. If reported in wet weight, a water content of 50% may be assumed for conversion to dry weight.

8.4.4.5 F.4.5 Pesticides

A pesticide is commonly defined as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest". A pesticide may be a chemical substance or biological agent (such as a virus or bacteria) used against pests including insects, plant pathogens, weeds, molluscs, birds, mammals, fish, nematodes (roundworms), and microbes. Pesticides are usually, but not always, poisonous to humans. An extensive list and data of pesticides is provided in the PAN Pesticides Database (http://www.pesticideinfo.org/List_ChemicalsAlpha.jsp).

Agricultural statistics commonly report quantities of pesticides used in (or sold to) the agricultural sector. Figures are generally expressed in terms of active ingredients. If multipliers are available, these figures should be converted to total mass.

8.4.4.6 F.4.6 Seeds

Seeds are the encapsulated embryos of flowering plants. Seeds for agricultural production are a common position in agricultural statistics (e.g. from FAO food commodity balance sheets).

8.4.4.7 F.4.7 Salt and other thawing materials spread on roads (incl. grit)

First estimations for these flows were carried out for Austria and the U.S. (Matthews et al. 2000). In Germany, for example, the use of salt on roads is recorded on the level of municipalities and reported nation-wide in specific studies. If data are not available, this position may be neglected.

8.4.4.8 F.4.8 Solvents, laughing gas and others

This category includes emissions from use of solvents (in particular NMVOC) and N_2O as a product (for anaesthesia).

Data for NMVOC solvents emissions can e.g. be taken from national inventory reports to UNFCCC from the CRF reporting categories:

3.A Paint application

3.B Degreasing & dry cleaning

3.C Chemical products manufacture & processing

3.D Other

N_2O (laughing gas) for anaesthesia is included in 3.D and its specific values may be extracted from detailed countries' air emissions databases.

8.4.5 Specific issues related to dissipative use of products

Manure produced versus manure spread on fields: Not all manure produced is actually spread on agricultural land. A part is lost from the economic system as emissions to water. The ISTAT estimated this loss at 5% (Barbiero et al. 2003) and reported it under emissions to water. Furthermore, manure loses some of its weight during stockpiling due to emissions to air (nitrogen compounds, methane and NMVOC, partly by combination with atmospheric gases). The DPO account may be corrected for these air emission losses from manure if information is available or a feasible estimation procedure has become available.

Compost in private households: Households may compost organic materials previously purchased (i.e., biomass that was recorded on the input side). Such composting is usually not recorded in statistics. If relevant for this DPO category, an estimate would have to be added on the output side.

8.5 F.5 Dissipative losses

8.5.1 Introduction

Dissipative losses are unintentional outputs of materials to the environment resulting from abrasion, corrosion, and erosion at mobile and stationary sources, and from leakages or from accidents during the transport of goods.

There are only very few data available internationally. Matthew et al. (2000) report estimated data for the abrasion from tires for Austria, Germany and USA.

Table 29: Domestic processed output: dissipative losses (refers to Table F5 of the MFA questionnaire)

1 digit	2 digit	3 digit
F.5. Dissipative losses (e.g abrasion from tires, friction products, buildings and infrastructure)		

F.5. Abrasion from tires, friction products, buildings and infrastructures and others

This category includes various types of dissipative flows. Many of them have never been quantified. It is recommended to fill in only those data that can be provided with a justifiable effort.

Abrasion from tires is rubber worn away from car tires. The procedure applied in the Austrian case study in Matthews et al. (2000) used data from transport statistics together with a coefficient of 0.03 g/km for the average abrasion per tire, taken from a special study on ecology and road traffic in Austria.

Particles worn from friction products, such as brakes and clutches, so far have never been addressed in EW-MFA.

Losses of materials due to corrosion, abrasion, and erosion of buildings and infrastructure are probably a quantitatively relevant position, and they appear to be relevant under environmental aspects as well. So far, there is no comprehensive approach to account of these flows. Single aspects like losses due to leachate of copper from roofing or paints from construction have been studied, though. Such studies may serve as a starting point towards more comprehensive accounts of material losses of this kind.

Dissipative losses may also result from the transport of goods. In German statistics, for example, the amount of chemicals irreversibly lost due to accidents during transport is reported.

Another position may be leakages during (natural) gas pipeline transport (if not reported as emissions to air). Data may be reported in specific studies.

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Overview Annexes

The EW-MFA questionnaire 2013 has the following 9 Annexes:

Annex1: Correspondences between EW-MFA categories for **biomass** and various **Eurostat statistics** (such as e.g. agricultural crop statistics, agricultural land use inform Farm structure Survey, forestry statistics, fishery statistics etc.)

Annex 2: Correspondence table between the EW-MFA categories of **metal ores, non-metallic minerals and fossil energy materials** with codes of Eurostat's **energy statistics/balances**, **PRODCOM** and **CPA**

Annex 3: Correspondence between **Combined Nomenclature (CN)** codes and **EW-MFA categories** for **imports** and **exports**

Annex 4: Assignment of **CN codes** to the **three stages of manufacturing**: raw products, semi-manufactured products, and finished products

Annex 5: Correspondence table between EW-MFA classification of **non-metallic minerals** and **CPA**, **PRODCOM**, **BGS** and **USGS**

Annex 6: Conversion factors (unit mass, Euro per Kg) – **CN 2009**

Annex 7: Conversion factors (unit mass, Euro per Kg) – **CN 2010**

Annex 8: Conversion factors (unit mass, Euro per Kg) – **CN 2011**

Annex 9: Conversion factors (unit mass, Euro per Kg) – **CN 2012**

In addition a tenth Annex is provided as a separate EXCEL file:

Annex 10: Complete version of the CN including the 2, 4, 6, and 8 digits codes, valid from 1988