Economy-Wide Material Flow Accounting

Step-by-step guide to the compiler

Table of Contents

List of Acronyms

AEA	Air emissions account
BGS	British Geological Survey
BOD	Biological oxygen demand
CH_4	Methane
CLRTAP	UNECE Convention on long-range transboundary air pollutants
CO	Carbon monoxide
CO_2	Carbon dioxide
COD	Chemical oxygen demand
DAP	Diammonium Phosphate
DE	Domestic Extraction
DPO	Domestic Processed Output
EIA	US Energy Information Administration
Eurostat	European Union statistical office
EW-MFA	Economy-wide material flow accounting
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO statistics
FISHSTAT	FAO fishery
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HS	Harmonized system
IEA	International Energy Agency
IO	Input-Output Model
IPCC	International Panel on Climate Change
ITGS	International Trade in Goods Statistics
LPG	Liquefied Petroleum Gas
MAP	Monoammonium Phosphate
mc	Moisture content
MF	Material Footprint of consumption
MFA	Material flow accounting
MRIO	Multi-Regional Input-Output models
N	Nitrogen
N_2O	Dinitrogen oxide or nitrous oxide
NAS	Net Additions to Stocks

NFR	Nomenclature for Reporting
NGL	Natural Gas Liquids
NMVOC	Non-methane volatile organic compounds
NO_x	Nitrogen oxides
NSO	National Statistics Office
OECD	Organization for Economic Co-operation and Development
OQB	Operator Questionnaire-Based
P	Phosphorus
PBTs	Persistent, bioaccumulative and toxic substances
POPs	Persistent organic pollutants
ppm	Parts per million
PTB	Physical Trade Balance
RMEIM	Raw Material Equivalents of Imports
RMEEX	Raw Material Equivalents of Exports
RMI	Raw Material Input
ROM	Run of Mine
scm	Solid cubic metres
SDG	Sustainable Development Goal
SF_6	Sulphur hexafluoride
SIEC	UNSD Standard International Energy Product Classification
SDMX	Statistical Data and Metadata eXchange
SMS	Secondary Mixed Sources
SO_2	Sulphur dioxide
TOC	Total organic carbon
TOMPs	Toxic Organic Micro Pollutants
UN	United Nations
UN Comtrade	UN Commodity Trade Statistics Database
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division
USGS	United States Geological Survey

Introduction

This guide was prepared to assist countries to use the Compiler for economy-wide material flow accounts (EW-MFA) to compile data that can be used to monitor progress in attaining the 2030 Agenda for Sustainable Development, specifically the SDG targets for sustainable use of natural resources (SDG 12.2), indicator 12.2.1 Material footprint (MF) and 12.2.2 Domestic Material Consumption.

EW-MFA based accounts and indicators deliver a comprehensive overview of natural resource extraction, trade in natural resources, waste disposal and emissions. They measure environmental pressures of natural resource use, and EW-MFA based headline indicators (Domestic Extraction, Direct Material Input, Domestic Material Consumption, Physical Trade Balance, Domestic Processed Output, Material Productivity) have been used as a proxy for overall environmental pressure and impact of a national economy.

EW-MFA Compiler supports countries to build Economy-Wide Material Flow Accounts. It provides a basic structure for these accounts and integrates some simple tools to assist with the calculations. This guide outlines the data that are needed and identifies potential sources for these data. It then describes the tables and supplementary tabs in the compiler. Finally, it outlines how to input the data. This guide is to be used alongside the manual The use of natural resources in the economy – A global manual on economy-wide material flow accounting.

Data Needed and their Sources

Table 1 provides an overview of data to be compiled for the economy-wide material flow accounts and indicates potential sources for these data.

Table 1: Overview of data to be compiled for the economy-wide material flow accounts and their potential sources

Material Category	Description	Potential Sources of Data
1. Biomass	Material of vegetable origin extracted by humans and their livestock – crops, used crop residues, fodder crops, grazed biomass, wood, capture of wild fish, and the biomass of hunted animals.	National statistical offices or national institutions concerned with agriculture, forestry and fisheries in their series of agricultural, forestry, and fishery statistics. Grazed biomass is not usually estimated by official statistics. When the United Nations Food and Agricultural Organization database (FAOSTAT) notes the data is from an official source, there will be a national body that has this information. If no data are available, local experts can be contacted to derive estimates.
2. Metal ores	Metal "ores" can best be thought of as those deposits of metal compounds in the Earth's crust which can be processed to produce desired metals at an economically viable cost. Ore deposits will generally be rock, but in certain important cases can be special soils or sand deposits. Only the portion of the excavated rock which is to be processed in some way to obtain the desired metals is included in the accounts. Data is compiled in three ore categories: iron, aluminium, and "other metal ores".	A questionnaire-based surveys of a country's major minerals producers is recommended. Contact the relevant national authority charged with licensing and oversight of mining operations to see if the government is already collecting mining statistics that include physical data on tonnages and ore grade, then this information can be used. If information on physical mine products is not collected, then proxy data such as data on royalties/taxes obtained from relevant authorities can be used. A third potential source of data is company reports that include physical data on tonnages and ore grade. Finally, it may be possible to back-calculate ore production using international data sets compiled by agencies such as those of the United States Geological Survey (USGS) and the British Geological Survey (BGS).
3. Non-metallic minerals	Defined by the System of National Accounts 1993 as: "stone quarries and clay and sand pits; chemical and fertilizer mineral deposits; salt deposits; deposits of quartz, gypsum, natural gem stones, asphalt and bitumen, peat and other non-metallic minerals other than coal and petroleum."	Official government statistics of non-metallic minerals, if available are preferred. A second option is to use industrial association reports. Data from official national statistical reports on consumption of cement, bitumen and bricks can indirectly indicate consumption of non-metallic minerals. If no other data are available, major international data sets such as those of the United States Geological Survey or the British Geological Survey might provide a direct account of non-metallic minerals or their proxies (for example, cement).

Material Category	Description	Potential Sources of Data
4. Fossil fuels	Includes coal and peat, crude oil, natural gas and natural gas liquids, and oil shale and tar sands.	Mining statistics, energy statistics and balances compiled by national statistical institutions provide data on the extraction of petroleum resources and other fossil energy carriers which may be reported to the International Energy Agency (IEA) and United Nations Statistical Division (UNSD) Energy Statistics Database. Where there is a lack of data, international databases for fossil energy materials are provided by the International Energy Agency (IEA), the UN Energy Statistics, the US Energy Information Administration (EIA) and the data collections of the United States Geological Survey (USGS) and the British Geological Survey (BGS).
Trade of Materials (Import/Export)		The statistical agencies of around 200 countries are already reporting trade statistics to the UN Comtrade. This means that in most countries, a practical first step is to determine who within the national statistical office is currently responsible for this, and then to ask how they source their primary data. If no data is reported to Comtrade, a national authority (for example, port authorities, customs/border control agencies, or taxation departments) is likely recording measures of imports and exports for certain materials for the purposes of taxation. This may be the responsibility of local port authorities, customs/border control agencies, or taxation departments.
1. Biomass	Material of vegetable origin extracted by humans and their livestock – crops, used crop residues, fodder crops, grazed biomass, wood, capture of wild fish, and the biomass of hunted animals.	A point of first contact is the national statistical office or other agency that is reporting trade data to FAO.
2. Metal ores	Metal "ores" can best be thought of as those deposits of metal compounds in the Earth's crust which can be processed to produce desired metals at an economically viable cost. Ore deposits will generally be rock, but in certain important cases can be special soils or sand deposits. Only the portion of the excavated rock which is to be processed in some way to obtain the desired metals is included in the accounts. Data is compiled in three ore categories: iron, aluminium, and "other metal ores".	First check which agencies are responsible for reporting trade data to Comtrade to find what data is being compiled for what purpose. For mixed/compounded manufactured items where it is clear they contain significant quantities of materials such as metals which can reasonably be separated, use information on trade flows to estimate amounts.
3. Non-metallic minerals	Defined by the System of National Accounts 1993 as: "stone quarries and clay and sand pits; chemical and fertilizer mineral deposits; salt deposits; deposits of quartz, gypsum, natural gem stones, asphalt and bitumen, peat and other non-metallic minerals other than coal and petroleum."	First check which agencies responsible for reporting trade data to Comtrade to obtain data that is being compiled for that purpose.

Material Category	Description	Potential Sources of Data
4. Fossil fuels	Includes coal and peat, crude oil, natural gas and natural gas liquids, and oil shale and tar sands.	A point of first contact is the national statistical office or other agency that is reporting trade data to IEA. Mixed/compounded products mainly from fossil fuels will include mainly bulk plastics, plastic precursors and resins, and plastic-dominated products. For items where it is clear they contain significant quantities of relevant materials information on trade flows can be used to estimate amounts.
5. Mixed/ complex products		Information on imports and exports of products.
6. Waste for final treatment and disposal	Defined as waste undergoing activities intended to change their nature to render them more suitable for further treatment or for final disposal (Conference of European Statisticians Framework on Waste Statistics, UN, 2022).	Waste statistics are collected by different international organisations such as the Basel Convention, UNSD/UNEP, Eurostat, OECD and UNECE.
Material outflows		
1. Emissions to air	"Discharge of pollutants into the atmosphere from stationary sources such as smokestacks, other vents, surface areas of commercial or industrial facilities and mobile sources, for example, motor vehicles, locomotives and aircraft." (UNSD, UNData website, Glossary, 2023)	Potential sources include national greenhouse gas inventories under the UN Framework Convention on Climate Change (UNFCCC) and/or the UNECE Convention on long-range transboundary air pollutants (CLRTAP). Air emission accounts if available should be used as the primary data source.
2. Waste landfilled (uncontrolled)	Waste refers to materials that are of no further use to the generator for production, transformation or consumption. Waste 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. Waste flows into controlled landfills are considered flows within the socioeconomic system and are not accounted for in domestic processed outputs.	Special studies or waste management authorities may have estimated uncontrolled disposal.
3. Emissions to water	Emissions to water are materials which cross the boundary from the economy back into the environment with water as a gateway. They include substances and materials released to natural waters by human activities after or without passing wastewater treatment. This category includes outflows from municipal or industrial sewage treatment plants.	Pollutant release and transfer registries may include this information. Facilities that discharge into water bodies may have such information at hand.

Material Category	Description	Potential Sources of Data
4. Dissipative use of products	Materials that are deliberately dissipated into the environment such as organic fertilizer (manure), mineral fertilizer, sewage sludge, compost, pesticides, seeds, salt and other materials spread on roads, solvents, laughing gas, and other materials.	Agricultural statistics will include information on sale or use of fertilizers, pesticides, and seeds. For manure, an estimate can be based on the number of livestock by type multiplied with the manure production per animal per year (dry weight). Lime, a fertilizer which can be used in forestry for example, is often not reported so specific sources need to be checked. If not available from agricultural statistics, information on compost may be available in environmental statistics, or in specific studies such as UNFCCC inventories within sectoral background data for waste. In countries where salt or other materials may be spread on roads, an estimation could be made based on the length of roads differentiated by street types, average number of frost days per year, and average materials deployed. Data for non-methane volatile organic compounds solvents emissions can be taken from national inventory reports to UNFCCC for paint application, degreasing and dry cleaning, chemical products manufacture and processing, and other sources. Laughing gas (N_2O) for anaesthesia is reported under the heading Other; information would be available from national air emissions databases.
5. Dissipative losses	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 accidents. This includes abrasion from tyres, friction products, buildings and infrastructure, leakages (for example, of gas pipelines), or from accidents during the transport of goods.	Many of these flows have never been quantified. It is recommended that only those data that can be provided with justifiable effort be completed. An attempt should be made to develop a comprehensive approach to account for these flows: Abrasion from tyres, particles worn from friction products, such as brakes and clutches, losses of materials due to corrosion, abrasion, and erosion of buildings and infrastructure, dissipative losses from the transport of goods, and leakages during (natural) gas pipeline transport (if not reported as emissions to air).
Balancing items	Balancing items on the input side account for those material flows of air and water that are included in DPO or exports, but not included in DE or imports. The main processes concerned are combustion of fuels, respiration of humans and livestock, the production of ammonia via the Haber-Bosch process, and water requirements for the domestic production of exported beverages. Oxygen for combustion processes is by far the quantitative most important balancing item on the input side (ca. 90%) (Eurostat 2018).	

Material Category	Description	Potential Sources of Data
Inputs	Balancing items are defined as the additional inputs and outputs necessary to establish a material balance. The compiler includes the following inputs: - Oxygen for combustion processes - Oxygen for respiration of humans and livestock and bacterial respiration from solid waste and wastewater - Nitrogen for Haber-Bosch process - Water requirements for the domestic production of exported beverages	Refer to Annex 1 below
Outputs	The compiler includes the following outputs: - Water vapour from combustion (Water vapour from moisture content of fuels; water vapour from the oxidized hydrogen components of fuels) - Gases from respiration of humans and livestock (CO_2 and H_2O), and from bacterial respiration from solid waste and wastewater (H_2O) - Excorporated water from biomass products	Refer to Annex 1 below

Using the Compiler

The Compiler includes four sheets including information about the tables to fill (shaded in green in Table 2), in addition to six tables (shaded in blue in Table 2) as well as 20 supporting ones to help in the calculations (shaded in orange).

Table 2: Contents of the compiler for economy-wide material flow accounts

Sheet	Title	Status
Contents	Table of contents	*for information*
Intro	Introduction and methodology	*for information*
Description & Definitions	Description of tables and Definitions	*for information*
Table_A	Domestic Extraction	*to fill in*
Table_B	Imports of Materials	*to fill in*
Table_C	Exports of Materials	*to fill in*
Table_D	Material Outflows	*to fill in*
Table_E	Balancing Items	*to fill in*
Table_F	Headline Indicators	*to be filled in automatically*
Corresp SDMX Codes	Correspondence EW-MFA Codes to SDMX Product Codes	*can be used for cross-referencing of selected items*
Corresp FAO Crop Codes_DE	Correspondence FAO Crop Codes to EW-MFA Codes_Domestic Extraction	*can be used for cross-referencing of selected items*
Crop Residues Tool_DE	Calculated totals for Crop Residues – Domestic Extraction	*can be used for estimation of selected items*
Grazed Biomass Tool_DE	Calculated totals for Grazed Biomass – Domestic Extraction	*can be used for estimation of selected items*
ConvFact Wood_DE	Conversion Factors Wood – Domestic Extraction	*can be used for estimation of selected items*
Metal Ores Tool 1_DE	Calculated totals for Metal Ores – Mined Ores	*can be used for estimation of selected items*
Metal Ores Tool 2_DE	Calculated totals for Metal Ores – Processed/Shipped Ores	*can be used for estimation of selected items*
Metal Ores Tool 3_DE	Calculated totals for Metal Ores – SMS Back Calculation	*can be used for estimation of selected items*
ConvFact Non-Met Minerals	Conversion Factors Non-Metallic Minerals	*can be used for estimation of selected items*
Chalk, Dol and Limest Tool_DE	Calculated totals for Chalk, Dolomite and Limestone_Domestic Extraction	*can be used for estimation of selected items*
ConvFact Clays_DE	Conversion Factors Clays – Domestic Extraction	*can be used for estimation of selected items*
Sand and Gravel Tool_DE	Calculated totals for Sand and Gravel for Construction_Domestic Extraction	*can be used for estimation of selected items*

Sheet	Title	Status
Fossil Fuels Tool_DE	Calculated totals for Fossil Fuels – Domestic Extraction	*can be used for estimation of selected items*
Fossil Fuels Tool_Imp	Calculated totals for Fossil Fuels – Imports	*can be used for estimation of selected items*
Fossil Fuels Tool_Exp	Calculated totals for Fossil Fuels – Exports	*can be used for estimation of selected items*
ConvFact Peat	Conversion Factor Peat	*can be used for estimation of selected items*
ConvFact Crude Oil and NGL	Conversion Factors Crude Oil and Natural Gas Liquids_Domestic Extraction	*can be used for estimation of selected items*
ConvFact Natural Gas	Conversion Factors Natural Gas	*can be used for estimation of selected items*
Corresp HS2017_Trade	Correspondence Table HS 2017 Codes to EW-MFA Codes	*can be used for cross-referencing of selected items*
Corresp SITC20 Rev.4_Trade	Correspondence Table SITC Rev. 4 Codes to EW-MFA Codes	*can be used for cross-referencing of selected items*

The data sheets in the compiler have different formats:

- In the sheets entitled Table_A, Table_B, Table_C and Table_D categories include subcategories. For example, in Table_A domestic extraction biomass is subdivided into components:

  A.1 Biomass

  A.1.1 Crops

  A.1.1.1 Cereals

  A.1.1.1.1 Rice

  A.1.1.1.2 Wheat, and so on.

A.1.1.1.2 Wheat and A.1.1.1.1 Rice are sub-components of A.1.1.1 Cereals, that in turn is a sub-component of A.1.1 Crops, that in turn is a sub-component of A.1 Biomass. The increase in the indent (A.1, A.1.1, …) identifies the level of a sub-component within the hierarchy. Quantities in the lower level of the hierarchy contribute to the amounts in the levels above and are automatically added to the total quantities of each component.

- Table_D focuses on the needed environmental statistics (water, oxygen, nitrogen and gases), and has a simpler hierarchal approach.
- Table_E is used to calculate balancing items, which are inputs and outputs that are needed to compile a full mass balance.
- Values of Table_F are automatically calculated once the other sheets are completed. More information is provided in the section on Table_F below.

Table_A – Domestic extraction (DE)

Domestic extraction includes four groups of extracted materials:

A.1 Biomass,

A.2 Metal ores,

A.3 Non-metallic minerals, and

A.4 Fossil fuels.

Many national statistical offices or agencies assign the data they collect a Statistical Data and Metadata eXchange (SDMX) code. The SDMX codes are used to extract data needed from various statistical databases. The orange sheet Corresp SDMX Codes lists the codes used in the compiler and the corresponding SDMX code to identify the data that needs to be extracted from statistical databases to compile the national economy-wide material flow accounts.

A.1 Biomass (Manual Section 2.1)

According to EW-MFA conventions, Domestic Extraction of biomass includes all biomass of vegetable origin extracted by humans and their livestock, capture of wild fish, and the biomass of hunted animals. Biomass of livestock and livestock products (for example, milk, meat, eggs, and hides) is not considered a domestic extraction since it is a flow within the economic system.

A.1.1 Crops

If your government collects national data on agriculture, forestry, and fisheries, and data are available in the FAOSTAT format, use these data to fill Table_A. Use the Orange Sheet **Corresp FAO Crop Codes_DE** to find the relevant FAO code for the crop subcaterogy (A.1.1) in the Compiler and input the relevant data on yearly production (in tonnes) in the corresponding cells.

If the data are not available in FAOSTAT format, create a concordance between the available data and the categories in the Compiler. Then input the relevant data on yearly production (in tonnes) in the corresponding cells. If data are not publicly available, identify responsible institution to get the needed data. Create a concordance and input the data into the Compiler. If no data are available, work with experts and establish estimates to input into the Compiler.

A.1.2 Crop residues (used), fodder crops, grazed biomass

A.1.2.1 Straw and 1.2.2 Crop residues

In most cases, primary crop harvest is only a fraction of total plant biomass and the residual biomass, such as straw, leaves, stover etc., is often subject to further economic use. MFA accounts distinguish between two types of crop residues: Straw of cereals (all harvested straw of cereals including maize) and all other crop residues (for example tops and leaves of sugar crops). FAOSTAT does not include information on residues used and only a few countries compile these data.

Note: Only residues that are used are included – residues left in the field and ploughed into the soil or burned in the field are not accounted for as DE.

If data on use of residues are already available, use these to input into Table_A, lines A.1.2.1 and A.1.2.2. If not, identify the crops which provide residues that are then further used. In most cases this will include cereals (1.1.1), sugar crops (1.1.3) and some oil-bearing crops (1.1.6); only in exceptional cases will other crops have to be considered. When the amount of crop harvested is known, use the orange sheet Orange Sheet **Crop Residues Tool_DE** to estimate quantities for sub-categories A.1.2.1 Straw and A.1.2.2 Other crop residues (sugar and fodder beet leaves, other). It is adapted from section 2.1.3.3 of the Global Manual on EW-MFA. It can be used to calculate the amount of crop residues used according to this formula:

*crop residues used (t) = primary crop harvest (t) * harvest factor * recovery rate*

With:

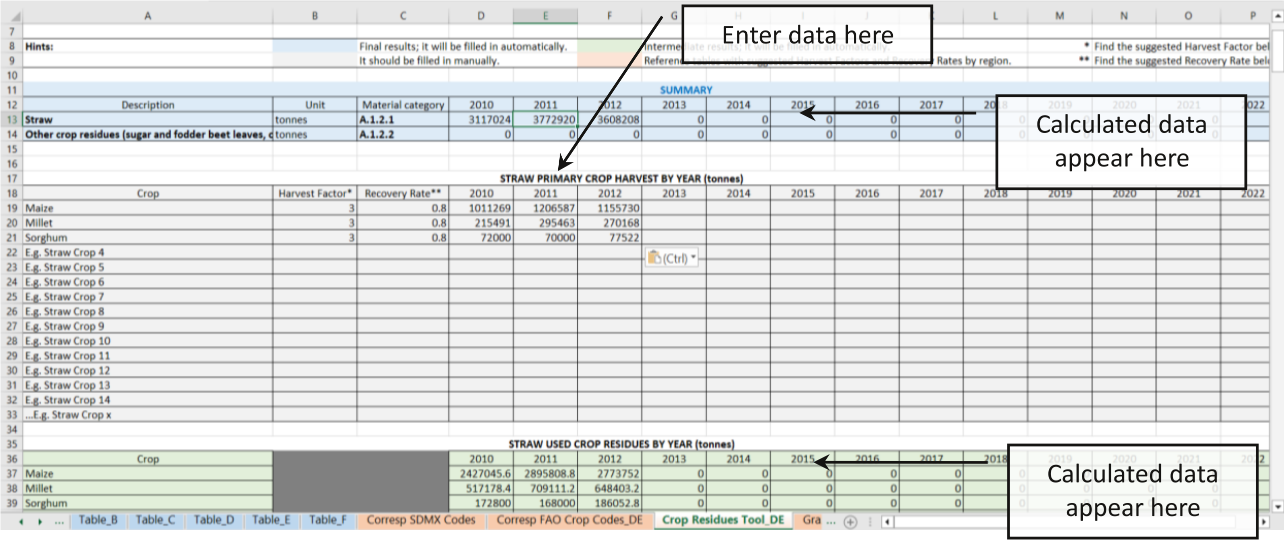
Crop residues used (t) expressed as weight

Primary crop harvest (t) expressed as weight

In the table *Straw primary crop harvest by year* (see Figure 1), for each of the relevant crops, enter crop name, the harvest factor and recovery rate and the amounts harvested (by year, in tonnes). Use country-specific harvest factors and recovery rates when available. Otherwise use the regional factors found in the reference tables in the sheet. Once these values are entered, the corresponding residue amounts will be calculated and appear in the Crop straw used crop residues by year table and the totals in the summary table. Summary information will also appear in line A.1.2.1 of Table_A.

Repeat the approach using the table *Non-straw primary crop harvest by year (tonnes)* to calculate the amount of residues used for these crops. Results of these calculations will appear in line A.1.2.2 of Table_A.

Figure 1: Entering straw primary crop data into the Orange Sheet Crop Residues Tool_DE



A.1.2.3 Fodder crops and A.1.2.4 Grazed biomass

These categories incorporate different types of roughage including fodder crops, biomass harvested from natural or improved grassland (meadows) and biomass directly grazed by livestock. Coverage of these flows in agricultural statistics is usually poor. Fodder crops includes all types of fodder crops including maize for silage, grass type and leguminous fodder crops (clover, alfalfa etc.), fodder beets as well as mown grass harvested from meadows for silage or hay production.

Note: Do not include any of the commercial feed crops (for example barley, maize, soybeans, etc.) that may be used for food production or as industrial raw materials since these are accounted for under A.1.1.

FAOSTAT no longer reports on fodder crops, but data on fodder crops are often available in national agricultural statistics. Where national feed balances exist, estimates of biomass harvested from grassland and grazed biomass can be derived. According to EW-MFA conventions, these fodder crops must be accounted for at air dry weight, i.e., at a standardized moisture content of 15%. When national data are available enter these in lines A.1.2.3 and A.1.2.4.

In cases where no reliable data are available for fodder crops (A.1.2.3) and grazed biomass (A.1.2.4) you can use the **Grazed Biomass Tool_DE** to estimate total roughage demand. When this is done, no data are reported in line A.1.2.3 (fodder crops).

In the table *Grazing livestock (number of animals)* found in the orange sheet **Grazed Biomass Tool_DE**, enter the following information for each of the relevant animal types in your country:

- name of animal,
- roughage intake (t/head/y),
- % of roughage intake from grazing for that animal type, and
- number of animals in each corresponding year.

If you do not have country-specific information on roughage intake, then you may select the appropriate coefficient from the reference table in the worksheet. Once these values are entered, the corresponding demand for grazed biomass by animal type will be calculated and *Demand for grazed biomass by animal type* table and the total in the summary table. Summary information will also appear in line A.1.2.4 of Table_A.

Note: Another method is to estimate grazed biomass based on feed conversion efficiency. Because such data are probably less certain than livestock numbers and are limited to animals that produce milk or meat, this approach has not been included in the compiler.

A.1.3 Wood

This category comprises timber or industrial roundwood (A.1.3.1) and fuelwood and other extraction (A.1.3.2). It includes wood harvest from forests as well as from short rotation plantations or agricultural land. Extraction of wood is reported in forestry statistics which usually differentiate between coniferous and non-coniferous wood. Wood from short rotation plantations may also be recorded in agricultural statistics because short rotation forests are considered cropland in many countries. National wood balances, if available, often provide more comprehensive data sets, because they also include wood harvested from non-forested land.

Forestry statistics, especially forest inventories, sometimes distinguish between felling and removals. The EW-MFA considers only the biomass removed from forests for further socioeconomic use (i.e., wood removals) measured in tonnes of wood at 15% moisture content (t at 15% mc). Wood removals may be reported in volumes under bark (i.e., without bark) and as stacked cubic metres. Before entering data on wood removals Orange Sheet **ConvFact Wood_DE**, you may need to do the following adjustments using national coefficients or the default factors identified below:

- Convert stacked cubic metres to solid cubic metres through:

  solid m^3 *= stacked* m^3 ** 0.70*

- Convert removals under bark into removals including bark through:

  *removal including bark = removals under bark * 1.1*

- Add the estimated of quantity of wood extracted through illegal logging activities[1]

Use the Orange Sheet **ConvFact Wood_DE** to calculate weight of wood in tonnes at 15% moisture content (t at 15% mc). Adjust the calculations using national coefficients and disaggregated data by coniferous and non-coniferous trees, when possible.

1 Where illegal logging is an issue, consult with local forestry experts or consult specific reports on illegal logging.

In the input column enter the amount of wood removals including bark for coniferous, non-coniferous or mixed woods in solid cubic metres (scm). **ConvFact Wood_DE** will calculate the corresponding weight of wood in tonnes at 15% moisture content (t at 15% mc). Enter the total corresponding output value in line A.1.3.1 – timber (Industrial roundwood) of Table_A. Repeat this step to enter data for multiple years.

Forestry statistics commonly only record commercial wood harvest, ignoring fuelwood extracted for subsistence needs. If available, enter data for wood fuel and other extraction (line A.1.3.2) in tonnes at 15% moisture content (t at 15% mc) directly into Table_A.

A.1.4 Wild harvest not elsewhere classified (n.e.c.)

Fish capture (A.1.4.1) and extraction of other aquatic animals (A.1.4.2) and plants (A.1.4.3) are reported in national fishery statistics and by FAO fishery statistics (FISHSTAT). Only fish captured (including recreational fishing) and other animals and plants extracted from unmanaged fresh and seawater systems are included in items A.1.4.1 to A.1.4.3; that is, harvests from aquaculture operations are excluded.

Gathered wild terrestrial plants (A.1.4.4) and hunted wild terrestrial animals (A.1.4.5) are quantitatively of minor significance and only accounted for if data are available in national statistics. The 2018 version of the Eurostat EW-MFA compilation guide provides a list of average weights of hunted animal species which can be used to convert from the number of animals or other physical units if necessary.

For each year in question, enter the available data in lines A.1.4.1, A.1.4.2, A.1.4.3, A.1.4.4, A.1.4.5 of Table_A as appropriate.

A.2 Metal ores (Manual Section 2.2)

Only that portion of the excavated rock which is to be processed in some way, to obtain the desired metals, is included in the EW-MFA. This means that any soil or rock which is simply excavated and moved, to gain access to the metal ore itself is excluded from the quantities that are recorded. Quantities of ore measured on a “run of mine” (ROM) basis can be used for the EW-MFA . These are usually recorded at one or more of the following locations:

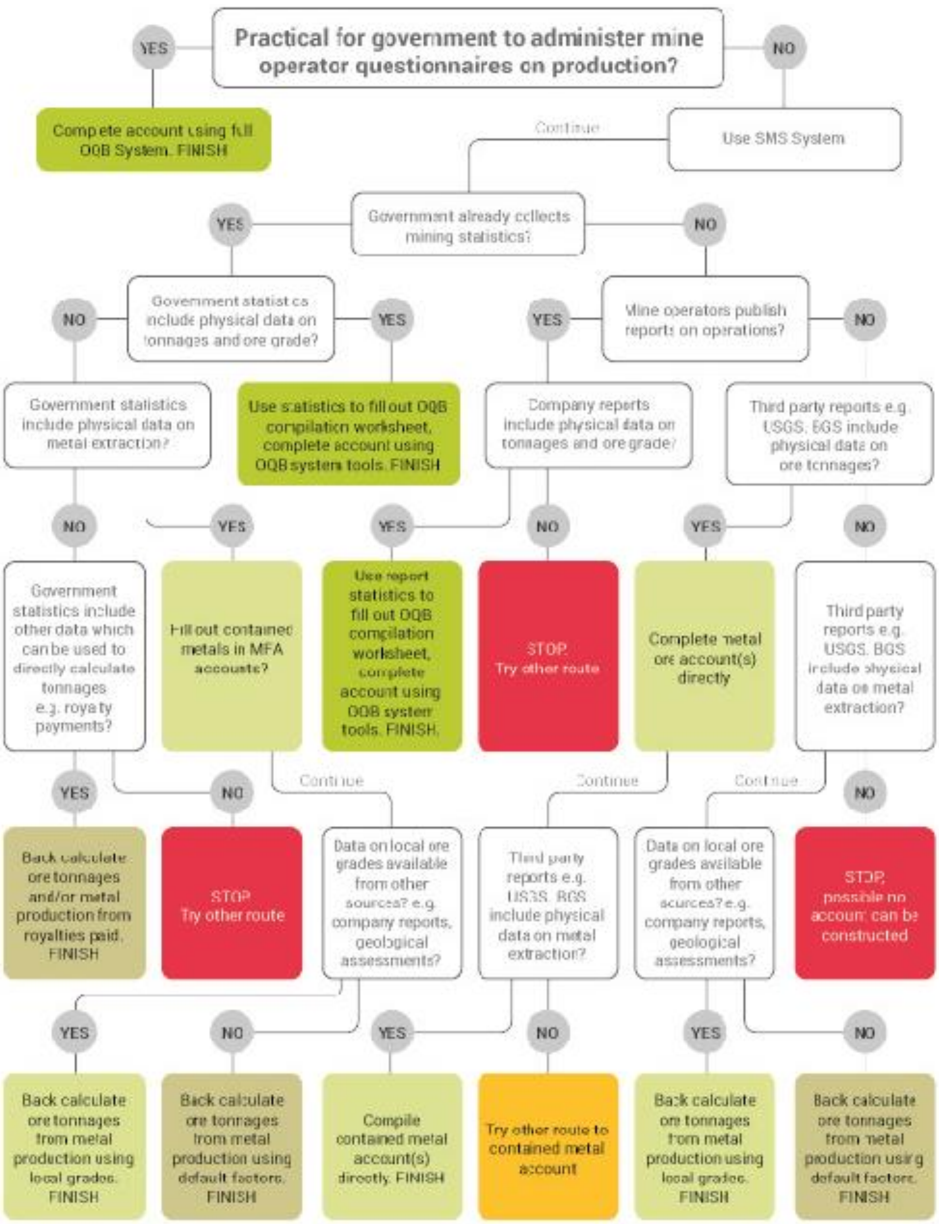
- At the "ore pad", the initial place where ore is dumped at the surface; and/or

- At a weighbridge, either as a truck leaves the mine to transport the ore to the plant for further processing, or at the entry to the processing plant, or before being dumped "on the heap" for heap leaching operations.

In some cases, the in-situ leaching will be used to extract the metal. This involves injecting a solvent directly into an ore body, then recovering the solvent after it has dissolved the target metals, and extracting the metals from this leachate. As no ore is really extracted as such, this situation is best dealt with by entering the extracted metal tonnage as an ore tonnage, and setting the ROM grade to 1,000,000 parts per million (ppm) (that is, 100%).

Data on metal ores are collated in three categories: Iron ores (A.2.1), Aluminium ores (A.2.2), and Other metal ores (A.2.3).

Figure 2: Flow chart to aid in decisions on how to best compile metal ore accounts



Note: Where possible, following a path to one of the three bright green FINISH nodes that include use of at least some of the OBQ system tools is likely to yield the highest quality and most useful results.

The preferred approach is to compile data from the operator-based questionnaire system (OBS) which the responsible authority would have collected (see Figure 2). In the gray shaded table *"Mined ore data"*, of the Orange Sheet **Metal Ores Tool 1_DE** enter the following information for each ore stream:

- **Ore_Stream_ID:** This is simply an identifier field used to identify individual ore streams. In the simplest and most common cases, the Ore_Stream_ID should correspond to one mine or individual ore deposit's output for a year, however where the output from several mines cannot be separated, one Ore_Stream_ID may be used to cover all. Alternatively, where one mine has multiple significantly different ore streams, different Ore_Stream_ID names should be used to identify each, especially where their processing or stockpiling fate differs.

- **Year:** This is the year for which the recorded data applies.

- **ROM Ore (tonnes):** The estimated total tonnage of Run of Mine (ROM) ore extracted via one Ore_Stream_ID for the relevant year.

- **Ore type:** This is the ID code of the EW-MFA material category, that is, A.2.1 for Iron ores, A.2.2 for Aluminium ores, or A.2.3 for Other metal ores.

- **Metal:** This is used to identify the component metal analysed for the current row. The naming convention is M.2.x where x is the symbol for the element in the periodic table, for example, M.2.Cu for copper, and M.2.Sn for tin.

- **ROM Grade (ppm):** This is the estimated average concentration for one of the metals in an ore stream, averaged over the relevant year. There should be a value for each of the target metals, however if there is also data for incidental metals, especially if they are of potential future economic interest, or are particularly environmentally sensitive, this should also be recorded. *The number of such individual metals for which there is data ultimately determines the number of individual lines entered under one Ore_Stream_ID for one year.*

  The concentration is determined on a weight basis, in parts per million (ppm).

  Example: a grade of 15,000 for A.2.Cu would mean that there are 15,000 grams (15kg) of pure copper contained in each tonne of ore.

  Grades should always be given in terms of weight in ppm of the metal, so if grade is recorded in terms of a compound, for example, TiO_2, this should be adjusted by the weight fraction of Ti in TiO_2 (0.6). Examples of how this can be calculated are provided for common metal compound grades in the table to the right of the sheet. For many metals, the original data will give the grade as a percentage. In these cases, the conversion is achieved simply by multiplying by 10,000.

  The grade given should be the volume weighted average (not arithmetic mean) over the year if aggregating up from short time periods (less than yearly). Where data on the concentration of one or more of the contained metals is sporadic, care should be taken not to count missing grade data as a 0 for grade averaging purposes.

- **Waste rock (tonnes):** If available, data on the quantity of waste rock and overburden excavated over the year to access the metal ores associated with each Ore_Stream_ID should be recorded here. This flow is not central to EW-MFA, and so is optional. This quantity is of importance in some other reporting schemes for material flows and does have environmental implications in its own right.

The data on Processed/Shipped ore is not required for basic EW-MFA. It is, however, crucial for making the data collected on mined ore above much more useful in a number of non-EW-MFA related, practical, policy-relevant roles. Use the Orange Sheet **Metal Ores Tool 2_DE** to input data on Processed/Shipped ore. In the gray-shaded table enter the following information:

- **Ore_Stream_ID:** This is simply an identifier field used to identify individual ore streams, either fed into a specific beneficiation process, or shipped directly (as ore) to a customer. In the simplest cases these will largely mirror the

Ore_Stream_IDs used for mined ore, but could vary considerably where for example ore from different mined streams is blended prior to processing or shipment. The mine operator is best placed to determine sensible Ore_Stream_ID names. Minor variations between mined ore and processed/shipped ore will occur where the ore is actually measured, analysed and recorded at two locations between exit from the mine and entry into processing, such as at a mine ore pad, and then again upon delivery to the processing plant. These minor variations will mainly be due to measurement error.

- **Year:** This is the year for which the recorded data applies.

- **Input (tonnes):** The estimated total tonnage of ore corresponding to the Ore_Stream_ID for the relevant year.

- **Ore type:** This is the ID code of the EW-MFA material category, that is, A.2.1, A.2.2, or A.2.3, for Iron ores, Aluminium ores, or Other metal ores respectively.

- **Metal:** This is used to identify the component metal analysed for the current row. The naming convention is M.2.x where x is the symbol for the element in the periodic table, for example, M.2.Cu for copper, and M.2.Sn for tin.

- **Input Grade (ppm):** This is the estimated volume weighted average concentration for the current component in the current ore stream, averaged over the relevant year, as it enters beneficiation or as it is sold. There should be a value for each of the targeted metals, however if there is also data for incidental metals, especially if they are of potential future economic interest, or are particularly environmentally sensitive, this should also be recorded. The number of such individual metals for which there is data ultimately determines the number of individual lines entered under one Ore_Stream_ID. The concentration is determined on a weight basis, in parts per million (ppm).

  Example: a grade of 15,000 for A.2.Cu would mean that there are 15,000 grams (15kg) of pure copper contained in each tonne of ore.

  Grades should always be given in terms of weight ppm of the metal, so if grade is recorded in terms of a compound, for example, TiO_2, this should be adjusted by the weight fraction of Ti in TiO_2 (0.6). Examples of how this can be calculated are provided for common metal compound grades in the table to the right of the sheet. For many metals, the original data will give the grade as a percentage. In these cases, the conversion is achieved simply by multiplying by 10,000.

- **Recovery factor:** This is the percentage of the total metal contained in the Run of Mine (ROM) ore entering the processing plant which is retained in the metal concentrate. Where the ore is merely shipped rather than processed, this factor should always be approximately 100%. However virtually any beneficiation process will lead to some loss of contained metal, and in many cases that loss can be over 50%.

- **Sold:** This field just records whether the mining operator receives payment for this specific component of the ore or concentrate. It is common for mining operations to only be paid in full for some of the valuable metals contained in their ore or concentrates. Other metal components may be only partially paid for, not paid for at all, or even attract a penalty if they are seen as a contaminant, such as bismuth in a copper concentrate.

  Note: This field is not important for the basic EW-MFA accounts. It has been included due to its value for other potentially important policy questions.

  Example: A mine produces a concentrate which is analysed for copper, gold, and bismuth content, but only receives payment for the copper and gold, then there should be a 1 for both of these and a 0 for bismuth. If the bismuth actually incurs a penalty from the customer (i.e. reduces the price of the concentrate), then enter -1 for bismuth in this field.

Using the secondary mixed source (SMS) system

If the OBS approach is deemed impractical, then finding substitute data will often be a largely ad hoc process, and vary greatly depending on the current arrangements for the reporting of minerals production in the country. The first step would be to identify the relevant national authority charged with licensing and oversight of mining operations, to ascertain what reporting is mandated. Detailed data from mining operators on the quantity and characteristics of ore mined may be reported on an annual basis. If the only information available is financial, this information may be combined with other data on the geological characteristics of the mineral deposits exploited and metal prices to back-calculate the quantity of ore extracted.

Company reports are another potential source of data. These may provide detail on production of ore, and tonnages of metal produced, in annual or quarterly reports.

If the compilation and categorization of direct quotations of ore tonnages from primary sources account for much of the ore produced, expanding the account using back-calculation from metal production to get broader coverage may not be desirable. This is because major errors can easily accumulate which may greatly outweigh the benefits of apparent broader coverage. This is especially the case for minor metals.

If forced to fall back on the SMS system, it is recommended that the information collected be entered into the Mined ore worksheet (Orange Sheet **Metal Ores Tool 1_DE**). Sufficient information may have been collected and reasonable accounts compiled even without mine operators' direct input. It is probably not feasible to fill out the Processed/ Shipped ore worksheet (Orange Sheet **Metal Ores Tool 2_DE**) without mine operator input.

The last option is to back-calculate ore extracted from metal produced which can be done using the Orange Sheet **Metal Ores Tool 3_DE**. Ore tonnages from metal production is estimated using an assumed ore grade and recovery factor from the full metal content of the ore to the produced metal.

In the table *Back-calculation tool for metal ores from known domestic metal extraction* table (Orange Sheet **Metal Ores Tool 3_DE**) for each ore type enter the:

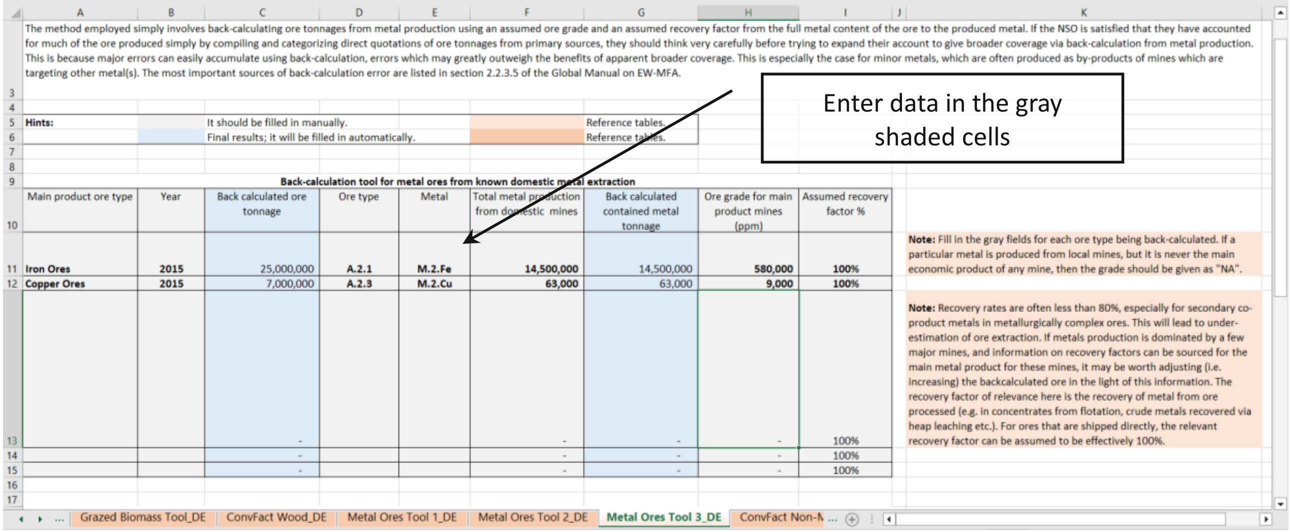
- Year of production,
- Ore type,
- Metal,
- total metal production from domestic mines,
- ore grade for main product mines (ppm), and
- assumed recovery factor % (See Figure 3).

The tool will calculate the ore and contained metal tonnage. When filling out the table take note of the following:

- If a particular metal is produced from local mines, but it is never the main economic product of any mine, enter "NA" for the grade.
- Recovery rates are often less than 80%, especially for secondary co-product metals in metallurgically complex ores. This will lead to under-estimation of ore extraction. If metals production is dominated by a few major mines, and information on recovery factors can be sourced for the main metal product for these mines, it may be worth adjusting (that is, increasing) the back-calculated ore in the light of this information. The recovery factor of relevance here is the recovery of metal from ore processed (that is, in concentrates from flotation, crude metals recovered via heap leaching, etc.). For ores that are shipped directly, the relevant recovery factor can be assumed to be effectively 100%.

The most important sources of back-calculation errors are listed in section 2.2.3.5 of the Global Manual on EW-MFA.

Figure 3: Entering data into the Orange Sheet Metal Ores Tool 3_DE



The method employed simply involves back-calculating ore tonnages from metal production using an assumed ore grade and an assumed recovery factor from the full metal content of the ore to the produced metal. If the NSO is satisfied that they have accounted for much of the ore produced simply by compiling and categorizing direct quotations of ore tonnages from primary sources, they should think very carefully before trying to expand their account to give broader coverage via back-calculation from metal production. This is because major errors can easily accumulate using back-calculation, errors which may greatly outweigh the benefits of apparent broader coverage. This is especially the case for minor metals, which are often produced as by-products of mines which are targeting other metal(s). The most important sources of back-calculation error are listed in section 2.2.3.5 of the Global Manual on EW-MFA.

Hints: It should be filled in manually. Reference tables.
Final results; it will be filled in automatically. Reference tables.

Enter data in the gray shaded cells

Back-calculation tool for metal ores from known domestic metal extraction

Main product ore type	Year	Back calculated ore tonnage	Ore type	Metal	Total metal production from domestic mines	Back calculated contained metal tonnage	Ore grade for main product mines (ppm)	Assumed recovery factor %
Iron Ores	**2015**	25,000,000	**A.2.1**	**M.2.Fe**	**14,500,000**	14,500,000	**580,000**	**100%**
Copper Ores	**2015**	7,000,000	**A.2.3**	**M.2.Cu**	**63,000**	63,000	**9,000**	**100%**
		-			-	-	-	100%
		-			-	-	-	100%
		-			-	-	-	100%

Note: Fill in the gray fields for each ore type being back-calculated. If a particular metal is produced from local mines, but it is never the main economic product of any mine, then the grade should be given as "NA".

Note: Recovery rates are often less than 80%, especially for secondary co-product metals in metallurgically complex ores. This will lead to under-estimation of ore extraction. If metals production is dominated by a few major mines, and information on recovery factors can be sourced for the main metal product for these mines, it may be worth adjusting (i.e. increasing) the backcalculated ore in the light of this information. The recovery factor of relevance here is the recovery of metal from ore processed (e.g. in concentrates from flotation, crude metals recovered via heap leaching etc.). For ores that are shipped directly, the relevant recovery factor can be assumed to be effectively 100%.

Grazed Biomass Tool_DE | ConvFact Wood_DE | Metal Ores Tool 1_DE | Metal Ores Tool 2_DE | Metal Ores Tool 3_DE | ConvFact Non-N ...

A.3 Non-metallic minerals (Manual Section 2.3)

The System of National Accounts 1993 officially defines non-metallic minerals as "[...] stone quarries and clay and sand pits; chemical and fertilizer mineral deposits; salt deposits; deposits of quartz, gypsum, natural gem stones, asphalt and bitumen, peat and other non-metallic minerals other than coal and petroleum. The EW-MFA compiles data on the following non-metallic minerals:

A.3.1 Ornamental or building stone: This category consists of rocks that may be used in the form of tiles, slabs or blocks, for either structural or decorative purposes. Data are often provided in cubic metres, and have to be converted to tonnes.

A.3.2 Carbonate minerals important in cement

A.3.2.1 Chalk: A soft, white, porous form of limestone composed of the mineral calcite, also a sedimentary rock.

A.3.2.2 Dolomite: A carbonate rock and a mineral consisting of calcium magnesium carbonate found in crystals. Dolomite is often combined with limestone in statistical reporting.

A.3.2.3 Limestone: A mineral mostly used for cement production. It is also commonly used as crushed-rock aggregate. Limestone used for industrial purposes (for example, production of lime or cement) is reported under EW-MFA classification item A.3.2, whereas crushed limestone aggregate is allocated to item A.3.8 (sand and gravel), and limestone as a dimension stone is assigned to item A.3.1 (ornamental or building stone).

A.3.4 Chemical and fertilizer minerals: Many types of minerals used in industry.

A.3.5 Salt: 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, and to prevent the formation of ice on roads.

A.3.6 Gypsum

A.3.7 Clays

A.3.7.1 Structural clays

A.3.7.2 Specialty clays

A.3.8 Sand and gravel: There are two major groups of sand and gravel which are distinguished by their principal use:

A.3.8.1 Industrial sand and gravel

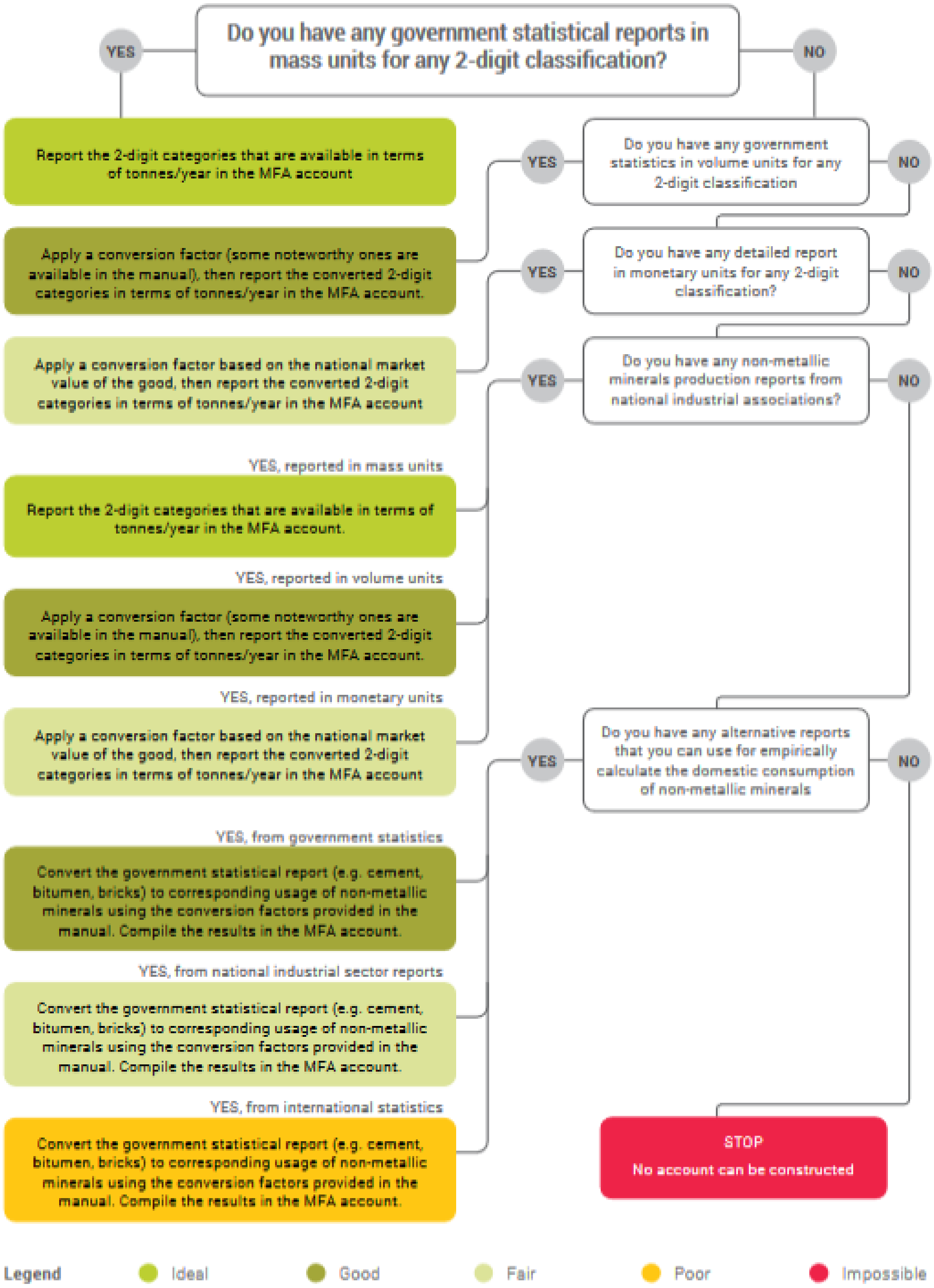
A.3.8.2 Sand and gravel for construction

A.3.9 Other non-metallic minerals, n.e.c.

Compiling information on non-metallic minerals

While they are widely used, many countries do not report on use of these minerals or have limited data sets. Cement, bitumen, and brick consumption can be used as proxies to calculate raw non-metallic mineral consumption.

Figure 4: Flow chart for the compilation of non-metallic mineral EW-MFA



When compiling information for the EW-MFA the first choice is to use government statistical reports that provide data on amount of any of the minerals identified above (see Figure 4). Preference is given to data by mass (for example, tonnes) which can be entered directly into the compiler. In Table_A enter the amounts in tonnes in corresponding lines under the appropriate year. Note that lines A.3.2, A.3.7 and A.3.8 as well as the total for non-metallic minerals (line A.3) are calculated sums.

If data are only available by volume, use the Orange Sheet **ConvFact Non-Met Minerals** tool to convert data on different non-metallic minerals reported in volume units of cubic metres (m^3) to tonnes (t). To calculate the tonnage of different non-metallic minerals using the conversion factors, a user should just enter the real value in cubic metres under the "Input (m^3 of material)" column. The appropriate conversions will be shown under the "Output (t of material)" column. While it is not necessary to alter any columns in the existing table apart from the input column ideally conversion factors should be specific to the minerals extracted in the specific area. Users are encouraged to modify these factors to reflect national conditions more accurately. Note that the conversion factor for 'Slate, broken' is provided as a range of 1.29 – 1.45; therefore, most suitable factor must be selected and manually entered into the pink field to enable the output calculation. Enter the resulting amounts in tonnes/year in Table_A.

If the only information available is financial terms, use the average market value per tonne of material to estimate of the quantities in tonnes. Enter the amounts in tonnes/year in Table_A.

If none of the above information is available, minerals production reports from national industrial associations can be used. If the information is reported by mass, use these data for Table_A. If these are only available as volume, use the conversion factors in Orange Sheet **ConvFact Non-Met Minerals** to convert the volumes into mass units. If the information is only available in monetary units, use the average market value convert this into the equivalent mass in tonnes. Enter the amounts in tonnes/year in Table_A.

If none of the above are available, consider alternative reports that allow to calculate the domestic consumption of non-metallic minerals. The order of preference is to use reports of government statistics, followed by reports of national industrial sectors, and as a last option, international statistics. If necessary, convert available data into the equivalent tonnes/year and enter the amounts in Table_A. If these do not yield any useable information, no data is entered into the compiler.

Some considerations when compiling data

A.3.2.3 Limestone:

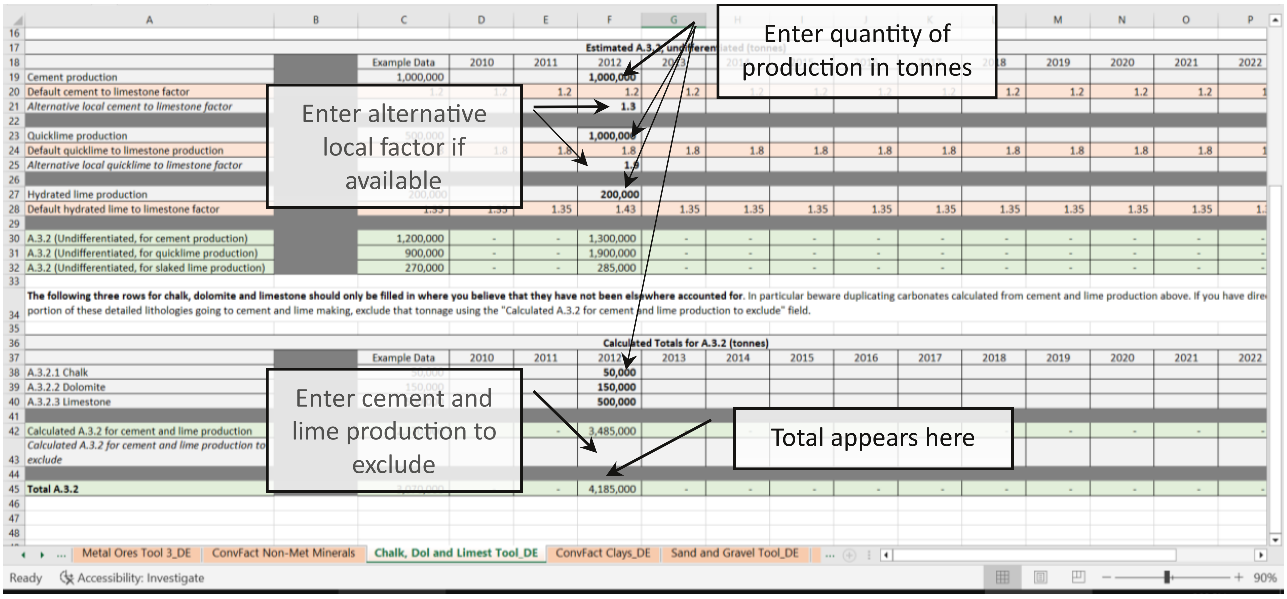
Use of limestone extracted for construction purposes is often underestimated. To check if it is necessary to correct for missing limestone extraction for cement production: take the corresponding production figures for cement, and multiply these by a factor of 1.216. The ratio of 1.216 tonnes of limestone for the production of 1 tonne of Portland cement can be used as a typical value. The higher number should be selected as data for the domestic material extraction of limestone (with a tolerance of ±10% in favour of using the original statistical values). If limestone for other uses than cement is clearly indicated in statistics, this amount must be added to the estimate for limestone for cement.

Limestone may be partially replaced by dolomite in cement production. When this the case, data reported for dolomite under A.3.2 may need to be adjusted to avoid double counting.

Orange Sheet **Chalk, Dol and Limest Tool_DE** allows users to do estimations for material category A.3.2 Carbonate minerals important in cement. Default values have been included (in pink). While the data compiler can use the default values, alternative factors that take account local conditions can be inserted into the respective gray sections (Figure 5). In the *Estimated A.3.2, undifferentiated* table, enter the quantity of cement, quicklime and hydrated lime for each year and the local factor value if available. The amounts of undifferentiated production will be calculated.

If necessary, you can adjust the calculated totals for chalk, dolomite and limestone using the *Calculated Totals for A.3.2* table by entering the appropriate amounts not accounted elsewhere. Take care not to double count carbonates calculated from cement and lime production above. If you have direct data on some portion of these detailed lithologies going to cement and lime making, exclude that tonnage using the "Calculated A.3.2 for cement and lime production to exclude" field. Transfer the results of the calculations to the appropriate lines in Table_A.

Figure 5: Entering data into the orange sheet Chalk, Dol and Limest Tool_DE



A.3.4 Chemical and fertilizer minerals

This subcategory includes:

- Natural calcium or aluminium calcium phosphates, often combined under the heading "phosphate rock", mostly used to produce fertilizers. These are also used in the production of detergents, animal feedstock, and a multitude of other minor applications.

- Carnallite, sylvite, and other crude natural potassium salts, often combined under the heading "potash". Potassium is essential in fertilizers 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.

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

- Crude or unrefined sulphur, a fundamental feedstock to the chemical industry. Technical note: not all domestic sulphur production is accounted for in category A.3.4. Chemical and fertilizer minerals. For EW-MFA three principal 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 desulphurization of petroleum resources: This sulphur is included in the amounts of extracted petroleum resources and should not be reported under A.3.4; and (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.

- 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. 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 used as wood preservatives. The most common borate mineral is boron.

- Fluorspar (fluorite), a colourful mineral which is industrially used as a flux for smelting, and in the production of certain glasses and enamels.

A.3.7 Clays

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 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. These should be accounted for in section **A.3.7.2 Specialty clays**.

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 should be accounted for in **A.3.7.1 Structural clays**, but are often under-represented or excluded from statistics. It is strongly advised to look for specific national sources (such as, industrial associations) to convert data on production of clay products into amounts of crude clay, and hence insert the appropriate conversion factor into its respective place. If no national conversion factors are available, there is no reason to alter any columns in the existing table apart from the input column. The EW- MFA manual used in Europe gives a general conversion factor from kg of clay product to tonnes of crude clay as 1.349 tonnes of clay for 1 tonne of clay product. The orange sheet **ConvFact Clays_DE** can be used to convert data on production of clay products into amounts of crude clay if needed.

Converting bricks reported in volume, or tiles reported in number of pieces, can be very challenging due to the large range of products available on the market. Ideally, a country-specific coefficient should be developed, but where not enough data are available, use a factor of 1,351 kg/m^3 for bricks, or 2.37 kg/tile for clay roofing tiles. If national conversion factors are available, replace the pre-filled conversion factors in column B. In the case where national conversion factors are not available there is no reason to alter any column in the existing table apart from the input column. The orange sheet **ConvFact Clays_DE** can be used if needed. Note that the factors used are derived from typical European commodities, and their values might differ from the typical bricks and tiles produced in other parts of the world. The estimation result should be compared against the figures for common clays and loams extraction reported in statistics (excluding industrial or special clays). The higher number should be selected for the domestic extraction of common clay and loam (with an eventual tolerance of about 10% for using the original statistics figure).

A.3.8 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. Some statistical sources (for example, the USGS) explicitly report sand and gravel in industrial production processes.

Sand and gravel for construction are used in structural engineering (for example, buildings) and civil engineering (for example, roads). The 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 often underreport or fail to report the total amount extracted for both industrial and construction use. Frequently, only special sand and gravel for industrial use is included (see above). The following checks can be performed to find out if sand and gravel is inadequately reported or underestimated in statistical sources:

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 significantly differs from the values shown in Table 3 below, it can be assumed that sand and gravel for construction purposes is not adequately reported and needs 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 should be estimated.

Table 3. Average consumption of non-metallic minerals per capita by world region, taken from The use of natural resources in the economy: A Global Manual on Economy-Wide Material Flow Accounting, UNEP, 2023, page 65. Original source: Miatto et al. 2016

World Region	Yearly Consumption of Non-Metallic Minerals Per Capita [T/Cap] For 2010
Africa	1.5
Asia and the Pacific	6
Eastern Europe, Caucasus and Central Asia	3.5
Europe	5
Latin America and Caribbean	2.5
North America	5.3
West Asia	8.2
World (average)	4.8

The **Sand and Gravel Tool_DE** allows users to estimate the amounts of sand and gravel for construction (A.3.8.2). It is adapted from section 2.3.3.6 of the Global Manual on EW-MFA and follows estimation steps 1-4 described in the section. The compiler uses default values (in pink or inserted directly into the equations). If alternative factors are available, they can be inserted into the respective gray sections.

In table *Step 1: Estimation of sand and gravel required for the production of concrete*, insert the local concrete conversion factor in cell B22 if available. It will then be automatically used in the calculations. Under each year insert the amounts for Cement Production, Cement Imports, Cement Exports and Stockpile Changes. Insert a negative value if stockpiles have decrease during the year. The total amount of sand and gravel used will be calculated.

Table *Step 2: Estimation of sand and gravel required for the production and maintenance of roads* is based on Table 2.17 of the Global Manual on EW-MFA. It classifies roads into the seven categories and applies two different factors (one for new road construction, one for maintenance of road network) to linear km of each, further multiplied by the width in metres. As different roads in the same cross-section class can have different widths, an important pre-processing step is to calculate the kilometre.metre (equivalent to 1,000 m^2) in each cross-section class, for both new construction and total road network.

Example 1: in the "intermediate type pavement" class, 100 km of 10 m wide road as well as 20 km of 20 m wide road were newly constructed.

Total kilometre.metres of new road in this class = (100 x 10) + (20 x 20) = **1,400 km.m**

Example 2: there are 8,000 km of 4 m wide and 2,000 km of 8 m wide road in the "Low pavement type" class in the entire road network.

Road requiring maintenance = (8,000 x 4) + (2,000 x 8) = **48,000 km.m**

Under each year in the *Estimated kilometre.metres of road by class* table, enter the total number of kilometres.metres of each road type constructed or maintained that year. The total amount of sand and gravel will be calculated.

Then use table *Step 3: Estimation of sand and gravel required for the construction of railways* to estimate the amount of sand and gravel needed of railway construction as needed. First insert the gauge of the railways constructed in metres (cells B74-B78). Then enter an alternate sand and gravel factor (t/km) in cells D74-D78, if known. Then in the *New railway constructed by gauge class* table enter the number of kilometers of rail constructed each year. The total amount of sand and gravel required for railway construction will be calculated.

Then calculate the amount of sand and gravel required for building sublayers. There is a large variation in the quantity of A.3.8.2 materials used in building sublayers depending on local soil composition, groundwater depth, weather patterns, typical construction methods and average building loads. Consult with local experts to determine appropriate estimation methods. Table *Step 4: estimation of sand and gravel required for building sublayers* uses the default a factor of 0.08 to the tonnage of sand and gravel used in concrete production, estimated in Step 1. It does not require any further data entry. If you have alternative estimates based on local knowledge and expertise, enter those in the "Local Knowledge based estimate" row, and it will replace the default estimate in the subtotal for this component.

Example: for the year 2010, in cell D102, enter the formula =D100*0.09, where 0.09 is the local factor.

The total sand and gravel used for construction will be calculated in the summary table and inserted into row A.3.8.2 of Table_A.

Note: The use of recycled sand and gravel should be taken into account and subtracted from the total used as appropriate.

A.3.9 Other non-metallic minerals not elsewhere classified (n.e.c.)

This is a diverse group that essentially comprises all minerals not covered by the previous groups. It includes: bitumen and asphalt, natural asphaltites and asphaltic rock; precious and semi-precious stones; graphite; quartz and quartzite; siliceous fossil meals; asbestos; steatite and talc; and feldspar. Definitions of each mineral is provided in Annex 2.

Specific issue: crushed rock needs to be considered when compiling data on non-metallic minerals and are presented in brief in Annex 3.

Figure 6: Decision tree for sourcing data for fossil fuel extraction accounts

A.4 Fossil fuels (Manual Section 2.4)

Fossil fuels are still the major energy carriers worldwide. Energy statistics and energy balances such as those reported to the IEA provide a comprehensive illustration of the supply and use of all energy carriers. In EW-MFA the domestic extraction of energy materials/carriers is limited to the extraction of fossil energy carriers. Materials required to construct renewable energy infrastructure such as hydropower plants, wind turbines or solar panels are considered in the metal or mineral accounts of the country where they are extracted.

Note: Biomass used for energy purposes is reported under biomass. The domestic extraction of the energy carrier uranium is reported under metals.

There are four main sources of energy statistics: Administrative data, statistical surveys, modelling, and in-situ measurements.

The two main international reporting requirements on fossil fuels are: Reporting to the IEA and to UNSD for the Energy Statistics Database. Check data availability by reviewing which data sets have already been compiled in according to (international) standards. If the IEA or UNSD reports include data from your country (https://www.iea.org/data-and-statistics, https://unstats.un.org/unsd/energystats/pubs/yearbook/), it is very likely that some local source is already reporting official data to the IEA. It should thus be possible to get these data directly from that source. If such data do not exist, other sources can be used. The preferred option for sourcing data for fossil fuel extraction is outline below and in Figure 6.

If the government already collects data on fossil fuel production and they are available as reported to IEA, UNSD SIEC, or other international bodies, use Orange **Sheet Fossil Fuels Tool_DE** to compile the accounts (see Figure 7).[2] If the data are available but not in an international format, create a concordance and then enter the data into the compiler. You may need so create the necessary concordance before compiling the information. Identify the responsible institution to get data and compile accounts.

If the government is not collecting data, and data are available from an international body, complement these data with surveys and then compile accounts. Where there is a lack of data, the International Energy Agency, the United Nations Energy Statistics, the US Energy Information Administration (EIA) and the data collections of the USGS and the BGS provide data. These data can be used to compile material flow accounts. There may be differences in the values reported that stem from variances in definition or unit conversion procedures. In countries, the resource people responsible for the EW-MFA should collaborate with the personnel responsible for compiling the energy data reported to these sources.

If data are not available from an international body, consider creating and implementing a survey of energy producers. If a survey is not feasible but data are available which can be used to estimate fossil fuel production, then, use these data to estimate fossil fuel production and compile the accounts. If no such data are available it may be possible to carry out in-situ measurements and use this information to compile the accounts. Otherwise, it will not be possible to compile information on fossil fuel production.

Where data on the extraction are reported in mass units, they can be integrated into EW-MFA without further processing. Values given in volume or energy content must be converted into mass units. The orange sheets **ConvFact Peat, ConvFact Crude Oil and NGL, ConvFact Natural Gas** can be used to assist in these calculation. Country-specific factors should be identified and used for these conversions, as the technical characteristics of petroleum resources vary from region to region.

A.4.1 Coal and peat

Category A.4.1 includes all forms of coal:

A.4.1.1 Brown coal

A.4.1.1.1 Lignite (brown coal): The lowest ranked true coal, lignite tends to have a soft, brown, earthy texture and still have a high moisture content. It is a non-

2 In 2016 the UN Statistical Division published the UNSD Standard International Energy Product Classification (SIEC) as part of the International Recommendations for Energy Statistics (IRES). Data compiled under the SIEC perfectly fit the EW-MFA structure; however, only a small section needs to be used, as the SIEC also discerns energy products in addition to energy carriers.

agglomerating coal with a gross calorific value <17.4 MJ/kg containing more than 31% volatile matter on a dry mineral matter free basis.

A.4.1.1.2 Other sub-bituminous coal: Higher ranked sub-bituminous coals tend to be dull black. They are non-agglomerating coals with a gross calorific value of 17.4–23.9 MJ/kg, containing more than 31% volatile matter on a dry mineral matter free basis.

A.4.1.2 Hard coal
Bituminous coals that are shiny and black with a high heating value.

A.4.1.2.1 Anthracite: Anthracite is highest ranked coal. It is hard, black and shiny and has very low moisture and volatiles content, making it preferred for high value metallurgical uses.

A.4.1.2.2 Coking coal: A hard coal with gross calorific value >23.9 MJ/kg.

A.4.1.2.3 Other bituminous coal.

A.4.1.3 Peat
Peat can be thought of as the lowest rank of coal, or more properly as its precursor. It is a soft, often spongy, organic material composed mainly of partly decayed plant material, minor mineral matter, and having a very high moisture content.

A.4.2 Crude oil, natural gas and natural gas liquids

A.4.2.1 Crude oil
Mineral oil consisting of a mixture of hydrocarbons of natural origin.

A.4.2.2 Natural gas
Liquefied or gaseous gases occurring in underground deposits, consisting mainly of methane; including both "non-associated" gas originating from fields producing only hydrocarbons in gaseous form and "associated" gas produced in association with crude oil as well as methane recovered from coal mines (colliery gas).

A.4.2.3 Natural gas liquids (NGL)
Liquid hydrocarbons, generally three to eight carbon atoms per molecule dissolved in natural gas in a hydrocarbon reservoir, extracted with the gas stream. The lighter components (three to four carbon atoms, largely propane, butane, butylenes, propylene and isomers thereof) are gaseous at standard temperatures. The heavier components (five to eight carbon atoms), generally liquid at standard temperature and pressure, constitute the "condensates".

In addition to crude oil recovered from conventional oil wells, and using enhanced recovery techniques including hydraulic fracturing (fracking), the crude oil component of this category will also include all extraction of petroleum from oil sands which takes place in situ (that is, where the oil sand is left in place, but the petroleum component is extracted directly by such techniques as steam and/or solvent injection). The same principle applies to oil shales if/where there is any direct extraction of petroleum products without first physically excavating the host rock. Quantities of produced natural gas are measured after purification and extraction of NGL and sulphur.

Re-injected gas, quantities vented or flared (so-called total dry production) are reported separately in energy statistics and should be included where possible. Data in mass units can be integrated without further processing into the EW-MFA. However, the production of natural gas is often reported in volume or energy content ("gross calorific value", GCV). For conversion into metric tonnes, ideally region-specific factors should be applied. Where no such data are available, average factors can be used. The orange sheets **ConvFact Crude Oil and NGL** and **ConvFact Natural Gas** can be used to do these conversions.

If both condensates (particularly "lease condensates") and NGL are recorded separately, they should generally be added together to get Domestic Extraction of NGL. In contrast, where liquefied petroleum gas (LPG) is recorded separately, it should NOT be added to Domestic Extraction. Generally, LPG is a refinery product and so should already have been included as part of the NGL. Adding LPG would result in double counting.

A.4.3 Oil shale and tar sands

Category 4.3 consists of two materials

Oil shale: Sedimentary rock containing kerogen, a solid organic material.

Tar sands: Naturally occurring bitumen-impregnated sands that yield mixtures of liquid hydrocarbon and require further processing other than mechanical blending before becoming finished petroleum products.

Oil sand or oil shale that is physically excavated, and then either processed or used directly, are accounted in this category. When the oil sand or oil shale is physically excavated, all of the excavated component which is then processed or used directly should be counted, not just the petroleum component extracted. If only the petroleum product extracted is recorded, and a local factor is not available, a default factor of 2 tonnes of oil sand per barrel of oil can be applied. At present, petroleum production from true oil shales is insignificant, with world production dominated by production from one country (Estonia).

Calculating totals for Fossil Fuels – Domestic Extraction

The orange sheet **Fossil Fuels Tool_DE** can be used to calculate the totals for fossil fuel extraction that are reported in Table A. It includes the concordance for use when compiling EW-MFA data on fossil fuels from data formatted for the UNSD Energy questionnaire.

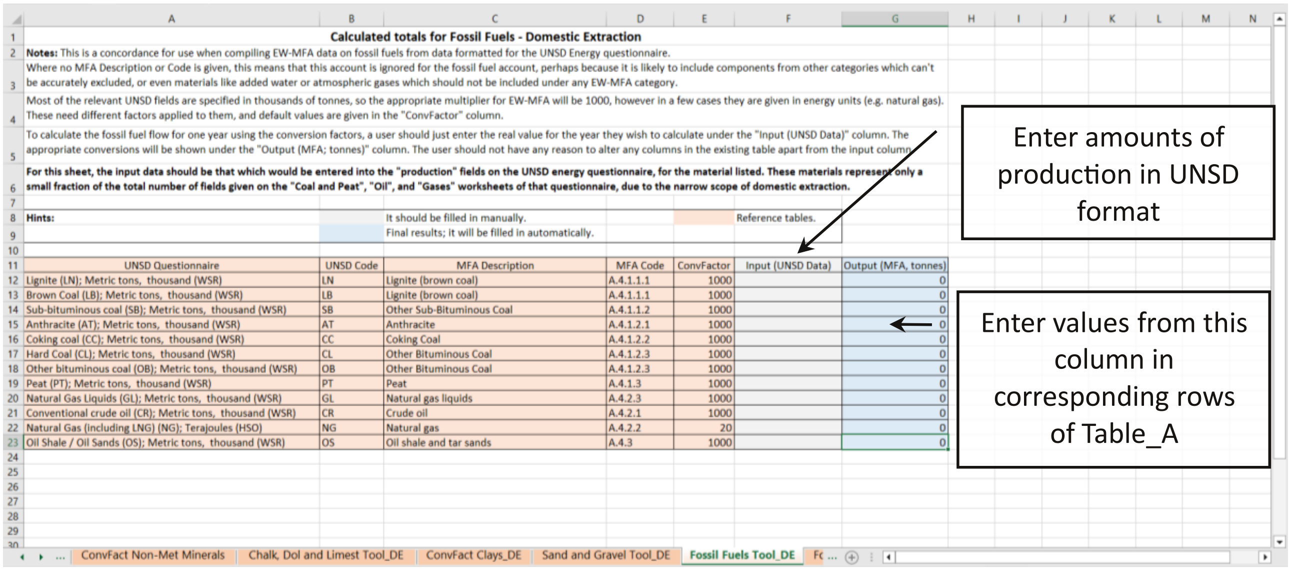
Where no MFA Description or Code is given, this means that this account is ignored for the fossil fuel account, perhaps because it is likely to include components from other categories which cannot be accurately excluded, or even materials like added water or atmospheric gases which should not be included under any EW-MFA category.

Most of the relevant UNSD fields are specified in thousands of tonnes, so the appropriate multiplier for EW-MFA will be 1,000, however in a few cases they are given in energy units (for example, natural gas). These need different factors applied to them before the data are entered into the accounts (refer to orange sheets **ConvFact Crude Oil and NGL** and **ConvFact Natural Gas**).

To calculate the fossil fuel flow for one year using the conversion factors, a user should just enter the real value for the year to be calculated under the "Input (UNSD Data)" column. The appropriate conversions will be shown under the "Output (MFA; tonnes)" column. The user should not have any reason to alter any columns in the existing table apart from the input column.

For this sheet, the input data should be that which would be entered into the "production" fields on the UNSD energy questionnaire, for the material listed. These materials represent only a small fraction of the total number of fields given on the "Coal and Peat", "Oil", and "Gases" worksheets of that questionnaire, due to the narrow scope of domestic extraction.

Figure 7: The orange sheet Fossil Fuels Tools_DE to calculate totals for fossil fuels – domestic extraction with production data from the UNSD energy questionnaire



Table_B - Imports of materials/ Table_C - Exports of materials (Manual Section 3)

The method of accounting for the trade of materials aims to capture the maximum amount practicable in physical mass terms, in categories closely aligned to those used for domestic extraction in a way that does not introduce large errors from excessive back calculation, modelling of tonnages, or miscategorization of traded materials.

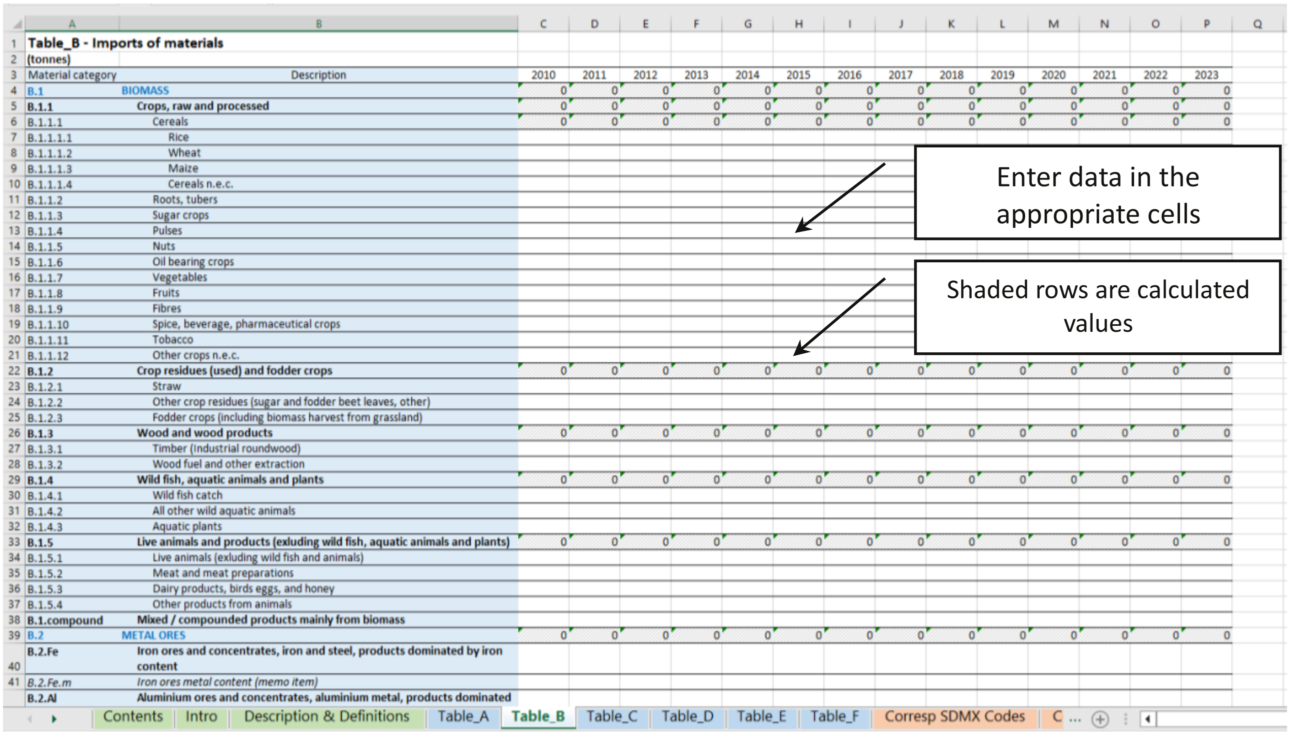
The categories for EW-MFA trade accounts are broader than those of domestic extraction as they include materials that have been transformed. For example, domestic extraction only accounts for wood as it is extracted from the environment, the trade accounts include processed wood and wood products. Similarly for petroleum, domestic extraction only accounts for crude oil and natural gas liquids, while the traded petroleum accounts also include refined fuels and other secondary petroleum products. While the range of products counted for trade is much wider than for domestic extraction, the scope of actual materials which should be included is the same, that is, care should be taken not to include materials such as additional water, or gases from the atmosphere, which are not counted in domestic extraction.

Note: Transit flows (materials imported to the country and then exported) are not included the trade accounts.

The categories of materials considered are listed in Table_B Imports of materials (Figure 8). The same categories are listed in Table_C Export of materials. They correspond closely to categories used for domestic extraction with a few additional categories that capture additional goods which have been processed to some degree, and even some manufactured goods where they are dominated by specific material categories.

Example: category B.4.compound (Mixed/ compounded products mainly from fossil fuels) allows the compiler to record significant tonnages of tyre imports, which are usually composed mainly of rubber, or of petrochemical origin, but also have significant components of metals, and perhaps some biomass-based rubber.

Figure 8: Table_B Import of materials



Table_B - Imports of materials

(tonnes)

Material category	Description	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
B.1	BIOMASS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B.1.1	**Crops, raw and processed**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B.1.1.1	Cereals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B.1.1.1.1	Rice														
B.1.1.1.2	Wheat														
B.1.1.1.3	Maize														
B.1.1.1.4	Cereals n.e.c.														
B.1.1.2	Roots, tubers														
B.1.1.3	Sugar crops														
B.1.1.4	Pulses														
B.1.1.5	Nuts														
B.1.1.6	Oil bearing crops														
B.1.1.7	Vegetables														
B.1.1.8	Fruits														
B.1.1.9	Fibres														
B.1.1.10	Spice, beverage, pharmaceutical crops														
B.1.1.11	Tobacco														
B.1.1.12	Other crops n.e.c.														
B.1.2	**Crop residues (used) and fodder crops**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B.1.2.1	Straw														
B.1.2.2	Other crop residues (sugar and fodder beet leaves, other)														
B.1.2.3	Fodder crops (including biomass harvest from grassland)														
B.1.3	**Wood and wood products**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B.1.3.1	Timber (Industrial roundwood)														
B.1.3.2	Wood fuel and other extraction														
B.1.4	**Wild fish, aquatic animals and plants**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B.1.4.1	Wild fish catch														
B.1.4.2	All other wild aquatic animals														
B.1.4.3	Aquatic plants														
B.1.5	**Live animals and products (exluding wild fish, aquatic animals and plants)**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B.1.5.1	Live animals (exluding wild fish and animals)														
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														
B.1.compound	**Mixed / compounded products mainly from biomass**														
B.2	METAL ORES	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B.2.Fe	**Iron ores and concentrates, iron and steel, products dominated by iron content**														
B.2.Fe.m	*Iron ores metal content (memo item)*														
B.2.Al	**Aluminium ores and concentrates, aluminium metal, products dominated**														

Compiling information on imports and exports

The statistical agencies of around 200 countries report trade statistics to the UN Comtrade. Therefore, a first step is to determine who within the national statistics office is responsible for this, then find out how they source their primary data. In addition, countries may report separate trade data on biomass to the FAO for biomass and/or on fossil fuels to the IEA. These data should be identified as the data held by these agencies are often superior to what is reported to Comtrade.

When no data are reported to Comtrade, FAO or IEA, a national authority (for example, local port authority, customs/border control agency, or taxation department) could be collecting information on quantities of imports and exports. It may be possible to use these data to reconstruct physical trade accounts if these can be mapped to categories in the MFA, and monetary values converted to physical tonnes.

The most important practical matter to keep in mind when compiling EW-MFA trade accounts is that they are physical accounts, measured in tonnages, and that the great bulk of traded tonnage is accounted for by a relatively small number of low unit value ($ per kg), primary or near primary commodities. For this reason, when compiling the data, it is more important to ensure that the accounts of bulk commodities are correct than to refine accounts for high unit value products. Accounting for higher unit value goods is usually done as counts of individual units and/or in monetary value terms. The relationship between individual product items or their values, and their physical mass is often highly variable. Therefore, any attempt to convert these to physical trade is as likely to introduce error as to improve the account. The classification systems used in reporting trade typically have many thousands of categories,[3] however, for most countries less than 1% (and often less than 0.1%) of these categories will account for more than 90% of the total tonnage of trade.

The following sections deal with compiling each of the major traded materials categories. The four major material categories align with those used in the DE accounts, however, trade category names can reflect either a primary material directly, or the primary material from which a product was mainly derived. This is made clear in the 2-4-digit level subcategory names. The 2-digit subcategories include an extra subcategory, with suffix ".compound". This category is provided to accumulate tonnages of traded products which are judged to be clearly dominated by one of the main material categories, but which are mixed and impractical to attribute accurately across more specific subcategories.

Note: The classification for imports and exports are identical except that the prefix B is used for "Imports" and C for "Exports".

B.1/C.1 Traded biomass (Manual Section 3.3.1)

For biomass, the 2-4-digit level descriptions should cover the great bulk of the relevant biomass primary and near primary materials.

Example: wheat, wheat flour, rye bread, pre-mixed bread doughs, kibble etc. would go under B.1.1.1.2 or B.1.1.1.4 depending on the degree to which the compiler is able to ascertain the cereal(s) used. While bread has other components besides cereals, in most cases the cereal component is sufficiently dominant that placing it under B.1.1.12 or B1.compound would probably unnecessarily lose information.

Option 1: as always, local information should take precedence, so if the compiler happens to have good information indicating that the great majority of flour or bread internationally traded in their country actually uses mainly banana flour, for example, then they should not hesitate to classify the tonnage of traded bread under B.1.1.8. The goal is to reflect the dominant original primary materials as closely as practicable.

Option 2: if the compiler has ready access to data which indicates that they trade large volumes of a mainly cereal product which is 30% wheat, 30% rice, 20% other crop-based materials (non-specified), and 20% meat processing by-products, then the optimum solution would be to allocate those percentages of the traded weight of that product to B.1.1.1.2, B.1.1.1.1, B.1.1.12, and B.1.5.2 respectively. In the absence of such detailed compositional information, a similar product could be classified under B.1.compound.

3 Refer to orange sheets **Corresp HS2017_Trade** Correspondence Table HS 2017 Codes to EW-MFA Codes, and **Corresp SITC Rev.4_ Trade** Correspondence Table SITC Rev. 4 Codes to EW-MFA Codes as examples.

Option 3: in a third case for a similar product where the compiler knows the product is 50% wheat and 50% other things dominated by unspecified biomass, then splitting the total tonnage evenly between B.1.1.1.2 and B.1.compound would be appropriate.

The above examples illustrate the general approach to take. Again, at all times the compiler should consider whether the time spent finding the information required to perform such detailed allocations would not be better spent checking and refining large tonnage items elsewhere in the accounts, for example, perhaps ensuring bulk cereals trade is correct to within a few per cent.

One issue which can affect some biomass products that the compiler needs to be aware of relates to beverages. The bulk of many beverages is water which has been added to relatively minor quantities of crop-derived products, and so should not be counted. This is the case for things like sugary soft drinks and beer. On the other hand, for wine and fruit juice concentrates, the contained water is actually derived from the crop as it was harvested, and so should be counted to remain consistent with the DE accounts. While volumes of such liquids can be converted reasonably well to tonnes (usually in the range of 1.0–1.5 tonnes per m^3), unless the compiler can exclude the major added water products (beer and soft drinks), or is sure they are a relatively minor component, it may be best to exclude beverages from the trade account entirely. Similarly, while most dairy products should be counted under B.1.5.3, liquid milk should be either excluded entirely, as it is >85% water, or have its apparent tonnage reduced accordingly. This is because the great majority of that water is not derived from the cow's biomass intake, but instead from additional water it drinks.

Most high tonnage biomass product flows will be recorded in tonnes or other unit of mass, however a number of products are recorded in volumetric units, individual pieces, or even area or length units. This is common with wood products. For example, of the major categories most countries will already be reporting to the FAO, the various types of wood pulp and paper are typically recorded in tonnes, and can enter the accounts directly. Industrial round wood, fuelwood, sawn wood, particle board and other components are recorded in m^3, and by type (coniferous or non-coniferous), so these must be converted to tonnes using coefficients, such as those provided in the orange sheet **ConvFact Wood_DE**, or by using specific local coefficients where possible.

While things like wood chips and particle board appear in FAO statistics as either tonnes or m^3, a compiler should check whether the original data supplied by the local agency was provided in these units. Things like particle board and sawn wood are quite often originally recorded in m^2 or linear metres. If so, the compiler should independently check if the conversion to m^3 or tonnes appears reasonable given local knowledge.

Note: densities of wood, wood particles, and particle board per m^3 will all vary widely, even when made from identical tree species. This is due to the introduction of air-filled voids for the granulated products, and compression for the board products. Again, locally relevant coefficients are best here, but a good range of densities for different woodchips is available at https://www.simetric.co.uk/si_wood.htm (along with a wide variety of densities for other bulk commodities, both biomass and mineral).

B.2/C.2 Traded metal ores (Manual Section 3.3.2)

There is no equivalent international agency which has achieved a standard of centralized reporting on minerals, either metallic or non-metallic, comparable to what the FAO or IEA have achieved for biomass and fossil fuel respectively. There should be a local agency responding to Comtrade questionnaires, which have categories for metal ores and concentrates, and for a wide variety of metal products. Unfortunately, the categories used by Comtrade do not distinguish well between some large tonnage, as very different products (for example, the ores and concentrates of individual metals) are pooled. Also, deriving adequate factors to convert the units used to record many products (for example, number of items) to tonnages can be difficult and are subject to large error. As a result, accounting comprehensively for this category is very challenging, and the risk of increasing error through trying to include too many products is high. The compiler should reflect often on whether they have reached the point where attempting accounting for more products is likely to introduce more error than it removes.

The existing harmonized system (HS) scheme of reporting to Comtrade (see **Corresp HS2017_ Trade**) already uses a classification system based on a relatively detailed disaggregation of ores and concentrates according to the main metal contained, for example, "2603. Copper ores and concentrates". Consequently, it is more practical for the EW-MFA categories for metal ores trade to follow the system used for contained metals rather than the mined ores outlined above. The resulting categories are thus constructed as B.2.x where x is the main metal, for example, B.2.Fe for iron ores and concentrates.

Much less emphasis is placed on trying to record the detailed composition of metal ores traded than was the case for domestic extraction. This is because there is unlikely to be any data recorded for trade comparable to the detailed operational data that mine operators routinely assemble. In the event that such detailed data on the metal content in traded ores and concentrates are available, or can be calculated, these should be accounted for using the appropriate contained metals code. These additional codes deal with the pure metal content that can be accounted for, and are constructed B.2.x.m, where x is the main metal, for example, B.2.Cu.m and C.2.Cu.m for contained copper in imports and exports respectively. As with Domestic Extraction, the contained metals accounts are kept separate from the main trade account, and not added when creating totals, as this would be double counting.

While traded metal ores are categorized using individual metals, these are aggregated under the three-category system B.2.Fe (for iron), B.2.Al (for aluminium), and B.2.x (for all others), plus one additional category B.2.compound (for compound products made mainly of metals).

The main tonnages that can safely be accounted for will be in primary or near primary products. For example, iron ore and concentrates, pig iron, steel, scrap iron and steel, basic steel products such as bars, beams, etc. (if recorded in tonnes) should account for the bulk of B.2.Fe; bauxite, alumina, aluminium ingots, basic aluminium products are allocated to B.2.Al; and other metal ores, concentrates, basic products, and compounds such as copper sulphate, titanium oxide, rutile, etc. for the bulk of materials under B.2.x.

In some cases, it may be worth trying to account for some complex manufactured items where it is clear they contain significant quantities of materials which can reasonably be separated.

Example: while the exact average composition and weight of cars traded differs between nations and years, rather than ignoring this flow completely, the compiler could attempt allocation in one of two ways.

Option 1: the simplest would be to allocate a tonnage equal to the estimated average weight per vehicle x the number of vehicles to B.2.compound.

Option 2: given better data on vehicle composition, a more detailed allocation could be performed by splitting the total estimated tonnage of vehicles into, say, 60% steel (allocate to both B.2.Fe and B.2.Fe.m), 10% aluminium (allocate to both B.2.Al and B.2.Al.m), 15% rubber and plastic (allocate to B.4.compound Mixed/compounded products mainly from fossil fuels), and leaving 15% unallocated. In a case such as this, where a reasonable (or conservative) estimate of both the average size of the item, and its composition, can be made, the item is probably worth including.

In cases where the items are of highly variable individual mass (for example, vehicles other than automobiles, pots, pipes, boats, refrigerators etc.), attempting such a calculation could easily introduce more error than it removes. The decision will depend on the raw data available to the compiler. Tables of standard weights for products have been established for certain product classification schemes, and presented for use in EW-MFA, most notably in the annexes to Eurostat (2013). However, it is strongly recommended that the compiler makes their own judgement as to whether these compilations apply to their local situation, and whether the flows involved are likely to be significant. Often, the effort required to apply such schemes would be better-spent refining estimates on large tonnage, basic commodity flows.

B.3/C.3 Traded non-metallic minerals (Manual Section 3.3.3)

Non-metallic minerals are similar to metal ores in that there is no major international agency which specializes in establishing trade accounts for this category. Comtrade does request data for the trade of most non-metallic minerals, so a compiler should first check which local agencies are responsible for reporting trade data to Comtrade, and what data are being compiled for that purpose in this category. The allocation to EW-MFA categories is likely to be best if the detailed original national data are used, rather than any aggregates reported to Comtrade. The compiler should then decide how to best allocate those material categories to the categories listed in Table_B and Table_C (see also Table 3.1 of the Manual).

One area where caution must be exercised is for fertilizer minerals. While some bulk fertilizers, such as those containing phosphorous and potassium, are largely of mineral origin, the major class of nitrogenous fertilizers is in most cases predominantly sourced from the artificial Haber process. Most of the mass thus comes from either atmospheric nitrogen or oxygen, neither of which should be counted. Unless the compiler knows that the source is likely to be nitrate mineral deposits, nitrate fertilizers such as ammonium nitrate should be excluded from the physical trade account. Further complicating this are mixed fertilizers such as MAP (Monoammonium Phosphate), and DAP (Diammonium Phosphate). The ratios of mineral-derived components for most of these mixed fertilizers are higher than the atmospheric-derived components, and so they should be accounted for as fertilizer minerals. The B.3.compound category is available at the compiler's discretion.

B.4/C.4 Traded fossil fuels (Manual Section 3.3.4)

As with domestic extraction, the first step for a compiler of traded material flow accounts for fossil fuels is to check whether their country is already reporting to the IEA or responding to the UNSD Annual Questionnaire on Energy Statistics. If so, the level of data already being compiled for those purposes should be much more than adequate for the main body of the material flows accounts. Constructing the material flow accounts should then be largely a matter of allocating the detailed traded fossil fuel categories recorded for IEA/UNSD reporting to the fossil fuel categories listed in Table_B and Table_C, although in some cases it may be necessary to convert units, for example, converting natural gas from contained energy or volume to mass unit (use conversion factors provided in orange sheets **ConvFact Peat, ConvFact Crude Oil and NGL** or **ConvFact Natural Gas)**.

If a country is not currently reporting to either agency, and has very limited resources to do so, it is recommended that at a minimum the compiler downloads the UNSD questionnaire and associated guidelines, and endeavours to complete at least the production, import, and export fields for each of the main commodities given on the worksheets "Coal and Peat", "Oil", and "Gases" (refer to orange sheets **Fossil Fuels Tool_Imp** and **Fossil Fuels Tool_Exp**).

As with the other material categories, traded fossil fuels should account for both fossil fuels extracted from the environment, and for any products subsequently derived from them.

Example: traded gasoline, kerosene, diesel, etc., will all be counted under petroleum in the trade accounts, not just crude oil and NGL.

The only aspect of the material flows accounts for fossil fuels that will not be adequately covered by collecting data required to fill out the UNSD questionnaire is the B.4.compound category. This category will include mainly bulk plastics, plastic precursors and resins, and plastic-dominated products (if viable estimates for tonnages are possible). For plastic-dominated products, the approach should be similar to that described for the compound metal products in the preceding section.

Example: a country may have a large tyre trade. It may be reasonable to assume a conservative average weight for imported/exported tyres (say 10 kg), use this to calculate total tonnages from the number of tyres traded, and attribute these to B.4.compound and C.4.compound respectively.

Trying to calculate tonnages of more variable items, such as plastic toys and containers, on the other hand, is unlikely to be worth the effort required. Local knowledge would be important in making this judgement.

B.5/C.5 Mixed/Complex Products N.E.C.

Some product groups cannot be assigned to the main four material categories because their material-wise composition is too heterogeneous. Enter the total mass of mixed/complex products imported or exported into line 81 of Table_B and Table_C as appropriate.

B.6/C.6 Waste for Final Treatment and Disposal

This category includes material dedicated to cross-border flows of waste material intended for further treatment or final disposal and after-care of disposal sites. These fields are supposed to accommodate cross-border movement of waste material that is not included in international trade in goods statistics (ITGS).

There is no globally agreed classification of non-hazardous wastes. However, most international waste and waste statistics frameworks, refer to or are compatible with the European Waste Classification for Statistics, Revision 4 (EWC-Stat, European Commission (2010)).

The Basel Convention provides an internationally agreed classification for hazardous wastes and is used for controlling the transboundary movement of waste. However, this is not covering all hazardous waste and is not harmonized with the EWC-Stat classifications. A classification for electronic wastes has been developed recently by the Partnership for Measuring ICT for Development (Forti V. et.al., 2018). It links to multiple data sources and data formats, such as the Harmonized Commodity Description and Coding System (HS) and the EU WEEE Directive reporting.

HS codes allows participating countries to classify traded goods on a common basis for customs purposes, and thus is relevant for statistics on imports and exports of waste. However, the actual imports and exports of wastes cannot be distinguished from products through the HS classification, thus posing a problem for producing official statistics. Solutions need to be found to better adapt the HS for monitoring of transboundary movements of waste.

Disposal means any operation which main purpose is not the recovery of materials or energy even if the operation has as a secondary consequence the reclamation of substances or energy. According to Annex I of the EU Waste Framework Directive, disposal operations include deposit into or on to land (e.g., landfill), biological and physico-chemical treatment, incineration, permanent storage, etc.

Table_D - Material outflows (Manual Section 4)

On the output side of the economy, EW-MFA considers the total mass of materials released to the environment as wastes and emissions after having been used in the domestic economy. Output flows occur at the processing, manufacturing, use and final disposal stages of the economic production and consumption chain. In EW-MFA, outputs to the environment are summarized as domestic product output (DPO).

The DPO account comprises five major categories:

D.1. Emissions to air

D.2. Waste landfilled (uncontrolled)

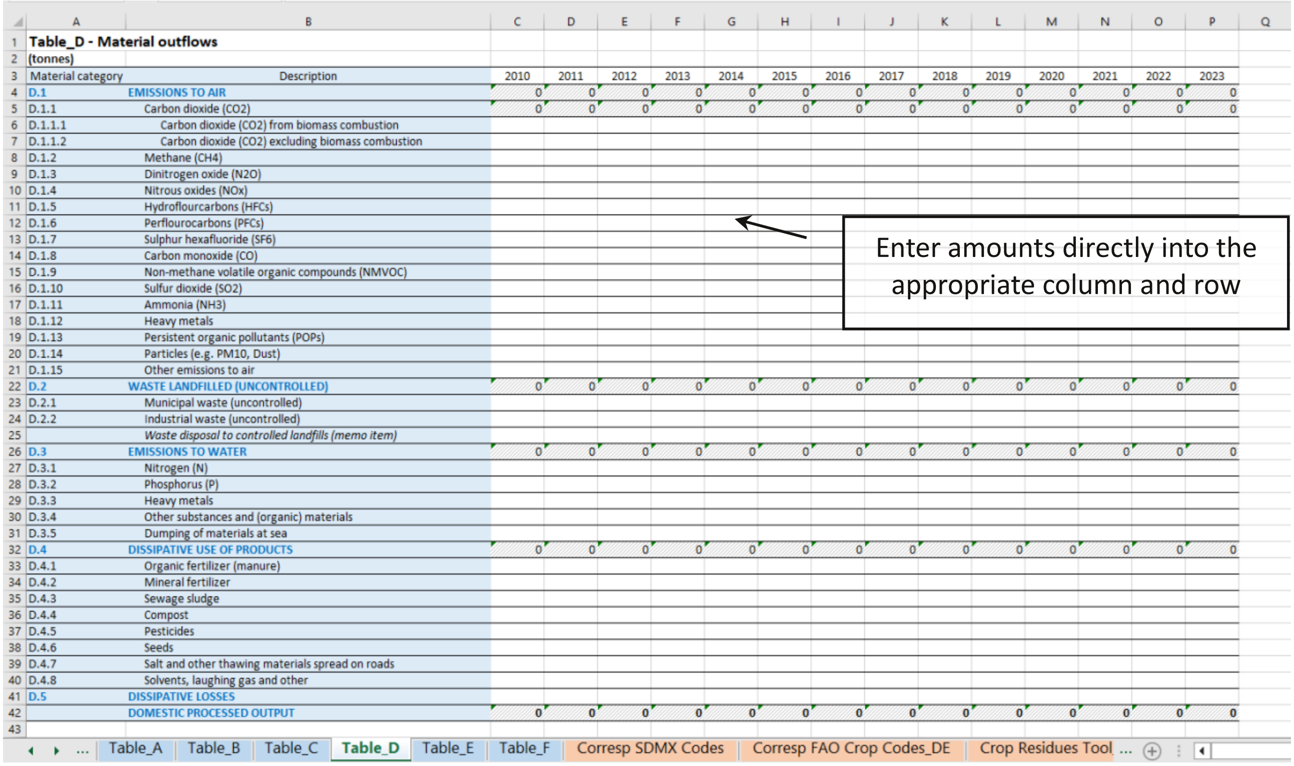
D.3. Emissions to water

D.4. Dissipative use of products

D.5. Dissipative losses (See Figure 9)

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

Figure 9: Table_D Material outflows



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Table_D - Material outflows**																
2	(tonnes)																
3	Material category	Description	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	
4	D.1	EMISSIONS TO AIR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	D.1.1	Carbon dioxide (CO2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	D.1.1.1	Carbon dioxide (CO2) from biomass combustion															
7	D.1.1.2	Carbon dioxide (CO2) excluding biomass combustion															
8	D.1.2	Methane (CH4)															
9	D.1.3	Dinitrogen oxide (N2O)															
10	D.1.4	Nitrous oxides (NOx)															
11	D.1.5	Hydroflourcarbons (HFCs)															
12	D.1.6	Perflourocarbons (PFCs)															
13	D.1.7	Sulphur hexafluoride (SF6)															
14	D.1.8	Carbon monoxide (CO)															
15	D.1.9	Non-methane volatile organic compounds (NMVOC)															
16	D.1.10	Sulfur dioxide (SO2)															
17	D.1.11	Ammonia (NH3)															
18	D.1.12	Heavy metals															
19	D.1.13	Persistent organic pollutants (POPs)															
20	D.1.14	Particles (e.g. PM10, Dust)															
21	D.1.15	Other emissions to air															
22	D.2	WASTE LANDFILLED (UNCONTROLLED)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	D.2.1	Municipal waste (uncontrolled)															
24	D.2.2	Industrial waste (uncontrolled)															
25		*Waste disposal to controlled landfills (memo item)*															
26	D.3	EMISSIONS TO WATER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
27	D.3.1	Nitrogen (N)															
28	D.3.2	Phosphorus (P)															
29	D.3.3	Heavy metals															
30	D.3.4	Other substances and (organic) materials															
31	D.3.5	Dumping of materials at sea															
32	D.4	DISSIPATIVE USE OF PRODUCTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
33	D.4.1	Organic fertilizer (manure)															
34	D.4.2	Mineral fertilizer															
35	D.4.3	Sewage sludge															
36	D.4.4	Compost															
37	D.4.5	Pesticides															
38	D.4.6	Seeds															
39	D.4.7	Salt and other thawing materials spread on roads															
40	D.4.8	Solvents, laughing gas and other															
41	D.5	DISSIPATIVE LOSSES															
42		DOMESTIC PROCESSED OUTPUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
43																	

The following recommendations follow the Eurostat bottom-up approach and highlight open issues with full balancing. The following guidelines are of a general nature and will inevitably leave questions unanswered. It certainly will require the judgement and creativity of the practitioner to apply these general rules to the specific national situation. It is good practice to clearly specify the assumptions made and the data sources used so the issue of completeness can be evaluated.

D.1 Emissions to air (Manual Section 4.2)

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 of 15 main material categories which are discussed in more detail below (See also Figure 9 above).

When compiling information on emissions to air national data sources should be used. A combination of data sources will be necessary to complete the EW-MFA accounts. The primary sources are identified below.

Data reported to the UN Framework Convention on Climate Change (UNFCCC) greenhouse inventory can be used for the following substances: carbon dioxide, methane, dinitrogen oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, nitrogen oxides, non-methane volatile organic compounds, carbon monoxide, and sulphur dioxide. Greenhouse gas emissions in this inventory are reported as global warming potential (GWP) in CO_2 equivalents. Therefore, it is necessary to use the underlying inventories when compiling the EW-MFA account.

Important: Before they are used for the EW-MFA account, the data reported to UNFCC have to be converted to the residence principle, where emissions by emitters of a specific nationality but outside of the territory are included. For this aim, the Eurostat developed "bridge tables" as described in the Eurostat Manual for Air Emissions Accounts (Eurostat 2015). General information on the residence principle and its implications for DPO can be found in the Eurostat handbook on economy-wide material flow accounts (Eurostat 2018), chapters 2.3 and 4.7.

Countries that are parties to the UNECE Convention on long-range transboundary air pollutants (CLRTAP) can use the data on substances reported under that convention: Sulphur oxides, nitrogen oxides, carbon monoxide, non-methane volatile organic compounds, ammonia, particle matter ($PM_{2.5}$, PM_{10}), lead, cadmium, mercury, polycyclic aromatic hydrocarbons, polychlorinated dibenzo-p-dioxins and furans (PCDD/F), hexachlorobenzene, and polychlorinated biphenyls (PCBs). As for the data reported to UNFCC, these have to be converted to the residence principle.

Air emission accounts (AEA) record flows of gaseous and particulate materials (six greenhouse gases including CO_2 and seven air pollutants) emitted by the economy into the atmosphere. They follow the national accounts' residence principle which includes emissions by resident economic units even when these occur outside the territory (for example, resident airlines and shipping companies operating in the rest of the world). Because of this, **if AEA data are available** they should be used as the primary data source for EW-MFA.

D.1.1.1 Carbon dioxide (CO_2) from biomass combustion

CO_2 emissions from the combustion of biomass from the following: biofuels such as biodiesel and bioethanol; biogas used as biofuel or as a fuel for producing electricity and heat; biomass for electricity and heat (mainly wood and agricultural harvest residuals); and, biomass used in rural areas of developing countries, especially firewood and residuals or wastes from agriculture and forestry (also referred to as traditional biomass).

Note: It does **not** include CO_2 emissions from land use and land use changes (considered flows within the environment) or human or animal respiration (considered as output balancing items).

D.1.1.2 Carbon dioxide (CO_2) excluding biomass combustion

Includes CO_2 emissions from the combustion of fossil fuels from the following sources: energetic sources (for example, oil); non-energetic non-biotic sources (industry, agriculture, waste); and international bunkers estimated following IPCC (2019) methodology.

The compiler should indicate the estimation method used in a footnote.

D.1.2 Methane (CH_4)

Includes CH_4 emissions from the following sources: 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.

Note: CH_4 emissions from uncontrolled landfills are not included in the "emissions to air" total. They may be reported as a separate memorandum item.

D.1.3 Dinitrogen oxide (N_2O)

Includes emissions from the following sources: Fossil fuel combustion; industrial processes; biomass burning; and, cattle and feedlots.

Note 1: It does not include N_2O emissions from: Product use (should be allocated to "dissipative use of products"; agriculture; or wastes to uncontrolled landfills. Emissions to air from fertilizer application such as N_2O are excluded from D.1. Emissions to air. The related primary output is fertilizer spread on agricultural soil which is already accounted for under D.4. Dissipative use of products.

Note 2: N_2O (laughing gas) used for anaesthesia is included in D.4.8.

D.1.4 Nitrogen oxides (NO_x)

Includes emissions from the following sources: Road transport; energy production and distribution; commercial institutions and households; energy use in industry; non-road transport; industrial processes; agriculture; solvent and product use; and waste.

D.1.5 Hydroflourcarbons (HFCs)

Includes emissions from the following sources: Manufacturing process and throughout product life of refrigerators, air conditioners, etc.; and production of metals and semiconductors.

D.1.6 Perflourocarbons (PFCs)

Includes emissions from the following sources: Aluminium smelting, uranium enrichment, and the manufacturing of semiconductors.

D.1.7 Sulphur hexafluoride (SF_6)

Includes emissions from the following sources: Insulation of high voltage equipment; and, manufacturing of cable-cooling systems.

D.1.8 Carbon monoxide (CO)

Includes emissions from the following source: Incomplete combustion of carbon-containing compounds, notably in internal combustion engines.

D.1.9 Non-methane volatile organic compounds (NMVOC)

NMVOC emissions from solvents are accounted for in "dissipative use of products" and not in "emissions to air".

D.1.10 Sulfur dioxide (SO_2)

Includes emissions from the following sources: Energy production and distribution; energy use in industry (industrial processes such as extracting metal from ore); industrial processes and product use; commercial, institutional, households; non-road transport (locomotives, ships and other vehicles and heavy equipment that burn fuel with a high sulphur content).

D.1.11 Ammonia (NH_3)

Emissions to air from fertilizer application such as NH_3 are excluded from D.1. Emissions to air. The related primary output is fertilizer spread on agricultural soil which is already accounted for under D.4. Dissipative use of products.

D.1.12 Heavy metals

Heavy metals are a group of elements between copper and bismuth on the periodic table of the elements having specific gravities greater than 5.0. This subcategory includes heavy metal emissions from the following sources: Road transport; and "Industrial processes and product use" sector.

D.1.13 Persistent organic pollutants (POPs)

Includes emissions from the following sources: "Commercial, institutional and households" sector; and "Industrial processes and product use" sector. The groups of compounds that make up POPs are also classed as PBTs (Persistent, Bioaccumulative and Toxic) or TOMPs (Toxic Organic Micro Pollutants).

D.1.14 Particles (e.g. PM_{10}, Dust)

Includes PM_{10} emissions from the following sources: Road transport; agriculture; and, "Energy Production and Distribution" sector.

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

D.1.15 Other emissions to air

Includes mass of substances emitted to air that is not accounted for above.

D.2 Waste landfilled (uncontrolled) (Manual Section 4.3).

This category **only** includes wastes disposed of in uncontrolled landfills. If data are available distinguish between D.2.1 Municipal waste (uncontrolled) and D.2.2 Industrial waste (uncontrolled). If these streams are not known or cannot be estimated, report these waste flows as a total in D.2 without distinction.

Note: There is a row where users are encouraged to include data on waste disposal to controlled landfills. This is a memo item for information purposes only.

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

Construction and demolition waste consists mainly of building materials and soil, including excavated soil. For the requirements of EW-MFA, special attention must be paid to avoid double counting but also to include all relevant flows to arrive at a comprehensive data set. As unused excavated soil or earth are not part of domestic extraction, only the used parts of excavated soil are included both as EW-MFA input and output.

D.3 Emissions to water (Manual Section 4.4)

For category D.3, Emissions to Water, only emissions from point sources need to be considered, whereas emissions from diffuse sources should be included in the DPO category D.4. Dissipative use of products.

There are two accounting approaches that can be used for the first three subcategories in this section: nitrogen, phosphorus, and heavy metals emissions to water.

First, annual flows of pollutants (in quantity per year) can be derived from statistics on emissions to water, if available. If these are not available, emissions to water can be estimated based on the maximum legal limit value for each pollutant multiplied by the quantity of water treated by wastewater treatment plants. This approach assumes that plants respect legal regulations and that the concentration of pollutants in water emitted is close to the legal maximum. The second approach can result in over- or underestimation. Further analysis of the specific national or local situation is highly recommended.

D.3.1 Nitrogen (N)

Total nitrogen (N) is 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 fertilizers. Nitrogen emissions to water include emissions in wastewater from households and industry.

D.3.2 Phosphorus (P)

Total phosphorus is the sum of all phosphorus compounds. Emissions from agriculture are excluded since they are included in "dissipative use of products" as phosphorus fertilizers. Phosphorous emissions to water include emissions by wastewater from households and industry.

D.3.3 Heavy metals

Heavy metals are a group of elements between copper and bismuth on the periodic table of the elements having specific gravities greater than 5.0. Emissions of heavy metals to water may come from municipal and industrial discharges.

D.3.4 Other substances and (organic) materials

Organic substances are commonly reported in water emission inventories as indirect summary indicators (compound indicators). The most commonly used are: BOD (biological oxygen demand); COD (chemical oxygen demand); TOC (total organic carbon); and (adsorbable organic halogen compounds) which do not correspond to EW-MFA accounts.

Compilers need to decide which indicator to use. Using TOC, if available, is recommended as it is the most comprehensive and sensitive indicator. Convert the reported quantity, which indirectly indicates organic substances, into the quantity of the organic substance itself by using a simplified stoichiometric equation.

D.3.5 Dumping of materials at sea

The category includes a complex compound of very different flows from various data sources, which are often inconsistent and incomplete. Data may be totally unavailable. Pay attention not to include materials which are part of unused domestic extraction, such as dredging materials, in order to be consistent with the material input side.

Material flows comprised as "dumping at sea" can be differentiated into land-based and sea-based litter. Sea-based litter includes litter from the fishing industry, shipping (for example, tourism, transport), offshore mining and extraction, illegal dumping at sea, and discarded fishing gear. Land-based litter comprises litter ending up in the oceans from coastal regions and litter reaching the ocean via rivers. It includes discharge to oceans and seas from landfills, rivers and floodwaters, industrial outfalls, discharge from stormwater drains, untreated municipal sewage, and littering of beaches and coastal areas (tourism).

D.4 Dissipative use of products (Manual Section 4.5)

Some materials are deliberately dissipated into the environment because dispersal is an inherent quality of product use or quality and cannot be avoided. The materials included in the EW-MFA are described below.

D.4.1 Organic fertilizer (manure)

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

Manure spread on agricultural land is usually not reported or insufficiently reported in agricultural statistics and has to be estimated. 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 below:

	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

Note 1: when calculating, if estimates are available, emissions to air during stockpiling of manure should be included in D.1 Emissions to air.

Note 2: organic fertilizer contains not only the manure of animals, but also other substances, such as straw used as bedding material in livestock farming. This additional material is considered domestic extraction and needs be accounted for accordingly.

D.4.2 Mineral fertilizer

Agricultural statistics commonly report domestic consumption of specified nitrogenous fertilizers, phosphate fertilizers, potash fertilizers, and multi-nutrient fertilizers (NP/NPK/NK/PK) in agriculture. FAOSTAT, for example, reports nitrogenous fertilizers, phosphate fertilizers and potash fertilizers. Data in such statistics usually refer to the nutrient content of fertilizers. These need to be adjusted to derive the total mass of material used. A fertilizer often not reported is lime (used in forestry for example) for which specific sources should be checked.

D.4.3 Sewage sludge

Sewage sludge refers to any solid, semi-solid or liquid residue removed during the treatment of municipal wastewater or domestic sewage. It is often used as a fertilizer and soil conditioner. By convention, category D.4.3. only includes sewage sludge spread on agricultural land or used for landscape management. Other applications of sewage sludge, for example, composting should be included in D.4.4 Compost, landfill in D.2 Waste landfilled (uncontrolled), dumping at sea in D.3.5 Dumping of materials at sea and incineration in D.1 Emissions to air.

Note: 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.

D.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. It is used for fertilizing and conditioning land.

Compost may be reported in agricultural statistics, in environmental statistics, or in specific studies such as UNFCCC inventories within sectoral background data for waste. Care needs to be taken to avoid double counting.

Example: if emissions from the incineration of biogas are included in D.1. emissions to air, compost incinerated for energy recovery needs to be excluded from D.4.4 compost.

Note: 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.

Note: Private households may compost organic materials previously purchased (such as 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 need to be added on the output side.

D.4.5 Pesticides

Agricultural statistics commonly report quantities of pesticides used in (or sold to) agriculture. Figures are generally expressed in active ingredients. Multipliers should be applied to convert these figures to total mass.

D.4.6 Seeds

Seeds for agricultural production are commonly recorded in agricultural statistics such as in FAO food commodity balance sheets.

D.4.7 Salt and other thawing materials spread on roads

In countries with rigorous winters, the use of salt and other thawing materials spread on roads is significant. Data on use may be available from departments responsible for road maintenance. Amounts could be estimated based on the length of roads in the country, street types (considering altitude and slope), average number of frost days per year, and average materials deployed.

D.4.8 Solvents, laughing gas and other

This category includes emissions from diverse dissipative use of products, such as use of solvents, road paving, N_2O for anaesthesia (laughing gas). Data for NMVOC solvents emissions can, for example, be obtained from national inventory reports to UNFCCC in the common reporting format categories:

- 3.A Paint application
- 3.B Degreasing & dry cleaning

- 3.C Chemical products manufacture & processing
- 3.D Other

N_2O for anaesthesia is included in Other (3.D) and its specific values may be extracted from national air emissions databases.

D.5 Dissipative losses (Manual Section 4.6)

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 accidents. This includes abrasion from tyres, friction products, buildings and infrastructure, leakages (for example, of gas pipelines), or from accidents during the transport of goods.

This category includes various types of dissipative flows. Losses of materials due to corrosion, abrasion and erosion of buildings and infrastructure are assumed to be of significant size and environmental relevance. Another significant unknown flow is the loss of lubricants, which is estimated at about 50% of total lubricant use.

Many of these flows have never been quantified. It is recommended that only those data that can be provided with justifiable effort be completed. The air emission submissions to the UNECE Convention on Long Range Transboundary Air Pollutants (CLRTAP) are the most significant data source for this item. The database includes information on emissions in road transport from automobile tyre and brake wear (NFR code: 1A3bvi) and from automobile road abrasion (NFR code: 1A3bvii).

An attempt should be made to develop a comprehensive approach to account for the following flows:

- Abrasion from tyres is rubber worn away from vehicle tyres.
- Particles worn from friction products, such as brakes and clutches.
- Losses of materials due to corrosion, abrasion, and erosion of buildings and infrastructure are probably quantitatively relevant. So far, there is no comprehensive approach to account for these flows. Single aspects such as losses due to leaching 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. German statistics, for example, report chemicals irreversibly lost due to accidents during transport.
- Another relevant flow may be leakages during (natural) gas pipeline transport (if not reported as emissions to air). Data may be available in specific studies.

Table_E – Balancing items (Manual Section 5)

A main advantage of organizing environmental statistics employing a material flow accounting approach is the ability for coherence checks of individual data sets by establishing a material balance of inputs and outputs. The material balance is established by adding domestic extraction, imports and balancing items which equal exports, domestic processed output, net additions to stock (NAS) and balancing items, where NAS includes intermediate consumption, final consumption and accumulation (or stock), where:

DE + Imports + Balancing items (input side)

= Exports + DPO + NAS + Balancing items (output side)

Balancing items are defined as the additional inputs and outputs necessary to establish a material balance. On the input side, these can be:

- Oxygen for combustion processes;
- Oxygen for respiration of human and livestock; bacterial respiration from solid waste and wastewater;
- Nitrogen for Haber-Bosch process;
- Water requirements for the domestic production of exported beverages.

On the output side, balancing items are comprised of:

- Water vapor from combustion;
- Gases from respiration of humans and livestock (CO_2 and H_2O), and from bacterial respiration from solid waste and wastewater (H_2O);
- Excorporated water from biomass and products.

A detailed and comprehensive explanation of balancing items is provided in section 4.8 of the Eurostat handbook on economy-wide material flow accounts (Eurostat 2018).

In practice, net additions to stock would be calculated as the residual of the material balance identity. As a consequence, NAS would contain all calculation errors. It is possible to calculate material stock and changes in material stock directly using a combination of bottom-up and top-down accounting principles which would allow running quality checks on the material balance.

The material balance also reveals important relationships among the different indicators and provides a sense of whether an economy invests in establishing physical stocks or is fuelled by a large throughput of materials.

Table_F – Headline indicators (Manual Section 6)

The relationships between headline indicators within the economy-wide material flow accounting model is shown in Figure 10. Table_F extracts the totals for the following headline indicators as calculated in Tables A to E:

- Domestic extraction (DE)
- Imports
- Exports
- Direct material input (DMI)
- Domestic material consumption (DMC)
- Physical trade balance (PTB)
- Domestic processed output (DPO)
- Net additions to stock (NAS)

These results are used for calculating SDG Indicator 8.4.1/12.2.1, Material Footprint, material footprint per capita, and material footprint per GDP. The material footprint is calculated this way:

$MF = DE + RME_{IM} - RME_{EX}$

With:

MF: Material Footprint

DE: Domestic Extraction

RME_{IM}: Raw Material Equivalent of Imports

RME_{EX}: Raw Material Equivalent of Exports

The MF per capita and MF per GDP can then be derived.

They are also used to calculate SDG Indicator 8.4.2/12.2.2, Domestic material consumption (DMC) and DMC per capita, per GDP this way:

DMC = Direct Imports of Materials + DE - Direct Exports of Materials

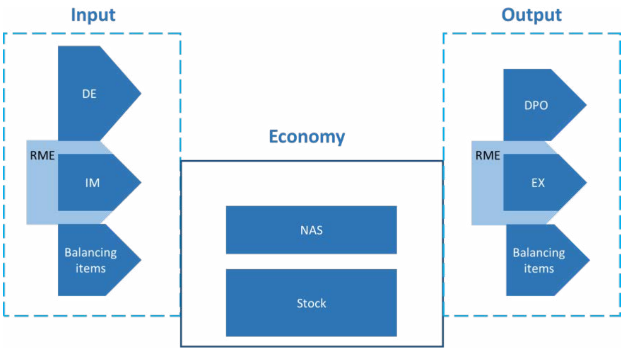
With:

DMC: Domestic Material Consumption

DE: Domestic Extraction of Materials

The DMC per capita and DMC per GDP can then be derived.

Figure 10: Simplified structure of EW-MFA



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Annexes

Annex I. Economy-wide material flow accounts Handbook, 2018 edition, Eurostat

The following sections are taken word by word from sections 4.8.1 and 4.8.2. of the Economy-wide material flow accounts Handbook, published in 2018 by Eurostat.

I.1 Balancing items: input side (MF.8.1)

Balancing items on the input side account for those material flows of air and water that are included in DPO or exports, but not included in DE or imports. The main processes concerned are combustion of fuels, respiration of humans and livestock, the production of ammonia via the Haber- Bosch process, and water requirements for the domestic production of exported beverages. Oxygen for combustion processes is by far the quantitative most important balancing item on the input side (ca. 90%).

Data sources and compilation

The following sections provide possible data sources and further compilation guidelines for the various groups within MF.8.1 'balancing items: input side'.

MF.8.1.1 Oxygen for combustion processes

Oxygen for combustion is calculated in a stepwise approach. Step 1 determines the mass weight of the oxygen included in the emissions arising from combustion (CO_2, CO, SO_2, N_2O and NO_2). Step 2 determines the oxygen requirement for the oxidation of the hydrogen incorporated in the combusted material. Oxidation of the hydrogen (H) leads to water vapour (H_2O) (see equation presented in para. 475). Step 3 corrects the oxygen requirements determined in steps 1 and 2 by deducting the oxygen already incorporated in the combusted material itself (indigenous oxygen). As a result one obtains the exogenous oxygen demand for combustion processes, i.e. the balancing item MF.8.1.1.

Step 1

Oxygen for combustion processes can be calculated stoichiometrically from respective data for emissions of CO_2, CO, SO_2, N_2O and NO_2 from combustion:

- $C + O_2 \rightarrow CO_2$, i.e. in molar masses: 12 + 32 = 44, which implies that 0.727 tonnes of oxygen are required for one tonne of CO_2;
- $C + O \rightarrow CO$, i.e. in molar masses: 12 + 16 = 28, which implies that 0.571 tonnes of oxygen are required for one tonne of CO;
- $S + O_2 \rightarrow SO_2$, i.e. in molar masses: 32 + 32 = 64, which implies that 0.5 tonnes of oxygen are required for one tonne of SO_2;
- $2N + O \rightarrow N_2O$, i.e. in molar masses: 28 + 16 = 44, which implies that 0.364 tonnes of oxygen are required for one tonne of N_2O;
- $N + O_2 \rightarrow NO_2$, i.e. in molar masses: 14 + 32 = 46, which implies that 0.696 tonnes of oxygen are required for one tonne of NO_2.

The required data for emissions from combustion should be taken from the DPO class MF.7.1 'emissions to air' (see section 4.7.1). The emissions recorded under MF.7.1 are multiplied with the above factors for each emission compound.

Correcting for process-related CO_2 emissions

The CO_2-emissions recorded in MF.7.1 include so-called process-related CO_2-emissions. Process-related CO_2 emissions from intrinsic CO_2-contents of materials refer to cement and lime production: $CaCO_3$ + heat $\rightarrow$ CaO + CO_2. These emissions can be derived from the UNFCCC greenhouse gas emission inventories: CRF codes 2A1 and 2A2 – Mineral industry, Cement and lime production).

Process-related CO_2-emissions are included in DPO item MF.7.1. However, they do not constitute combustion emissions. Hence, they need to be deducted before compiling step 1 of MF.8.1.1.

Step 2

In addition, oxygen is required for oxidising the hydrogen (H) intrinsically incorporated in the combusted material, with the resulting emission being water vapour (H_2O) (see balancing item: output side MF.8.2.1):

- $2H + O \rightarrow H_2O$, i.e. in molar masses: 2 + 16 = 18, which implies that 0.889 tonnes of oxygen are required for one tonne of H_2O from intrinsic H.

Step 2 requires knowing the overall amount of hydrogen intrinsically incorporated in the materials combusted. First, one needs to know how much of the different materials has been combusted. Secondly, one needs to know the hydrogen content of each of the different materials combusted.

Three possible data sources can be used to determine the materials combusted:

- The most appropriate source for determining the various materials combusted are physical energy flow accounts (PEFA): PEFA table C records the combustion-emission-relevant use of energy products. Notably, PEFA reports in energetic units (tera joule) which need to be converted into mass units (tonnes) employing respective net calorific values.

- Energy statistics and balances could also be used. Note that emission-relevant use is not explicitly separated in energy statistics. Further, energy statistics are not adjusted for the residence principle.

- Data reported in the EW-MFA questionnaire: The compilation tool included in the EW-MFA questionnaires uses data already reported in the EW-MFA questionnaire (tables A, B and D; i.e. domestic extraction plus imports minus exports of fossil energy materials/carriers) to approximate the material combusted.

Step 2 also requires information on the hydrogen incorporated in the various materials combusted. The hydrogen content of a combusted material determines the amount of resulting water vapour which again reveals the amount of oxygen required. Table 25 provides respective coefficients used in German emission inventories.

Table 25: Intrinsic hydrogen, oxygen demand for oxidising intrinsic hydrogen, and resulting water vapour by energy carriers

Energy carrier	Intrinsic hydrogen in t per t energy carrier	Oxygen demand in t per t energy carrier	Water vapour in t per t energy carrier
Sewage gas/ Biogas/ Landfill gas	0.20	1.57	1.77
Hard coal	0.05	0.37	0.42
Coke (hard coal)	0.01	0.06	0.07
Hard coal briquettes	0.04	0.33	0.37
Brown coal, crude	0.02	0.15	0.17
Dust- and dry coal	0.04	0.33	0.37
Hard brown coal	0.04	0.32	0.36
Brown coal briquettes and -coke	0.04	0.33	0.37
Mine gas	0.20	1.57	1.77
Coke oven gas	0.20	1.57	1.77
Natural gas, Crude oil gas	0.23	1.83	2.05
Gasoline	0.14	1.14	1.28
Diesel	0.13	1.06	1.19
Aviation gasoline	0.15	1.19	1.34
Fuel oil, light	0.13	1.07	1.21
Fuel oil, medium and heavy	0.12	0.93	1.05
Liquid gas	0.18	1.41	1.59
Refinery gas	0.21	1.71	1.92
Other solid fuels	0.05	0.40	0.45
Blast furnace gas	0.002	0.02	0.02

Step 3

Most materials combusted contain oxygen. This intrinsic oxygen content is used in the combustion process. It has to be subtracted from the oxygen demand calculated in the previous steps in order to derive the actual amount of exogenous oxygen requirement. Table 26 presents some coefficients on the oxygen content of various energy carriers.

Table 26: Oxygen content of energy carriers (% of weight)

	Oxygen content in % (wt / wt)
Sewage gas/ Biogas/ Landfill gas	14.93
Hard coal	4.94
Coke (hard coal)	1.70
Hard coal briquettes	2.78
Brown coal, crude	6.00
Dust- and dry coal	16.78
Hard brown coal	12.73
Brown coal briquettes and -coke	16.78
Mine gas	14.93
Coke oven gas	14.93
Natural gas, Crude oil gas	0.19
Other solid fuels	35.97
Blast furnace gas	34.35

Source: Derived from Frischknecht et al., 1994; Kugeler et al., 1990; Osteroth, 1989

Note that the three data sources for determining the amounts of materials combusted mentioned in Step 2 can be used in Step 3 as well.

MF.8.1.2 Oxygen for respiration of human and livestock; bacterial respiration from solid waste and wastewater

MF.8.1.2 records the oxygen inputs related to respiration of human and cultivated livestock (the corresponding outputs is recorded under MF.8.2.2). Oxygen for respiration can be calculated using standard coefficients based on population numbers and livestock numbers (see Table 27). Data on livestock are available in various Eurostat data sets (see para. 432).

Table 27: Metabolic oxygen demand of humans and livestock

Oxygen demand for respiration	t O_2 per capita resp. head and per year
Humans	0.25
Cattle	2.45
Sheep	0.20
Horses	1.84
Pigs	0.25
Poultry	0.01

Source: Wuppertal Institute data base, based on Matthews et al., 2000

MF.8.1.2 also includes oxygen for bacterial respiration from solid waste and wastewater. It can be calculated based on the amounts of the corresponding CO_2 emissions (0.727 tonnes of oxygen are required for one tonne of CO_2, see para. 481). The following CRF codes record the corresponding CO_2-emissions:

- 5A 'Solid waste disposal on land',
- 5B 'Biological treatment of solid waste' and
- 5D 'Wastewater handling'.

MF.8.1.3 Nitrogen for Haber-Bosch process

The Haber-Bosch process is a process that uses nitrogen (N_2) and hydrogen (H_2) for industrial production of ammonia.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The nitrogen required for the Haber-Bosch process is taken from the ambient air and hence needs to be considered as a balancing item on the input side of the economy-wide material balance.

The nitrogen used in the Haber Bosch process can be estimated. About 0.83 tonnes of N_2 are required to produce 1 tonne of ammonia.

Data on the amount of ammonia produced by the Haber Bosch process might be found in national data sources. One important international data source is USGS.

MF.8.1.4 Water requirements for the domestic production of exported beverages

Water requirements for the domestic production of exported beverages may also be a relevant balancing item for the input side in some countries. The amount of water withdrawn from the domestic territory may be estimated based on export data.

Data for this item can be extracted from ITGS: the exported quantities of fruit and vegetable juices (code CN 20.09) and beverages (CN 22) adjusted by a factor of water content (0.85 and 0.9, respectively).

Specific issues related to balancing items input side (and in total): Nitrogen for combustion as balancing item – input side

Emissions of nitrogen oxides (NO, NO_2) from fuel combustion in motors result at least partly from inputs of elementary nitrogen originating from ambient air. This nitrogen input can in principle be calculated using standard coefficients based on emissions of NO_2. For the time being this is not undertaken in EW-MFA due to non-availability of appropriate coefficients. This item is also of minor quantitative importance.

I.2 Balancing items: output side (MF.8.2)

Balancing items on the output side of the economy-wide material balance correspond widely to the balancing items on the inputs side. The main processes concerned are combustion of fuels and respiration of humans and livestock. Water vapour from combustion is by far the quantitatively most important balancing item on the output side (more than 60%).

Data sources and compilation

Data sources underlying the derivation of output balancing items are:

- water vapour related to combustion: data for the combustion of materials to account for resulting emissions of water vapour, taken e.g. from energy statistics (see also MF.8.1 balancing items – input side);
- auxiliary data needed to account for CO_2 and water vapour from respiration are population numbers and livestock numbers commonly found in general statistical sources and agricultural statistics, respectively.

MF.8.2.1 Water vapour from combustion

Water vapour from combustion (MF.8.2.1) is further broken down depending on the origin of the water vapour. Some originates from the moisture content of the material combusted (MF.8.2.1.1). Another part originates from the oxidation of the intrinsic hydrogen incorporated in the combusted material.

MF.8.2.1.1 Water vapour from moisture content of fuels

The combusted material usually has some moisture content (humidity degree). In the combustion process the moisture contained in the combusted material is emitted as water vapour (H_2O). Resulting emissions can be estimated based on average values for water vapour emitted per tonne material combusted. Table 28 presents coefficients for moisture content that converts into water vapour for some common materials combusted (energy carriers).

Table 28: Moisture content of selected energy carriers that convert into water vapour during combustion

Energy carrier	Moisture content converting to water vapour during combustion in t per t energy carrier
Hard coal	0.02
Coke (hard coal)	0.02
Hard coal briquettes	0.02
Brown coal, crude	0.59
Dust- and dry coal	0.11
Hard brown coal	0.18
Brown coal briquettes and -coke	0.12
Fuel oil, light	0.001
Fuel oil, medium and heavy	0.005
Other solid fuels	0.16

Source: Derived from Frischknecht et al., 1994; Kugeler et al., 1990; Osteroth, 1989

The compilation tool included in the EW-MFA questionnaire uses some average moisture content coefficients for 7 material groups reported already in the EW-MFA questionnaire. It is implicitly assumed that the consumption (domestic extraction plus imports minus exports) of these 7 material groups is entirely for combustion.

MF.8.2.1.2 Water vapour from the oxidised hydrogen components of fuels

MF.8.2.1.2 quantifies the water vapour resulting from the oxidation of hydrogen intrinsically incorporated in the combusted material (see also paras. 474 and 475).

MF.8.2.1.2 relates very closely to step 2 when calculating the corresponding oxygen demand for combustion (MF.8.1.1), see paras. 488ff. Table 25 presents all the coefficients needed to estimate the water vapour for commonly combusted materials.

The compilation tool included in the EW-MFA questionnaire employs 7 material groups reported already in the EW-MFA questionnaire to estimate the amount of material combusted. It is implicitly assumed that the consumption (domestic extraction plus imports minus exports) of these 7 material groups is entirely for combustion.

MF.8.2.2 Gases from respiration of humans and livestock, and from bacterial respiration from solid waste and wastewater

CO_2 and water vapour (H_2O) from respiration can be calculated using standard coefficients based on population numbers and livestock numbers (see Table 29).

Table 29: Metabolic CO_2 and H_2O production of humans and livestock

	t CO_2 per capita resp. head and per year	t H_2O per capita resp. head and per year
Humans	0.30	0.35
Cattle	2.92	3.38
Sheep	0.24	0.27
Horses	2.19	2.53
Pigs	0.30	0.35
Poultry	0.01	0.01

Source: Wuppertal Institute data base, based on Matthews et al., 2000

The biological treatment of solid waste and waste water involves bacterial respiration. The hydrocarbons contained in the respective waste and waste water are digested by bacteria. As a result one obtains CO_2 and water vapour. The CO_2 is accounted for in DPO (it is recorded in UNFCCC greenhouse gas emissions; CRF codes 5B 'Biological treatment of solid waste' and 5D 'Wastewater handling'). The water vapour can be estimated from the CO_2, assuming that one molecule CO_2 corresponds to one water molecule: the coefficient 0.41 (18/44, the ratio of the molar masses of H_2O and CO_2) can be used.

MF.8.2.3 Excorporated water from biomass products

MF.8.2.3 accounts for two sub-items: (1) the loss of water from biomass products, and (2) the water contained in imported beverages.

Two points need to be tackled under this item:

- Water content of biomass

On the input side of the material balance biomass is accounted for under domestic extraction and imports mainly in wet weight. On the output side of the material balance biomass is widely accounted for in dry weight (sewage sludge or compost). Therefore, the water content has to be balanced. In practice, here we estimate the water content of the domestic extraction of biomass products (except wood fuel which is already included in MF.8.2.1.1) by using production by crops (more detailed than the EW-MFA categories) and water content coefficients. The same approach holds for imports and exports (also by multiplying CN position with standard water content). Finally, domestic extraction plus imports minus exports provides apparent consumption.

Assuming that sludge originally has 85% moisture content and compost originally has 50%, the 'missing water' from conversion to dry weight can be determined. However, this water only partially stems from biomass extraction. As a balancing item, water consumed through the apparent consumption of domestically extracted food crops can be estimated based on the moisture content of that food upon extraction.

The compilation tool in the EW-MFA questionnaire provides a table of the moisture content of crops at a more detailed level than the EW-MFA categories in the tool (sheet name: 'Annex to Table G tool') of which NSIs with more detailed consumption data should make use. Average moisture content values for EW-MFA categories are proposed in the tool in order to obtain an initial estimate of the water content of consumed food.

- Water contained in imported beverages

Bulk water from imports of beverages, which is exactly the mirror image of the item MF.8.1.4 of the input side of the balancing items. Data for this item can be extracted from trade statistics: the imported quantities of fruit and vegetable juices (code CN 20.09) and beverages (CN 22) adjusted by a factor of water content (0.85 and 0.9, respectively).

Annex II. A.3.9 Other non-metallic minerals not elsewhere classified (n.e.c.) - Global Manual on EW-MFA, page 69

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 are accounted for in this category. Note that bitumen for road construction is usually recycled, and this part should not be taken into account when calculating material extraction.

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

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

Quartzandquartzite: special types of silicon used e.g. in the optical industry and in metal manufacturing.

Siliceous fossil meals: minerals such as Kieselgur, Tripolite, Diatomite and other siliceous earths, used, for instance, as absorption agents or materials for heat insulation.

Asbestos: a fibrous mineral, now restricted in its use due to serious health hazards.

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

Feldspar: an essential component in glass and ceramic manufacture.

Annex III. Specific issue: crushed rock – Global Manual on EW-MFA, page 70

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 building 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 (carbonate minerals important in cement), A.3.6 (gypsum), A.3.8 (sand and gravel), 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 2.12 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 double counting occurs.

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

The total for these minerals may then be compared with the total amount of crushed rock shown in national statistics. Where 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 of additional domestic extraction of crushed rock which cannot be further identified.

If so, 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.