FACT SHEET

Economy Wide Material Flow Accounting (EW-MFA)

Description of the method of Economy Wide Material Flow Accounting (EW-MFA).

Scope (conceptual model & main characteristics)

Goal and scope:

Material Flow Analysis (MFA) is a group of methods analysing material flows in society with the aim to match the use of material resources and the release of wastes and pollutants with the capacity of the environment to provide these resources and to absorb the wastes and emissions. Within the MFA field, two variants can be distinguished that have a more specific scope and methodology: Economy-Wide Material Flow Accounting (EW-MFA), accounting for all material flows in national economies, and Substance Flow Analysis (SFA) accounting or modelling the flows (and sometimes stocks) of individual substances or groups of substances at different geographic scale levels. This factsheet will focus on Economy Wide Material Flow Accounting (EW-MFA).

The EW-MFA is supposed to form a physical complement to the monetary national economic accounts (System of National Accounts) in the System of Environmental-Economic Accounting (SEEA)(UN, 2016). EW-MFAs are part of official statistics of the European Union. Its main indicator, the Domestic Material Consumption (DMC), is presented as a counterpart of the Gross Domestic Product (GDP) and forms the bridge to an assessment of the state of a nation's natural resources.

Object of analysis:

EW-MFA takes into account all material inputs and outputs of a national economy. It accounts for a large number of resources within four main categories: fossil fuels, metals, minerals and biomass.

Economy–wide MFA provides an overview of annual material inputs and outputs of an economy (see also figure 1). These include inputs (extractions) and outputs (emissions, waste) from and to the domestic environment, as well as the imported and exported goods via trade flows (Eurostat, 2013 & 2001). The difference between inputs and outputs is classified into two categories: either domestic waste and emissions, or net addition to stock. The accounts are expressed in physical units: tonnes per year.

Contexts of use, application fields	-> contexts (e.g., environmental, economic, social assessment) -> which types of stakeholder questions are concerned?

Types of applications:

In general the EW-MFAs are used to support government policy on resources, resource use and resource efficiency.

EW-MFA may serve as a database for data on the input, output and (net) use of materials in national economies. This information can be used in different types of policy supporting studies. The domestic extraction data are highly detailed and can be useful information for a national resource conservation policy. Import and export data can be used to assess the physical trade balance of a nation. Together with the information on extraction, the self-sufficiency of a nation can be assessed. Countries can be characterized with regard to the nature of their economy: resource producing or resource consuming nations. Also the state of development of a country can be characterized by its metabolic profile. On an aggregated level the materials flows accounts determine the resource productivity (€/kg) or resource intensity (kg/€) of an economy. These aggregated mass indicators are used by EEA and Eurostat. Presently, the leading indicator for the EU Resource Efficiency policy is GDP/DMC: the national income over the domestic material consumption, an indicator for resource productivity. The methodology can be used to monitor de-coupling, that is the de-linking of the physical system from the monetary system. The use of MFA indicators as proxys for environmental pressure is disputed. Presently the main view is that material flows form the interface between economic development and environmental pressure, as also mirrored in the EU resource efficiency policy.

Conceptually Economy-wide Material Flow Accounts (EW-MFA) belong to the international system of environmental economic accounting (SEEA-Central

Framework) (UN, 2016). Furthermore, EW-MFA is one of several physical modules of Eurostat's programme on European environmental economic accounts. It is covered by Regulation (EU) No. 691/2011 (EC, 2016) on European environmental economic accounts.

Type(s) of data or knowledge needed and their possible source(s)	-> which types of data are needed to run the method, from which sources could they come… -> could be qualitative data or quantitative data, and also tacit knowledge, hybrid, etc.

EW-MFAs are part of official statistics of the European Union (Eurostat, 2016). The data set 'material flow accounts' (env_ac_mfa) are annual and start with the year 1990 (EU since 2000). The data set 'resource productivity' (env_ac_rp) are annual and start with the year 2000 (EU since 2000).

Within the next year, a global database will become available with time series information for all countries in the world from 1970 until 2013 (UNEP and CSIRO, 2016). It has been used to develop the reports of UNEPs International Resource Panel on decoupling, and it can be used by nations to assess their progress on the decoupling road.

According to the Eurostat methodological guide (Eurostat, 2013 & 2001), the following components are distinguished on the material input side of an economy−wide MFA (see also figure 1). On these components, data must be collected, for the most part statistical data:

- Used domestic extraction i.e.: raw material extractions from the domestic environment which are directly used in subsequent economic processing
- Unused domestic extraction (domestic hidden flows): i.e. those primary material inputs associated with the above mentioned used domestic extractions which are not directly used in economic processing and hence are not valued economically. Examples are mining overburden, harvest losses and soil erosion.
- Imports: i.e. the materials in goods imported to the national economy
- Indirect flows associated with imports (foreign hidden flows): i.e. the 'hidden' cradle−to−border primary resource extractions (used and unused) that have been required to produce the imported good (often referred to as 'ecological rucksacks')

On the material output side of an economy−wide MFA, the following components are distinguished:

- Processed outputs to nature: i.e. the emissions and waste flows of production or consumption processes
- Exports: i.e. the materials of exported goods

- Unprocessed outputs: this equals the unused domestic extraction (domestic hidden flows)
- Indirect flows associated with exports i.e. the 'hidden' lifecycle−wide primary resource extraction that had been required to produce the exported good (often referred to as 'ecological rucksacks')

The difference between inputs and outputs is labelled "Net Addition to Stock" (NAS).

Data on imports, exports and extractions are generally present in production and trade statistics. Data on waste and emissions are more difficult to obtain and the quality varies per country. Data on hidden flows are not collected regularly and standardly. In EW-MFA, these are based on very rough estimates.
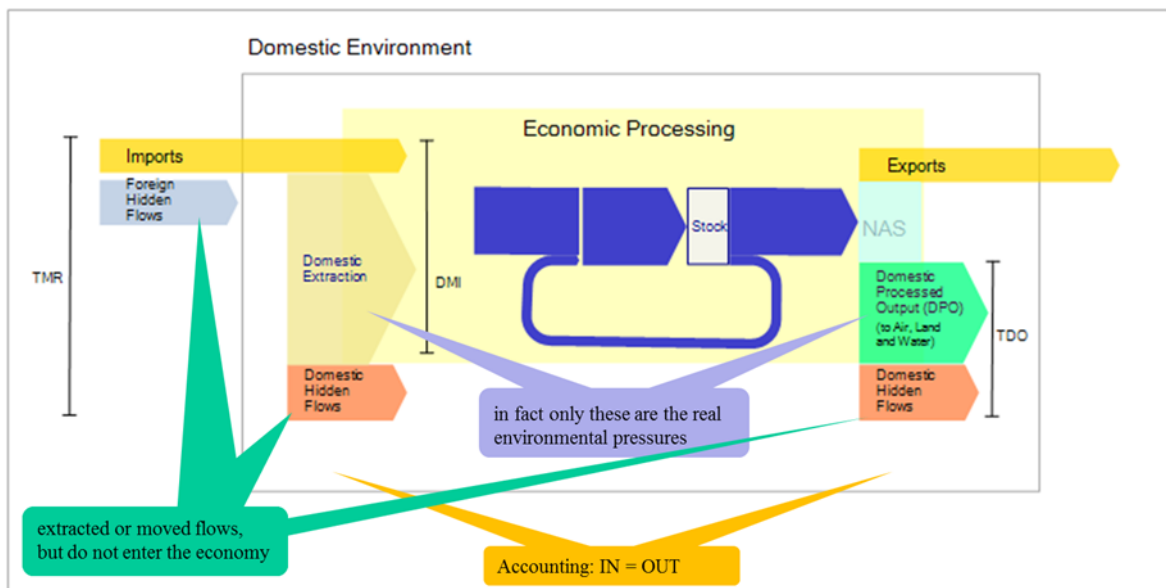

Figure 1   The system of Economy Wide Material Flow Accounts

Model used (if any, geological mathematical, heuristic…)	-> e.g., geological model for mapping -> e.g., mathematical model such as mass balancing, matrix inversion, can be stepwise such as agent -based models, dynamic including time or quasidynamic specifying time series… -> can also be a scenario

EW-MFA is an accounting scheme. The only mathematical model used is the mass balance of a national economy in a given year. Information on natural resources extracted and traded products is provided by different statistical units. That implies either some data reconciliation must be done, or the discrepancies between the different data sources will end up in the balancing item: net additions to stock.

System and/or parameters considered	-> **the system can be described by its boundaries**. These can refer to a geographic location, like a country, or a city, the time period involved, products, materials, processes etc. involved, like flows and stocks of copper, or the cradle-to-grave chain of a cell phone, or the car fleet, or the construction sector, or the whole economy… -> **parameters** could possibly refer to geographic co-ordinates, scale, commodities considered, genesis of ore deposits and others…

Economy-wide material flow accounts (EW-MFA) uses administrative system boundaries: the object is a national economy in a given year. Different accounts can be combined into larger administrative or geographical units. Different years can be combined in time series. Like the system of national accounts, EW-MFA constitutes a multi-purpose information system. The detailed material flows provide a rich empirical database for numerous analytical purposes. Further, EW-MFA are used to derive various material flow indicators (see below).

Material flow accounts include all solid, liquid and gaseous materials used in the economic system (excluding water and air) crossing the system boundary on the input side or on the output side. The economy is demarcated by the conventions of the national accounting system (resident units).

Time / Space / Resolution /Accuracy / Plausibility…	-> to which spatio-temporal domain it applies, with which resolution and/or accuracy (e.g., near future, EU 28, 1 year, country/regional/local level…) -> for foresight methods can also be plausibility, legitimacy and credibility…

Spatial and temporal characteristics:

EW-MFA is specified in space and time. EW-MFA applications consider flows in a national economy during a year. EW-MFA monitoring is used to observe trends and developments over time. Global time series data are available for all countries in the world, for 1970 – 2013.

Economy-wide material flow accounts (EW-MFA) use a specific hierarchical classification (up to 4-digits) with some 50 material categories such as biomass, metal ores, non-metallic minerals, and fossil energy materials/carriers. Material inputs from the natural environment to the economy are called domestic extraction.

Indicators / Outputs / Units	-> this refers to what the method is actually meant for. Units are an important part but that is most of the time not sufficient to express the meaning. For example, **the indicators used in LCA express the cradle-to-grave environmental impacts of a product or service**. This can be expressed in kg CO_2-equivalent. But also in €. Or in millipoints. Or in m^2year land use. -> for foresight methods the outputs are products or processes

EW-MFA specifies in- and outflows of society in an overview of society's metabolism. The metabolism of society in general is linked to environmental pressures, however, EW-MFA normally do not specify environmental interventions. When they do, all environmental interventions are lumped together and expressed in one indicator (Total Domestic Output, TDO). Specific attention is sometimes given to the "ecological rucksacks" or hidden flows of primary production.

Material flows from the EW-MFA are combined into indicators such as:

- Domestic extraction (DE): total amount of material extracted for further processing in the economy, by resident units from the natural environment;
- Imports (IMP): imports of products in their simple mass weight;
- Direct material input (DMI): a sum of DE and IMP, all materials that enter the national economy
- Exports (EXP): exports of products in their simple mass weight;
- Domestic material consumption (DMC): measures the total amount of material actually consumed domestically (DE+IMP-EXP).

The indicators are expressed in mass units per year.

They can be compared over time for one nation, or can be compared across countries for one year. To make comparisons between countries possible, these indicators also can be expressed per capita, or per monetary unit.
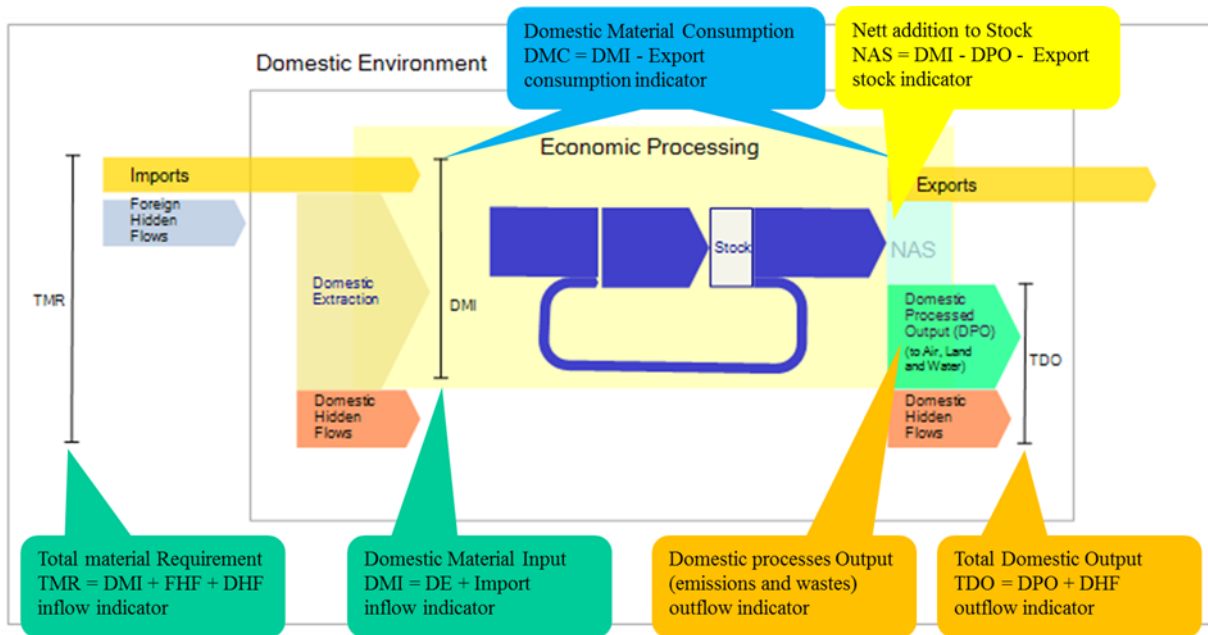
Figure 2   Material indicators derived from EW-MFA

Resource productivity (GDP/DMC) is defined as the ratio of gross domestic product (GDP) over domestic material consumption (DMC) and commonly expressed in Euro per kilogram of material. The term designates an indicator that reflects the GDP generated per unit of resources used by the economy. This is typically a macro-economic concept that can be presented alongside labour or capital productivity.

Treatment of uncertainty, verification, validation	-> evaluation of the uncertainty related to this method, how it can be calculated/estimated

Limitations:

EW-MFA only describes transboundary flows: the national economy itself is a black box. No relation can be established between inputs and outputs, nor between the different consumption and production activities. In what way the resources are used and enter the consumption phase is therefore invisible, with consequences for the possibility to perform checks and sensitivity analyses. Recycling and reuse activities are only indirectly visible, as a reduction of flows of primary materials. This means that disaggregation is not really possible, and that the accounts are not suitable for any analysis at a more detailed level.

The DMC, and other indicators derived from EW-MFA, are a measure for the metabolism or material basis of a society. DMC is also coined as a measure, be it indirect, for the total environmental pressure of a national economy: with each kilogram being taken out of the environment some impact is being created. However, this is being disputed, since the impact potential of the different materials is not taken into account, which may differ largely between materials.

Handling of uncertainties:

To ensure quality of the data Eurostat implements the following procedures/guidelines:

1) Methodological guidelines to assist countries in compiling EW-MFA;
2) Extensive validation procedure of the data received. The validation tools check:
   • consistency (several cells check, validation level 1);
   • plausibility with an extra check for fluctuations between two consecutive years;
   • illegal symbols (cell by cell check, validation level 1)
   • illegal footnotes

   The validation procedure offers a gap overview, the response rate and an annual plausibility that enables the comparison of data for common reporting years between the previous and the current questionnaire which constitutes a validation check at level 2.
3) Gap-filling of missing statistical information.

Main publications / references	-> e.g. , ILCD handbook on LCA, standards (e.g. , ISO) -> can include reference to websites/pages

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Related methods	-> List of comparable methods, their particularities… (or a link to one or several other fact sheet(s))

The accounts of material and substance flows in physical units allow for a link to regional economic performance indicators (integrated environmental and economic accounting).

The EW-MFA is designed to form a physical complement to the monetary national economic accounts (System of National Accounts) in the System of Environmental-Economic Accounting (SEEA) (UN, 2016).

Substance flow accounts (SFA) and economy wide – material flow accounts (EW-MFA) are different methodologies that belong to the same family of Material Flow Analysis (see separate factsheet Material / Substance Flow Analysis). They both monitor material flows in physical units, mass (kg) of substances, raw materials, products, wastes and emissions related to economic activities in a geographical region, comprising extraction, production, consumption, waste disposal.

To add an environmental dimension to the EW-MFA accounts, the Environmentally weighed Domestic Consumption (EMC) indicator has been developed (van der Voet et al., 2005). This indicator combines mass balances for the individual materials in the account with an environmental multiplyer based on LCA data (see separate factsheet Life Cycle Assessment).

Some examples of operational tools (CAUTION, this list is not exhaustive)	-> e.g., software… Only give a listing and a reference (publication, website/page…) -> **should be provided only if ALL main actors are properly cited**

Software availability:

EW-MFA studies are mostly conducted with the help spreadsheet or database tools such as Excel and Access.

Key relevant contacts	-> list of relevant **types** of organisations that could provide further expertise and help with the methods described above.

Wuppertal Institut, prof. S. Bringezu, stefan.bringezu@wupperinst.org

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Glossary of acronyms /abbreviations used	-> Definition