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Economy-wide material flow accounts and derived indicators

A methodological guide

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CONTENTS

Figures

Tables

Accounts

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Preface

This guide presents a framework and practical guidance for establishing material flow accounts and material balances for a whole economy. Material flow accounts and balances, as described in the Introduction, are being compiled in a number of Member States. The guide is a first step towards harmonised terminology, concepts and a set of accounts and tables for compilers at national level.

This publication is one of the outputs of Eurostat's Environmental Accounting work. It contributes to various EU-wide and international activities in the context of national and environmental accounting, including the revision of the United Nations' System of Integrated Environmental and Economic Accounting (SEEA). The publication was prepared by Mr H. Schütz of the Wuppertal Institute and Mr A. Steurer of Eurostat B1.

The publication was only possible due to the substantial contributions made by the members of the Eurostat Task Force on Material Flow Accounting. The Task Force met in June 2000 and in December 2000 to develop the framework, concepts and accounts presented in this Guide. Special thanks are therefore due to the members of the Eurostat Task Force on Material Flow Accounting:

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Pilot accounts in several EU Member States and the development of this Guide benefited from financial support provided by the European Commission's Environment Directorate-General, in the context of the *Communication from the Commission to the Council and the European Parliament on "Directions for the EU on Environmental Indicators and Green National Accounting - The Integration of Environmental and Economic Information Systems"* (COM(94) 670).

The work on material flow accounting is continuing at Eurostat together with the Task Force on Material Flow Accounting. Work is now focusing on pooling the practical experience with economy-wide material flow accounts that are becoming progressively available and on collecting material use indicators derived from these accounts more regularly from more Member States.

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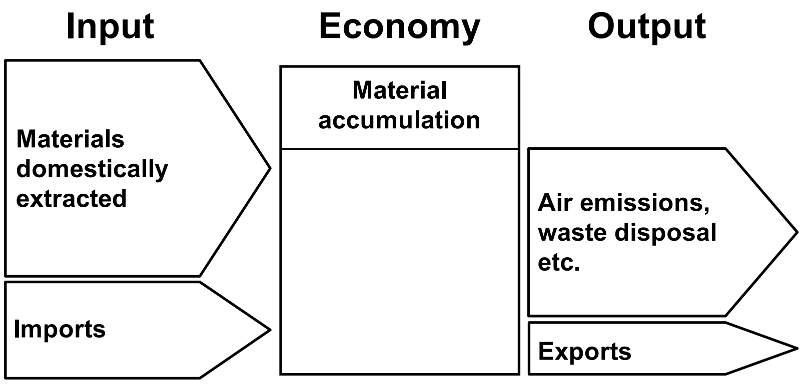
1. Introduction

1.01 This Guide focuses on material flow accounts (MFA) and balances for a whole economy. These *economy-wide material flow accounts and balances* show the amounts of physical inputs into an economy, material accumulation in the economy and outputs to other economies or back to nature as illustrated by Figure 1.

Figure 1: Scope of economy-wide material flow accounts



1.02 Most statistical institutes in Europe have the experience and data needed to compile economy-wide MFA and balances (see Eurostat 1997). Work at Eurostat includes projects on the policy use of material flow information, physical input-output tables and economy-wide MFA and balances. Since the first economy-wide MFA and balances for Austria (Steurer 1992) and Japan (Environmental Protection Agency 1992) many researchers and statisticians have used similar approaches. Within the EU, economy-wide MFA are now available for Denmark, Germany, Italy, the Netherlands, Austria, Finland, Sweden and the United Kingdom.

1.03 Research has advanced in recent years and standard concepts and formats are evolving. The European Commission funded ConAccount project (1996-1997) and the international projects leading to the publication of 'Resource Flows: the material basis of industrial economies' (Adriaanse et al 1997) and 'The Weight of Nations – material outflows from industrial economies' (Matthews et al 2000) were important steps towards internationally comparable data based on harmonised approaches.

1.1 Policy demand and uses

1.04 Indicators for flows of materials through the economy feature prominently on the political agenda in the context of concepts such as 'factor 4 or 10' or 'eco-efficiency'. Resource use and resource efficiency is listed among the future key policy issues in the Review of the Fifth Environmental Action Programme (Decision N° 2179/98/EC) and the Presidency conclusions of the meeting of the EU Environment Ministers in Helsinki, 23-25 July 1999. Also, the EU Environmental Headline Indicators and the United Nations' Indicators for Sustainable Development include a resource use or material consumption indicator based on a material balance approach.

1.05 Developments in statistics are similar. The Council Decision of 22 December 1998 on the Community statistical programme 1998 to 2002 (1999/126/EC, OJ L 42/38 of 16.2.1999) and the Communication from the Commission to the Council and European Parliament 'Directions for the EU on environmental indicators and green national accounting - The integration of environmental and economic information systems' (COM(94) 670) call for the development of environmental satellite accounts linked to the national accounts covering inter alia 'the stocks and use of the main natural resources, flows of materials, emissions'.

1.06 Economy-wide MFA and balances complement and supplement other environmental data sets and accounts. For example, foreign trade or production statistics as well as environmental statistics and environmental accounts for forests, sub-soil assets, water or air emissions provide great detail on individual material flows and related environmental issues. Organising such existing data sets in a consistent accounting framework, the main purposes of economy-wide material flow accounts and balances are to:

- provide insights into the structure and change over time of the physical metabolism of economies;
- derive a set of aggregated indicators for resource use, including for the EU-level initiative on Headline Indicators and the United Nations' initiative on Sustainable Development Indicators;
- derive indicators for resource productivity and eco-efficiency by relating aggregate resource use indicators to GDP and other economic and social indicators;
- provide indicators for the material intensity of lifestyles, by relating aggregate resource use indicators to population size and other demographic indicators;
- through their underlying datastructure integrated with the national accounts contribute to organising, structuring and integrating available primary data and ensure their consistency;
- react flexibly and quickly to new policy demands (e.g., related to specific materials) through this datastructure which can be adjusted easily and put to additional uses;
- permit analytical uses, including estimation of material flows and land use induced by imports and exports as well as decomposition analyses separating technological, structural and final demand changes.

1.07 The Chairman's conclusions at the OECD Special Session on Materials Flow Accounting (24 October 2000 in Paris) underlined that the main uses of MFA are the derivation of indicators, the provision of data for modelling and direct use for waste and resource management policies. The derivation of sustainability indicators is a promising application of MFA. For this, indicators derived from the accounts must be policy relevant, analytically sound and measurable. Future work should explore the links of MFA to other accounting systems and indicators and analyse the effects of methodological issues and of data quality and availability on the interpretation of indicators (Moriguchi 2000).

1.2 Objectives of this Guide

1.08 As a response to the policy demand for resource use indicators, Eurostat has developed this Guide primarily as an aid for compilers and users of economy-wide MFA and balances. The Guide is a step towards harmonised terminology, concepts, methods and accounts, facilitating compilation of accounts and derived indicators nationally and enhancing comparability of results across countries.

1.09 The Guide offers methodological guidance and practical suggestions, including:

- a set of definitions, classifications and terminology for economy-wide MFA and balances;
- a set of staged accounts which together represent the full material balance but allow flexible compilation of those accounts considered most relevant nationally;
- standards and conventions on units of measurement and coverage of individual accounts.

1.10 The Guide offers help to compilers as well as users in terms of:

- recommendations on the types of accounts to be implemented first;
- data sources and methods for compilation;
- undercoverage to be investigated, and methods to estimate missing data;
- an understanding of how the structure and development trends of an 'average' industrialised country look like and the factors that influence the structure and trends.

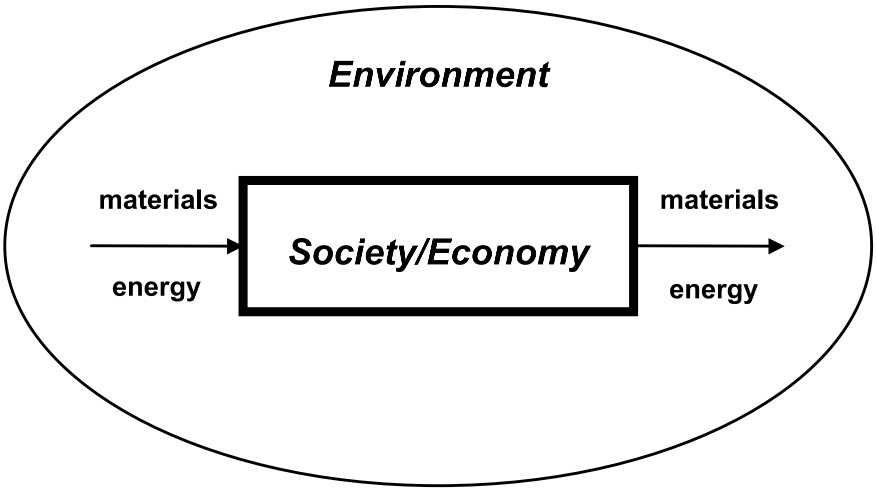
1.11 The Guide is not designed to be a fully operational compilation guide. Such a compilation guide is beyond the current scope and will require additional studies and pooling of experience over the next years, including establishing sets of default coefficients for various purposes. As the area is quickly evolving, a revision and extension of this Guide in a few years is conceivable.

1.12 The Guide is organised as follows. Chapter 2 summarises the conceptual foundation of material flow accounts and balances. Chapter 3 presents concepts, definitions and classifications. Indicators derived from the accounts are described in Chapter 4. Chapter 5 presents data sources and methods. Chapter 6 offers a system of national material flow accounts and balances. Physical input-output tables (PIOT) are summarised in chapter 7. Chapter 8 illustrates the uses of the accounts to show environmental impacts. Chapter 9 offers recommendations for implementation of the accounts. In the annexes, detailed classifications are presented.

2. Conceptual foundation

2.01 Economy-wide MFA and balances and the indicators derived from them are descriptive tools aiming to provide information on the material and energy coming into and leaving a society/economy. They are conceptually based on a simple environment-economy model where the latter is embedded into the former (see Figure 2). The economy is connected with the surrounding environment via material and energy flows. To illustrate these material and energy flows, terms such as ‘industrial metabolism’ (Ayres 1989) or ‘societal metabolism’ (Fischer-Kowalski and Haberl 1993) have been suggested. Such terms metaphorically consider modern economies as living organisms with a characteristic ‘metabolic profile’ (Schandl and Schulz 2000) whose dominance in, or impact on, the environment can be indicated by the size of the metabolic throughput (i.e. the amount of materials these ‘organisms’ appropriate from their environment and return back to it in an altered form).

Figure 2: The economy/environment system



2.1 The material balance principle

2.02 The first law of thermodynamics on the conservation of matter states that matter, i.e. mass or energy, is neither created nor destroyed by any physical transformation (production or consumption) process. This material balance principle provides a logical basis for the physical book-keeping of the economy-environment-relationship and for the consistent and comprehensive recording of inputs, outputs and material accumulation. The material balance principle can be applied from either a systems perspective or from a flow perspective.

2.03 For a given *system* such as production or consumption processes, companies, regions or national economies, the material balance principle leads to the following identity:
total inputs ≡ total outputs + net accumulation
meaning that what goes into the system is either accumulated in the system or is leaving the system again as an output.

2.04 For a given physical *flow* the material balance identity can be expressed as:
origin ≡ destination (other terms used are **supply ≡ demand**, or **resources ≡ uses**)
meaning that all flows have an origin and a destination, and a breakdown by origin must be exhaustive in the sense that the sum of masses by origin must be equal to the sum of masses by destination. Matter changes form during production and consumption processes. When this identity is used to establish economy-wide balances for specific material groups (e.g. fossil fuels or biomass), the raw materials must be related to e.g. the emissions or wastes that are the final destinations of these materials.

2.2 Applications

2.05 The principles of statistical approaches towards material flow accounts and material balances have been formulated in the 1970s (see e.g. United Nations 1976). In Europe, material flow accounts are part of official statistics in several EU Member States and EFTA countries (see Eurostat 1997). The idea of economy-wide aggregated material flow accounts and balances (as opposed to single-material or substance accounts) has been applied already in the 70s (see e.g. Gofman et al 1974), and was re-vitalised in the early 90s and put into statistical practice in e.g. Austria (Steurer 1992, Fischer-Kowalski and Haberl 1993), Germany (Schütz and Bringezu 1993), Japan (Japanese Environmental Agency 1992) and the USA (Rogich et al 1992, Wernik et al 1996).

2.06 Using this approach for environmental accounting, the German Federal Statistical Office published a first national material flow balance in 1995 (German Federal Statistical Office 1995). Eurostat has underlined the importance of materials flow accounts and supports the further use and development of MFA within the framework of integrated environmental and economic accounting, and as a basis for the derivation of indicators for sustainability (Eurostat 1999a). The European Environment Agency, in its indicator report 'Environmental Signals 2000' (EEA 2000a) included a first experimental estimate of Total Material Requirement (TMR) for the EU. The European Commission's Directorate General for the Environment is collaborating with Eurostat and the EEA on environmental headline indicators one of which is built on a material balance.

2.3 Role in environmental accounting and relation to national accounts

2.07 Material flow accounts are a part of environmental accounting work. They are an integral part of natural resource accounting, e.g., for wood materials in forest accounting (Eurostat 2000), of the work on NAMEA (National Accounts Matrix including Environmental Accounts), e.g. for the use of energy or emissions generated (see e.g. Eurostat 1999b) and of the world-wide System of integrated Environmental and Economic Accounting (SEEA). An interim version of the SEEA was published in 1993 by the United Nations (see also United Nations 2000). The SEEA is currently under revision by the London Group on Environmental and Resource Accounting. The revised SEEA-2000 is expected to be published in 2001 by Eurostat, OECD, the World Bank and the United Nations.

2.08 As a separate area within environmental accounting, material flow accounting work focuses on economy-wide MFA, economy-wide material balances and Physical Input-Output Tables (PIOT). These three aspects are fully linked but differ by level of detail and the data and resource requirements for compilation.

2.09 PIOTs are the most comprehensive description of material flows between environment and economy as well as within the economy, distinguishing not only categories of materials but also branches of production. Economy-wide material balances are aggregate descriptions of the material inputs and outputs of economies and cover the full set of inputs, outputs and stock changes in a consistent way. Inputs and outputs are balanced and a comprehensive set of material use indicators can be derived.

2.10 When full balances cannot be set up due to resource constraints or because data are incomplete (e.g., on the output side), individual economy-wide MFA can still be compiled (see the sequence of accounts in chapter 6) and will allow derivation of some (but not all) material use indicators.

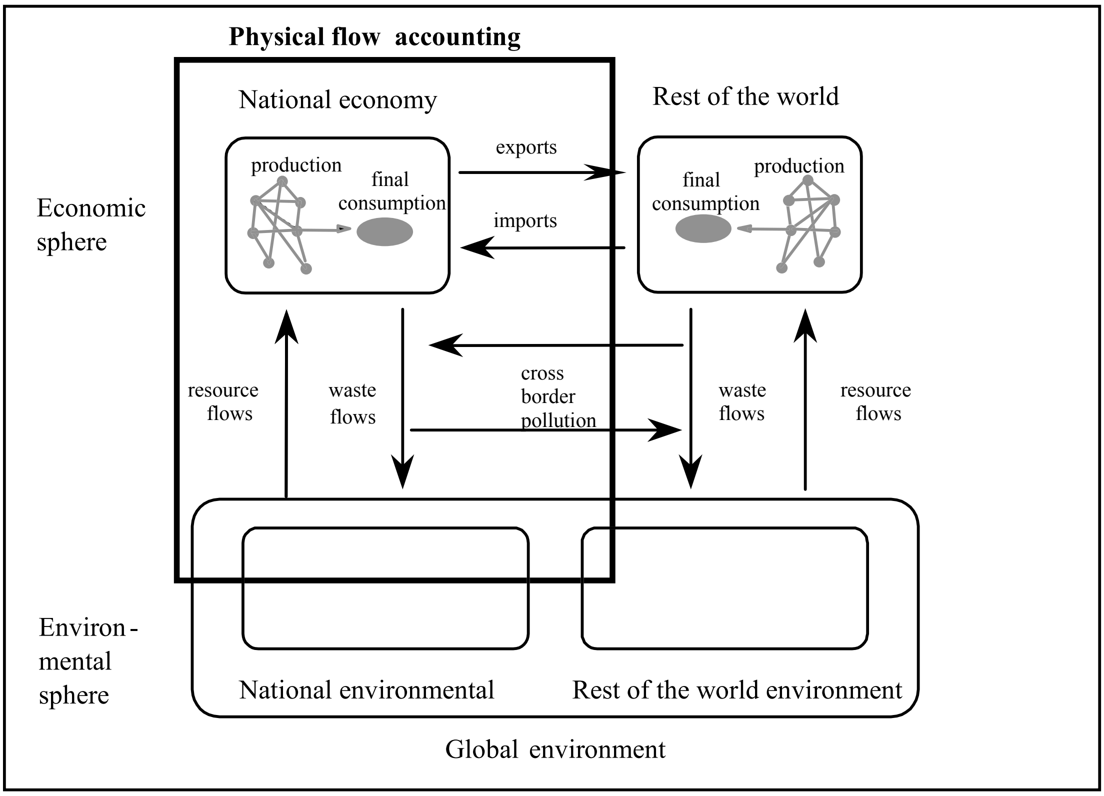
2.11 In practice, all three approaches can be used in a consistent way. For example, full PIOTs may be compiled every five years, full balances every second or third year and some individual accounts annually to allow regular and timely derivation of selected indicators.

2.12 Economy-wide MFA, full material balances and PIOTs should be consistent with each other and with the national accounts and should follow the national accounts system definitions. However, the physical economy does not always strictly correspond to the monetary economy. In addition, deviations from a strict consistency may be considered for practical reasons (see section 3.2 for details).

2.13 Clear links and full consistency should be maintained with the SEEA and NAMEA systems, and data flows among them optimised. NAMEA allows the presentation of environmental indicators linked to the national accounts in a flexible way and using different units of measurement. The physical accounts in NAMEA do not necessarily cover all material inputs and outputs, nor are these accounts necessarily additive. PIOTs show the physical outputs (emissions, etc.) and the natural resource inputs and are directly related to the NAMEA substance accounts.

2.14 Figure 3 below gives a more complete presentation of the relation between economy and environment. In this figure, the economic sphere is divided into the national economy and the rest of the world (in the national accounting sense), and the environmental sphere is divided into the national environment and the environment belonging to the rest of the world. The spatial boundaries of the national environment correspond to the economic territory as defined in the System of National Accounts (Commission of the European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations and World Bank 1993, 14.9, p. 319).

Figure 3: Physical flows and the scope of physical flow accounting



Source: Chapter 3 of SEEA 2000, version of 1 May 2000, draft for public review, full chapter available at: http://ww2.statcan.ca/citygrp/london/publicrev/pubrev.htm

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3. Concepts, definitions and classifications

3.1 General presentation of economy-wide MFA and balances

3.01 *Economy-wide MFA and balances* provide an aggregate overview, in tonnes, of annual material inputs and outputs of an economy including inputs from the national environment and outputs to the environment and the physical amounts of imports and exports. The net stock change (net accumulation) is equal to the difference between inputs and outputs. Economy-wide MFA and balances constitute the basis from which a variety of material flow based indicators can be derived.

3.02 A complete material balance for an economy is statistically difficult to achieve since not all material input and output flows are observed in a systematic way. Some material flow categories must be estimated and available data complemented by additional estimates.

3.03 This Guide offers a system of accounts (presented in full in chapter 6) which in a stepwise progression allows to complete the material balance. These accounts are called *economy-wide material flow accounts*. Each account allows the derivation of one or several indicators. As in the sequence of accounts each step requires additional data (and additional compilation effort), compilers may in practice only complete some of the accounts.

Indirect flows and hidden flows

3.04 In applications allowing calculation of Total Material Requirements (TMR), 'hidden flows' are also included. The term 'hidden flow' has been used to mean the movements of the unused materials associated with the extraction of raw materials, domestically and abroad (see e.g. Adriaanse et al. 1997). This is an extension compared to standard national accounts in two ways:

- materials that are extracted from the national environment but not actually used by the economy are included (so-called domestic hidden flows such as mining overburden or soil excavation during construction);
- the upstream resource requirements associated to imported products (so-called foreign hidden flows such as the mining overburden arising abroad when raw materials are imported).

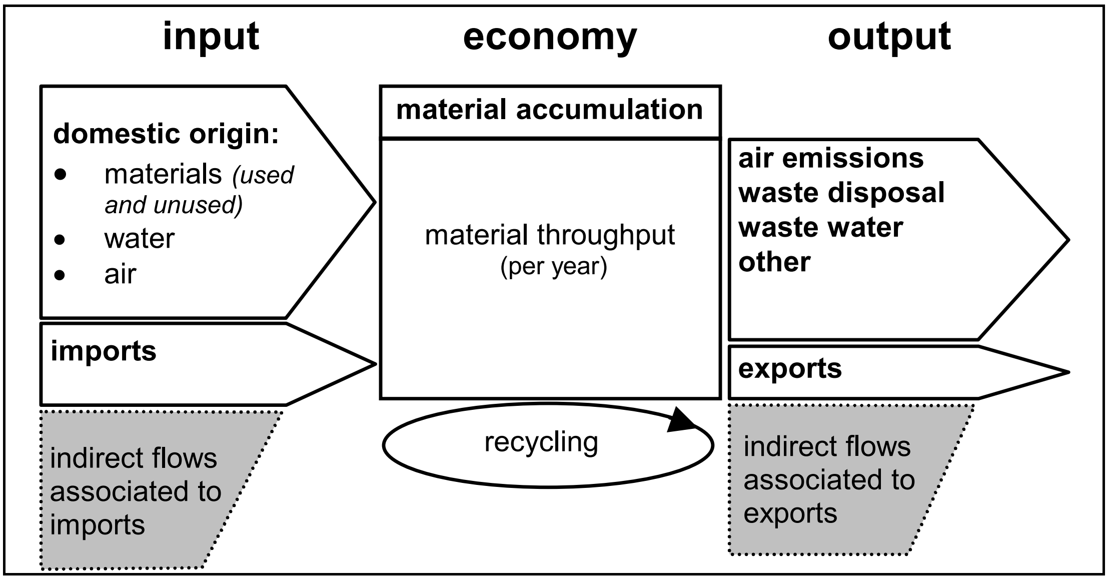
3.05 In this Guide, hidden flows of domestic origin are called *domestic unused extraction*. Upstream material flows associated to imports are called *indirect flows*. The concept of indirect flows is developed in a systematic way (for details see section 3.3) and is also applied to exports so as to allow calculating a Total Material Consumption (TMC) indicator defined in analogy to national accounts aggregates such as GDP. In economy-wide MFA and balances these indirect flows only arise in relation to physical imports and exports. Conceptually, the inclusion of indirect flows associated to imports can be seen to constitute an analytical accounting unit of 'tonnes of primary resource extraction equivalent'. This analytical accounting unit allows conversion of imported products (semi-manufactured and finished products in particular) into a common unit consistent with material flows of domestic origin.

The general material balance scheme

3.06 A general scheme of a material balance is presented in Figure 4 below. This scheme includes indirect flows associated to imports and exports as well as water and air flows through the economy. The categories indicated in Figure 4 can be broken down. For instance, within materials of domestic origin the domestic extraction intended for use and unused extraction can be distinguished. Domestic extraction of materials can be further disaggregated (following some qualitative criteria) into, e.g., fossil fuels, metal ores, industrial minerals, construction minerals and biomass. Each of these broad material groups can be further broken down, e.g. fossil fuels into fuel types, biomass into timber, agricultural harvest, fish catch, etc.

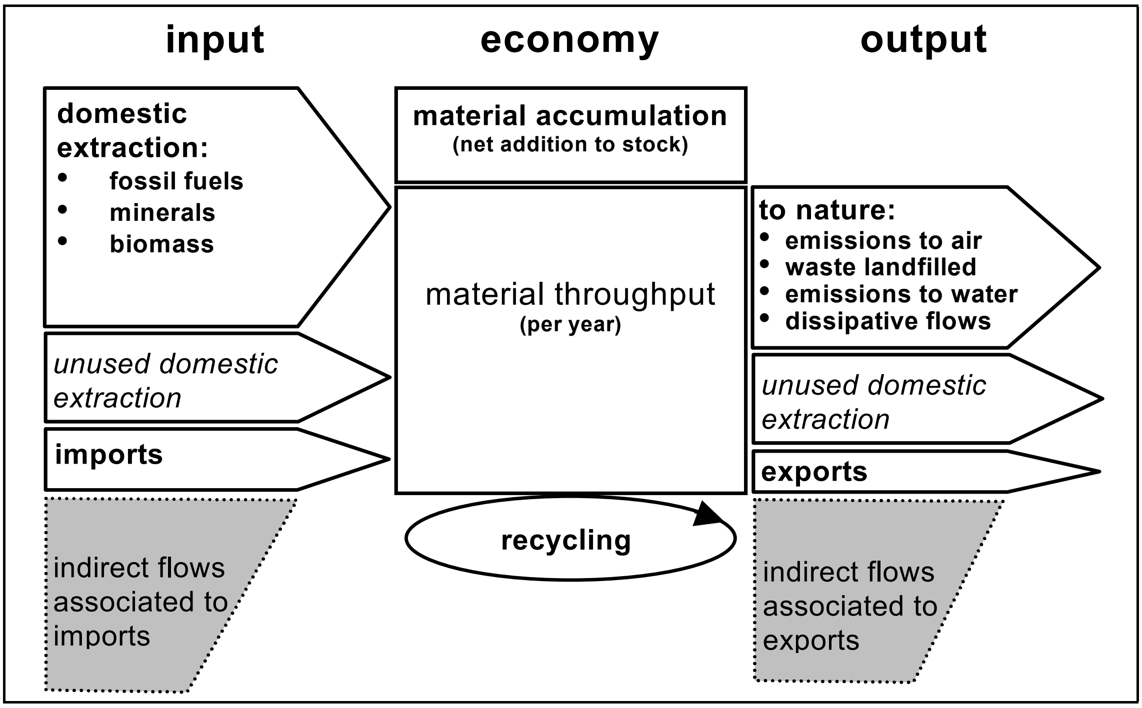
3.07 In order to measure material inputs and outputs consistently, some accounting conventions are introduced in this Guide. For example, for combustion processes to balance, the oxygen used must either be included on the input side or CO2 emissions, for example, are only described in terms of carbon content (27% of the total weight of CO2 emissions are carbon, 73% are oxygen). Other examples are the water content of biomass or of minerals. Such aspects are described in detail in section 3.3.

Figure 4: Simplified general material balance scheme (including air and water)



3.08 Experience suggests that water flows represent enormous mass flows (one order of magnitude more than all other materials). Accounts for water flows should therefore be drawn up and presented separately. It should be noted that also within the EU system of Headline Indicators a separate Headline Indicator for 'Quantitative Water Resources' is foreseen. Excluding water and air, and separating used and unused extraction of materials, the economy-wide material balance would look like the one presented in Figure 5.

Figure 5: Economy-wide material balance scheme (excluding air and water flows)



3.2 System boundary of the accounts

Definition of material inputs and outputs

3.09 The focus of economy-wide MFA and balances is on the economy's metabolism, i.e. on the flows between a given economy and the environment. Therefore, the system boundary is defined:

1. by the extraction of primary (i.e., raw, crude or virgin) materials from the national environment and the discharge of materials to the national environment;
2. by the political (administrative) borders that determine material flows to and from the rest of the world (imports and exports). Natural flows into and out of a geographical territory are excluded.

3.10 Inputs from the environment refer to the extraction or movement of natural materials on purpose and by humans or human-controlled means of technology (i.e., involving labour). Output released to the environment means that society loses control over the location and composition of the materials.

3.11 Only flows are counted that cross the system boundary at the input side or at the output side. Material flows *within* the economy are not presented in economy-wide MFA and balances. Therefore, inter-industry deliveries of products, for example, are not described. However, they are described in Physical Input-Output Tables (PIOT). Also, flows within the economy may be instrumental for estimating primary input flows, for example when data on primary extraction are lacking.

3.12 In the following, several borderline cases are presented that have to be settled by convention. The national accounts and the Pressure-State-Response framework offer useful guiding principles for these borderline cases. In general, economy-wide MFA should be consistent with the national accounts, and materials recorded as inputs or outputs should generally belong to the Pressure (rather than State) category.

3.13 The domestic production of livestock is considered a process *within* the economy, and the domestic harvest of plant biomass as feedstuff for this livestock, including the plant biomass directly taken up by grazing livestock, as well as imported feedstuff, are counted as inputs.

3.14 Fertiliser used on agricultural land is defined as an output to the environment because dispersion and decomposition processes within soil and subsequent emissions are difficult to measure and can hardly be considered as completely under human control.

Material stocks and the system boundary

3.15 Stocks of materials that belong to the economy are mainly man-made fixed assets as defined in the national accounts such as infrastructures, buildings, vehicles and machinery as well as inventories of finished products. Durable goods purchased by households for final consumption are not considered fixed assets in the national accounts but should be included in economy-wide MFA and balances.

3.16 In principle the stocks and changes in stocks of human bodies and livestock should also be recorded in economy-wide MFA and balances. However, experience suggests that these stocks are very small compared to other stocks such as buildings, machinery or consumer durables and also do not change much over time. In practice, therefore, the stocks of human bodies and livestock and their changes may be ignored unless there is evidence that these stocks change rapidly.

3.17 There are some material stocks for which compilers have to determine whether they should be treated as part of the economy or of the environment. Cases in point are controlled landfills and cultivated forests. These decisions have an impact on the input and output flows that are recorded in the accounts. When controlled landfills are included within the system boundary, the emissions and leakages from landfills rather than the waste landfilled must be recorded as an output to the environment. For cultivated forests, the nutrients taken up by the trees rather than the timber harvested would be recorded as an input.

3.18 When deciding on the inclusion or not of these stocks, arguments in favour and against including them within the system boundary should be considered, including:

- The availability (or not) of data on these stocks and on the additions (e.g., the nutrients extracted from soil, water and air by plants) and removals (e.g., leakage from and decomposition in landfills or natural decay of trees);
- The treatment of these stocks in national accounts and in international environmental reporting systems. Cultivated forests are defined as produced assets in the national accounts, and the annual increment of cultivated forests is production (an addition to inventory). In international air emissions reporting and in NAMEA, methane emissions from landfills are included as an emission from the economy;
- In the Pressure-State-Response model waste landfilled is generally considered a pressure but landfills can also be considered a driving force - a stock from which pressure flows (e.g. methane emissions or water pollution) are generated - depending on the environmental themes considered. In a land use perspective there is no principal difference between controlled landfills and infrastructure;
- Treating landfills as a stock requires to assess when landfills are abandoned and the distinction of ‘controlled’ and ‘uncontrolled’ landfills becomes important, paralleling the distinction between ‘cultivated’ and ‘non-cultivated’ forests.

3.19 This Guide recommends to treat forests and agricultural plants as part of the environment in economy-wide MFA and the harvest of timber and other plants as material inputs. Treating forests and agricultural plants as part of the economy would require to include the bio-metabolism of these plants in the accounts. This extension is laborious, difficult to underpin with actual data and probably does not increase the information content of the accounts.

3.20 In this Guide, waste landfilled is considered an output to the environment but compilers are free to choose the treatment they prefer. If controlled landfills are included within the system boundary, the classifications of outputs and stock changes presented in this Guide (see sections 3.6 and 3.7) must be adapted. It is recommended to show waste landfilled as a separate category of stock changes so as to facilitate international comparison of data.

3.21 The system boundary between economy and nature as used in economy-wide MFA does not necessarily have to be identical to the system boundary used for PIOT as long as the categories that differ are clearly separated. For example, controlled landfills can be considered a part of the economy in PIOT but not in economy-wide MFA.

3.22 Table 1 shows the changes in the German material stocks in 1990 as an illustration of the relative size of different stock changes. In this table, the changes in inventories exclude 19.9 million tonnes of felled timber due to wind-throws caused by severe storms in 1990. These storms also affected the removals from standing timber stocks (harvest). In normal years, removals are lower than additions (natural growth), see e.g. Eurostat 1999c.

Table 1: Changes in physical stocks, Germany 1990

	Additions	Removals	Net change
	million tonnes		
Machinery and equipment	10.9	8.2	2.7
Buildings and infrastructures	553.6	32.5	521.1
Changes in inventories	n.a.	n.a.	5.4
Consumer durables	7.1	4.1	3.0
Standing timber	23.0	49.9	-26.9
Controlled landfills	149.3	n.a.	149.3

Source: Eurostat calculations based on Stahmer et al 1998 and 2000.

Residence versus territory principle

3.23 Economy-wide material flow accounts and balances should be consistent with the national accounts. The national accounts define a national economy as the activities and transactions of producer and consumer units that are resident (i.e. have their centre of economic interest) on the economic territory of a country. Some activities and transactions of these units may occur outside the economic territory and some activities and transactions on the geographical territory of a country may involve non-residents. Standard examples for illustrating this difference are tourists or international transport by road, air or water. Due to such activities the environmental pressures generated by a national economy may differ from the environmental pressures generated on a nation's geographical territory. Trans-boundary flows of emissions through natural media (e.g., emissions to air or water generated in one country but which are carried by air or rivers and impact on another country) are not part of economy-wide MFA.

3.24 For physical accounts to be consistent with the national accounts means the application of the residence (rather than territory) principle. Hence, in principle, materials purchased (or extracted for use) by resident units abroad would have to be considered material inputs (and emissions abroad material outputs) of the economy for which the accounts are made. Likewise, materials extracted or purchased by non-residents on a nation's territory (and corresponding emissions and wastes) would have to be identified and excluded from that nation's economy-wide MFA and balances.

3.25 Current knowledge suggests that the most important difference between residence and territory principle results from fuel use and corresponding air emissions related to international transport including bunkering of fuels and emissions by ships and international air transport as well as to fuel use and emissions of tourists. This should be kept in mind for physical input-output tables because the differences would be concentrated on the road, air and water transport industries (divisions 60, 61 and 62 of NACE Rev. 1) and households.

3.26 The significance of international transport and tourism activities and in particular the net balance of emissions and energy use by resident units abroad and non-resident units on a nation's territory will differ across countries. If the net balance is assumed to be significant, emissions and energy use by non-residents on national territory and by residents abroad should be estimated (see also United Nations 2000, pages 139-142).

3.27 While underlining the need to apply the residence principle, this Guide suggests that the effort to estimate such flows only for purposes of economy-wide MFA and balances could be difficult to justify. For compiling economy-wide MFA and balances it is suggested to use the data readily available nationally. In particular, accounts for air emissions and energy use based on the NAMEA system are available for virtually all EU Member States and should be used, as NAMEA emission and energy accounts follow the residence principle.

3.28 If NAMEA data are not available, care should be taken to ensure that the primary data on inputs of fuels (e.g., from energy statistics) and on air emissions (e.g., from national emission inventories) are consistent with each other.

3.3 Main categories of flows

Terminology

3.29 Three dimensions (pairs of distinction) are used in this Guide to characterise categories of material flows and indicators. These are:

- the territorial dimension to indicate the origin and destination of flows: *domestic <–> rest of the world (ROW);*
- the product-chain or life-cycle dimension to indicate whether flows are directly observed or calculations of up-stream material requirements: *direct* <–> *indirect;*
- the product dimension to indicate whether flows enter (any) economic system or not: *used* <–> *unused*. This pair is only used for inputs. For outputs, the distinction *processed* <–>*non-processed* is used, i.e. flows stemming from an economic system or not.

3.30 The first two dimensions refer to flows in relation to the entity (the economy) for which the accounts are made. The third dimension refers to the flows only. Domestic flows are materials that are extracted from, or released into, the national environment. Direct flows are materials physically entering the national economy (i.e., the system for which the accounts are made) as an input. Indirect flows are material flows for the production of a product that have occurred up-stream in the production process.

3.31 “Used” refers to an input for use in any economy, i.e. whether a material acquires the status of a product. All direct flows are also used but not all used flows are direct. Some are indirect, e.g. the raw materials used in the rest of the world to produce products that are then imported by the economy for which the accounts are made. Unused flows are materials that are extracted from the environment without the intention of using them, i.e. materials moved at the system boundary of economy-wide MFA on purpose and by means of technology but not for use. Examples are soil and rock excavated during construction or overburden from mining.

3.32 In economy-wide MFA the whole economy including production and consumption activities is a single black box. Only flows that cross the system boundary of the economy are recorded. The term ‘indirect flows’ therefore only refers to upstream flows associated to imports and exports of this economy. In PIOTs the economy is further disaggregated into sub-systems (branches of production and categories of final use). Therefore, indirect flows can also be estimated for product flows among branches and to final use categories. For example, accumulated material use associated with final consumption may be calculated based on PIOTs.

3.33 Combining the three dimensions leads to five categories of inputs relevant for economy-wide MFA. These categories are summarised in Table 2 below. For PIOT, additional combinations are relevant as indirect flows may also be calculated for flows within the economy.

Table 2: Summary of terminology for material input categories

Product-chain	***Used or unused***	***Domestic or ROW***	***Term used in this Guide***
direct	used	domestic	domestic extraction (used)
not applied	unused	domestic	unused domestic extraction
direct	used	ROW	imports
indirect (up-stream)	used	ROW	indirect (input) flows associated to imports
indirect (up-stream)	unused	ROW	

3.34 For output flows the column ‘used<–>unused’ is called ‘processed <–>non-processed’, i.e. stemming from an economic system or not, and the distinction ‘domestic<->ROW’ refers to the destination (rather than the origin) of the flows. The output categories relevant for economy-wide MFA are summarised in Table 3. Again, for PIOT additional combinations are relevant.

Table 3: Summary of terminology for material output categories

Product-chain	Processed or not	Domestic or ROW	Term used in this Guide
direct	processed	domestic	domestic processed output to nature
not applied	non-processed	domestic	disposal of unused domestic extraction
direct	processed	ROW	exports
indirect (up-stream)	processed	ROW	indirect (output) flows
indirect (up-stream)	non-processed	ROW	associated to exports

Definitions

Direct material inputs

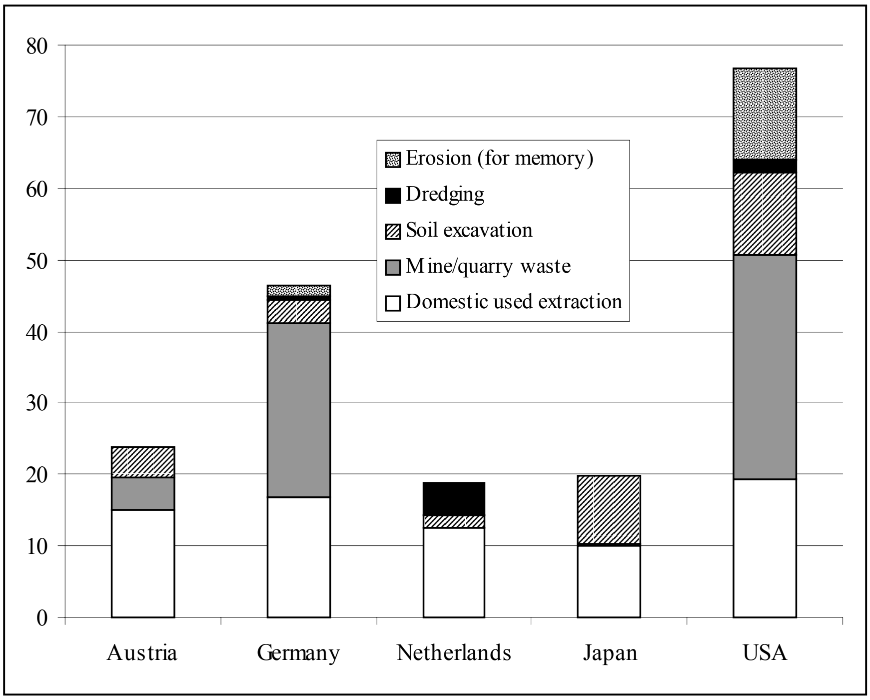
3.35 Direct (used) material inputs are defined as all solid, liquid and gaseous materials (excluding water and air but including e.g. the water content of materials) that enter the economy for further use in production or consumption processes. The two main categories are raw materials domestically extracted and imports. The sum of these two categories constitutes one of the indicators derived from the accounts, the Direct Material Input (DMI). Deducting exports from this indicator results in the Domestic Material Consumption (DMC). For the full set of indicators see Chapter 4.

Unused domestic extraction

3.36 Unused domestic extraction are materials extracted or otherwise moved on a nation's territory on purpose and by means of technology which are not fit or intended for use. Examples are soil and rock excavated during construction, dredged sediments from harbours, overburden from mining and quarrying and unused biomass from harvest. Agricultural soil that is eroded is not moved on purpose but may be included as an optional memorandum item.

3.37 Figure 6 illustrates that unused domestic extraction is of the same order of magnitude as direct (used) material input in industrialised countries. These unused material flows are counted as both inputs and outputs, with the net effect for the material balance being zero.

Figure 6: Domestic used and unused extraction, tonnes per capita, 1996



Source: Matthews et al (2000)

Outputs to the environment

3.38 Outputs to the environment are defined as all material flows entering the national environment, either during or after production or consumption processes. Outputs include emissions to air and water, waste landfilled as well as materials dissipatively used (e.g., fertiliser or thawing materials). Outputs also include the disposal of unused domestic extraction.

Indirect flows and hidden flows

3.39 The term 'ecological rucksack' has been used to mean the life-cycle-wide material requirements associated with the production of a product (both used and unused material flows; see e.g. Schmidt-Bleek et al. 1998). In this Guide, *indirect flows* are defined for economy-wide material flows only, i.e., they only refer to imports and exports. In a PIOT framework, indirect flows can also be compiled for material flows within the economy.

3.40 On the input side, indirect flows are defined as the up-stream material input flows that are associated to imports but are not physically imported. On the output side, indirect flows are defined as the up-stream material input flows associated to exports but are not physically exported. Indirect flows are the 'cradle to border' inputs necessary to make a product (i.e., a good or a service) available at the border for import or export, excluding the mass of the product itself. Two types of indirect flows associated to imports and exports are distinguished: used and unused indirect flows. Indirect flows can only be calculated after the accounts for direct (used) materials have been completed. For a detailed description see below 'The concept of indirect flows'.

3.41 The term 'hidden flow' has been used to signify the movements of the unused materials associated with the extraction of raw materials (i.e., for use), both nationally and abroad (see e.g. Adriaanse et al. 1997). In this Guide hidden flows are defined, in line with most of the current practices, as a synonym for unused extraction. Unused domestic extraction may therefore be called 'domestic hidden flows'. The indirect flows of unused extraction abroad associated to imports may be called 'foreign hidden flows (associated to imports)'.

Memorandum items for balancing

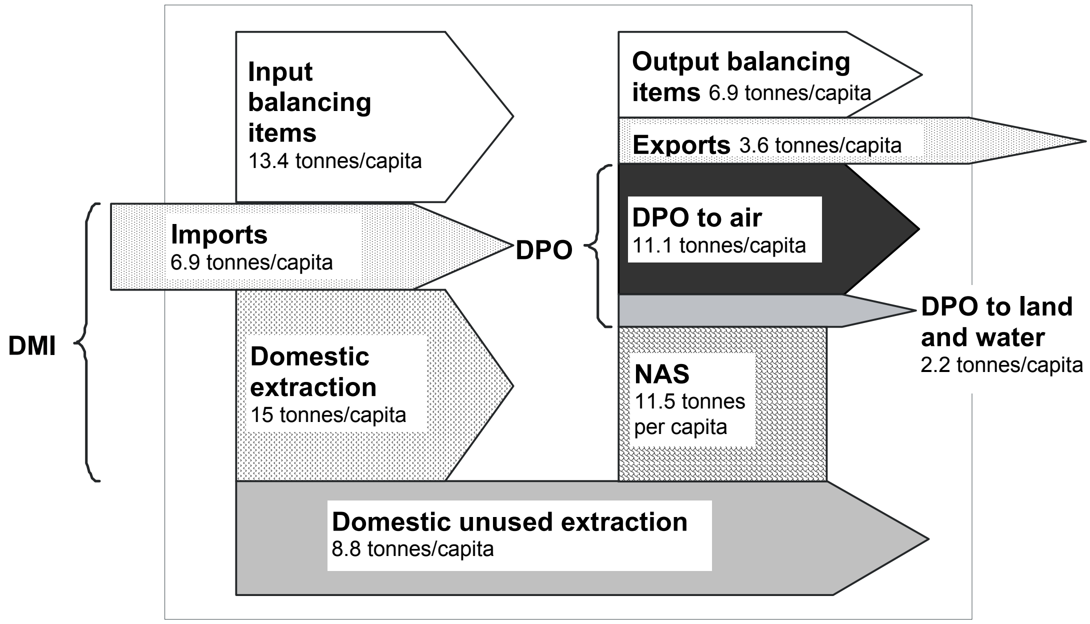
3.42 It is recommended to set up the accounts in actual (reported) weights. With this convention most of the accounts can be set up based on existing data – for details and exceptions see chapter 5. However, for the full material balance, material inputs and outputs must be measured consistently. For example, in combustion processes, the fuels are combined with air and oxidised, resulting in emissions to air including carbon dioxide and water vapour as well as other residues such as ashes. The difference in weight between fuel inputs and emission can be quite large. For example, only 27% of the total weight of CO_2 emissions are carbon and 73% are oxygen. Another example is the water content of inputs of biomass or minerals or of outputs of waste - the weights as recorded by statistical sources often include the water content of these inputs and outputs.

3.43 There are different options to ensure consistency of the material balance and to allow a meaningful interpretation of differences between inputs and outputs. In this Guide it is recommended to introduce memorandum items for balancing. These memorandum items are only introduced for balancing purposes. They are not to be included in the indicators derived from the accounts. Important memorandum items for balancing are listed in the classifications of inputs and outputs (see sections 3.5 and 3.6).

3.44 For example, for the air emissions to balance with the fuels used in combustion, the oxygen must be included as a memorandum item for balancing on the input side. Alternatively, CO_2 emissions and water vapour could be described only in terms of their carbon and hydrogen content. Also memorandum items for the water content of materials will have to be introduced.

3.45 The memorandum items for balancing are quantitatively important as illustrated by Figure 7 below. In this figure, the balancing items include the oxygen for combustion, for biometabolism and for the production of technical gases as well as the water input for evaporation by animal and human metabolism on the input side. On the output side, the balancing items include the water vapour from combustion (from the water content of fuels and from oxidation of hydrogen in fuels) as well as the water evaporation from animal and human metabolism.

Figure 7: Balancing items for Austria, 1996



Source: Fischer-Kowalski (2000)

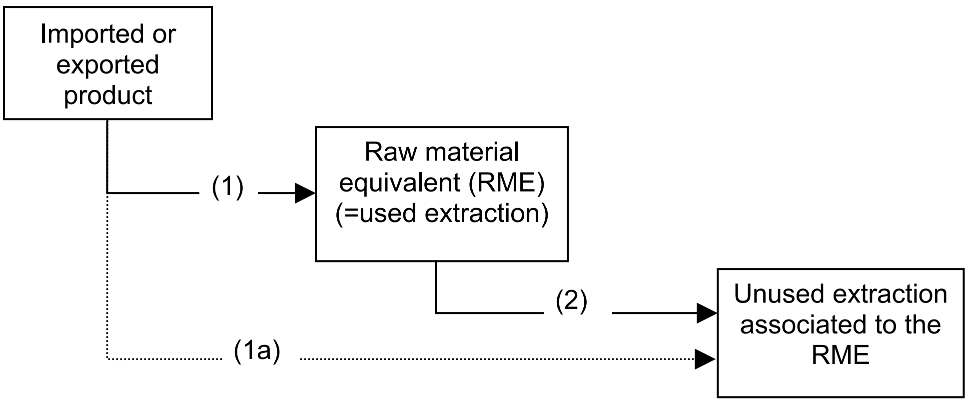
The concept of indirect flows

3.46 In economy-wide MFA only flows that cross the system boundary of the economy are recorded. For the purposes of economy-wide MFA indirect flows are always up-stream material flows and they are always input flows. The term 'indirect flows' therefore only refers to upstream flows associated to imports and exports of this economy. For PIOTs, where the economy is further disaggregated into sub-systems (several branches of production and categories of final use), indirect flows also refer to upstream flows of deliveries among branches and to final use categories.

3.47 For economy-wide MFA, two components of indirect flows are distinguished:
(a) up-stream indirect flows expressed as the Raw Material Equivalents (RME) of the imported or exported products (less the weight of the imported or exported product). The RME is the used extraction that was needed to provide the products;
(b) up-stream indirect flows of unused extraction (e.g. mining overburden) associated to this RME.

3.48 The correct calculation is shown in Figure 8. The first step (1) is to compile the RME of imports or exports, i.e. the vector of raw materials needed to provide the product at the border. In a second step (2) the unused extraction associated to this RME is compiled.

Figure 8: Calculating indirect flows



3.49 The RME of many raw materials (which are always products) and even semi-manufactures may be assumed to differ only marginally from the weight of the product itself. The difference would for example correspond to some fuel used to extract and transport a raw material to the border. For these materials, the calculation of indirect flows simplifies to (1a), i.e. directly estimating unused extraction.

3.50 Compiling the unused extraction associated to imported raw materials and some semi-manufactures may be a useful first step in the analysis, allowing a first estimate of TMR. In this case it is recommended to document the categories that have been included in compiling TMR. With the increasing importance of finished goods and of services in imports (and exports) the error introduced by this simplification may become quite large. The structure of imports and exports by broad categories (raw materials, semi-manufactures, finished products) and its change over time provides a useful indication for the size and development of this error.

3.51 When imports and exports are converted into their RME, the weight of the RME includes the weight of the imports or exports. For the purpose of economy-wide MFA and balances, the indirect flows of type (a) (i.e., those based on the RME) are calculated by subtracting the weight of the imports or exports from the RME associated to these imports or exports so as to ensure additivity.

3.52 The RME of imports allows to compile an input indicator based entirely on RME by substituting the imported products by their RME. Compiling also RME for exports permits calculating the material consumption expressed in RME for an economy.

3.53 Some of the indirect flows associated to exports may consist of the indirect flows associated to products previously imported. This effect would be particularly pronounced for countries with important harbours where a substantial part of imports is direct transit to other countries (the ‘Rotterdam effect’). It is recommended to show direct transit as a separate category of imports and exports in the accounts and to leave out direct transit when compiling indicators.

3.54 Indirect flows associated to imports and exports should be calculated using input-output techniques in the same way as e.g. ‘embedded’ energy is calculated, maybe even based on hybrid – i.e. mixed physical/monetary - input-output tables (for the principles see e.g. Miller/Blair 1985). As such input-output tables are not usually available for a nation’s trading partners, the indirect flows associated to imports may be estimated using the national input-output tables. This assumes that imported products are produced in the same way (materials, energy, technology) as domestically produced products.

3.55 Compilation of indirect flows with input-output techniques alone may be limited. Ideally, specific coefficients per product category would be available based on process chain analysis. Data on indirect flows will usually suffer from some degree of imprecision but their calculation can shed light on the effects of trade and globalisation. Such questions may become increasingly important with the further integration among national economies. Accounts for materials used domestically (i.e., DMI and DMC) are relevant in a national context but may be less meaningful in a global context.

3.56 The accounts for indirect flows of unused materials should be based, to the extent possible, on direct information on the trading partners. A practical solution may also be – in a stepwise approach – to focus on some important indirect flows of unused materials (e.g. associated to raw materials imported) first and achieve completeness later. Direct information on the trading partners may also be useful for some other flows. For example, for electricity imported the fuels required abroad to generate the electricity would be indirect flows associated to imports.

3.57 Complementary analyses may be made, e.g. calculation of emissions or units of land use equivalent associated to products imported or exported. For example, in addition to the indirect material flows, the land used abroad to produce the goods and services imported by a nation as well as the land used nationally to produce the goods and services exported may be estimated. Indicators may be derived for land use ‘imported and exported’ as well as a net trade balance expressed in hectares. Similarly, emissions ‘imported or exported’ (and the balance of these) may be calculated, i.e. the emissions to air or water or the waste generated abroad to produce the goods and services imported by a nation as well as the emissions and wastes generated domestically to produce the goods and services exported. These aspects are not further explored in this Guide.

3.4 The material balance

3.58 The considerations in sections 3.1 to 3.3 above can be summarised in a composite material balance (see Figure 9 below) that allows the derivation of several aggregate material-related indicators. The balance in Figure 9 is called 'composite' because it shows all the items important for the full set of economy-wide MFA in a summary form but is not actually used for balancing purposes. In practical work, a Direct Material Flow Balance is set up which will be the last step (data reconciliation) after the individual accounts for main categories of inputs, outputs and stock changes have been made. These individual accounts are sub-sets of the composite balance and include a Direct Material Input Account, a Physical Trade Balance Account, an Unused Domestic Extraction Account and a Total Material Requirements Account. The full sequence of accounts, including the Direct Material Flow Balance, is presented in Chapter 6.

Figure 9: Composite economy-wide material balance with derived resource use indicators

INPUTS (origin)	OUTPUTS (destination)
Domestic extraction	**Emissions and wastes**
Fossil fuels (coal, oil…)	Emissions to air
Minerals (ores, sand…)	Waste landfilled
Biomass (timber, cereals…)	Emissions to water
	Dissipative use of products and losses
Imports	(fertiliser, manure, seeds; corrosion...)
DMI - direct material inputs	***DPO - domestic processed output to nature***
Unused domestic extraction	**Disposal of unused domestic extraction**
From mining/quarrying	From mining/quarrying
From biomass harvest	From biomass harvest
Soil excavation	Soil excavation
TMI – total material input	***TDO - total domestic output to nature***
	Exports
	TMO – total material output
Indirect flows associated to imports	
TMR - total material requirements	***Net Additions to Stock***
	Infrastructures and buildings
	Other (machinery, durable goods, etc.)
	Indirect flows associated to exports

Note: excludes water and air flows (unless contained in other materials).

3.59 The composite balance allows calculation of aggregate material consumption indicators, as follows:

- *DMC (domestic material consumption)* = Domestic extraction (used) plus Imports minus Exports;
- *a Physical Trade Balance* (PTB) may be defined as Imports minus Exports;
- *TMC (total material consumption)* = TMR (Domestic extraction (used and unused) + Imports + indirect flows imported) minus Exports minus indirect flows exported.

3.60 When the appropriate memorandum items for balancing are introduced (see section 3.3 above), the indicators derived on the input and the output side can be linked by accounting identities. For example, DMI equals DPO plus NAS plus Exports, or NAS equals DMC minus DPO.

3.61 The above presentation employs classifications that emphasise different aspects on the input and on the output side. Actual direct economic use of materials on the input side (direct material inputs versus unused extraction and indirect flows) and environmental pressures (outputs to the domestic environment versus exports and additions to stocks) on the output side.

3.62 Applying these basic classification principles differently, further aggregates could be defined. For example, an aggregate for *Direct* Material Output (DMO) may be defined as DPO (domestic processed output to nature) plus exports. This is the basis for the Direct Material Flow Balance defined as DMI (domestic extraction (used) plus imports) = DMO (domestic processed output to nature plus exports) plus NAS (net additions to stocks). This balance also requires the introduction of memorandum items for balancing.

3.63 Table 4 illustrates the principles of a direct material flow balance as well as the importance of some of the flows recorded in it. The data are an aggregation from the Danish Physical Input-Output Tables for 1990 (Gravgaard Pedersen 1999).

3.64 Table 4 also illustrates alternative ways of accounting for some specific items. For example, externally recycled materials are explicitly shown on the input side (recycling within an industry is not shown). On the output side the wastes delivered to other industries for recycling are included under residuals. The gross accumulation corresponds to the material content of the national accounts' gross fixed capital formation. Durable consumer goods are not included. Demolition waste is not included under residuals, partly due to lack of data and partly because much of Danish demolition waste is reused within the construction industry. The balancing of air emissions with fuel inputs is achieved by recording the air emissions net of oxygen (e.g., carbon dioxide emissions are recorded as carbon). Biomass resources were estimated net as the difference between the input and output of products of the agriculture, forestry and fisheries industries. This means that no biomass residues from these industries are included under the heading residuals. This method gives a lower resource consumption compared to a recording of all biomass extraction as input.

Table 4: Material balance for Denmark - all commodities 1990, million tonnes

Origin/resources		Destination/uses	
Imports	38.3	Exports	25.2
Danish resources	79.6	Accumulation (gross)	58.7
Waste recycled	2.4	Changes in inventories	-3.1
Water added to products	3.3	Residuals[1)]	42.8
Total	*123.6*	*Total*	*123.6*

1) Includes wastes for external recycling. Carbon dioxide emissions are recorded as carbon.

Source: Gravgaard Pedersen (1999)

3.65 The following sections 3.5 – 3.7 present the classifications of material inputs, material outputs and material stocks and stock changes. Chapter 4 describes the indicators derivable from the composite balance in more detail.

3.5 Classification of material inputs

General classification rules

3.66 The classifications presented in sections 3.5 – 3.7 and in the Annexes are based on the following principles:

- The classifications should allow to distinguish between renewables and non-renewables, i.e. allowing separate identification of biomass;
- The main level of the classification of domestic extraction carries through to all other classifications to allow compilation of sub-accounts and derivation of indicators by main material groups (e.g., separately for fossil fuels, minerals and biomass).

3.67 If controlled landfills (or forests and agricultural plants) are treated as part of the economy, some adjustments to the classifications will be needed. For example, in the classification of outputs the waste landfilled has to be replaced by the emissions and leakages from landfills. In the classification of changes in stocks, waste landfilled has to be added to the additions to stocks and emissions and leakages from landfills to the removals.

Direct material inputs

3.68 *Direct (or used) material inputs* are all solid, liquid and gaseous materials (excluding water and air but including the water and air content of materials) that enter the economy for further use, either in production or consumption processes. Direct material flows are first classified by their origin into domestic extraction (used) and imports. Material inputs of domestic origin are further classified into three main material groups:

- fossil fuels;
- minerals (metal ores, other industrial minerals, construction minerals);
- biomass.

3.69 *Imports* are classified according to their level of manufacturing into raw materials, semi-manufactured products, finished products and other products. Other products are products without further characterisation of their manufacturing level in the classifications of foreign trade, mostly products of the nutrition industry. Imports (and exports) are classified according to the Harmonised commodity description and coding System (HS) and the Standard International Trade Classification (SITC - derived from HS). At EU level, the Combined Nomenclature (CN) is used, which is consistent with the HS but more detailed.

3.70 The classification of imports (which is also used for exports) with its sub-categories for raw materials, semi-manufactures and finished products as proposed in this Guide is potentially laborious as it requires to aggregate trade data from detailed levels but has the advantage of showing trends in the structure of foreign trade. At EU level, imports may be classified based on either the Combined Nomenclature (CN - the classification of foreign trade) or the more aggregated Classification of Products by Activities (CPA). Using coefficients for “indirect flows” would speak for CN. Using I/O analysis would speak for CPA where a direct match with branches is easier to achieve. In Annex 4 (detailed classification of imports) the HS/CN codes and the corresponding CPA codes are shown. As can be seen, correspondences are direct, except for a few groups of products which are typically of minor quantitative importance.

3.71 A further classification level for imports is based, just as for domestic extraction, on the basic material components of the commodities:

- fossil fuels (further subdivided by type of fuel);
- minerals (further subdivided by metals and non-metallic minerals);
- biomass (from agriculture, forestry, fishing or hunting).

3.72 This material attribution is clear for base materials like coke (semi-manufactured fossil fuels), pig iron (semi-manufactured metals) or copper ware (finished metal products). It may also be applied to other products whose (main) base material can be identified, such as passenger cars which have traditionally been a product of the metal manufacturing line of an economy. A detailed proposal for classifying products by main material component based on the commodities classifications of foreign trade statistics is presented in Annex 4.

3.73 However, the more complex the material mix of a manufactured product, the more critical its attribution to a ‘dominant’ material category. The share of ‘secondary’ material categories (e.g., synthetic materials in cars) may be important and may change over time so that conversion tables may need to be set up for the detailed attribution of imports (and exports) to material categories.

Unused domestic extraction

3.74 *Unused domestic extraction* comprises three major groups:

- unused extraction from mining and quarrying (mining/quarrying extraction wastes such as overburden, interburden and parting materials);
- unused extraction from biomass harvest (discarded by-catch, wood harvesting losses – i.e. timber felled but left in the forests, other harvesting wastes);
- soil (and rock) excavation and dredged materials (materials extracted during construction and dredging activities).

Air inputs

3.75 Although air is not treated as a material input for the derivation of indicators such as DMI, DMC or TMR, it is useful to estimate the oxygen demand of some processes to ensure that inputs and outputs balance. Hence, oxygen will appear as a memorandum item on the input side corresponding to the emissions on the output side of oxidised compounds (CO_2, water vapour, etc.) from combustion and other processes. Input of oxygen (and nitrogen) can be easily estimated based on chemical equilibrium formulae. The input may then be classified as follows:

- oxygen (O_2) for the combustion of fuels (i.e., carbon, hydrogen, sulphur, nitrogen, etc. contained in fuels);
- oxygen (O_2) for respiration of humans and livestock;
- nitrogen to balance the NOx emissions from combustion;
- air for other industrial processes.

3.76 A general overview of classes of material inputs is shown in Table 5 below. A more detailed classification is presented in Table 6. For more detail see the Annexes 2, 3 and 4. In Annex 4 also the correspondence with CPA is shown.

Table 5: Classification of material inputs – broad categories

Domestic extraction (used)
 Fossil fuels
 Minerals
 Biomass

Imports*
 Raw materials
 Semi-manufactured products
 Finished products
 Other products
 Packaging material imported with products
 Waste imported for final treatment and disposal

Memorandum items for balancing *(oxygen for combustion, etc.)***

Unused domestic extraction
 Unused extraction from mining and quarrying
 Unused biomass from harvest
 Soil excavation and dredging

Indirect flows associated to imports
 Raw material equivalents of imported products***
 Unused extraction associated to imported products

Notes:
Soil erosion could be shown as an optional memorandum item of unused domestic extraction and unused extraction associated to imported products but is not to be included when compiling indicators.
* ....Imports (and exports) are categorised by degree of manufacturing (raw materials, semi-manufactured and finished products) and by the dominant material type (fossil fuel, mineral, biomass) to the extent possible.
** ....Memorandum items for balancing are not to be included when compiling indicators.
*** .....The indirect flows (of used materials) are compiled as raw material equivalents minus the weight of the imports.

Table 6: Detailed classification of material inputs

Domestic extraction (used)
- ***Fossil fuels***
  - Hard coal
  - Lignite (brown coal)
  - Crude oil
  - Natural gas
  - other (crude oil gas, peat for combustion, oil shale, etc.)
- ***Minerals***
  - Metal ores
    - Iron ores
    - Non-ferrous metal ores
      - *Bauxite*
      - *Copper ores*
      - *Other*
  - Industrial minerals
    - Salts
    - Special clays
    - Special sands
    - Peat for agricultural use
    - Other
  - Construction minerals
    - Sand and gravel
    - Crushed stones (incl. limestone for cement making)
    - Common clays (for brick making etc.)
    - Dimension stones
    - Other
- ***Biomass*** *(including biomass extracted for own final use)*
  - Biomass from agriculture
    - Biomass from agriculture reported by harvest statistics
      - *Cereals*
      - *Roots and tubers*
      - *Pulses*
      - *Oilcrops*
      - *Vegetables*
      - *Fruits*
      - *Treenuts*
      - *Fibre crops*
      - *Other crops*
    - Biomass from agriculture as a by-product of harvest
      - *Crop residues used as fodder*
      - *Straw used for economic purposes*
    - Biomass from grazing of agricultural animals
      - *Grazing on permanent pastures not harvested*
      - *Grazing on other land (including alpine pastures)*
  - Biomass from forestry
    - Wood
      - *Coniferous*
      - *Non-coniferous*
    - Raw materials other than wood
  - Biomass from fishing
    - Marine fish catch
    - Inland waters (freshwater) fish catch
    - Other (aquatic mammals and other)
  - Biomass from hunting
  - Biomass from other activities (honey, gathering of mushrooms, berries, herbs etc.)

Imports*

Raw materials
- Fossil fuels
- Minerals
- Biomass
- Secondary raw materials

Semi-manufactured products
- From fossil fuels
- From minerals
- From biomass

Finished products
- Predominately from fossil fuels
- Predominately from minerals
- Predominately from biomass

Other products
- Other products of abiotic kind
- Other products of biotic kind
- Other products n.e.c.

Packaging material imported with products

Waste imported for final treatment and disposal

Memorandum items for balancing**

Oxygen for combustion *(of C, H, S, N, etc.)*

Oxygen for respiration

Nitrogen for emissions from combustion

Air for other industrial processes *(liquefied technical gases, polymerisation, etc.)*

Unused domestic extraction

Unused extraction from mining and quarrying of fossil fuels

Unused extraction from mining and quarrying of minerals

Unused biomass from harvest
- Wood harvesting losses
- Agricultural harvesting losses
- Other (discarded by-catch, etc.)

Soil excavation and dredging
- Excavation for construction activities
- Dredging materials

Indirect flows associated to imports

Raw material equivalent of imported products*
- Fossil fuels
- Minerals
- Biomass

Unused extraction of imported products
- Unused extraction from mining and quarrying of fossil fuels
- Unused extraction from mining and quarrying of minerals
- Unused biomass from harvest
- Soil excavation and dredging

Notes:

Soil erosion could be shown as an optional memorandum item of unused domestic extraction and unused extraction associated to imported products but is not to be included when compiling indicators.

* ....Import (and export) data should be organised at a more detailed level in parallel to the classification of domestic extraction to the extent possible, to allow aggregation. See also Annex 4.

** ....Memorandum items for balancing are not to be included when compiling indicators.

*** .....The indirect flows (of used materials) are compiled as raw material equivalents minus the weight of the imports.

3.6 Classification of material outputs

3.77 Material outputs of an economy can be classified at the first level by main destination, i.e. into outputs to the environment and exports.

Outputs to the environment

3.78 *Outputs to the environment* are defined as all material flows entering the environment, either during or after production or consumption processes. Included is the disposal of unused domestic extraction. Outputs to the environment can be classified further into processed and unprocessed outputs. *Unprocessed outputs* correspond to the disposal of unused domestic extraction (equal to unused domestic extraction on the input side). *Processed outputs* are the result of production or consumption processes. Processed outputs to the environment are classified into:

- Emissions and waste flows;
- Dissipative use of products and dissipative losses of materials.

3.79 Main groups of *emissions and wastes* are:

- emissions to air;
- waste landfilled;
- emissions to water.

3.80 *Dissipative uses of products and dissipative losses* are defined as the quantity (weight) of materials which are dispersed into the environment as a deliberate, or unavoidable (with current technology) consequence of product use. These flows comprise two components: *dissipative uses* (for example, fertilisers and manure spread on fields, or salt and other thawing materials spread on roads), and *dissipative losses* (for example, rubber worn away from car tires, particles worn from friction products such as brakes, abrasion from roads, losses due to evaporation of e.g. water or other solvents[1] carrying paints or other coatings). Dissipative uses can be part of an ultimate throughput flow, e.g. mineral fertiliser, or part of recycling, e.g. manure, compost and sewage applied on fields for nutrient recycling. Dissipative *uses of products and dissipative losses* are mainly:

- use on agricultural land (fertiliser, manure etc.);
- use on roads (sand, salt etc.);
- losses (corrosion and abrasion of products and infrastructures, leakage etc.).

Exports

3.81 *Exports* are classified in the same way as imports. This allows to account for physical trade balances (imports minus exports) and for domestic material consumption (domestic extraction plus imports minus exports) per category of materials. Also *indirect flows associated to exports* may be classified in the same way as those associated to imports.

3.82 A general overview of classes of material outputs is shown in Table 7 and a more detailed classification is presented in Table 8 below. For further detail on some categories of outputs see the Annexes 5 and 6.

[1] Note: solvents may be included in estimates of air emissions (VOCs). In this Guide solvents are classified as a dissipative use rather than air emissions. However, in practice data availability may require to adapt the classification and include certain dissipative material flows in emissions and wastes (e.g. to include solvents in air emissions).

Table 7: Classification of material outputs – broad categories

Emissions and wastes
- Emissions to air
- Waste landfilled
- Emissions to water

Dissipative use of products and dissipative losses
- Dissipative use of products
- Dissipative losses

Exports*
- Raw materials
- Semi-manufactured products
- Finished products
- Other products
- Packaging material exported with products
- Waste exported for final treatment and disposal

Memorandum items for balancing**
- Water vapour from combustion
- Water evaporation from products
- Respiration of humans and livestock (CO2 and water vapour)

Disposal of unused domestic extraction
- Unused extraction from mining and quarrying
- Unused extraction from biomass harvest (discarding of by-catch, harvesting losses and wastes)
- Soil excavation and dredging

Indirect flows associated to exports
- Raw material equivalents of exported products***
- Unused extraction associated to exported products

Notes:
Soil erosion could be shown as an optional memorandum item of disposal of unused domestic extraction and unused extraction associated to exported products but is not to be included when compiling indicators.

* ....Export data should be organised at the same level of detail as imports to the extent possible, to allow compilation of physical trade balances per material category.

** ....Memorandum items for balancing are not to be included when compiling indicators.

*** .....The indirect flows (of used materials) are compiled as raw material equivalents minus the weight of the exports.

Table 8: Detailed classification of material outputs

Emissions and wastes

- ***Emissions to air*** *from combustion and industrial processes*
    - *CO_2*
    - *SO_2*
    - *NO_x as NO_2*
    - *VOC (NMVOC excl. solvents and CH_4 excl. CH_4 from landfills)*
    - *CO*
    - *PM - Particulate matter (incl. dust)*
    - *N_2O excl. use of products and N from agriculture and wastes*
    - *NH_3 excl. N from fertilisers*
    - *CFCs and Halons*
- ***Waste landfilled***
    - from private households (and household-type waste from industry and commerce)
    - from industry and commerce (production waste and construction/demolition waste)
    - from waste and waste water management activities (sewage sludge, etc.)
- ***Emissions to water***
    - Nitrogen (N)
    - Phosphorus (P)
    - Other substances and (organic) materials
    - Dumping of materials at sea

Dissipative use of products and dissipative losses

- ***Dissipative use of products***
    - Dissipative use on agricultural land
        - *Mineral fertilisers*
        - *Farmyard manure*
        - *Sewage sludge*
        - *Compost*
        - *Pesticides*
        - *Seeds*
    - Dissipative use on roads (thawing and grit materials)
    - Dissipative use of other kind (incl. solvents)
- ***Dissipative losses***
    - Abrasion (tyres, etc.)
    - Accidents with chemicals
    - Leakages (natural gas, etc.)
    - Erosion and corrosion of infrastructures (roads, etc.)

Exports* (detailed classification is the same as for imports)

Memorandum items for balancing**

- ***Water vapour from combustion (H_2O)***
    - From water (H_2O) contents of fuels
    - From hydrogen (H) contents of fuels
- ***Water evaporation from products***
    - Water content of biomass
    - Water content of other materials
- ***Respiration of humans and livestock***
    - CO_2
    - Water vapour (H_2O)

Disposal of unused domestic extraction (same detailed classification as for unused domestic extraction)

Indirect flows associated to exports (same detailed classification as for indirect flows associated to imports)

Notes:
Soil erosion could be shown as an optional memorandum item of disposal of unused domestic extraction and unused extraction associated to exported products but is not to be included when compiling indicators.

* .... Export data should be organised at the same level of detail as imports to the extent possible, to allow compilation of physical trade balances by material groups.

** .... Memorandum items for balancing are not to be included when compiling indicators.

3.7 Classification of material stocks and stock changes

3.83 Stocks in the context of economy-wide MFA and balances are mainly man-made fixed assets. They are classified by main categories into Infrastructures and buildings and Other stocks (machinery, vehicles, durable goods, etc.). Experience suggests that infrastructures and buildings usually represent more than 90% of the total physical stock and stock changes measured in tonnes (see also Table 1 above). In the following, the stocks and changes in stocks related to human bodies and livestock, cultivated forests and controlled landfills are not described (see section 3.2 for details).

3.84 Stock changes result from the material flows to and from the stocks (additions and removals) during the accounting period. Additions to the stock of infrastructures and buildings would be construction materials for new constructions or renewal, and removals would be construction and demolition wastes (and dissipative losses by corrosion and abrasion of infrastructures and buildings). In the case of machinery, vehicles and similar durable goods, additions would be new machines or new parts, removals would be the wastes from discarding these durable goods. Demolition waste recycled and used for new constructions should be included under both gross additions and removals, leaving the net additions unaffected. Removals could also be due to e.g. the export of second-hand durable goods or abandonment of buildings but these flows may not be significant in practice.

Table 9: Classification of material stock changes

Total (gross) additions
- ***Infrastructures and buildings***
  - construction minerals
  - metals
  - wood
  - other construction materials
- ***Other (machinery, durable goods, etc.)***
  - metals
  - other materials

Removals (incl. losses)
- ***Infrastructures and buildings***
  - by demolition
    - construction minerals
    - metals
    - wood
    - other materials
  - by dissipative loss
    - construction minerals
    - metals
    - wood
    - other materials
- ***Other (machinery, durable goods, etc.)***
  - by discard
    - metals
    - other materials
  - by dissipative loss
    - metals
    - other materials

Net additions to material stock (gross additions minus removals)
- ***Infrastructures and buildings***
  - construction minerals
  - metals
  - wood
  - other materials
- ***Other (machinery, durable goods, etc.)***
  - metals
  - other materials

4. Indicators derived from the accounts

4.1 Indicators derivable from the accounts

4.01 A set of indicators can be derived from the material balance (see Figure 9 in section 3.4) so as to provide an aggregate picture of the 'industrial metabolism'. These indicators can be grouped into input, consumption and output indicators. The set of main indicators is briefly characterised below. More indicators could be derived from the accounts, e.g. by setting the boundaries of the accounts differently or by compiling indicators per material group. Most of the indicators listed below, taken individually, can be derived from individual economy-wide MFA (see the sequence of accounts presented in chapter 6) without the need to compile a complete material balance and without the need to introduce memorandum items for balancing. For presentational purposes it is useful to relate these indicators to socio-economic indicators such as GDP or population.

4.02 The terminology for the indicators follows the terms already widely used (see e.g. Adriaanse et al 1997, EEA 2000a and Matthews et al 2000). However, the names of the indicators are not in all cases easy to understand. When publishing results of economy-wide MFA and balances, deviations from the proper indicator names may be justified. Indicator names used for publication purposes should be easily understandable and self-explanatory, in particular when the target audience is a wider public. For example, all indicator names should include the term 'material'. Terms such as 'direct', 'domestic' or 'processed' may not be necessary in all circumstances. For the benefit of advanced users and to allow international comparisons, the proper indicator names and their definitions should be included in a footnote or the methodological notes in publications.

4.03 It is not yet clear which of the indicators will be considered the most relevant and useful in the longer term. Only future use in analysis can provide a sound basis for such recommendations. The choice of the most relevant indicators will depend on the policy focus and on proven usefulness and applicability of indicators in policy analysis. Policy analysis and policy application of resource use indicators is, however, only just developing. At this stage, only a set of criteria for the selection of indicators can be offered:

- Ease of understanding the meaning of an indicator;
- Ease of compilation;
- Data availability;
- Compatibility with the national accounts;
- Potential for policy uses;
- Completeness of the indicator.

4.04 At present it appears that good candidates for core indicators would be the input indicators DMI and TMR as well as the consumption indicators DMC and, maybe, TMC (the latter being difficult to estimate because of the need to estimate also indirect flows associated to exports). NAS and PTB may be interesting supplementary indicators. These indicators are put in bold below. Further considerations on indicator interpretation and selection are presented in section 4.2.

4.05 'The Weight of Nations' (see Matthews et al 2000) documents the feasibility and usefulness of output indicators. However, the availability of primary data for regularly compiling output indicators is currently more limited than for input indicators (e.g., data on waste disposal and emissions to water are often incomplete – see Schütz and Bringezu 1999).

Input indicators

Direct Material Input (DMI) – measures the direct input of materials for use into the economy, i.e. all materials which are of economic value and are used in production and consumption activities; DMI equals domestic (used) extraction plus imports. DMI is not additive across countries. For example, for EU totals of DMI the intra-EU foreign trade flows must be netted out from the DMIs of Member States.

Total Material Input (TMI) – includes, in addition to DMI, also unused domestic extraction, i.e. materials that are moved by economic activities but that do not serve as input for production or consumption activities (mining overburden, etc.). Unused domestic extraction is sometimes termed 'domestic hidden flows'. TMI is not additive across countries.

Total Material Requirement (TMR) – includes, in addition to TMI, the (indirect) material flows that are associated to imports but that take place in other countries. It measures the total 'material base' of an economy. Adding indirect flows converts imports into their 'primary resource extraction equivalent'. TMR is not additive across countries. For example, for EU totals of TMR the intra-EU trade and the indirect flows associated to intra-EU trade must be netted out from the TMRs of Member States.

Domestic Total Material Requirement (domestic TMR) – includes domestic used and unused extraction, i.e. the total of material flows originating from the national territory. Domestic TMR equals TMI less imports. Domestic TMR is additive across countries.

Consumption indicators

Domestic material consumption (DMC) – measures the total amount of material directly used in an economy (i.e. excluding indirect flows). DMC is defined in the same way as other key physical indictors such as gross inland energy consumption. DMC equals DMI minus exports.

Total material consumption (TMC) – measures the total material use associated with domestic production and consumption activities, including indirect flows imported (see TMR) but less exports and associated indirect flows of exports. TMC equals TMR minus exports and their indirect flows.

Net Additions to Stock (NAS) – measures the 'physical growth of the economy', i.e. the quantity (weight) of new construction materials used in buildings and other infrastructure, and materials incorporated into new durable goods such as cars, industrial machinery, and household appliances. Materials are added to the economy's stock each year (gross additions), and old materials are removed from stock as buildings are demolished, and durable goods disposed of (removals). These decommissioned materials, if not recycled, are accounted for in DPO (see below).

Physical Trade Balance (PTB) – measures the physical trade surplus or deficit of an economy. PTB equals imports minus exports. Physical trade balances may also be defined for indirect flows associated to Imports and Exports.

Output indicators

Domestic Processed Output (DPO) - the total weight of materials, extracted from the domestic environment or imported, which have been *used in the domestic economy*, before flowing to the environment. These flows occur at the processing, manufacturing, use, and final disposal stages of the production-consumption chain. Included in DPO are emissions to air, industrial and household wastes deposited in landfills, material loads in wastewater and materials dispersed into the environment as a result of product use (dissipative flows). Recycled material flows in the economy (e.g. of metals, paper, glass) are not included in DPO. An uncertain fraction of some dissipative flows (manure, fertiliser) is 'recycled' by plant growth, but no attempt is made to estimate this fraction and subtract it from DPO.

Total Domestic Output (TDO) - the sum of DPO, and disposal of unused extraction. This indicator represents the total quantity of material outputs to the environment caused by economic activity.

Direct Material Output (DMO) - the sum of DPO, and exports. This indicator represents the total quantity of material leaving the economy after use either towards the environment or towards the rest of the world. DMO is not additive across countries.

Total material output (TMO) - measures the total of material that leaves the economy. TMO equals TDO plus exports. TMO is not additive across countries.

4.06 The indicators presented above are linked by accounting identities. In particular:

- DMC (domestic material consumption) = DMI (i.e., domestic extraction (used) plus Imports) minus exports = domestic extraction plus PTB;
- TMC (total material consumption) = domestic extraction (used and unused) plus imports plus indirect flows imported minus exports minus indirect flows exported.

4.07 Introducing the appropriate memorandum items for balancing on the input and the output side, the following accounting identities also hold. Indicators with the subscript i include the appropriate input memorandum items for balancing. Indicators with the subscript o include the appropriate output memorandum items for balancing.

- DMI_i (direct material input) = DPO_o (domestic processed output) plus NAS (net additions to stock) plus Exports = DMO_o (direct material output) plus NAS;
- DMC_i (domestic material consumption) = DPO_o (domestic processed output) plus NAS (net additions to stock);
- TMI_i (total material input) = TMO_o (total material output) plus NAS;
- NAS = DMC_i minus DPO_o.

4.08 NAS may be calculated indirectly as the balancing item between the annual flow of materials that enter the economy (DMI), minus exports, minus DPO, taking into account the appropriate memorandum items for balancing. This method is not necessarily very reliable (for details see section 5.4). NAS may also be calculated directly as gross additions to material stocks, minus removals (such as construction and demolition wastes and disposed durable goods, but excluding materials recycled).

4.09 On the input side the two components of physical consumption (DMC) are domestic extraction and the physical trade balance (PTB). On the output side the two components of DMC are the materials accumulated domestically (NAS) and disposed of in the environment (DPO - taking account of the appropriate memorandum items for balancing). These two components of DMC are the physical analogy to final use categories in national accounts (capital formation and final consumption) but there is no direct relation between the components of DMC and the concepts of capital formation and final consumption in the national accounts. Also, physical consumption should not be confused with e.g. materials delivered to households for final consumption. Waste and emissions arise in industries during production (for exports and for domestic intermediate or final use) as well as during consumption. Physical stock increases may take place in all institutional sectors (including new consumer durables purchased by households).

4.2 Interpretation and selection of indicators

4.10 Resource use and resource efficiency has emerged as a major issue for long-term sustainability and environmental policy at EU and Member States level. Objectives include to substantially increase the resource efficiency of the economic system, thereby reducing the use of natural resources and the related negative impacts on the environment. Two main themes have been identified as policy relevant: the ‘total quantity used’ and the ‘efficiency in use’. This implies that the resource issue should be analysed in terms of ‘resource efficiency or productivity’ - a main current policy focus - and in terms of absolute use levels and the ‘scarcity’ of resources. Domestic Material Consumption (DMC) or Total Material Requirement (TMR) were considered good indicators by the EPRG (Environmental Policy Review Group) at its meeting in Lisbon in April 2000 but more practical experience will be needed before final decisions can be made.

4.11 Certain characteristics of indicators are already known. For example, TMR includes indirect flows associated with imports so as to signal the impacts on other countries. However, this means that materials are included in the indicators of both the exporting and the importing country. For example, the TMR of the EU would be different from the sum of Member States’ TMR and may show quite different trends. In the following, aspects of indicator interpretation and selection are discussed and some preliminary conclusions offered.

Relation to national accounts aggregates

4.12 As resource indicators are typically related to GDP at constant prices to show trends in resource productivity (efficiency), it is useful to compare the way resource use indicators are constructed with the way GDP is defined. GDP can be defined in several ways. Briefly, as the sum of gross value added (output minus intermediate consumption), as the sum of final uses (i.e. excluding intermediate consumption and imports) and as the sum of primary income distributed by resident units.

4.13 In the economy, as materials are processed, and goods and services produced, value added is generated along the production chain. The monetary unit value of materials generally increases when they move from raw materials to semi-manufactured to final products. After final use, the value of materials tends to become very small (recyclable waste and scrap) or negative (waste and emissions). At the same time, the amount of useful material gets reduced along the production and consumption chain due to the losses (wastes and emissions) at each transformation stage. In general, as value is added, material is 'used up' and the material content of products is reduced. Also, the standard circular model of the economy shows that money and physical goods (or labour) flow in opposite directions in economic transactions (hence, e.g., physical exports of products are an 'import' of money).

4.14 The closest parallel to material flow accounting can be established for the calculation of GDP as the sum of final uses. The textbook formula for this is GDP = C+I+X-M, with C for final consumption of households and government, I for investment (gross capital formation), X for exports and M for imports. Imports are deducted in this formula whereas for material input indicators imports are added, and for DMC and TMC exports are deducted. This is because physical and money flows have opposite directions.

4.15 However, the physical economy does not always strictly parallel the economy as described in the national accounts so that direct relations between physical and monetary data require care. For example:

- consumer durables are treated as final consumption in the national accounts - adding final consumption expenditure on consumer durables to the gross capital formation is an option to make the physical and monetary figures more comparable (see e.g. Stahmer et al 2000);
- gross capital formation includes non-physical items (such as software) so that the result of any comparison would be the average physical intensity of capital formation, influenced by structural changes in the composition of capital formation;
- there is no direct correspondence between the consumption of fixed capital (depreciation) and the physical discard of capital goods (see e.g. Smith 1995).

4.16 The consumption indicators presented above are therefore the closest equivalents to national accounts aggregates (GDP, NDP or gross capital formation, as the case may be). Domestic Material Consumption (DMC) or Total Material Consumption (TMC) are best integrated with macroeconomic performance indicators such as GDP and better suited for calculating overall efficiency or productivity measures in which the numerator and denominator are consistent. Also key energy indicators such as Gross Inland Energy Consumption are consumption indicators.

4.17 Adding up input indicators that include imports (DMI, TMI, TMR) across countries leads to double-counting. For these indicators, the better correspondence to national accounts aggregates is to add imports also to the denominator, e.g., TMR/(GDP+M). For details see e.g. Moll et al (1999) and Femia et al (1999).

Relation between input and consumption indicators

4.18 The difference between input and consumption indicators can be of practical importance, especially for small economies. Figures 10 and 11 below illustrate the trends in resource productivity (efficiency), measured as GDP at constant prices generated per tonne of material consumption (TMC and DMC) and compared with GDP per tonne of material input (TMR and DMI) for Finland and Austria. The figures illustrate that efficiency increases are higher when compiled on the basis of consumption indicators, and the gap widens over time. One likely reason for this is that both imports and exports of materials have grown fast over the past decades, due to trade liberalisation and EU accession (internal market). Specific factors may magnify trade-induced biases, e.g., the 'Rotterdam effect' in the case of the Netherlands (see Adriaanse et al 1997).

4.19 Table 10 below shows preliminary estimates of DMC for EU Member States and for the EU. The table also shows the distance between DMI and DMC and how this distance has evolved over time. As could be expected, for the EU as a whole the difference between DMI and DMC is small and does not change much over time, whereas for small economies the differences tend to be more important (and increasing).

Table 10: Comparison of DMI and DMC for the EU

DMC in tonnes per capita, 1997	
P	12.6
I	13.8
NL	15.4
UK	15.7
EL	18.1
F	18.2
B/L	18.3
EU 15	18.8
A	19.5
D	20.7
E	21.9
S	27.3
DK	27.6
FIN	35.3
IRL	40.3

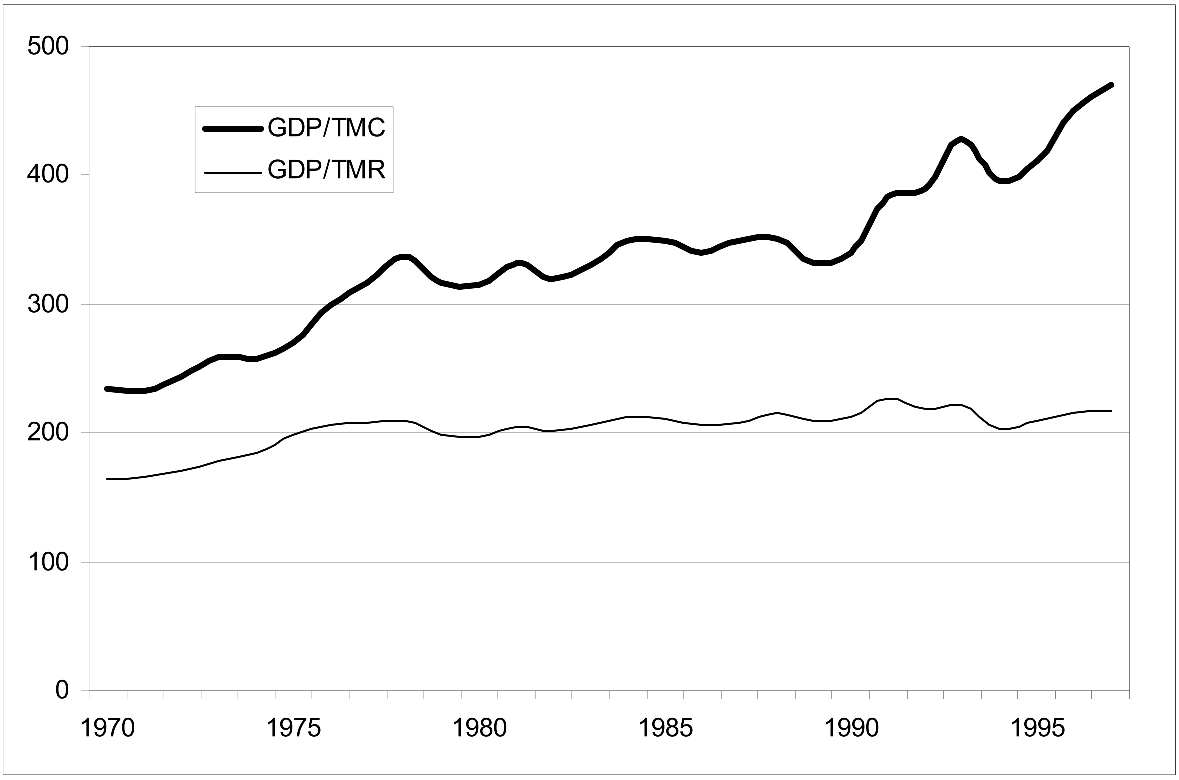
DMI in % of DMC, 1997	
EU 15	105.5
IRL	107.7
E	109.7
EL	112.0
P	112.0
I	113.8
D	114.1
F	116.9
FIN	119.2
A	120.1
UK	120.1
DK	123.9
S	129.3
B/L	180.2
NL	187.8

Increase in distance DMI – DMC between 1980 and 1997, in %	
EU 15	1.5
E	3.2
EL	3.7
IRL	3.8
F	4.3
D	4.5
I	5.9
P	6.9
UK	7.2
A	8.7
DK	11.8
FIN	11.9
NL	15.8
S	17.7
B/L	22.6

Source: Eurostat and Wuppertal Institute 2000, results are preliminary estimates

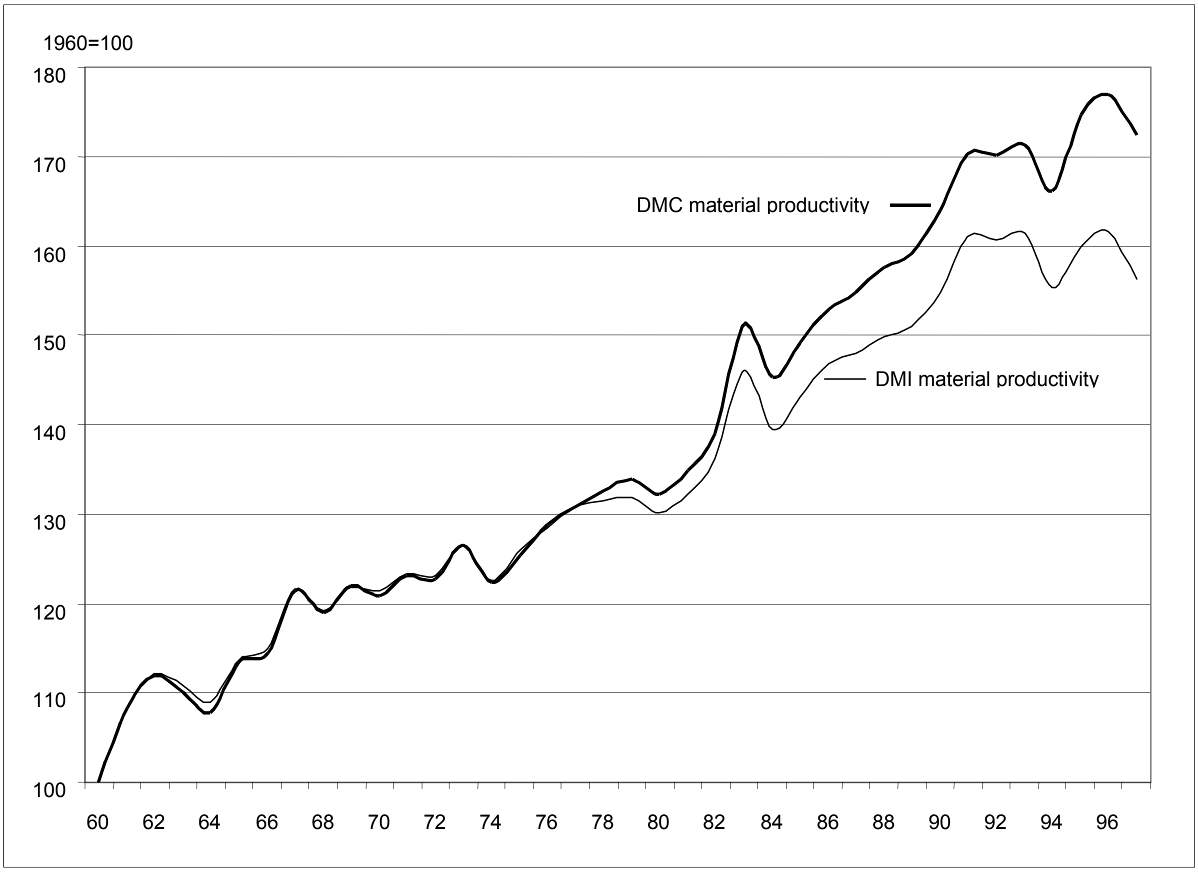
4.20 There may also be other factors that must be taken into account when interpreting indicators. Figure 12 shows the physical trade balance as well as imports and exports for the UK – the increase in physical exports (and decrease in imports) in the 70s/early 80s being due to increasing domestic extraction of North Sea oil.

Figure 10: TMC and TMR efficiencies of the Finnish economy 1970 - 1997, euro per tonne



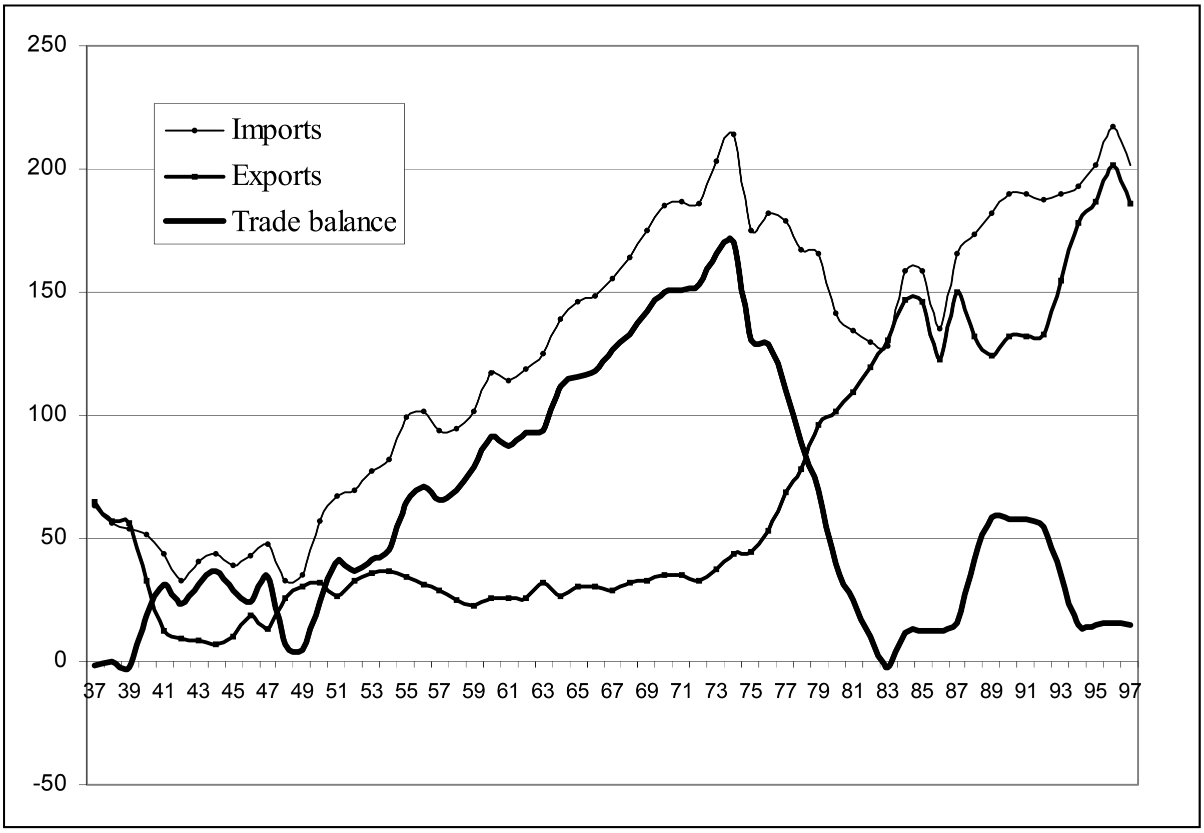
Source: Mäenpää and Juutinen (2000)

Figure 11: Material productivity of the Austrian economy 1960 - 1997, index 1960=100



Source: Gerhold and Petrovic (2000)

Figure 12: The physical trade balance of the UK economy, 1937 - 1998, in million tonnes



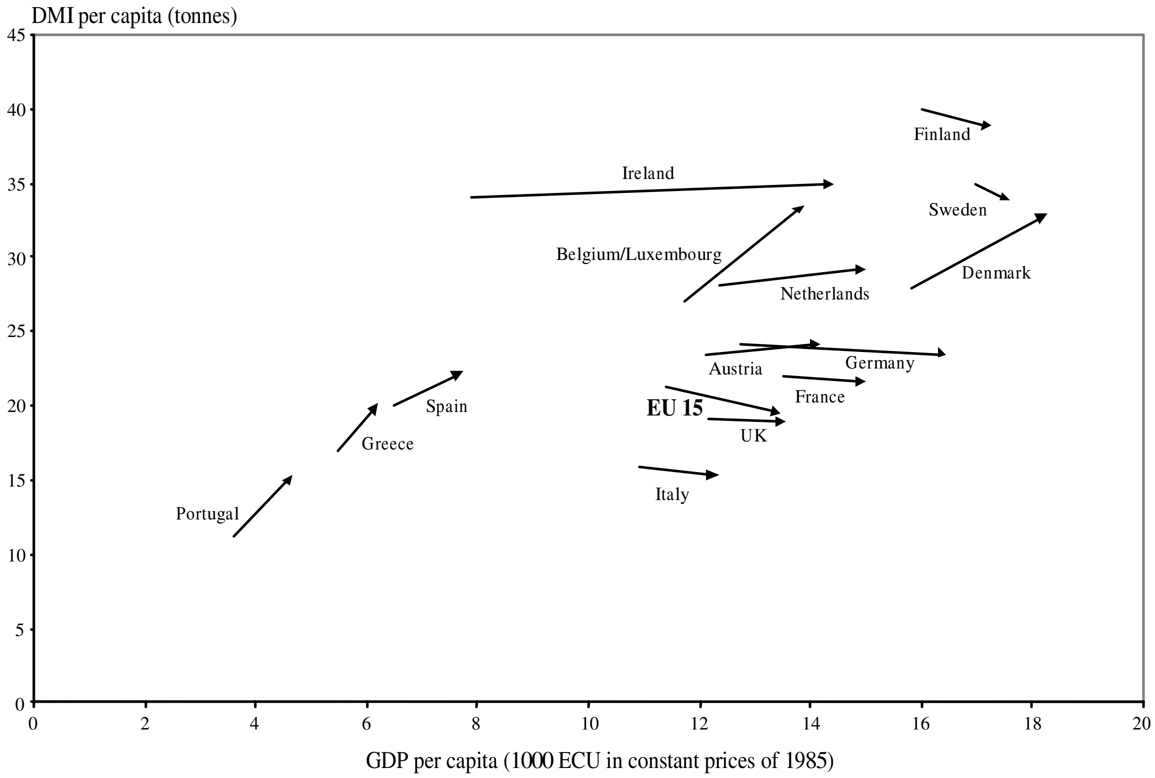
Source: Eurostat calculation based on Schandl and Schulz (2000)

Comparisons across countries and future research needs

4.21 Apart from ensuring comparability of data sets across countries, more research will be essential to guide interpretation of indicators in future. This includes research into the precise meaning of the various indicators and their relation to key socio-economic indicators, more experience with analytical applications and analysis and improved understanding of the reasons for changes in the indicators. A first analysis can be found in Berkhout (1999). Analysis of the correlation between different indicators is highly relevant in this context. An example of such kind of analysis is presented in Figures 13 and 14 below.

4.22 Figure 13 shows DMI per capita in relation to GDP per capita for EU Member States and suggests that DMI is correlated to GDP but also that small (open) economies with their higher dependence on international trade tend to have a higher DMI per capita than larger economies. This in turn suggests that DMC would be the better indicator for comparison across countries as it neutralises the effect of economic size on trade.

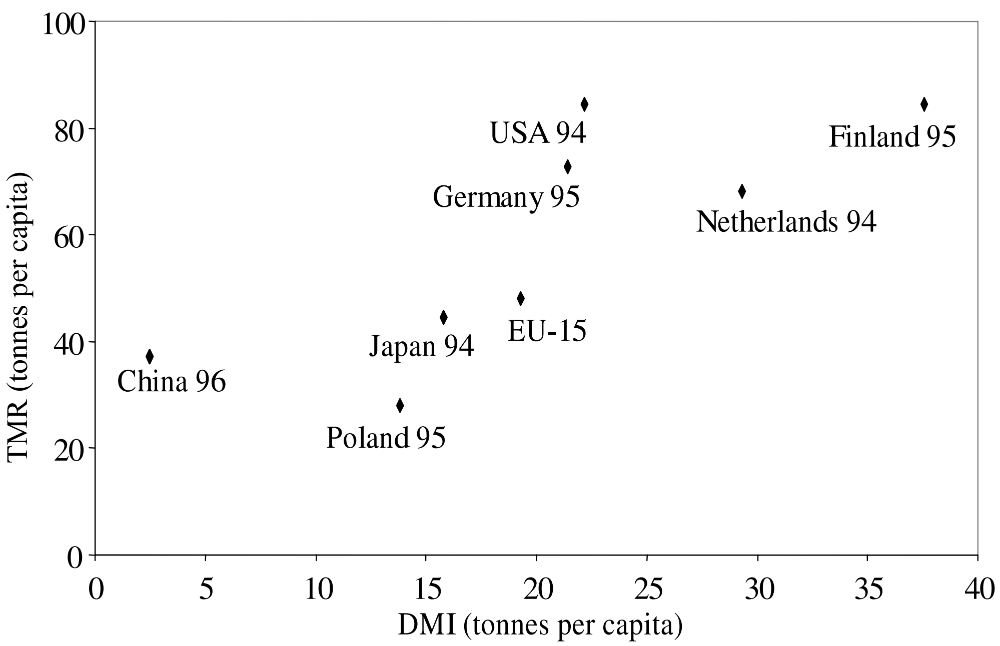
Figure 13: GDP and DMI per capita in EU-15 and Member States between 1988 and 1997



Note: DMI of Member States includes intra-EU trade, but EU-15 DMI does not.
Source: EEA (2000b)

4.23 Figure 14 shows TMR versus DMI per capita. While the data are not strictly comparable, Figure 14 suggests that DMI might be well correlated with TMR. If such a correlation can be proved in future, compiling DMI (or DMC) may be sufficient to monitor progress towards better resource productivity on a regular basis. Such a minimum set of indicators could be coupled with additional accounts. For example, domestic TMR accounts may be used to monitor the burden of resource extraction on the country's own environment. In addition, data on physical trade and the associated indirect flows can be used to indicate the burden sharing and problem shifting between countries and regions.

Figure 14: TMR per capita in relation to DMI per capita



Source: EEA (2000b)

Preliminary conclusions

4.24 Some factors influencing the trends and structures shown by resource use indicators have been identified in this section but comparable data and analyses are still limited. More data, research and analyses of the factors underlying changes in indicators over time are needed before firm conclusions on indicator selection and interpretation and on the practical importance of country-specific factors can be drawn. At this stage, relatively little guidance can be given for the selection and interpretation of indicators. Some preliminary conclusions may be made:

- The input indicators measure the materials used/mobilised for sustaining economic activity (incl. production for export) and are more closely related to the mode of production of a country;
- Consumption indicators are more closely related to the mode of consumption, are more stable over time and more comparable across countries. They can be added up across countries;
- Input indicators are more sensitive to the level of foreign trade, the changes in trade patterns and other specific factors (e.g., whether a country is an exporter of natural resources such as oil and gas or not);
- The difference between consumption and input indicators is an indication of the degree of integration of an economy with the global economy, which in turn tends to depend on the size of the economy;
- DMC measures the material that actually physically remains on the territory of a country, either as emissions and wastes or as an addition to the economic material stock. It thus has a particular relevance from a 'national' perspective;
- In general, including the indirect flows (at least the RME) gives a more comprehensive picture useful for assessing global effects;
- Differences across countries may be quite large. For example, small economies will tend to have relatively higher imports as well as exports than large economies which tend to be more self-sufficient physically. The specific role of a country in international trade can introduce a substantial bias (e.g., the 'Rotterdam effect', see above). Resource-poor industrialised economies will tend to have relatively large imports (and a substantial net import of materials). Countries that are main exporters of raw materials will tend to have very large domestic extraction and large exports;
- Indicators can be used to express "Material efficiency or productivity" (unit of GDP per unit of material indicator) or "Material intensity" (material indicator per GDP). Using 'efficiency/productivity' tends to be more common among economists and for comparison with other economic indicators whereas 'intensity' tends to be more commonly used by environmentalists;
- Output indicators (DPO, TDO, etc.) are also important but it has to be acknowledged that the data available are often less complete than for other indicators at present, and long time series are less likely to be available.

Table 11: A preliminary categorisation of indicators

	Input indicators	Consumption indicators	Comment
Total requirements (incl. unused extraction and indirect flows)	TMR	TMC	More related to global impacts such as resource extraction elsewhere and the effects of international trade
(Raw materials equivalents)	(RMI)	(RMC)	Not further developed in this Guide
Direct flows	DMI	DMC	More related to national policy and materials entering (DMI) and staying in the economy or released to the national environment (DMC)
Comment	More related to the mode of production (incl. for exports)	More related to residents' needs	

5. Data sources and methods

5.1 Accounting principles for material inputs and outputs

Units of measurement

5.01 Material inputs and outputs are counted with their reported (fresh) weights. This weight includes water contained in the materials (for example, the water content of timber, cereals and other biomass but also the water content of e.g. lignite or sand). It is possible to make supplementary accounts in dry weight (and it is necessary to identify the water content of material flows for establishing a full balance). For some special cases where reported data must be complemented by estimates (e.g. fodder plants taken up by grazing livestock) it is recommended to convert these into a weight that is equivalent to that of products typically reported in statistics so as to render reported and estimated data comparable. This involves using a 'standardised water content'. For most bulk biomass materials (timber, cereals, hay) such a standardised water content will be around 15% of total product weight. Deviations from using reported actual weights should be clearly indicated.

5.02 Materials are usually reported with their actual (gross) weights. An exception are minerals where the metal or mineral content may be given instead of gross weight. In that case it has to be defined which grade (%) of the metal/mineral was contained in the crude material in order to account for the total crude ore or mineral mass (which is the direct material input).

5.03 Some units of measurement in primary data may be other than tonnes. Empirically this is mainly the case for wood, soil and some stones (all reported in cubic meters) and for natural gas and other gases (reported in cubic meters or in energy units such as Joules). Conversion coefficients are usually available nationally, for example, to convert natural gas in Terajoules (TJ) or in m3 to tonnes, or m3 of wood to tonnes. A first proxy for conversion coefficients may be derived from foreign trade statistics.

Flows not statistically captured

5.04 Some material flows are not statistically observed. Indirect flows associated to imports or exports are generally not available from official sources and must be estimated. For imports and exports the packaging materials are often not recorded by foreign trade statistics. For domestic extraction, all materials are counted as *direct* inputs (DMI) that have an economic use (including own use) but not all of these materials are actually marketed and appear in official statistics. The main categories of flows usually not captured by data sources are presented below.

5.05 Hay and feedstuff for animals may be traded or may be grown and harvested by farmers for own use. Most fodder plants grown, harvested and fed to livestock by farmers will be reported by agricultural statistics except fodder plants taken up by the grazing livestock which have to be estimated and included in biomass extraction. Estimates may be derived by analysing the agricultural land use and attributing a yield for grazing to the permanent pastures not reported to be harvested. This yield may by first approximation be assumed to be the same as for reported harvest of green biomass of a similar kind. Some other biomass harvested and used as feedstuff may not be reported directly by statistics. This concerns for example the leaves of sugar beet and fodder beet, and catch crops. When such data are not available, they may be estimated from known ratios of leaves to beets.

5.06 Data may be missing on own final use by households including wood harvested for own use (e.g. fuel wood) or mushrooms and berries picked by householders. Household panel data on heating materials used combined with forestry statistics may be used to estimate own final use of fuel wood. Estimates for the own final use of agricultural products by farmers (e.g., vegetables or cereals used for final consumption) exist in many countries as part of nutrition balances.

5.07 Ancillary extraction activities that are integrated within a single statistical unit are often not recorded. For example, the extraction of limestone for cement production or clay for brick making, when made as an integral part of one kind of activity unit (establishment) will lead to the output of cement or bricks being reported in statistics but not of the limestone or clay extracted. Also, construction enterprises may have sand or gravel pits for own use.

5.08 Extraction activities done by small-sized enterprises may not be covered by production enquiries. Reporting systems may use thresholds linked to the size of the statistical unit (e.g., surveys operated with a minimum limit of 10 or more employees may tend to exclude local gravel pits) or linked to small masses (e.g. harvest of wood or extraction of minerals below a certain area or volume limit does not have to be reported to administrative or statistical authorities). This is especially the case for sand and gravel and crushed stones or dimension stones. Alternative data sources may be available, e.g., publications of industrial associations. If there are none, or in order to check available data for consistency, the data may be estimated based on specific material requirements for documented production figures (e.g., sand and gravel needed for concrete production, or limestone required for cement production, or common clays needed for the production of bricks and tiles). Excavation materials may also be directly used on-site (gravel, sand or rock excavated and directly used for construction).

5.09 Excavation of earth for construction purposes is often not, incompletely or only sporadically reported by statistics. Data may be estimated based on coefficients for e.g. soil excavated per number of houses built or per km road constructed, or even per unit gross value added.

5.10 Unused domestic extraction and soil erosion (optional memorandum item) may not be available in many case and specific estimation procedures using coefficients may have to be developed or existing databases used (see also section 5.5).

5.11 The importance of such flows not captured by statistics may vary considerably across countries. An analysis of the units and activities not covered by statistical sources, combined with an analysis of the supply and use of selected materials (those most likely to show substantial undercoverage) will permit developing estimation procedures. For example, energy balances combined with household panel data on heating materials used and with forestry statistics will allow estimating own final use of fuel wood. Data on cement production combined with typical factors for raw material requirements (limestone, clay, etc.) will allow identifying non-captured extraction, combining livestock data with data on land use, land cover and soil types will allow estimating the biomass taken up by grazing cattle, etc.

Delimitation of categories of material flows

5.12 Material inputs also include unused domestic extraction, i.e. flows which are caused by generating direct flows but which are of no further economic use such as overburden of coal mining, timber felled but not removed from forests, etc. In the case of domestic extraction of ores (and also some minerals, especially phosphate and potash) it has to be decided which part of the total material extracted is counted as used extraction (contributing to DMI) and which is counted as unused extraction. Three ways of accounting for domestic extraction of ores may be considered: as crude ore, as concentrate or as metal content. In this Guide it is recommended to base the accounts on the ‘run of mine’ concept and to always account for the crude ore (see also Isacsson et al. 2000). If primary data are only available for concentrates (e.g. due to vertical integration of the industry), these should be converted back to the crude ore equivalent. Crude ore extracted should be considered a direct material input and part of DMI and DMC.

5.13 On the material output side to the environment all materials are counted that are released to air, land or water so that man loses control over the location and composition of the materials released. Therefore, any subsequent emissions like methane (CH_4) from landfilled waste are not (double) counted under material outputs. The information, however, may be kept in the database to evaluate further environmental impacts resulting from the atmospheric emission of e.g. methane.

5.14 Domestic unused extraction on the input side is also completely counted under disposal of unused domestic extraction on the output side. This holds even if waste landfilled contains unused domestic extraction like soil excavated by construction activities. In that case, the amount of soil excavation or other unused extraction is deducted from the amount of total waste landfilled and counted under disposal of unused domestic extraction. This procedure is proposed in order to be consistent with the accounting of direct material flows and unused extraction on both the material input and output side.

Material recycling

5.15 Recycling of materials refers to the definitions and data available from official waste statistics. Recycling may be further characterised by material types such as metals, plastics, construction materials etc. Recycling flows are not part of the material balance (they are neither counted as inputs nor as outputs, except as part of imports or exports or the net addition to stock). The main purpose for monitoring recycling flows is to ensure that double counting is avoided. Separate recording of recycling and the derivation of indicators (e.g. ratio of recycled materials to material inputs or outputs) may be interesting but does also pose problems. First, data on materials recycled within statistical units are not normally available. Second, the definition and measurement of recycling flows is difficult. Further work on recycling may be useful but it is not recommended making recycling accounts part of a standard set of economy-wide MFA at present.

5.2 Data sources and methods for material inputs

Data sources for material inputs

5.16 Material inputs (excluding water and air) are domestic extraction (used and unused), imports and indirect flows associated to imports. Together, these make up the total material requirement (TMR) of the economy. For domestic extraction, the sum of these material inputs for individual Member States results in the EU total. A specific situation arises for imports where this is not the case. Due to the system boundary definition imports by individual Member States comprise both Intra-EU trade and Extra-EU trade, whereas imports of the EU as a whole comprise Extra-EU trade only.

5.17 Main data sources for material inputs include:

- forestry statistics and accounts (timber harvested and removed, other products of forestry, supply and use tables of wood, etc.);
- agricultural statistics (cereals, vegetables, hay, etc.);
- industry/production statistics (extraction of fossil fuels, crude ores, industrial and construction minerals, identification of recycled materials);
- energy statistics and energy balances (extraction of fuels and estimation of oxygen demand);
- statistics of foreign trade (imports);
- supply-use tables and input-output tables (accounts for individual product groups);
- estimates: e.g. air inputs may be estimated based on combustion of fossil fuels.

5.18 The most important industries involved in domestic material extraction are (with reference to NACE Rev. 1):

- Agriculture, hunting and related activities (NACE 01;
- Forestry (NACE 02;
- Fishing (NACE 05;
- Mining and quarrying of coal and lignite, extraction of peat (NACE 10;
- Extraction of crude petroleum and natural gas (NACE 11;
- Mining of uranium and thorium ores (NACE 12;
- Mining of metal ores (NACE 13;
- Other mining and quarrying – stone, slate, sand, clay, gravel, salt, etc. (NACE 14;
- Manufacture of other non-metallic mineral products – glass, bricks, cement, etc. (NACE 26);*
- Electricity, gas, steam and hot water supply (NACE 40);**
- Collection, purification and distribution of water (NACE 41);**
- Construction (NACE 45).*

* ...... Mainly useful to identify ancillary extraction including for establishing supply-use tables of materials.

** ..... Useful for compiling water accounts.

5.19 These data sources may be complemented by more specific sources such as reports and statistics produced by associations of enterprises, ministries of mining, trade and industry, agriculture and fisheries, geological institutes, etc. Most of the data will be available for direct material inputs, maybe less for unused extraction and no direct sources are available for indirect flows associated to imports.

Direct Material Inputs – specific issues

Fossil fuels

5.20 *Fossil fuels* are counted in this group whether they are used as energy sources or not, except when clearly indicated (e.g. peat for agricultural use is excluded from fossil fuels). Empirically, non-energy use is negligible except for crude oil. The quantitative use of fossil fuels for non-energy purposes can be taken from energy statistics. The energetic use of fossil fuels is generally well documented in energy statistics. In Germany, for example, even the specific use of imported (vs. domestic) hard coal (as well as briquettes and coke) is documented. In a strict sense, also oil shale and peat for combustion should be counted in this group.

Non-metallic minerals (industrial and construction minerals)

5.21 Non-metallic mineral raw materials comprise two subgroups, *industrial minerals* and *construction minerals*. They are clearly differentiated from minerals for production of metals (metal ores) and from minerals for the generation of energy (fossil fuels). However, the distinction between industrial minerals and construction minerals is not always clear, especially because one type of mineral may be used in an industrial process (e.g. limestone for the production of fertiliser by the chemical industry) or for construction purposes (e.g. limestone used as an aggregate directly for construction or used for the production of cement). A pragmatic approach is to consider industrial minerals as those which are not bulk materials for construction purposes. Care has to be taken that minerals grouped under industrial minerals are not double counted under construction minerals (e.g. basaltic lava under natural stones, clay for pottery under clay for bricks, and limestone for fertiliser under limestone for construction).

5.22 *Construction minerals* are bulk materials, used directly or indirectly for structural and civil engineering. For pragmatic reasons, only the bulk material flows for construction are counted in this group. These are mainly natural stones (including limestone for cement making), sand and gravel, and clay for bricks. Information on the use of sand and gravel, crushed stone, dimension stone or clay for construction purposes versus other uses is often not available (see e.g. Bergstedt and Linder 1999 for a description of the sand and gravel MFA for Sweden).

5.23 Experience suggests that there is often some risk of double counting related to domestic extraction of bulk materials. For example, reported total extraction of sand and gravel may or may not include sands for industrial use, total clay may or may not contain special clays such as kaolin, total crushed or dimension stones may or may not include specific stones also recorded separately (such as green sandstone etc.). One reason can be parallel reporting of enterprises to different organisations (ministry of mining, statistical office, geological survey, industry association) with overlapping coverage. For example, limestone production for cement making may be reported under limestone and total dolomite extraction under crushed or dimension stones.

5.24 Double counting may also arise from the accounting for unused extraction. In some cases the extraction wastes reported for one mineral may be further used for the production of a second mineral. For example, in Germany a large part of silica and pegmatite sands are produced from the unused extraction related to kaolin production. The unused extraction related to kaolin should comprise only materials not further used, whereas the silica and pegmatite sands extraction should include primary extraction from specialised quarries as well as the (secondary) production from kaolin quarries.

Biomass

5.25 All (domestic) biomass is counted which is reported by agricultural harvest statistics, logging statistics, fishery statistics and hunting statistics. In addition, the input of biomass by grazing of animals can be taken from feedstuff statistics or can be estimated based on land use or nutrition balances of livestock. Feedstuff statistics will often also report on domestic biomass inputs of sugar and fodder-beet leaves, and of catch crops. Internationally, a great part of biomass input can be taken from the website of the Food and Agriculture Organization (FAO - http://apps.fao.org).

Imports

5.26 Recorded is the mass of commodities that cross the economy's border. The basis of the accounting of imports and exports is the official foreign trade statistics which gives data in monetary as well as physical units. Foreign trade statistics reports the net weight of traded commodities, excluding the weight of packaging materials. In the European Council and Commission Regulations on intra-EU trade statistics (Intrastat) the net weight is defined as 'the actual mass of the good in kilograms excluding all packaging'. In practice, finished products may be recorded as they are sold in the shop. In the case of marmalade, for example, this would include the weight of the glass jars. Possible sources of data on packaging materials are the studies and analyses undertaken in Member States to fulfil the reporting obligations of the EU Packaging Directive.

5.27 Traded commodities are aggregated into material groups such as fossil fuels, metals etc. (see classification of imports). The individual materials or material groups should be recorded as far as feasible by countries of origin so as to provide a basis for the estimation of indirect flows. Country-specific information may be especially useful:

- with respect to high volume flows (crude oil, iron ore, etc.);
- with respect to high indirect flows of imports (e.g., gold or tin ore);
- with respect to land use for agricultural commodities.

5.28 Such data can be very useful in providing a basis for estimating indirect flows associated to imports but also for other purposes. For example, the magnitude of agricultural land occupied abroad for national consumption can be estimated. For many EU countries the arable land they 'occupy' in other countries can be substantial. For example, it was estimated by Sachs et al. (1998), that German consumption of agricultural products is based on a considerable net claim to farming areas in other countries. In addition, land use data are the basic information needed to account for associated (optional) ecological rucksacks such as soil erosion. Based on information specific to the country of origin, data of the quantity of indirect flows associated with commodity flows can be applied. For Germany, the Wuppertal Institute concentrated on the non-saleable fractions of primary materials extraction and erosion for agricultural products. Alternatively, the data for domestic material extraction and biomass harvest/land use can be used to estimate indirect flows of commodities imported (however, this assumes similar geological, soil and climate conditions in the countries of origin, and similar technologies being employed – evidence suggests this assumption can be highly misleading).

Other flows – specific issues

Erosion of arable land

5.29 *Erosion of arable land* may be included as a memorandum item in the accounts. Erosion may be estimated using average coefficients except for maize and root crops which may make the soil more prone to erosion and in addition lose attached soil by harvest and transport. Detailed erosion models, taking account of slope, exposure to wind and crop types may be used when available. For the compilation of indicators, soil erosion is not to be included.

Inputs of Air (O_2, N_2)

5.30 This category is needed as a balancing item and comprises mainly the (domestic) input of oxygen (O2) which relates to the emission of oxidised materials (CO2, CO, NO2, SO2, H2O from H in hydrocarbons) from the components (C, N, S, H) of combusted fossil fuels. Oxygen demand for combustion can be estimated stochiometrically from the air emissions resulting from combustion. In a further step the oxygen already contained in the energy carriers may be taken into account, and deducted from the oxygen input calculated from the emissions. Analogously to the combustion of energy carriers, the input of oxygen to the consumption of food (energy) by humans and domestic animals (in agriculture and in private households) may be accounted for. Finally, the domestic chemical industry produces technical gases (e.g., N2 and O2) which are based on a real input of air (e.g. by liquefaction).

Indirect flows of imports

5.31 The status of the accounting of indirect flows of imports can be summarised as follows:

- they have been estimated/determined for some raw materials and semi-manufactured products but, so far, hardly for any finished products;
- country-specific data are available especially for some imported raw materials from agriculture, fossil fuels, metals and some other minerals;
- indirect flow coefficients may be taken from available studies (e.g., for Japan, Netherlands, Finland, Sweden, Poland, UK, USA, Brazil, Venezuela, etc.) or from general databases available e.g. at Wuppertal Institute (see also section 5.5).

5.3 Data sources and methods for material outputs

Data sources for material outputs

5.32 The main material output categories are emissions to air or water, landfilled waste, dissipative use of products and dissipative losses, unused domestic extraction and exports. Together they sum up to the total material output (TMO). The sum of TMO of EU Member States does not equal TMO of the EU.

5.33 Statistical sources for the accounting of material outputs include the following:

- Environmental accounts (especially NAMEAs with air emissions, waste, etc.);
- environment statistics (for several output flows including air emissions, solid waste disposal, waste water, and partly for recycling);
- agricultural statistics (dissipative use of products on agricultural land such as fertiliser);
- statistics of foreign trade (exports);
- energy statistics (domestic consumption of energy carriers to account for additional emissions not reported in emission inventories).

5.34 Some flows will always have to be estimated (e.g., emission of water vapour from the combustion of fuels), and data gaps filled by estimates (e.g., waste disposal for years not covered by official waste statistics).

Material outputs – specific issues

Waste disposal in controlled landfills (excluding incineration)

5.35 This category comprises wastes disposed of in controlled landfills. Any „wild“ dumping – if important - should be presented as a separate category of material output. Households may compost organic materials previously purchased (i.e., biomass that was recorded on the input side). Such composting is usually not recorded in statistics. If important, an estimate would have to be added on the output side. In order to account for the contribution to DPO (domestic material output to land), unused domestic extraction (soil excavation and extraction wastes) included in waste data should be subtracted here and counted under the disposal of unused domestic extraction. This also includes garden waste contained in recorded (organic) waste flows. Dumping of unused extraction at mines and quarries is also excluded from this category (for example slag heaps).

5.36 Activities of landfilling wastes concern public landfills, landfills owned by industry, and commercial (or private) landfills. It is useful to disaggregate waste landfilled by type, at least separating household-type wastes, industrial and construction/demolition wastes. For household-type wastes it may be useful to differentiate between those from private households and household-type wastes from industry and commerce. Some other waste types may show an outstanding importance in some Member States (e.g., sewage sludge in the Netherlands), so the classification of outputs may be extended by (optional) waste categories.

5.37 Waste statistics may be incomplete. Empirically, this is most crucial for construction and demolition wastes. Specific data sources may be available for wastes imported or exported. Wastes are usually reported in fresh weights (including water content). Sewage sludge may be reported in dry weights. Waste outputs should comprise landfilled waste only. Waste incinerated should be represented under emissions to air. Any subsequent emissions from landfills such as methane should not be counted as an output (unless waste landfilled is considered an addition to material stocks). Changes in disposal routes (e.g., increasing amounts of waste are incinerated rather than landfilled) may pose problems to the interpretation of material output indicators. Wastes are reported in fresh weight but it may be difficult to determine the water content emitted to air by incineration.

Emissions to air

5.38 Emissions to air include:

- emissions from energy use and (non-energetic) industrial processes;
- emissions from energy use include (but show separately) emissions from international transport according to NAMEA conventions. When NAMEAs are not available, the international marine and aviation bunker fuels loaded in the economy studied as required under IPCC guidelines for submission to the Framework Convention on Climate Change may be used as a proxy. This procedure was for example used in the pilot UK environmental accounts (Vaze and Balchin 1998) and also in Matthews et al. (2000);
- in addition to common emission data also water vapour from the combustion of fuels is included for balancing purposes, but it is excluded from the output indicators. Water vapour stems from two components of fuels, from the hydrogen (H) in the fuels by oxidation and from the water (H_2O) content of solid fuels by evaporation. In the first case, also the corresponding input of oxygen (O_2) has to be taken into account for the material balance. Emission estimates can be based on standardised composition data for fuels;
- similarly, emissions resulting from the respiration of humans and livestock are included for balancing purposes, but they are excluded from the output indicators.

5.39 Emissions to air may be accounted by the following major categories:

- CO_2 total (combustion of energy carriers, non-energy sources and from respiration;
- SO_2;
- NOx as NO_2;
- VOC (NMVOC excl. emissions by use of solvents, CH_4 excl. CH_4 from landfills);
- CO;
- Dust;
- N_2O excl. N from agriculture and landfills and excl. N_2O from the use of products;
- NH_3 (excl. the amount which stems from fertiliser use);
- CFCs and Halons;
- H_2O from combustion and respiration (as memorandum items for balancing);
- Emissions of water vapour from materials (as memorandum item for balancing).

5.40 The data for the categories listed above will be available from the national NAMEAs or from national emission inventories, except for CO2 from respiration, H2O from combustion and respiration and water emissions from materials. Respiration outputs (carbon dioxide and water vapour) were first estimated for the physical input-output table for West Germany 1990 (Stahmer et al. 1998). It is recommended to set up a separate sub-account for fuels and air emissions to facilitate balancing.

Emissions to water

5.41 Statistical information on emissions of materials into water are usually incomplete. Data may exist on N and P emissions, BOD and COD and on a range of toxic substances. These may allow estimating the total material flows that go directly to water (e.g., via the sewage system). These emissions to water should be estimated after waste water treatment has occurred (e.g., sewage sludge may be landfilled, incinerated or used as fertiliser). Dredging of sediments from rivers (unused extraction) may move materials already accounted in emissions to water.

Dissipative use of products and dissipative losses

5.42 These material outputs refer to dissipative uses of products on agricultural land, on roads and for other purposes, and to dissipative losses by erosion and corrosion of infrastructures, by abrasion of car tyres and roads and by leakage. Data on products dissipatively used will often be available (fertiliser, pesticides, seeds, thawing materials etc.). Data on manure may be derived from coefficients per type of livestock, along with reference values for water contents. For material balances it is recommended to account for the dry weight of manure.

5.43 Data on dissipative losses will generally not be available. Abrasion of car tyres and breaks may be estimated based on the use of these products. The potentially much more important flows related to corrosion, abrasion and erosion of infrastructures must to be estimated based on expert knowledge. Dissipative losses open a wide field for research and up to now not much experience is available.

Exports

5.44 Official foreign trade statistics provide physical and monetary data on exports on an annual basis, using the same commodity structure as for imports. Hence, the same procedures as for imports apply. Estimating indirect flows associated to exports is still a matter of research and relatively little experience is available. In general, input-output techniques should be used for estimating indirect flows as illustrated e.g. by Mäenpää (1999) for Finland.

5.4 Data sources and methods for material stock accounting

5.45 In principle, the total amount of materials additionally stocked within the economy could be derived from well-balanced accounts of inputs and outputs as a residual item, i.e. as the difference between inputs and outputs. However, data on inputs and outputs are subject to uncertainties, *inter alia* due to:

- data inconsistencies (e.g., waste generation may differ from waste disposal of the same material);
- material properties (especially water contents of biomass, coal, etc.);
- risk of double counting (e.g., waste which is incinerated may be included under „waste disposal“ as well as under „emissions to air“);
- missing data and the uncertainties inherent in estimates of missing data (inputs not statistically captured, memorandum items for balancing, waste, waste water, etc.).

5.46 Hence, the derivation of stock changes as a residual item from total inputs and outputs risks lumping significant statistical discrepancies and real stock changes together (see also Muukkonen 2000). Even if the statistical difficulties can be overcome, the resulting single number for total material additionally stocked within the economy is not particularly useful without knowing the main material components and the major activities responsible for the stock changes.

5.47 Therefore it is recommended to estimate net additions to material stock (NAS) by separately estimating the flows that make up the net change (i.e., gross additions and removals from stocks). Ideally, a complete account of physical stocks would be set up in analogy to the national accounts balance sheets including reconciliation accounts that explain the changes between opening and closing stocks (see Table 12). If stocks cannot be estimated, the NAS may be derived by estimating only the gross additions and the removals.

Table 12: Physical stock account (in tonnes)

	Transport infrastructure	Buildings	Machinery	Other durables	Inventories*
Opening stock (1 January)					
Additions (gross)					
Removals (incl. discard and demolition)					
Losses (incl. due to corrosion & abrasion)					
Other incl. changes in classification					
Total net additions to stock					
Statistical discrepancy					
Closing stock (31 December)					

* excluding inventories of standing timber

5.48 It is recommended to set up separate accounts for infrastructure and buildings on the one hand and machinery and other durable goods on the other. The material categories that are most relevant for the stock under consideration (e.g., materials used in construction, demolition waste etc.) should be separately identified to estimate the individual categories of change as presented in Table 9 (see section 3.7).

5.49 Empirically, a rough but meaningful estimate of additions to stocks of buildings and infrastructure can be based on the domestic use of main construction materials such as sand and gravel, natural stones, products from stones and clays for constructions, steel and other metals. Following the supply-use framework, domestic production plus imports minus exports gives the amount of domestic uses. For this, an interim step of accounting for the domestic physical production of goods (e.g., cement, steel for construction, etc.) has to be established, which otherwise is not necessary for economy-wide MFA. This step has also to be performed when PIOTs are established. And, it has also to be performed if the rucksacks of domestically produced goods should be estimated, for example, in order to account for the TMC (total material consumption) of the economy, or in order to derive rucksack factors for manufactured goods as a first estimate for imported goods. Similar calculations as for the domestic use of construction materials may be performed for other stocks, e.g. for vehicles and machinery.

5.50 Some important products (asphalt, crushed and dimension stones, etc.) will be mainly used for construction purposes. Data on input flows with multiple uses (e.g. glass, steel, wood, plastic) may be complemented by specific information on the main use categories of these products. This allows estimating gross additions to stocks by material category. Deducting removals from stocks (demolition waste) the net additions can be estimated. These should be compared to the residual item derived from the material balance so as to establish an estimate for 'statistical discrepancies and flows of unknown destination'.

5.51 The physical stock and its material composition may be estimated directly. For example, inventories of buildings, vehicles or transport infrastructure by types and age classes may be transformed into an estimate of the physical stock. Coefficients for the material composition by type and age class may allow to compile the physical stock by main material category.

5.52 So far, estimates of material stocks have been rarely done. Stock estimates are useful for economy-wide MFA and balances. For example, when primary data on removals are not available, the perpetual inventory method may be used to set up a physical stock account and to estimate annual removals from stock. For this, time series of (gross) additions to stock must be coupled with assumptions on the lifetime of these stocks. Contrary to the normal calculation of the (monetary) consumption of fixed capital in national accounts, physical removal from stocks will take place at the end of the estimated lifetime.

5.53 Stock accounts can be used for estimating also future waste flows from these stocks and the amounts of recoverable materials in the stocks. Such detailed accounts have for example been set up in Finland (Isaksson 1993) with the purpose of estimating flows of construction and demolition wastes based on changes in the stock of buildings as recorded in buildings registers.

5.54 It is possible to estimate both stock changes and outflows to the environment based on the characteristics of the input flows. The World Resources Institute (WRI) developed a method to characterise material flows (see Matthews et al 2000 and Chapter 8 for more detail). The WRI material flows characterisation includes the velocity (expressed as residence time) with which materials travel through the economy. For the U.S., the available information allowed the velocity of flows to be estimated according to 4 broad categories:

- V1) Flows that exit within two years after entry (food, fertiliser, packaging, petroleum used as fuel);
- V2) Flows that exit after from 3 to 30 years in the economy (durable consumer goods, automobiles);
- V3) Flows that stay in the economy for more than 30 years and are additions to the stock of built infrastructure (highways, buildings);
- V4) Construction and demolition waste, withdrawn from the stock of built infrastructure.

5.55 With these residence times assigned to the input flows and to the products made of the primary inputs it was possible to estimate, e.g., the DMO for each year as the sum of all flows in the (V1), and (V4) categories. The annual addition to stock was calculated by summing the (V2) and (V3) categories.

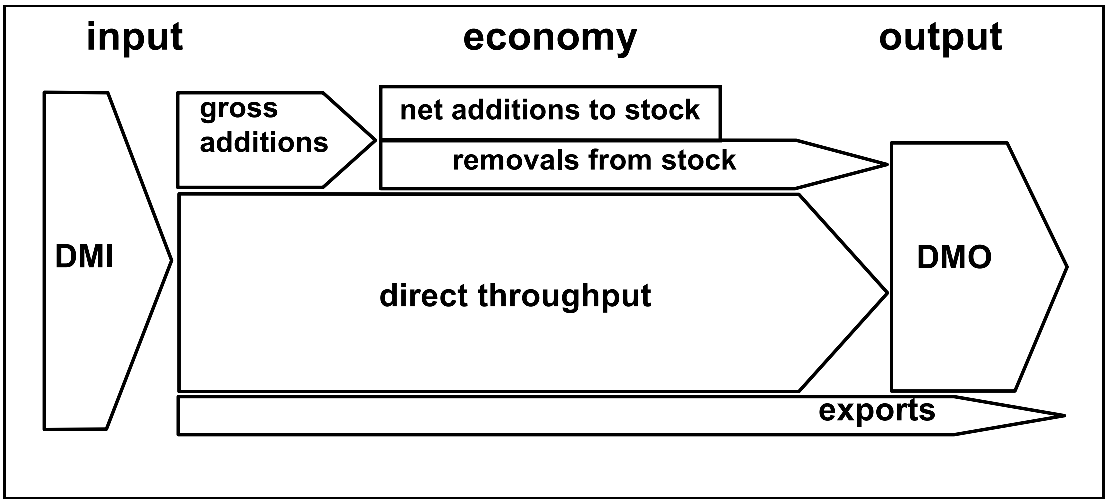
5.5 Specific methodological issues and outlook

Material throughput

5.56 An indicator for *material throughput* through the economy might be defined as material input (DMI or TMI) minus net additions to stocks (NAS), as is done in Figures 4 and 5 in section 3.1. Throughput so defined would equal material output (DMO or TMO, taking account of the appropriate memorandum items for balancing). It is not clear whether the term „throughput" is an appropriate term for these material flows. Throughput implies that material input is turned into material output during the accounting period. This is not the case when material output includes also wastes from the demolition of stocks and material input includes the materials that are added to stock (gross additions). In general, neither inputs nor outputs equal throughput defined as materials entering and leaving the economy in one accounting period (except for a flow equilibrium or steady state where stocks are constant).

5.57 An alternative definition of throughput could be the input flows that become output to the environment (i.e. excluding exports) in one accounting period. This would correspond to inputs minus gross additions to stock which is equal to outputs minus outputs due to removals from stocks (see Figure 15). It may be considered to define material throughput and include it in the list of indicators.

Figure 15: Material throughput – an alternative definition



EU-wide database for indirect flows

5.58 Indirect flows of imports and exports are probably the most difficult to establish in the context of economy-wide MFA. A set of default coefficients for indirect flows would permit estimation of indirect flows regularly and at low costs. Such a set would provide a shortcut to estimating indirect flows from import and export data. Information that could be used for establishing such a default set is partly available but scattered and more work will be needed to establish an easy-to-use database. The coefficients should allow a clear separation of used (i.e., direct) and unused material flows, a condition not universally met by information currently available.

5.59 To improve the accuracy of such a database the following activities may be envisaged:

- collect information on specific indirect flows (e.g. precious metals and precious stones);
- compilation of a database of standard coefficients for indirect flows that can be applied to the volume of traded commodities;
- establishment of a material resource database with direct material inputs and reference values of indirect flow coefficients for the extraction or harvest of raw materials by countries/regions;
- use and further development of global model systems integrating material flows into national economic accounts and interlinked trade models such as NAMEAs and the COMPASS model system (see Meyer and Uno 1999, Moll et al. 1998).

5.60 The sharing of indirect flow data and coefficients among countries and research institutes is a promising first step. The research community and network that has evolved in the context of the European Commission funded ConAccount concerted action should act as a catalyst and relevant information should be sent to the following e-mail address: conaccount@wupperinst.org.

5.61 In the interim, a first set of useful information may be found on the Wuppertal Institute's webpage at http://www.wupperinst.org/Projekte/mipsonline/download/download.html by downloading the file MIWerte.pdf.

5.62 As this file is in German, the Wuppertal Institute provided the following explanation: column titles stand for total material input (MI) in tonnes per tonne of the materials listed in the rows of (1) abiotic materials, (2) biotic materials, (3) water, (4) air, (5) soil, (6) energy requirements in kWh/t or MJ/t, (7) the region where the material in the row was produced/extracted (D=Germany, W=World, E=Europe). Material inputs for transport are not included. Materials in rows (e.g. Aluminium, primary) are presented with 3 standard values: the first row for materials excluding those which refer to electricity requirements, the second for materials needed to provide this electricity requirement, and the third line for the total of rows 1 and 2. It should be noted that the individual coefficients are total material inputs, including direct and indirect flows. For example, primary aluminium produced in Germany has a coefficient of 8.45 tonnes of abiotic materials per tonne excluding electricity requirements. As aluminium itself is an abiotic material, the 'ecological rucksack' is 7.45 tonnes. This 'ecological rucksack' of 7.45 tonnes consists of direct material flows in Germany or abroad (e.g. the diesel consumed by bauxite mining operation in Brazil) and materials extracted or otherwise moved but not used (e.g. the overburden removed for bauxite mining). The two types of flows, however, cannot be differentiated from the download document. This information, if at all, can only be obtained from the original detailed studies of the Division of Material Flows and Structural Change of the Wuppertal Institute.

6. A system of national material flow accounts and balances

6.01 In the following a system of accounts for economy-wide MFA and balances is presented. Starting from the composite balance (see Figure 9 in section 3.4), individual accounts are drawn up so as to aid practical and analytical work. The sequence of these accounts is such that the material flows for which data are more likely to be available are presented first. Progressing through the sequence of accounts, more primary data and compilation work will be required.

6.02 Each flow account has two sides. They are called resources and uses. Resources are by convention put on the left side. Other terms could be used for the two sides of the accounts, such as supply and use, origin and destination, inflows and outflows or inputs and outputs. This is not done because most of these latter terms have been used for other purposes in this Guide.

6.03 In the national accounts, the term resources is used for the side of the current accounts where transactions which add to the amount of economic value of a unit or sector appear. The uses side of the accounts relates to transactions that reduce the amount of economic value of a unit or sector.

6.04 In the sequence of economy-wide material flow accounts the flows that add to the amount of material in the economy are recorded on the resources side. For example, domestic extraction and imports are recorded on the resources side of the accounts. By extension, the same principle is also applied to unused extraction. On the uses side flows that reduce the amounts of materials in the economy are recorded. For example, exports and emissions are recorded on the uses side.

6.05 Furthermore, on the uses side accumulation and balancing items occur. For example, in the PTB account the physical trade balance, and in the Direct Material Flow Balance the net additions to stock appear on the uses side. More generally, indicators always appear on the uses side when they are first derived.

6.06 The individual accounts are:

1. Direct Material Input account;
2. Domestic Material Consumption account;
3. Physical Trade Balance account;
4. Direct Processed Output to nature account;
5. two alternative accounts to derive Net Additions to Stock;
6. Physical Stock account;
7. Direct Material Flows Balance;
8. Unused Domestic Extraction account;
9. Indirect Flows account;
10. TMR account;
11. TMC account.

6.07 In the sequence of accounts, a stock account is also presented (Account 6). In the sequence, the stock account is placed before the direct material flow balance because stock accounts provide a way of estimating the NAS (for details see section 5.4). Accounts for the material output indicators TDO and TMO are not included in the sequence of accounts but can easily be added.

6.08 The first account is to determine DMI. This is done simply by summing up the categories of material flows that constitute DMI.

Account 1: DMI account

RESOURCES	USES
Domestic extraction Fossil fuels (coal, oil…) Minerals (ores, sand…) Biomass (timber, cereals…) **Imports**	
	DMI - direct material input

6.09 The second account is to derive DMC as a balancing item by deducting exports from DMI.

Account 2: DMC account

RESOURCES	USES
DMI - direct material inputs	**Exports**
	DMC - domestic material consumption

6.10 The third account is to derive the physical trade balance by deducting exports from imports. Hence, a (physical) trade surplus (or net import of materials) occurs when imports exceed exports, and a physical trade deficit (or net export of materials) when exports exceed imports.

Account 3: PTB account

RESOURCES	USES
Imports	**Exports**
	PTB – physical trade balance

6.11 The fourth account is to determine Domestic Processed Output to nature. This account is put here in the sequence to allow derivation of NAS (see Account 5a). When NAS is derived from gross additions to stock minus removals from stock (see Account 5b), then the DPO account is not strictly necessary at this stage in the sequence of accounts.

Account 4: DPO account

RESOURCES	USES
Emissions and wastes Emissions to air Waste landfilled Emissions to water **Dissipative use of products and losses** (Fertiliser, compost; corrosion....)	
	DPO – Domestic Processed Output

6.12 The fifth account is to determine Net Additions to Stock. This can be done in two ways. Account 5a derives NAS as a residual from DMC less DPO (which is a very rough method). Account 5b derives NAS as a residual from gross additions to stock minus discard, demolition and losses from stock. Account 5b should be set up by main material categories.

Account 5a: NAS account (NAS as balancing item)

RESOURCES	USES
DMC- domestic material consumption	**Emissions and wastes**
	Emissions to air
	Waste landfilled
	Emissions to water
	Dissipative use of products and losses
	(Fertiliser, compost; corrosion....)
Memorandum items for balancing	*Memorandum items for balancing*
	NAS – Net additions to stock

Account 5b: NAS account (NAS directly compiled)

	Transport infrastructure	Buildings	Machinery	Other durables	Inventories*	Total
+ Additions (gross)						
- Discard and demolition waste**						
- Losses due to corrosion & abrasion						
= **Net additions to stock**						

* excluding inventories of standing timber, **…other removals (e.g. exports of second-hand cars) are conceivable

6.13 The sixth account is a full stock account similar to national accounts balance sheets showing the opening and closing stocks and changes for the main categories of physical stocks. In the sequence of accounts, this stock account is placed here because of its potential to estimate NAS and removals from stocks (for details see section 5.4).

Account 6: Physical stock account (balance sheet)

	Transport infrastructure	Buildings	Machinery	Other durables	Inventories*	Total
Opening stock						
Additions (gross)						
Removals (discard & demolition)**						
Losses (corrosion & abrasion)						
Other incl. changes in classification						
Total net change (NAS)						
Statistical discrepancy						
Closing stock						

* excluding inventories of standing timber, **…other removals (e.g. exports of second-hand cars) are conceivable

6.14 The above accounts allow to present a flow balance (in which inputs and outputs are equal) for direct material inputs and outputs.

Account 7: Direct Material Flow Balance

RESOURCES	USES
Domestic extraction	**Emissions and wastes**
Fossil fuels (coal, oil…)	Emissions to air
Minerals (ores, sand…)	Waste landfilled
Biomass (timber, cereals…)	Emissions to water
	Dissipative use of products and losses
Imports	(Fertiliser, manure, abrasion etc.)
	Exports
	Net additions to stock
Memorandum items for balancing	*Memorandum items for balancing*
	Statistical discrepancy
= (DMI + memorandum items for balancing)	**=** (DMO + NAS + memorandum items for balancing)

6.15 Account 8 simply presents unused domestic extraction (with inputs and outputs being equal by definition). Combining this account with the DMI account (Account 1) allows derivation of domestic TMR and combination with the DPO account (Account 4) allows derivation of TDO (Total Domestic Output to nature).

Account 8: Unused extraction account

RESOURCES	USES
Unused domestic extraction	**Disposal of unused domestic extraction**
From mining/quarrying	From mining/quarrying
From biomass harvest	From biomass harvest
Soil excavation	Soil excavation
=	**=**

6.16 Account 9 presents a physical trade balance for indirect flows. Note that international trade flows and associated indirect flows can be quite complex and need further research. For example, additional categories for 're-export (re-import) of indirect flows associated to imports (exports)' may be considered. For the uses side, the indirect flows associated to exports could be separated into domestic indirect flows and imported indirect flows associated to the production of the products exported.

Account 9: Indirect flows trade balance

RESOURCES	USES
Indirect flows associated to imports	**Indirect flows associated to exports**
Used (RME less the weight of imports)	Used (RME less the weight of exports)
Unused extraction associated to RME	Unused extraction associated to RME
	Indirect flows trade balance

RME = Raw Material Equivalent

6.17 Account 10 summarises the Accounts 1, 8 and 9 to calculate TMR.

Account 10: TMR account

RESOURCES	USES
Domestic extraction Fossil fuels (coal, oil…) Minerals (ores, sand…) Biomass (timber, cereals…) **Imports** **Unused domestic extraction** From mining/quarrying From biomass harvest Soil excavation **Indirect flows associated to imports** Used (RME less the weight of imports) Unused extraction associated to RME	
	TMR – total material requirement

6.18 Account 11 is to derive TMC by deducting exports and indirect flows associated to exports from TMR.

Account 11: TMC account

RESOURCES	USES
TMR – total material requirement	**Exports** **Indirect flows associated to exports** Used (RME less the weight of exports) Unused extraction associated to RME
	TMC – total material consumption

7. Physical Input-Output Tables

7.1 Basic features

7.01 Physical Input-Output Tables (PIOT) describe the flows of material and energy within the economic system and between the economic system and the natural environment. They also describe the physical accumulation of materials in the economy, but not the stocks of man-made or natural capital.

7.02 For the Netherlands, a PIOT covering several material flows (cement, paper, steel, etc.) has been compiled for 1990 (Konijn, de Boer and van Dalen, 1995). For Germany (Stahmer et al. 1998) and for Denmark (Gravgaard Pedersen 1999) complete PIOTs for 1990 have been compiled. In the German and Danish PIOTs, detailed NAMEA-type energy accounts and accounts for air emissions have been included.

7.03 Currently, PIOTs for the year 1995 are being compiled by the German Federal Statistical Office. They also form an important part of the Material and Energy Flow Information System (MEFIS) of the German Federal Statistical Office. The project Eco-efficient Finland (see http://thule.oulu.fi/ecoef) aims at analysing natural resource use in the Finnish economy and possibilities of reducing it. Main results include the compilation of a TMR and TMC time series 1970-1997 (with a recent update to 1999) and a first input-output analysis for 1995. An ongoing project (FINPIOT) aims at generating a full PIOT with 32 branches for 1995 (see Mäenpää 2000).

7.04 Statistics Netherlands is currently co-operating with the National Institute on Environmental and Health Research (RIVM), the Central Planning Bureau and the Free University of Amsterdam to construct PIOTs for ferrous metals and plastics. These PIOTs continue and expand earlier work (Konijn, de Boer and van Dalen, 1995) and are constructed by first converting the monetary supply and use tables into material balances. These balances are completed using physical and price information that is available in source data as well as using expert knowledge and waste flow data. The material balances are then converted to PIOTs. The project will create tables for 1990 and 1997 and will serve as the basis for a decomposition analysis of metal and plastic flows in the Netherlands. Results will become available in 2001.

7.05 A PIOT may include Input Tables (i.e., which branches use which materials or extract which materials from the environment?), Output Tables (which branches produce which goods or dispose of which materials?) and Material-Integration Tables (full Input-Output Tables). Input-Output Tables may either show the material flows between branches (industry by industry tables) or show the materials used to produce other materials (material by material tables – e.g., showing the amount of iron ore and coke used to produce steel). Separate sub-tables per material category are usually set up. Sub-tables should at least be made for water, energy, and other materials (the latter may be disaggregated by main material categories – biomass, construction materials, etc.).

7.06 As an example, the sub-table for energy includes all fuels and other materials (e.g. oxygen) necessary for the combustion and transformation of fuels on the input side. The output side shows the air emissions, water vapour from combustion and the combustion residues (e.g., ashes), as well as products made from fuels. It is recommended to set up tables in tonnes as well as in calorific values to show the material flows (coal, petrol etc.) and to ensure the comparability and consistency between the fuels.

7.07 The part of PIOT that describes flows within the economy (the production sphere) is very similar to the traditional Input-Output Tables (IOT). This maintains the compatibility to monetary IOT. In the production sphere the domestic production and the import and export of goods have to be integrated to determine the domestic availability. In a next step this quantity must be distributed between final and intermediate (i.e. used for further processing) consumption.

7.08 PIOT also describe changes to the natural environment caused by human activities such as the use of natural assets as source of raw materials and as sink for residuals. For natural assets a distinction should be made between produced assets including cultivated plants and animals, which are strongly linked to forestry and agriculture, and non-produced natural assets. The German PIOT, for example, describes the natural growth of produced biomass as an output of agriculture and forestry which is in line with national accounts conventions. Biomass results from a metabolic process. The input of this metabolic process are raw materials (such as water or oxygen) and products like animal feed or fertilisers. These are transformed into products like meat, eggs, milk or vegetables and into residuals (evaporated water, liquid manure etc.) going back into the nature. The biological metabolism has to be integrated to maintain the identity between inputs and outputs. The non-produced natural assets are intended to provide an indication of the economic use of the natural environment (e.g., as a sink for pollutants).

7.2 Uses

7.09 PIOT can be used for a variety of purposes. The main uses are (1) for balancing, consistency checks and estimation and (2) as a basis for modelling/analyses. PIOT require a combination of economic statistics in monetary units and economic and environmental statistics in physical units. During compilation, any gaps and inconsistencies in primary data become apparent when reconciling the inputs and outputs. These results can contribute to improving primary statistics as well as other data sets that use these primary data (for example, the monetary IOT). Another use of PIOT is as a tool for estimating missing physical data.

7.10 Like economy-wide MFA, PIOT can show the evolution of the material intensity and material efficiency of an economy over time. Due to the detailed presentation of flows between branches, PIOT provide a better understanding of the underlying reasons for changes. PIOT also allow to calculate materials efficiencies per branch of production.

7.11 PIOT may be used to analyse material flows, showing not only the direct material inputs and outputs of economic activities but also the indirect burdens of production and consumption. The analysis of direct, indirect and accumulated material inputs (or emissions) can be applied in policy analyses.

7.12 Because PIOT can be integrated with monetary IOT, they can be used to analyse the effects of measures (e.g. laws, taxes) intended to reduce the consumption of materials and energy or the generation of emissions. In connection with the monetary IOT the effects of changes in prices on the quantities of material and energy flows can be modelled and analysed in detail.

7.13 PIOT may be used in decomposition analyses. Tables in hybrid units, which combine monetary and physical input-output data, may be used for this purpose (Miller and Blair 1985). If these tables can be constructed for two or more years it is possible to analyse the determinants that have contributed to the changes in the material flows using structural decomposition analysis (Rose and Casler 1996). Determinant factors such as technological substitution or efficiency effects may be distinguished by change in the technical coefficient matrix. The effect of changes in consumer demand or export shifts can also be assessed.

7.14 The implementation of PIOT is a time-consuming and labour-intensive task. The work can be accomplished only if input-output experts and experts in environmental statistics and accounting co-operate. For a detailed PIOT, the costs will probably be comparable with those of compiling an input-output table in monetary units. PIOT data are very detailed and as such not very useful for policy makers. Therefore, summary tables and analytical uses (e.g. indirect effects, decomposition analyses) are absolutely essential to justify the compilation work and to communicate the results of PIOTs.

7.3 Simplified PIOTs

7.15 The department of social ecology of the Institute for Interdisciplinary Studies of Austrian Universities (IFF) has developed a simplified PIOT, combining the added value of economy-wide MFA and balances with PIOT. This system (Operating Matrix for material interactions between the Economy and Nature - OMEN) departs from a full PIOT in three aspects:

- It comprises the whole physical economy, but distinguishes only very few economic categories (5-6 aggregated branches, private households and 2 stock categories, for several categories of materials);
- It is compatible with economy-wide MFAs regarding the system boundaries;
- Establishing an aggregated PIOT is considerably less time demanding, making periodical compilation feasible.

7.16 A main function of this aggregated PIOT is for balancing, consistency checks and estimation of missing data in support of economy-wide MFA and balances and as tool for analysing specific branches of production. This allows to have annual information on some aggregated intra-economy material flows (the estimate was 3 person months for annual updates) and to react to policy demand very quickly.

7.17 Table 13 shows the overall structure of this aggregated PIOT, using the example of the minerals sub-table. Like any Input-Output Table, an aggregated PIOT consists of three quadrants, the input quadrant (left below) containing all direct material inputs (domestic extraction, imports, and memorandum items for balancing), the processing quadrant (left above), representing material flows within the economy, and the output quadrant (right above), containing all outputs to the domestic environment and to the rest of the world (i.e., DPO, exports, and memorandum items for balancing). Stock changes and final demand are implemented as vectors of the processing (I/O) quadrant. This structure corresponds to the system boundaries of the physical economy as defined by economy-wide MFA. However, for analytical reasons, e.g. scenario estimations using the Leontief inverse, it is necessary to implement stock changes as vectors of the input and output quadrants.

7.18 The classification of the branches in Table 13 is compatible to NACE and consists of 3 aggregated branches (extraction, other manufacturing, services), 3 detailed branches (machinery, transportation equipment, chemical industry), private households and two stock categories (buildings/infrastructure and durables/inventory). This classification reflects a predefined policy/research focus. In the example shown the focus is on stock accounting (composition of stocks, alternative ways to calculate NAS, relationship between stocks and flows), household consumption and chemical industry.

7.19 Separate tables for different kinds of materials (biomass, minerals, fossil fuels, water, air) are estimated in a way that allows for consistent aggregation to an economy-wide table, from which MFA indicators and additional branch-specific indicators can be derived directly. Methodologically the advantage of this framework is to allow for consistency checks on the sectoral level as well as on an economy-wide level, including the estimation of missing or checking of weak data and the possibility to extend the framework by integrating additional parameters such as energy, labour, land use or indirect flows. Politically the strength of this framework is to combine the advantages of both economy-wide MFA (readily available overall indicators, harmonised method) and PIOT (disaggregated information and indicators) approaches. In Table 13, the cells that directly link the aggregated PIOT with the economy-wide MFA are indicated (cells with dark grey shading).

Table 13: An aggregated PIOT - sub-table for minerals

	Extraction	Manufacturing				Services	House-holds	Accumulation										
		Machinery	Transport equipment	Chemical industry	Other manuf.			Construction	Durables, inventory	Total processed output	Exports	Emissions to air	Emissions to water	Emissions to land	Dissipative uses and losses	**Total systems output**	**Total sectoral output**	**Balance**
Extraction																		
Machinery																		
Transport equipment																		
Chemical industry																		
Other manuf.																		
Services																		
Households																		
Construction																		
Durables, inventory																		
Total processed input																		
Metals																		
Non-metals																		
Mass minerals																		
Additional water and air																		
Total domestic extraction																		
Imports																		
Total primary inputs																		
Total sectoral input																		

White cells: material flow estimates, generated from statistical sources using the aggregated PIOT approach.
Light grey cells: sums derived from white cells for the purpose of crosschecks and indicator estimation.
Dark grey cells: overlap with economy-wide MFA.

Source: Weisz (2000)

8. Using the accounts to indicate environmental impacts

8.01 A main function of economy-wide MFA and balances is to provide aggregate information and indicators that describe the physical economy, complementing other indicators and data sets which provide more detail (e.g. air emissions, forest statistics and accounts, etc.). Economy-wide MFA and balances provide background trends on environmental pressures but there are few direct links to environmental impacts. The relation between indicators derived from economy-wide MFA and the environmental consequences of material flows is not yet well understood, in particular for input and consumption indicators.

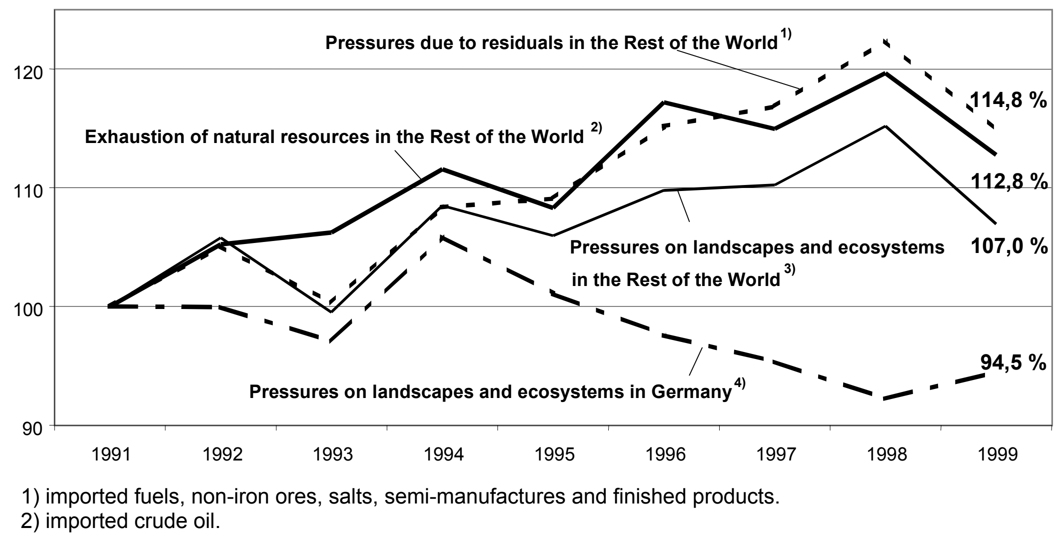
8.02 Better links to specific environmental pressures and impacts can be established in various ways. The economy-wide MFA already foresee presentation not only of the total flows but also of the main categories (e.g., biomass, minerals, fuels). For publication purposes, further detail can be provided to illustrate interesting changes in the underlying structure (e.g., detail on the types of fuels used, the categories of biomass extracted, etc.). The data structure on which the accounts are built provides more detail on individual flows of materials. PIOTs offer a way for very detailed analysis. Too much detail, however, hides the overall trends and is most useful for answering questions related to specific materials or natural resources (e.g., for carbon balances, recycling of paper, use of energy intensive products such as metals or cement, etc.).

8.03 Two approaches that employ the data structure of the economy-wide MFA and balances to show environmental impacts are presented below. These approaches are experimental and are presented for illustration. The first is a presentation that was developed by the German Federal Statistical Office where several material flow categories are qualified by 'main impact' (landscape, emissions, natural resource exhaustion). The second is a method to categorise material flows by release mode (to air, land, etc.), quality categories (e.g., biodegradable, chemically active, etc.) and by velocity (residence time in the economy), developed by the World Resources Institute.

8.04 The approach developed by the German Federal Statistical Office is presented in Figure 16 and Table 14 below. Using the example of raw material extraction (including imported raw materials and goods), material flows are grouped by categories of pressure related to environmental impacts. The categories are:

- Exhaustion of natural resources abroad;
- Pressures on landscapes and ecosystems in Germany;
- Pressures on landscapes and ecosystems abroad;
- Pressures due to residuals related to production abroad.

Figure 16: Fuel and mineral inputs by category of pressure, Germany, 1991 = 100



1) imported fuels, non-iron ores, salts, semi-manufactures and finished products.
2) imported crude oil.
3) imported brown and hard coal, crude oil, ores, stones and gravel, other minerals.
4) domestic extraction of coal, minerals and salts

Source: German Federal Statistical Office (2000b), data for 1999 are preliminary

8.05 To indicate the evolution of the pressures and impacts, the relevant materials are attributed to these categories and aggregated by physical units in tonnes (see Table 14). Materials are counted twice, if they are relevant to more than one category.

Table 14: Material extraction by category of pressure, Germany

Aspect	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Domestic Extraction in million tonnes								
Pressures on Landscapes and Ecosystems[1)]	1005,8	1005,4	975,9	1064,8	1016,5	981,4	958,9	927,4	950,4
	1991 = 100								
Pressures on Landscapes and Ecosystems[1)]	100	100,0	97,0	105,9	101,1	97,6	95,3	92,2	94,5
	Imports in million tonnes								
Exhaustion of Raw Materials[2)]	137,2	144,4	145,7	153,1	148,6	160,8	157,7	164,2	154,7
Pressures on Landscapes and Ecosystems[3)]	240,4	254,3	239,2	260,8	254,7	263,9	265,0	276,9	257,1
Pressures due to Residuals[4)]	286,1	300,6	286,9	310,0	312,1	329,5	334,3	350,1	328,5
	1991 = 100								
Exhaustion of Raw Materials	100	105,2	106,2	111,6	108,3	117,2	115,0	119,6	112,8
Pressures on Landscapes and Ecosystems	100	105,8	99,5	108,5	106,0	109,8	110,2	115,2	107,0
Pressures due to Residuals	100	105,1	100,3	108,4	109,1	115,2	116,8	122,4	114,8

1) domestic extraction of coal, minerals and salts.
2) imported crude oil.
3) imported brown and hard coal, crude oil, ores, stones and gravel, other minerals.
4) imported fuels, non-iron ores, salts, semi-manufactures and finished products.

Source: German Federal Statistical Office (2000b), data for 1999 are preliminary

8.06 The World Resources Institute (WRI), when compiling the national physical accounts for the United States for 1975-96, developed methods to characterise material flows (see Annex 2 of Matthews et al 2000). The characterisation is made on the basis of quantity, mode of first release (M), quality (Q), and velocity (V - expressed as residence time). The method also allows to estimate outflows to the environment and net additions to stock from the input flows based on the velocity (see section 5.4).

Mode of release

8.07 The spatial dimension, over which a flow impacts the environment, is related to its dispersion and freedom of movement. A first approximation of this can be inferred from the mode in which a flow exits the economy, the physical state of an output flow (gaseous, liquid, or solid), and the degree to which the output flow is, or can be controlled. Available information on the material life cycles, for most major flows, allows a reasonable judgement to be made about these two factors, at least at the point where a flow first enters the environment.

8.08 The following mode of release categories are proposed:

M0) Flows that become a “permanent” part of the built infrastructure, and do not exit the economy during the period under consideration, more than 20 years.
M1) Flows contained, controlled, on land as solids (landfills, overburden…);
M2) Flows contained on land as liquids or partial solids (tailings ponds, impoundments…). Since both M1 and M2 are controlled in essentially the same manner, they may be combined;
M3) Flows dispersed directly onto land in a solid, partial solid, or liquid form (fertilisers, pesticides, fungicides…);
M4) Flows discharged into water systems in a solid, partial solid or liquid form (dredge spoil, soil erosion, sewage effluent …);
M5) Flows discharged into air from point sources in a gaseous or particulate form (power plant and industrial source stack emissions…);
M6) Flows discharged into air from diffuse sources in a gaseous or particulate form (emissions from vehicles, household heating plants, spray paints…);
M7) Flows that take many, or no clearly defined path, or which are not classifiable.

Quality characterisation of flows

8.09 A quality descriptor should provide some information on whether the environment can assimilate a flow and if it is biologically harmful. A descriptor should also identify flows that are similar to geologic processes that operate over relatively short time frames. Assigning flows to quality categories is potentially more contentious than mode of first release. It should be noted that quality categories should not be treated as hierarchical. All flows cause environmental change, and none can automatically be considered to be innocuous. As an example, while biodegradable manure can be a useful soil supplement, too much in one place can be a significant problem. While recognising that many quality measures, useful for addressing specific questions, could be suggested, the following categories are proposed.

Q1) Flows that are biodegradable (agriculture, forestry, and fishery products…);

Q2) Flows that replicate rapid continuous geologic processes (particle size reduction and movement only);

Q3) Flows that have not been chemically processed but are chemically active (salt), or biologically hazardous (asbestos);

Q4) Flows that have undergone chemical processing. These may or may not be chemically active (fuel emissions, fertilisers, industrial chemicals, certain mineral processing wastes...);

Q5) Flows that are heavy metals, synthetic and persistent chemical compounds, or radioactive.

Velocity characterisation of flows

8.10 The velocity of a flow, or its converse, the residence time in the economy, is an important variable that can be related to potential impacts on the environment. Available information allows the velocity of a flow to be reasonably estimated according to three broad categories as shown below.

V1) Flows that exit within two years after entry (food, fertiliser, packaging, petroleum used as fuel...);

V2) Flows that exit after from 3 to 30 years in the economy (durable consumer goods, automobiles…). It would be useful if V2 could be further divided into 3-10, and 10-30 year categories, but it is not clear that the available data permits this distinction to be made;

V3) Flows that stay in the economy for more than 30 years and are additions to the stock of built infrastructure (highways, buildings…).

8.11 The mode of release, quality and velocity (MQV) descriptors proposed above will be applied to characterise discrete material flow outputs from the U.S. economy for the time period 1975-96. For some categories the data are quite fine grained and complete, for others this is not the case. In some cases where data are not directly available estimation methods are used. When completed this informational resource can be used to address a wide variety of questions, by creating aggregations of selected components based on the desired properties. Alternatively, individual users may assign their own descriptors, or weights depending on the question being asked.

9. Recommendations for a first implementation

9.01 It is recommended that in a first step some economy-wide material flow accounts should be compiled. National statistical institutes should start with compiling the accounts for direct material flows. The sequence of accounts presented in chapter 6 (with ‚direct' flow accounts first, then stock accounts and ‚indirect' flows) provides a suggestion for the direction and sequence of work. Initially, a long time series should be established using historical data. These accounts should then be updated annually.

9.02 Unused domestic extraction are materials that are economically not relevant (as materials) and thus often not statistically observed. Therefore, when accounts for unused domestic extraction are made, it is essential to clearly indicate the categories covered, to avoid that international comparisons are impaired by differences in methodology and coverage.

9.03 The division of work between statistical offices and research institutes may be a key to initiating the accounts work and also expanding the accounts further. For example, the initial development of suitable methods and estimation procedures could first be done outside statistical institutes and then the regular production undertaken by the institutes. Depending on the data available in a country, the more experimental accounts involving much estimation as well as the more analytical work including compilation of indirect flows could remain outside statistical offices for the time being.

9.04 Compilation of economy-wide material balances (or highly aggregated input-output tables) describing both inputs and outputs of materials – if performed by broad material groups – is instrumental for assuring that the accounts balance. Some additional estimates will generally be required because data on the output side are not always available annually (e.g. waste statistics). Full-fledged economy-wide material balances can be compiled at regular intervals, for example every 2-3 years linked to availability of e.g. waste and waste water statistics. Annual compilation is possible using appropriate estimation and interpolation methods. As a main statistical function of full balances is to ensure consistency of a variety of data sources, it should be considered to establish full balances also for some earlier benchmark years, underpinning the long time series established for individual indicators.

9.05 The compilation of fully detailed physical input-output tables is quite resource consuming and does not appear to be feasible for many countries. If feasible, fully developed physical input-output tables should be compiled at regular intervals (e.g. every 5 years linked to datasets available in census years, availability of monetary input-output tables, waste or waste water statistics, etc.). If detailed PIOTs are not feasible, aggregated PIOTs could be considered.

9.06 The implementation work nationally should be documented so as to facilitate updates. As the compilation of economy-wide MFA, balances and PIOT is a developing area, it is particularly important to insure stability of the data and their interpretation. The best way to ensure stability of final results in relation to primary data is to describe the methodology of the compilation process in an internal document for the use by compilers or in a national compilation guide. The dissemination of this national guide among data providers and advanced users can be useful. Such a document should describe:

- the data sources used;
- the treatment of the basic data (conversions, estimation procedures);
- the databases that have been set up;
- the time series for the main aggregates;
- the revision processes;
- the tables for publication.

9.07 A number of tools may be useful for accounting. The following list is an example of what should be available for making the accounts:

- conversion of other physical units (m^3, Joules etc.) to tonnes;
- metal/mineral contents (%) of crude minerals;
- water contents of materials;
- composition of fuels by substances;
- packaging coefficients for imports and exports;
- ratio of leaves to harvested biomass of sugar- and fodder-beets;
- yields for grazing of livestock on permanent pastures;
- manure produced by livestock, by substances and water contents;
- emission coefficients for emissions to water;
- respiration coefficients for humans and livestock;
- soil excavated per house built or km road constructed, or per unit gross value added;
- coefficients for indirect flows.

9.08 The following tables are proposed for implementation:

- Table 1: Direct material inputs by category (1000 tonnes), 1980-2000;
- Table 2: Indicators, 1980-2000 (DMI, DMC, PTB, total and by main material groups, in 1000 tonnes, in tonnes per capita and per unit of GDP in constant prices, supplementary data: population, GDP at constant prices, value added and output in constant prices for agriculture, forestry and fishing; mining; manufacturing; construction);
- Table 3: Direct material outputs by category (1000 tonnes), 1980-2000;
- Table 4: Direct material flow balance (1000 tonnes), 1980, 1985, 1990, 1995, 2000;
- Table 5: Unused domestic extraction by category (1000 tonnes), 1980-2000;
- Table 6: Indirect flows imported and exported, TMR and TMC (1000 tonnes), 1980-2000.

These tables should employ the classifications for inputs and outputs as presented in this Guide.

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Annexes

Annex 1: A glossary of MFA terms

Dematerialization
Absolute or relative reduction in the use of material and energy per unit of value added or output.

Ecological rucksack
The total input of primary materials and energy required for a particular product. Ecological rucksacks (or indirect material flows, or up-steam flows) is the life-cycle-wide material input during all upstream production stages minus the mass of a product itself.

Ecologically sustainable development (strong sustainability)
The strictest definition of sustainable development policy, seeking to conserve the well-being of the natural environment under all circumstances. It is axiomatic here that the natural environment cannot be replaced by any other commodity.

Eco-efficiency
a) An indicator for the output or value added generated per unit of ‘nature’ (materials/energy/pollution) used.
b) A social action strategy which seeks to reduce the use of materials in the economy in order to reduce undesirable environmental impacts. Ever smaller quantities of materials have to produce a relatively higher degree of economic affluence. The general objective of eco-efficiency is to "get more from less" (this is known as qualitative growth).

Eco-intensity
An indicator for the "use of nature" (materials/energy/pollution) per unit of value added or output. The inverse of eco-efficiency.

Environmental Space
The annual total consumption of natural resources to which each individual is "entitled", based on the capacity of the natural environment.

Factor 4
An objective whereby the input of natural resources, raw materials and energy in each unit of production is to be reduced to one quarter of its current level in the medium term, over the next 20 to 30 years.

Factor 10
This is an objective whereby the input of natural resources, raw materials and energy in each unit of production is to be reduced to one tenth of its current level in the long term, over the next 30 to 50 years.

Life Cycle Analysis, LCA
A method of assessing the environmental impacts of a product over its entire life cycle. The life cycle generally means the time between manufacturing the product and ultimately disposing of it.

Material efficiency
An indicator for the output or value added generated per unit of materials used.

(economy-wide) Material Flow Accounting, MFA
A monitoring system for national economies based on methodically organised accounts and denoting the total amounts of materials used in the economy. Material flow accounting enables monitoring of total consumption of natural resources and the associated indirect flows as well as calculation of indicators.

Material Flow Analysis, MFA
An evaluation method which assesses the efficiency of use of materials using information from material flow accounting. Material flow analysis helps to identify waste of natural resources and other materials in the economy which would otherwise go unnoticed in conventional economic monitoring systems.

Material productivity
An indicator for the output or value added generated per unit of materials used. Typically a macro-economic concept that can be presented alongside labour or capital productivity.

MIPS (Material Input Per Service)
A unit of measurement developed by the Wuppertal Institute, whereby the material intensiveness of various products and services can be monitored in relation to a single commodity unit produced.

Natural Resource Accounting, NRA
A system of monitoring based on methodically organised accounts, representing the size of economically valuable and limited reserves of natural resources and using physical quantifiers such as tonnes or cubic metres.

System of National Accounts, SNA
An organised system of social monitoring based on methodical accounts describing the scope of activities in the economy in monetary terms based on macroeconomic theory. A primary indicator derived from these accounts is the Gross Domestic Product (GDP) which indicates the magnitude of economic activity in monetary terms.

System of Accounts
A statistical package made up of several accounts which are generally of the same form, seeking to present statistical information on some particular phenomenon in a consistent and systematic manner. In most cases some effort is made to present the accounts in the form of a balance.

Substance Flow Analysis, SFA
An evaluation method and approach whereby the individual flows of environmentally undesirable substances through the environment and economy are evaluated systematically. Substance flow accounts primarily monitor the use and disposal of particularly undesirable and poisonous substances, for example over their entire life cycle, for some product or in some branch of industry. Substance flow accounts also serve as the basis for compiling Pressure Indicators and for analyses of particular products and branches of industry.

Total Material Requirement (TMR)
An overall indicator developed by the Wuppertal Institute to describe, in terms of total tonnage, not only the amount of natural resources contained in the commodities produced by the economy, but also the indirect flows which are involved in such production. These material flows which remain outside of the economy include wood materials which are not used in logging (branches, needles, leaves and roots), earth and stone which is excavated in mining and quarrying along with usable ore and minerals, earthworks necessary in the construction of infrastructure systems (roads and communities) and erosion resulting from human activities (including intensive agriculture).

Sources: adapted from Ministry of the Environment (Finland) (1999)

Annex 2: Domestic extraction of minerals (used) – detailed classification

I.1.2			**Minerals**		
I.1.2.1			**Metal ores**		
I.1.2.1.1			**Iron ores**		
	1		Iron ores		
I.1.2.1.2			**Non-ferrous metal ores**		
	1		Antimony	non-ferrous heavy metal	
	2		Arsenic	special metals	
	3		Bauxite (Aluminium)	light metals	
	4		Beryllium	light metals	
	5		Bismuth	non-ferrous heavy metal	
	6		Cadmium	non-ferrous heavy metal	
	7		Caesium	light metals	
	8		Chromium	steel alloying metals	
	9		Cobalt	steel alloying metals	
	10		Copper	non-ferrous heavy metal	
	11		Gallium	special metals	
	12		Germanium	special metals	
	13		Gold	precious metals	
	14		Indium and Thallium	non-ferrous heavy metal	
	15		Lead	non-ferrous heavy metal	
	16		Lithium	light metals	
	17		Magnesium	light metals	
	18		Manganese	steel alloying metals	
	19		Mercury	non-ferrous heavy metal	
	20		Molybdenum	steel alloying metals	
	21		Nickel	steel alloying metals	
	22		Niobium + Tantalum	special metals	
	23		Platinum-group (PGM)	precious metals	
		1	Platinum	(heavy PGMs)	
		2	Osmium	(heavy PGMs)	
		3	Iridium	(heavy PGMs)	
		4	Ruthenium	(light PGMs)	
		5	Rhodium	(light PGMs)	
		6	Palladium	(light PGMs)	
	24		Pyrite/Pyrrhotite	iron sulfides, mostly used for sulphur production	
	25		Rare Earths metals	special metals	
		1	Scandium	(special metals)	
		2	Yttrium	(special metals)	
		3	Lanthanium	(special metals)	
		4	Cer	(special metals)	
		5	Praseodym	(special metals)	
		6	Neodym	(special metals)	
		7	Promethium	(special metals)	
		8	Samarium	(special metals)	
		9	Europium	(special metals)	
		10	Gadolinium	(special metals)	
		11	Terbium	(special metals)	
		12	Dysprosium	(special metals)	
		13	Holmium	(special metals)	
		14	Erbium	(special metals)	
		15	Thulium	(special metals)	
		16	Ytterbium	(special metals)	
		17	Lutetium	(special metals)	
	26		Selenium	special metals	
	27		Silicium	special metals	
	28		Silver	precious metals	
	29		Strontium	light metals	
	30		Tellurium	special metals	
	31		Tin	non-ferrous heavy metal	
	32		Titanium (incl. Ilmenite and Rutile)	special metals	
	33		Tungsten	steel alloying metals	
	34		Uranium	nuclear fuels	
	35		Vanadium	steel alloying metals	

	36		Zinc	non-ferrous heavy metal	
	37		Zirconium and Hafnium	special metals	
I.1.2.2			**Industrial minerals**		
	1		Salt		
		1	Rock salt		**Im**
		2	From brine		**Im**
		3	In brine, sold or used as such		**Im**
		4	Boiled salt		**Im**
		5	Solar salt		**Im**
	2		Special clays		
		1	Ball clay		**Im**
		2	Bentonite, sepiolite and attapulgite		**Im**
		3	Fire, refractory and flint clay, Andalusite, kyanite and sillimanite (all Al-containing)		**Im**
		4	Fuller's earth		**Im**
		5	Kaolin		**Im**
		6	Pottery clay		**Im**
		7	Special clay		**Im**
		8	Slate clay		**Im**
	3		Special sands		
		1	Industrial sand		**Im**
		2	Silica sand (quartzsand)		**Im**
		3	Siliceous earth		**Im**
	4		Peat for agricultural use		**Im**
	5		Other		
		1	Abrasives, natural (puzzolan, pumice, volcanic cinder etc.)		**Im**
		2	Amber		**Im**
		3	Barite		**Im**
		4	Borate minerals		**Im**
		5	Diamonds, gems		**Im**
		6	Diamonds, industrial		**Im**
		7	Diatomite		**Im**
		8	Feldspar		**Im**
		9	Fluorspar		**Im**
		10	Forming sand		**Im**
		11	Graphite, natural		**Im**
		12	Iron ore for pigments		**Im**
		13	Magnesite		**Im**
		14	Mica		**Im**
		15	Ochre and pigment earths		**Im**
		16	Pegmatite sand		**Im**
		17	Phosphate rock (natural phosphates)		**Im**
		18	Potash		**Im**
		19	Quartz and quartzite		**Im**
		20	Strontium minerals		**Im**
		21	Sulphur		**Im**
		21	Sulphur from pyrites		**Im**
		21	Sulphur as a by-product of natural gas etc.		**Im**
		22	Talc (steatite, soapstone, pyrophyllite)		**Im**
		23	Talcous slate		**Im**
I.1.2.3			**Construction minerals**		
	1		Asphalt		**Cm**
	2		Common clay, clay for bricks etc.		**Cm**
	3		Dimension stone (marble, granite etc.)		**Cm**
		1	Igneous rock (basalt, basaltic lava, diabase, granite, porphyry, sandstone etc.)		**Cm**
		2	Limestone	Calcium carbonate and dolomite	**Cm**
		3	Marble, travertines etc.	Calcium carbonate and dolomite	**Cm**
		4	Sandstone		**Cm**
		5	Slate (incl. roof slate)		**Cm**
		6	Tufaceous rock		**Cm**
	4		Common sand and gravel		**Cm**
I.1.2.4			**Industrial and construction minerals (further analysis needed)**		
	1		Asbestos		**Im, Cm**
	2		Loam		**Im, Cm**

	3		Crushed stone		**Im, Cm**
		1	Calcite	Calcium carbonate and dolomite	**Im, Cm**
		2	Chalk	Calcium carbonate and dolomite	**Im, Cm**
		3	Chert and flint		**Im, Cm**
		4	Dolomite	Calcium carbonate and dolomite	**Im, Cm**
		5	Igneous rock (basalt, basaltic lava, diabase, granite, porphyry, sandstone etc.)		**Im, Cm**
		6	Limestone	Calcium carbonate and dolomite	**Im, Cm**
		7	Sandstone		**Im, Cm**
		8	Slate including fill (incl. roof slate)		**Im, Cm**
	4		Gluesand		**Im, Cm**
	5		Gypsum and anhydrite		**Im, Cm**
	6		Lavasand		**Im, Cm**
	7		Perlite		**Im, Cm**
	8		Sand and gravel		**Im, Cm**

Im: Industrial mineral
Cm: Construction mineral
Im, Cm: both used as industrial mineral and construction mineral

See also:
European Minerals Yearbook, The European Commission - DG Industry, http://europa.eu.int/comm/dg03/publicat/emy/index.htm
International Energy Agency, Energy statistics of OECD countries, OECD, Paris
United Nations, Industrial commodity statistics yearbook, UN, New York
U.S. Geological Survey, Mineral industry reports by countries, http://www.usgs.org/minerals/pubs/country

Annex 3: Domestic extraction of biomass (used) – detailed classification

Domestic (used) extraction (harvest) of biomass				
I.1.3				**Biomass**
I.1.3.1				**Biomass from agriculture**
I.1.3.1.1				**Biomass from agriculture reported by harvest statistics**
	1			**Cereals**
		1		Barley
		2		Buckwheat
		3		Canary Seed
		4		Maize (grain maize)
		5		Millet
		6		Mixed Grain
		7		Oats
		8		Rice, Paddy
		9		Rye
		10		Sorghum
		11		Triticale
		12		Wheat (and spelt)
			1	Common wheat
			2	Durum wheat
		13		Cereals n.e.c.
	2			**Roots and tubers**
		1		Potatoes
		2		Sweet Potatoes
		3		Yams
		4		Roots and Tubers n.e.c.
	3			**Pulses**
		1		Beans
			1	Beans, Dry
			2	Broad Beans, Dry
		2		Peas
			1	Chick-Peas
			2	Peas, Dry
		3		Lentils
		4		Lupins
		5		Vetches
		6		Pulses n.e.c.
	4			**Oilcrops**
		1		Groundnuts in Shell
		2		Hempseed
		3		Linseed
		4		Melonseed
		5		Mustard Seed
		6		Olives
		7		Poppy Seed
		8		Rapeseed (rape and turnip rape)
		9		Safflower Seed
		10		Seed Cotton
		11		Sesame Seed
		12		Soybeans
		13		Sunflower Seed
		14		Oilseeds n.e.c.
	5			**Vegetables+melons**
		1		Artichokes
		2		Asparagus
		3		Pulses
			1	Beans, Green
			2	Broad Beans, Green
			3	String Beans
		4		Cabbages
			1	Brussels sprouts
			2	White cabbage
		5		Carrots
		6		Cauliflower
		7		Chillies, Peppers, Green

		8		Cucumbers and Gherkins
		9		Eggplants
		10		Garlic
		11		Green Corn (Maize)
		12		Leeks and other Alliac. Veg.
			1	Leeks
			2	Endive
		13		Lettuce
		14		Melons
			1	Cantaloupes
			2	Watermelons
		15		Mushrooms
		16		Onions
			1	Onions+Shallots, Green
			2	Onions, Dry
		17		Peas, Green
		18		Pumpkins, Squash, Gourds
		19		Spinach
		20		Tomatoes
		21		Vegetables Fresh n.e.c.
	6			**Fruit excl melons**
		1		Apples
		2		Apricots
		3		Avocados
		4		Bananas
		5		Blueberries
		6		Carobs
		7		Cherries
		8		Currants
		9		Dates
		10		Figs
		11		Gooseberries
		12		Grapefruit and Pomelos
		13		Grapes
		14		Kiwi Fruit
		15		Lemons and Limes
		16		Oranges
		17		Peaches and Nectarines
		18		Pears
		19		Persimmons
		20		Pineapples
		21		Plums
		22		Quinces
		23		Raspberries
		24		Sour Cherries
		25		Strawberries
		26		Tang. Mand. Clement. Satsma
		27		Berries n.e.c.
		28		Citrus Fruit nes
		29		Fruit Fresh n.e.c.
		30		Fruit Tropical Fresh n.e.c.
		31		Stone Fruit n.e.c., Fresh
	7			**Treenuts**
		1		Almonds
		2		Chestnuts
		3		Hazelnuts (Filberts)
		4		Pistachios
		5		Walnuts
		6		Nuts n.e.c.
	8			**Fibre crops**
		1		Cotton Lint
		2		Flax Fibre and Tow
		3		Hemp Fibre and Tow
	9			**Other cops**
		1		Alfalfa for Forage and Silage
		2		Anise, Badian, Fennel
		3		Beets for Fodder

		4	Cabbage for Fodder
		5	Carrots for Fodder
		6	Chicory Roots
		7	Clover for Forage and Silage
		8	Coffee, Green
		9	Hay (Unspecified)
		10	Hops
		11	Maize for Forage and Silage (green maize)
		12	Peppermint
		13	Pimento, Allspice
		14	Pumpkins for Fodder
		15	Pyrethrum, Dried Flowers
		16	Rye Grass, Forage and Silage
		17	Sorghum for Forage and Silage
		18	Sugar Beets
		19	Sugar Cane
		20	Swedes for Fodder
		21	Tea
		22	Tobacco Leaves
		23	Turnips for Fodder
		24	Vegetables and Roots, Fodder
		25	Forage Products n.e.c.
		26	Grasses n.e.c. for Forage and Silage
		27	Leguminous n.e.c. for Forage and Silage
		28	Spices n.e.c.
		29	Other fodder plants
I.1.3.1.2			**Biomass from agriculture as a by-product of harvest**
	1		**Crop residues used as fodder**
		1	Fodder beet leaves
		2	Sugar beet leaves
	2		**Straw used for economic purposes**
I.1.3.1.3			**Biomass from grazing of agricultural animals**
	1		**Grazing on permanent pastures not harvested**
	2		**Grazing on other land (including alpine pastures)**
I.1.3.2			**Biomass from forestry**
I.1.3.2.1			**Wood**
	1		**Coniferous (round)wood**
	2		**Non-coniferous (round)wood**
I.1.3.2.2			**Raw materials other than wood**
I.1.3.3			**Biomass from fishing**
I.1.3.3.1			**Marine fish catch**
I.1.3.3.2			**Inland waters (freshwater) fish catch**
I.1.3.3.3			**Other (aquatic mammals and other)**
I.1.3.4.			**Biomass from hunting**
I.1.3.5.			**Biomass from other activities (honey, gathering of mushrooms, berries, herbs etc.)**

Eurostat: Theme: Agriculture, forestry and fisheries, Series: Yearbooks, 5A
FAO: FAOSTAT database on: http://apps.fao.org

Annex 4: Imports – detailed classification and allocation to HS and CPA

I.2			**Imports**	**HS/CN**	**CPA/NACE**
I.2.1			**Raw materials**		
I.2.1.1			**Fossil fuels**		
	1		**Hard coal**	2701	10
	2		**Lignite (Brown coal)**	2702	10
	3		**Peat**	2703	10
	4		**Crude oil**	2709	11
	5		**Natural gas**	2711	11
	6		**Bituminous crude materials**	2714	11
I.2.1.2			**Minerals**		
I.2.1.2.1			**Metallic minerals**		
	1		**Iron ores**	2601	13
	2		**Manganese ores**	2602	13
	3		**Copper ores**	2603	13
	4		**Nickel ores**	2604	13
	5		**Cobalt ores**	2605	13
	6		**Aluminium ores**	2606	13
	7		**Lead ores**	2607	13
	8		**Zinc ores**	2608	13
	9		**Tin ores**	2609	13
	10		**Chromium ores**	2610	13
	11		**Tungsten ores**	2611	13
	12		**Uranium/Thorium ores**	2612	12
	13		**Molybdenium ores**	2613	13
	14		**Titanium ores**	2614	13
	15		**Zirkonium ores**	26151000	13
	16		**Niob-/Tantalum ores**	26159010	13
	17		**Vanadium ores**	26159090	13
	18		**Silver ores**	261610	13
	19		**Precious metal ores**	261690	13
	20		**Antimony ores**	261710	13
	21		**Other ores, unspecified**	261790	13
I.2.1.2.2			**Non-metallic minerals**		
	1		**Salts**	2501	14
	2		**Pyrite**	2502	14
	3		**Sulphur**	2503	14
	4		**Graphite**	2504	14
	5		**Sands**	2505	14
	6		**Quartz**	2506	14
	7		**Kaolin**	2507	14
	8		**Clays and loams**	2508	14
	9		**Chalk**	2509	14
	10		**Phosphate**	2510	14
	11		**Baryte**	2511	14
	12		**Diatomaceous earth**	2512	14
	13		**Pumice stone**	2513	14
	14		**Clay slate**	2514	14
	15		**Marble etc**	2515	14
	16		**Granite etc**	2516	14
	17		**Fieldstones etc**	2517	14
	18		**Dolomite**	2518	14
	19		**Magnesite**	2519	14
	20		**Gypsum and anhydrite**	2520	14
	21		**Limestone**	2521	14
	22		**Asbestos**	2524	14
	23		**Mica**	2525	14
	24		**Soapstone etc**	2526	14
	25		**Kryolithe etc**	2527	14
	26		**Borates**	2528	14
	27		**Feldspar etc**	2529	14
	28		**Vermiculite etc**	2530	14
	29		**Diamonds, raw**	710210,-21,-31	14
	30		**Precious stones, raw**	710310	14
	31		**Quartz, manuf., other crude stones**	7104-10-20	14
	32		**Dust/powder of diamonds/precious stones**	7105	14
I.2.1.3			**Biomass**		
	1		**Agricultural**		
		1	Alive plants etc	06	01

		2	Vegetable	07	01
		3	Coconuts	080110,-11,-19	01
		4	Hazelnuts	080221,-22	01
		5	Walnuts	080231,-32	01
		6	Bananas	0803	01
		7	Citrus fruit	0805	01
		8	Grapes	0806	01
		9	Apple	080810	01
		10	Cherries	080920	01
		11	Prunes	080940	01
		12	Berries etc	0810	01
		13	Other fruit and nuts etc	08rest	01
		14	Coffee	090111	01
		15	Tea	0902	01
		16	Mate	0903	01
		17	Spices	0904-0910	01
		18	Wheat	1001	01
		19	Rye	1002	01
		20	Barley	1003	01
		21	Oat	1004	01
		22	Maize	1005	01
		23	Rice	1006	01
		24	Sorghum	1007	01
		25	Other cereals	1008	01
		26	Soy beans	1201	01
		27	Copra	1203	01
		28	Linseed	1204	01
		29	Rapeseed	1205	01
		30	Sunflowerseed	1206	01
		31	Hops	1210	01
		32	Other oilseeds etc	12rest	01
		33	Shellac, rubber, resin etc	1301	01
		34	Other plant juices and extracts	1302	01
		35	Plant fibres etc	14	01
		36	Cocoa	1801	01
		37	Tobacco	2401	01
		38	Natural rubber	4001	01
		39	Cotton	5201	01
		40	Flax	5301	01
		41	Hemp	5302	01
		42	Jute	5303	01
		43	Sisal	5304	01
		44	Coconut fibre	5305	01
	2		**Forestry**		
		1	Fuel wood etc	4401	02
		2	Roundwood	4403	02
		3	Wood roughly prepared etc	4404	02
		4	Natural cork	4501	02
			Fish		
		1	Fish etc	03	05
I.2.1.4			**Secondary raw materials**		
	22		**Slags, Ashes, Residues etc**	26rest	37
I.2.2			**Semi-manufactured products**		
I.2.2.1			**from fossil fuels**		
	1		**Coke**	2704	23
	2		**Hard coal gas**	2705	23
	3		**Hard coal tar**	2706	23
	4		**Hydrocarbons**	2707	23
	5		**Pitch and pitch coke**	2708	23
	6		**Mineral oils**	2710	23
	7		**Mineral waxes**	2712	23
	8		**Petroleum coke**	2713	23
	9		**Bituminous mixtures**	2715	23
	10		**Electricity**	2716	40
I.2.2.2			**from minerals**		
I.2.2.2.1			**from metallic minerals**		
	1		**Silver**	7106	27
	2		**Gold**	7108	27
	3		**Platinum**	7110	27
	4		**Precious metals waste/scrap**	7112	27
	5		**Iron and steel**	72	27

	6		**Copper mat, cement copper etc**	7401	27
	7		**Copper, unrefined etc**	7402	27
	8		**Copper, refined and alloyed etc**	7403	27
	9		**Waste/scrap of copper**	7404	27
	10		**Copper pre-alloys**	7405	27
	11		**Powder/tinsel of copper**	7406	27
	12		**Nickel mat etc**	7501	27
	13		**Nickel crude**	7502	27
	14		**Nickel waste/scrap**	7503	27
	15		**Powder/tinsel of nickel**	7504	27
	16		**Aluminium, raw**	7601	27
	17		**Waste/scrap of aluminium**	7602	27
	18		**Powder/tinsel of aluminium**	7603	27
	19		**Lead, raw**	7801	27
	20		**Waste/scrap of lead**	7802	27
	21		**Zinc, raw**	7901	27
	22		**Waste/scrap of zinc**	7902	27
	23		**Dust, powder/tinsel of zinc**	7903	27
	24		**Tin, raw**	8001	27
	25		**Waste/scrap of tin**	8002	27
	26		**Tungsten and goods thereof, also waste/scrap**	8101	27
	27		**Molybdenum and goods thereof, also waste/scrap**	8102	27
	28		**Tantalum and goods thereof, also waste/scrap**	8103	27
	29		**Magnesium and goods thereof, also waste/scrap**	8104	27
	30		**Cobalt and goods thereof, also waste/scrap**	8105	27
	31		**Bismuth and goods thereof, also waste/scrap**	8106	27
	32		**Cadmium and goods thereof, also waste/scrap**	8107	27
	33		**Titanium and goods thereof, also waste/scrap**	8108	27
	34		**Zirconium and goods thereof, also waste/scrap**	8109	27
	35		**Antimony and goods thereof, also waste/scrap**	8110	27
	36		**Manganese and goods thereof, also waste/scrap**	8111	27
	37		**Beryllium, chromium, germanium, vanadium etc and goods thereof, also waste/scrap**	8112	27
	38		**Cermets and goods thereof, also waste/scrap**	8113	27
I.2.2.2.2			**From non-metallic minerals**		
	1		**Lime**	2522	26
	2		**Cement**	2523	26
	3		**Phosphate fertilisers**	3103	24
	4		**Potassium fertilisers**	3104	24
	5		**Cement etc, fire-proof**	3816	26
	6		**Broken glass etc, Glassmass**	7001	26
	7		**Glass in spheres etc , unmanufactured**	7002	26
I.2.2.3			**From biomass**		
	1		**Forestry**		
		1	Charcoal	4402	20
		2	Wood-wool	4405	20
		3	Sleepers	4406	20
		4	Sawn wood	4407	20
		5	Veneer	4408	20
		6	Semi-manufactures of wood	47	21
I.2.3			**Finished products**		
I.2.3.1			**predominantly from fossil fuels**		
	x		**Not (yet) occupied**		
I.2.3.2			**predominantly from minerals**		
I.2.3.2.1			**predominantly from metallic minerals**		
	1		**Silver plated ware etc**	7107	27
	2		**Gold plated ware etc**	7109	27
	3		**Platinum plated ware etc**	7111	27
	4		**Jewellery of precious metals etc**	7113	36
	5		**Gold- and silver-smith goods**	7114	36
	6		**Goods of precious metals**	7115	36
	7		**Fantasy jewellery**	7117	36
	8		**Coins etc**	7118	36
	9		**Iron or steel ware**	73	27
	10		**Copper finished goods**	7407-7419	27-28
	11		**Nickel finished goods**	7505-7508	27-28
	12		**Aluminium finished goods**	7604-7616	27-28
	13		**Lead finished goods**	7803-7806	27-28
	14		**Zinc finished goods**	7904-7907	27-28
	15		**Tin finished goods**	8003-8007	27-28
	16		**Other non-precious metals and cermets finished goods**	8101-8113rest	27

	17		**Tools etc of non-precious metals**	82	28
	18		**Different ware of non-precious metals**	83	28
	19		**Nuclear reactors etc**	84	22,23,28,29,30,34,35
	20		**Electrical machines etc**	85	22,24,29,31,32,33,72,92
	21		**Rail vehicles etc**	86	34,35
	22		**Automobiles etc**	87	29,34,35,36
	23		**Airplanes etc**	88	17,35
	24		**Water vehicles etc**	89	35
I.2.3.2.1			**predominantly from non-metallic minerals**		
	1		**Glass ware**	7003-7010	26
	2		**Pearls, real or cultivated**	7101	05,36
	3		**Diamonds, manufactures**	710229	36
	4		**Diamonds, manufactures**	710239	36
	5		**Rubines etc , manufactured**	710391	36
	6		**Other precious stones, manufactured**	710399	36
	7		**Goods of pearls, precious stones etc**	7116	36
	8		**Goods of stones etc**	68	26
	9		**Ceramic goods**	69	26
I.2.3.3			**predominantly from biomass**		
	1		**Forestry finished products**		
		1	Wooden products	4409-4421	20
		2	Cork products	45rest	20
		3	Paper and board	48	21,22
		4	Paper ware	49	22,74
I.2.4			**Other products**		
I.2.4.1			**Other products of abiotic kind**		
	1		**Inorganic chemicals**	28	24
	2		**Powder, explosives etc**	36	24,36
	3		**Water incl /excl gas**	2201	15
	4		**Peltry, artificial and ware thereof**	4304	18
	5		**Synthetic stones etc**	710490	36
I.2.4.2			**Other products of biotic kind**		
	1		**Agricultural plant products**		
		1	Coffee, roasted and/or decaffeinated	090112to-90	15
		2	Wheat flour	1101	15
		3	Flour of other cereals	1102	15
		4	Groats/pellets of cereals	1103	15
		5	Cereal grains, processed	1104	15
		6	Potatoe products	1105	15
		7	Flour, groats of other field crops	1106	15
		8	Malt	1107	15
		9	Starch	1108	15
		10	Wheat gluten	1109	15
		11	Sugar of beets and sugar cane	1701	15
		12	Other sugars	1702	15
		13	Sugar molasses	1703	15
		14	Sugar confectionaries	1704	15
		15	Cocoa products	1802-1806	15
		16	Malt extract etc	1901	15
		17	Pastry	1902	15
		18	Tapioca preparations	1903	15
		19	Cereals preparations	1904	15
		20	Bread and bakery products	1905	15
		21	Vegetable preparations	2001	15
		22	Tomatoe preparations	2002	15
		23	Mushrooms preparations	2003	15
		24	Other vegetables preparations, frozen	2004	15
		25	Other vegetables preparations, not frozen	2005	15
		26	Fruit prepared with sugar	2006	15
		27	Marmelades, jellies etc	2007	15
		28	Fruit conserved	2008	15
		29	Fruit juices	2009	15
		30	Plant extracts	2101	15
		31	Beer	2203	15
		32	Wine etc	2204	15
		33	Vermouth	2205	15
		34	Apple wine	2206	15
		35	Ethanol	2207	15
		36	Spirits	2208	15
		37	Wine vinegar, other vinegar for nutrition	2209	15
		38	Residues of cereals/pulses	2302	15

		39	Residues of corn starch/sugar beets/draff, skins of grapes	2303	15
		40	Oilcake soybeans	2304	15
		41	Oilcake peanuts	2305	15
		42	Oilcake other oilseeds	2306	15
		43	Tartar	2307	15
		44	Acorns/horse-chestnuts/skins of pressed grapes/other	2308	15
		45	Tobacco products	2402-2403	16
		46	Cotton manufactures	5202-5212	17
		47	Lin, yarn	5306	17
		48	Jute, yarn	5307	17
		49	Other plant fibres, yarn	5308	17
		50	Tissues of flax, jute, and other plant fibres	53rest	17
		51	Wickerwork and basket-maker ware	46	20
	2		**Agricultural animal products**		
		1	Live horses etc	0101	01
		2	Live bovine animals	0102	01
		3	Live swine etc	0103	01
		4	Live sheep etc	0104	01
		5	Live poultry etc	0105	01
		6	Other live animals	0106	01
		7	Bovine meat, fresh, chilled	0201	15
		8	Bovine meat, frozen	0202	15
		9	Swine meat, fresh, chilled, frozen	0203	15
		10	Sheep(Goat meat, fresh, chilled, frozen	0204	15
		11	Horse meat, fresh, chilled, frozen	0205	15
		12	Edible offals	0206	15
		13	Poultry meat	0207	15
		14	Meat of other animals	0208	15
		15	Swine/Poultry fat	0209	15
		16	Meat/Offals, salted, dried	0210	15
		17	Milk and cream	0401	01,15
		18	Milkpowder etc	0402	15
		19	Buttermilk etc	0403	15
		20	Whey	0404	15
		21	Butter	0405	15
		22	Cheese and curd	0406	15
		23	Eggs	0407	01
		24	Eggyolk	0408	15
		25	Honey	0409	01
		26	Other animal goods	0410	01
		27	Sausages etc	1601	15
		28	Meat preparations	1602	15
		29	Meat extracts	1603	15
		30	Hides/skins of bovine/horse etc	4101	15
		31	Skins of sheep/lamb	4102	15
		32	Leather of bovine/calf/horse	4104	19
		33	Leather of sheep/lamb	4105	19
		34	Leather of goat	4106	19
		35	Silk worm cocoons	5001	01
		36	Grege	5002	17
		37	Silk wastes	5003	17
		38	Silk yarns	5004	17
		39	Silk yarns	5005	17
		40	Silk yarns	5006	17
		41	Silk weaves	5007	17
		42	Wool	5101	01,15,17
		43	Animals hair	5102	01
		44	Wool wastes	5103	17
		45	Wool textile fibre	5104	17
		46	Wool combed	5105	17
		47	Wool yarns	5106	17
		48	Wool yarns	5107	17
		49	Wool yarns	5108	17
		50	Wool yarns	5109	17
		51	Wool yarns	5110	17
		52	Wool tissue	5111-5113	17
	3		**Animals as products**		
		1	Fish products	1604	15
		2	Crab/Molluscs preparations	1605	15
	4		**Other biotic products**		
		1	Animal/Plant fertilisers	3101	24

		2	Other animal products etc	05	01,05,15,93
		3	Animal/plant fats and oils etc	15	01,15,24
		4	Yeasts	2102	15
		5	Sauce and preparations	2103	15
		6	Soups and broths	2104	15
		7	Ice cream	2105	15
		8	Other food preparations	2106	15
		9	Flour, pellets of meat/fish	2301	15
		10	Feedstuffs preparations	2309	15
		11	Hides/skins of goat/reptiles/other animals	4103	01,15
		12	Leather of pigs/reptiles/other animals	4107	19
		13	Leather-Rest	4108-4111	19
		14	Pelts crude, complete	4301	01
		15	Pelts, curried, prepared, assembled	4302	18
		16	Clothing, other ware of pelts	4303	18
I.2.4.3			**Other products n e c**		
	1		**Water incl sugar/flavour, soft-drinks incl /excl milk**	2202	15
	2		**Organic chemicals**	29	24
	3		**Pharmaceutics**	30	24
	4		**Nitrogen fertilisers**	3102	24
	5		**NPK-fertilisers and other fertilisers**	3105	24
	6		**Other fertilisers**	31rest	24
	7		**Tannin- and pigment-extracts etc**	32	24
	8		**Etheric oils etc**	33	24
	9		**Soaps etc**	34	24
	10		**Proteins etc**	35	15,24
	11		**Photographic goods etc**	37	24,74,92
	12		**Different products of chemical industry**	38rest	24,25,26
	13		**Plastics and plastic products**	39	24,25
	14		**Caotchouc and products thereof**	4002-4017	24,25
	15		**Leather ware etc**	42	18,19,36
	16		**Synthetic or artificial filaments**	54	17,24
	17		**Synthetic or artificial spinning fibres**	55	17,24
	18		**Wadding, felt etc**	56	17
	19		**Carpets etc**	57	17
	20		**Special tissues etc**	58	17
	21		**Processed tissues etc**	59	17,21 25,36
	22		**Woven and knitted goods**	60	17
	23		**Clothing of woven and knitted goods**	61	17,18
	24		**Clothing except of woven and knitted goods**	62	18
	25		**Other ready-made clothes etc**	63	17,18,29
	26		**Shoes etc**	64	19
	27		**Hats etc**	65	18,25
	28		**Umbrellas etc**	66	36
	29		**Feathers and downs etc**	67	36
	30		**Optical instruments etc**	90	30,33
	31		**Clocks**	91	33
	32		**Music instruments**	92	36
	33		**Weapons and ammunition**	93	28,29
	34		**Furniture etc**	94	17,25,26,28,31,33,36
	35		**Toys etc**	95	36
	36		**Different ware**	96	36
	37		**Art etc**	97	92
	38		**Fabrication plants for export**	98	not listed
	39		**Assembly of different ware**	99	not listed
I.2.5			**Packaging material imported with products**	not listed	not listed
I.2.6			**Waste imported for final treatment and disposal**	not listed	not listed

Annex 5: Emissions to water – detailed classification

O.1		**Emissions and wastes**
O.1.3		**Emissions to water**
O.1.3.1		**Nitrogen (N)**
O.1.3.2		**Phosphorus (P)**
O.1.3.3		**Other substances and (organic) materials**
	1	Carbon (C)
	2	Sulphur (S)
	3	Calcium (Ca)
	4	Chlorine (Cl)
	5	Bor (B)
	6	Iron (Fe)
	7	Lead (Pb)
	8	Cadmium (Cd)
	9	Copper (Cu)
	10	Zinc (Zn)
	11	Mercury (Hg)
	12	Aluminium (Al)
	13	Arsenic (As)
	14	Barium (Ba)
	15	Cer (Ce)
	16	Chromium (Cr)
	17	Cobalt (Co)
	18	Fluor (F)
	19	Gold (Au)
	20	Potassium (K)
	21	Lithium (Li)
	22	Magnesium (Mg)
	23	Manganese (Mn)
	24	Sodium (Na)
	25	Nickel (Ni)
	26	Rubidium (Rb)
	27	Selenium (Se)
	28	Silver (Ag)
	29	Silicium (Si)
	30	Strontium (Sr)
	31	Tin (Sn)
	32	Other substances and materials
O.1.3.4		**Dumping of materials at sea**
	1	Sewage sludge
	2	Other

Annex 6: Dissipative material flows – detailed classification

O.2			**Dissipative use of products and dissipative losses**
O.2.1			**Dissipative use of products**
O.2.1.1			**Dissipative use on agricultural land**
	1		Mineral fertilisers
		1	Nitrogen (N)
		2	Phosphate (P2O5)
		3	Potash (K2O)
		4	Other
	2		Farmyard manure
		1	Nitrogen (N)
		2	Phosphate (P2O5)
		3	Potash (K2O)
		4	Other
	3		Sewage sludge
	4		Compost
	5		Pesticides
		1	Fungicides
		2	Herbicides
		3	Insecticides
		4	Other
	6		Seeds
O.2.1.2			**Dissipative use on roads**
	1		Thawing and grit materials (sand, salt, etc)
O.2.1.3			**Dissipative use of other kind (incl solvents)**
	1		Solvents
	2		Other
O.2.2			**Dissipative losses**
	1		Abrasion (tyres, brakes)
	2		Accidents with chemicals
	3		Leakages (natural gas, etc)
	4		Erosion and corrosion of infrastructures (roads, etc)

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