MEASURING MATERIAL FLOWS AND RESOURCE PRODUCTIVITY

Volume III.
Inventory of Country Activities
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INTRODUCTION

This report\(^1\) is part of the **OECD work programme on material flows (MF) and resource productivity (RP)** that supports the implementation of the OECD Council recommendation on MF and RP adopted in April 2004. It takes stock of activities related to the measurement and analysis of resource and material flows carried out or planned in OECD countries and in selected non member countries. It describes the main features that characterise such activities and the extent to which information on material resources is used in environmental reporting and decision making. It is part of a series of guidance documents on measuring material flows and resource productivity and is designed to provide a factual basis for the further exchange of experience and information and for sharing lessons at international level.

The guidance documents include:

- **Volume I. The OECD guide.**
  Volume I describes the full range of MF approaches and measurement tools, with a focus on the national level and emphasis on areas in which practicable indicators can be defined. It is targeted at a non expert audience. It includes (i) an overall framework for material flow analysis (MFA), (ii) a description of different kinds of measurement tools, (iii) a discussion of those issues and policy areas to which MFA and material flow indicators can best contribute, and (iv) guidance on how to interpret material flow indicators. It is illustrated with a selection of practical examples from countries’ experience and is complemented with a glossary.

- **Volume II. The accounting framework.**
  Volume II provides a theoretical and technical description of the concepts and methodologies of material flow accounting. It is targeted at an expert audience. It draws upon the Handbook on national accounting - Integrated Environmental and Economic Accounting (the SEEA handbook), developed jointly by the United Nations, the European Commission, the IMF, the OECD, and the World Bank and on the guide published by Eurostat in 2001 Economy-wide material flow accounts and derived indicators – A methodological guide. It has benefited from co-operation with Eurostat and with the London Group on Environmental Accounting, and consultations with the UNSD and its Committee of Experts on Integrated Environmental Economic Accounting.

- **Volume III. Inventory of country activities.**
  Volume III takes stock of activities related to the measurement and analysis of natural resource and material flows in place or planned in OECD countries and in selected non member economies. It describes the main features that characterise such activities and the extent to which information on material resources is used in environmental reporting and in decision making. It is designed to provide a factual basis for the further exchange of experience and information and for sharing lessons at international level.

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• **Volume IV. Implementing national MF Accounts** (forthcoming, prepared jointly with Eurostat).

Volume IV provides practical guidance to assist countries in implementing national material flow accounts. It is targeted at practitioners of material flow accounting. It is constructed in a modular way to reflect several levels of ambition and completeness of accounts, and is being developed stepwise. The first edition will focus on the establishment of simple economy-wide material accounts building on a set of core tables tested and used by Eurostat.

The guidance documents are complemented by a *synthesis report* that summarises the work carried out, takes stock of progress made, and adds selected examples from applications of MFA.

This document builds on information **compiled from various sources**, among which:

• Country and expert contributions to the OECD Workshops on Material Flows and Resource productivity (Helsinki, June 2004; Berlin, May 2005; Rome, May 2006; Tokyo, September 2007) and to earlier OECD meetings, including the Special Session on Material Flow Accounting of the WGEIO (October 2000).


• Country contributions to the annual Round Table on Environmental Information held by the Working Group on Environmental Information and Outlooks (WGEIO).

• Replies by countries, experts and research institutes to a global survey of MF activities carried out jointly with the European Environment Agency (EEA) in 2004. Recipients of the survey included (i) OECD countries and partners, through national delegates to the Working Group on Environmental Information and Outlooks (WGEIO), and (ii) countries and experts participating in the EEA’s work on material flows. The replies covered 40 countries, including 27 OECD countries, the European Commission (Eurostat) and the Business and Industry Advisory Committee to the OECD (BIAC), as well as 13 non member countries. The survey was updated in 2007. It should however be noted that replies to the global survey often were the respondent’s views, and may not reflect the countries' official position.

Since material flow studies cover various approaches and measurement tools, the description of countries’ activities has not been limited to material flow accounts and indicators *per se*, but covers also other closely related work in the field of environmental accounting. It should be noted that the information contained in this document is **neither exhaustive nor final**. It will be complemented and updated as work on material flow analysis progresses, and as new information becomes available.
Measuring material flows and resource productivity
INVENTORY OF COUNTRY ACTIVITIES

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I. BACKGROUND

Material flow analysis (MFA) is a rapidly developing field of research with increasing policy relevance. Over the past decade, MFA has raised increasing interest as a tool that can provide a more holistic and integrated view of resource and material flows through the economy and that enables the derivation of economy-wide material flow indicators, including new indicators reflecting resource productivity or resource use efficiency that could parallel those describing labour productivity.

Much progress has been made in developing, refining and harmonising methodologies for various types of MFA, including accounts and indicators. Progress has been stimulated through joint research efforts by Austria, Germany, Japan, the Netherlands and the United States involving governmental and non-governmental institutions, and collaborative work in Europe carried out by Eurostat on methodologies for economy-wide material flows and by the European Environment Agency and its Topic Centre on Waste and Material Flows. It has further been supported with international work on Integrated Environmental and Economic Accounting (commonly referred to as SEEA), and with OECD work on environmental indicators (terminology, framework, selection criteria, guidance for use) and on environmental accounting and material flows.

Interest in MFA as a policy making tool across OECD countries has also risen significantly and practical applications have progressed. Most OECD countries that have developed a national set of environmental or sustainable development indicators include in their set one or several indicators derived from MFA. In some countries, this has led to a move towards integrating MFA work in the national system of official statistics. To date, almost all OECD countries carry out some activities on resource and material flows and related indicators.

Despite these advances, MFA remains a "young" tool. Countries are at a variety of stages in developing and using MFA. The status of their work, its characteristics and scope, purpose and policy use vary considerably. Some of this diversity is expected, for example in the coverage of resources or materials that reflects the varying economic and environmental importance of a given resource or material flow for different countries. Other differences, such as those concerning the concepts and methodologies applied, point to the need for additional clarification and convergence. More work is also needed to review and explain the added value of MFA compared to other monitoring and measurement tools and to appropriately position MFA within a broader architecture of environmental and economic accounts and indicators.

The implementation of the OECD Council Recommendation on material flows and resource productivity, adopted on 21 April 2004, will help address some of the current shortfalls in MF information, contribute to achieve greater convergence of already existing initiatives in OECD countries and facilitate wider dissemination and uptake of existing experience and guidance. It will also help to further broaden the geographic scope of MF work and to expand it to other interested OECD countries so as to support the sharing of lessons and related international work.


II. MEASURING AND ANALYSING RESOURCE AND MATERIAL FLOWS IN OECD COUNTRIES

1. CHARACTERISTICS AND SCOPE OF ACTIVITIES

Material Flow Analysis (MFA) includes a variety of approaches and measurement tools at different levels of ambition, detail and completeness. Work carried out so far has been covering different resource and material flows at different levels of detail for different entities and with different system boundaries. The term MFA therefore designates a family of tools making reference to the materials balance principle, ranging from economy-wide MFA to substance or product specific analysis and input-output analysis. Each type of analysis is associated to MF accounts or other measurement tools, and can be used to derive various types of indicators.

When analysing material flows, emphasis can be put on:
- all materials entering and leaving the national economy (top of the Figure);
- the industry level, enterprise level, and product level, from product groups down to specific products (left hand side of Figure);
- certain material and substance flow systems, from the national down to the local level (right hand side of Figure); or
- a combination of the different types of specifications.

Source: OECD.
Economy-wide MF accounts (EW-MFAcc)

Two third of OECD countries have developed or are developing EW-MFA (Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Japan, Korea, the Netherlands, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, the United Kingdom, and the United States). In 12 out of these 20 countries, EW-MF work is now a regular activity with annual updates. In 8 countries (Denmark, Hungary, Korea, the Netherlands, Poland, Portugal, Sweden, and the United States) EW-MF work has been carried out on a stand-alone or pilot basis.

A few countries did not report about plans to develop EW-MFA (Australia, Canada, Greece, Iceland, Luxembourg, Mexico, and New Zealand). In Mexico, EW-MFA (1970-2003) has been carried out at academic level as part of a PhD project at the Autonomous University of Barcelona (UAB), and included a comparative analysis with Peru, Ecuador and Chile (1980-2000). In Australia, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has done some EW-MFA work on domestic and international direct and indirect material flows, even though full material flow analysis at the macro-level is not a national priority.

Concerning frameworks and conceptual approaches, the System of Integrated Environmental and Economic Accounting (SEEA) and the methodological guide prepared by Eurostat (2001) appear to be instrumental in structuring work on natural resource accounts and EW-MFA in countries. In Europe, most EW-MF work is based on the Eurostat guide. Other references mentioned include documents published by the World Resources Institute (WRI) and the Wuppertal Institute for Climate, Environment, Energy, and training material from the IFF Vienna.

Individual resource and material flow accounts

A number of countries, including those that have not yet developed or do not plan to develop economy-wide MFAs, carry out closely related work as part of their environmental accounting activities. Such work often focuses on the development of individual flow accounts in areas of particular relevance to the country and its economy (e.g. Australia, Canada, Finland, France, Iceland, Ireland, New Zealand, Norway, and the Slovak Republic) and covers natural resources or residuals such as: energy, water, forests, fisheries, minerals, greenhouse gases. Most of these accounts are part of the countries' natural resource accounts (NRA) and build on related international work and frameworks.

Individual flow accounts are also prepared as part of more detailed MFA work, and focus for example on flows of raw materials, water, waste, energy and/or on flows of specific substances or materials (see also below). Systematic analysis of particular material flows (material system analysis) is not yet well developed, but is a potentially very useful tool since related to concrete policy and management issues.

More detailed MF approaches and accounts

The Input-Output framework is used in Australia, Austria, Canada, the Czech Republic, Denmark, Finland, Germany, Italy, Japan, Sweden and the United Kingdom in order to develop specific flow accounts distinguishing not only categories of materials but also branches of production. In some countries, hybrid flow accounts have been established by linking information from physical flow accounts to economic data from Monetary Input-Output tables. In some countries, input-output analysis supplements work on economy-wide flows. Efforts are also being made for developing simplified PIOTs that could usefully be linked to EW-MFA.
In Europe, many countries have established National Accounting Matrices including Environmental Accounts (NAMEAs) mainly in the field of air emissions and waste, following recommendations by Eurostat and pioneering work by the Netherlands. Such accounts, and in particular their sectoral breakdown and their links to economic accounts, are often seen as useful complementary tools and some countries have applied the NAMEA approach to material flow accounts. NAMEAs are also being established in other OECD countries, notably in Japan and Korea.

Among the most developed MF activities is the German Material and Energy Flow Information System (MEFIS) that uses an MFA framework. It is based on physical input-output tables (PIOTs) and uses a NAMEA-type breakdown for economic activities. Other examples are the Australian Stocks and Flows Framework (ASFF) and the Canadian Material and Energy Flow Accounts (MEFA).

In a number of OECD countries, research work has focussed on studying flows of specific substances or groups of substances (e.g. Austria, Belgium, Finland, Japan, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom and the United States). Such work often concentrates on heavy metals and on other substances with potential negative impacts on the environment and human health. Examples include the Toxic release inventory (TRI) of the United States, and substance flow analysis (SFA) carried out by the Norwegian Pollution Control Authority and the Swedish Chemicals Inspectorate.

There have also been a few attempts to weight material flows according to their environmental impacts. The impact-based weights might distinguish between large flows with little impact per unit of flow (inert or bulk materials) and small flows having large impacts per unit of flow (highly toxic or persistent materials). A recent example is environmentally weighted material consumption (EMC) that combines data from material flow analysis (MFA) and impact coefficients from life cycle assessments (LCA). EMC has been calculated for a group of European countries and for the Netherlands.

### Data availability and quality

To date, time series of economy-wide MF data are available for about two third of OECD member countries. This includes 19 countries of the European Union for which data are available from Eurostat and/or from national MF activities, and Japan, Korea and the United States.

Availability and quality are generally best for data describing direct flows and for indicators based on input and consumption variables (material extraction, imports, exports). The data underlying these indicators are readily available from known sources, and can easily be updated at regular intervals.

Output variables are less well covered, and related indicators are still in development both from a methodological point of view and in terms of data availability. Data needed to populate the output side of material flow accounts are available from waste statistics, emission inventories and other environmental statistics. But a number of gaps remain, and the use of these data for accounting purposes often requires a restructuring and adaptation to accounting definitions and classifications. Gaps also remain in the coverage of international flows of materials and in the coverage of unused or indirect flows. Little coherent information is available on flows of secondary raw materials (recycled materials). Almost no information is available on recyclable materials. The development of related data and indicators requires further work on definitions, methodologies and conversion factors, and an international consensus about the validity of these methodologies.

Data on individual material resource flows are available in most OECD countries, but with varying degrees of completeness and coverage. Information on physical stocks and flows of individual types of natural resources such as forest, freshwater or energy, is relatively advanced in many OECD

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6 Suggestions on how to weight material outflows were presented for example by Fröhlich et al. (2000) and Matthews et al. (2000).
countries and compiled in a more or less harmonised framework, the SEEA often serving as a
reference. Physical flow information on other material resources or residuals such as minerals and
selected metals, fish resources, greenhouse gases, is available in several countries, but appears to
be less harmonised across countries.

MF data have also become available as part of international work and of multi-lateral research
projects. The EU funded MOSUS project for example has led to the establishment of a MF database
focusing on domestic extraction of materials and covering 188 countries over the period 1980-2002.
The pilot OECD MF Database, extending the Eurostat data set, covers domestic extraction, imports,
exports and related indicators (e.g. PTB, DMC) for 12 material categories and for the 30 OECD
member countries over the period 1980-2002.

### Publication and use in reporting

Material flow and natural resource data are used and published in national state of the environment
reports or in national environmental data publications (e.g. Australia, Belgium, Finland, France,
Germany, Italy, Japan, Norway, Switzerland), or in national environmental or sustainable
development indicators reports (e.g. Austria, Germany, Hungary, the Slovak Republic, the United
Kingdom). Some countries have special publications (reports, CD-Rom, web based databases) on
environmental accounting, on natural resource use or on resource productivity (e.g. Australia,
Austria, Canada, the Czech Republic, France, Germany, Japan, the Slovak Republic, Spain, United
Kingdom). The data on natural resources and material flows included in these publications stem
from national MF activities or from information produced by international research institutes (e.g.
IFF-Vienna, SERI/Mosus, USGS, WRI, Wuppertal Institute) or by Eurostat (e.g. Hungary).

Material flow information used in environmental reporting often illustrates productivity or decoupling
trends in areas linked to natural resource use and waste generation. Australia has used material
flow information to assess the environmental impacts of human settlements in its 1996 and 2001
state of the environment reports. A more detailed analysis of the urban metabolism of three
selected settlements was used for the 2006 report.

### 2. INSTITUTIONAL ARRANGEMENTS AND PARTNERSHIPS

Traditionally, MF work has mainly been carried out by academics or as part of research projects
steered by national statistical offices, and in a few cases environment ministries and agencies. In
some countries, responsibilities have progressively moved from the academic and research side to
the policy side, with environment ministries being increasingly interested in indicators derived from
MF studies.

The production of MF accounts and data is generally in the hands of national statistical offices
(NSOs) as part of their environmental accounting activities or of research institutes. In a number of
countries, NSOs have taken responsibility for compiling EW-MF data as part of their country’s official
statistics (Austria, Finland, Germany, Italy, Spain, Switzerland, and the United Kingdom)?. This is
also the case for most work on individual natural resource accounts (e.g. Australia, Canada, Norway,
the Slovak Republic). In a few countries, research institutes or universities have the lead in
conducting MF research on behalf of their government sometimes with government funding and/or
in co-operation with government agencies (e.g. the Czech Republic, Hungary, Japan, Korea, Poland,

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7 See also Eurostat (1997), Materials Flow Accounting: Experience of Statistical Offices in Europe, Luxembourg.
Portugal, the United States). In some EU countries, funding from Eurostat or the European Commission has supplemented government funding.

The development and publication of material flow indicators, and their use in environmental reporting is shared among NSOs and environment agencies and ministries, and sometimes research institutes. The practical arrangements depend on the stage of development and the status of the indicators work, and on already existing arrangements in the field of environmental indicators and reporting.

In countries where MF work is well advanced, partnerships are commonly established among various partners within the country as well as with international networks and with partners in other countries. Examples of international MF networks and partnerships are the ConAccount network managed by the Wuppertal Institute and the recently established International Society of Industrial Ecology.

Some countries exchange information with and provide assistance to non member countries via their research activities. Examples are bilateral partnerships established between Japan and China, and between Switzerland and Columbia, and partnerships established by the University of Vienna (IFF) with other Universities in the world to promote the application of MFA in developing countries. Major research institutes active in the field of MFA (Wuppertal Institute, IFF-Vienna) have incorporated Southeast Asian and Latin American countries in their work, and have provided technical guidance to new-comer countries in Europe through projects partly funded by the European Commission (e.g. Amazonia21, SEAtrans project).

3. OUTPUTS AND RESULTS

Main uses of MF information

Practical applications of MFA and related information have progressed in many countries, mainly in areas where the demand for information on resource and material flows is clearly identified and linked to (i) specific policy questions and/or (ii) to associated indicator development, in line with lessons from earlier OECD work on the use of environmental account in decision making (Box 1).

According to the survey replies, information from resource and material flow accounts in OECD countries is most commonly used as a tool for:

- economy-wide indicator development (21 countries)
- linking environmental and economic information (19 countries)
- supporting modelling and outlook activities (11 countries)
- informing decision making (10 countries) and as a basis for policy analysis (6 countries)
- informing the public and policy makers (12 countries) about key issues and trends.
- monitoring the efficiency of material resource use (19 countries) and its sustainability at various levels (14 countries), often with a link to waste management policies (4 countries) or with other aspects such as: the effects of globalisation and trade (8 countries); the environmental impacts of material flows (5 countries), the economic impacts of material flows (4 countries); and the security of materials supply (2 countries).
MF information derived from more detailed and individual flow accounts and analysis, including PIOTs and SFA, is further used as a tool for natural resource and materials management. It supports for example the implementation of policies related to integrated product management, the control of chemicals (e.g. control of hazardous substances, heavy metals) or the control of air and GHG emissions. Information derived from SFA appears to be particularly useful when applied at the micro and local levels. Information derived from PIOTs appears to be particularly useful when applied at the meso level, to track structural changes at macro-level, and as an input into modelling and outlook work.

It is generally recognised that, though many countries have included economy-wide MF indicators in their sets of environmental or sustainable development indicators, the actual use of MF information in national policy debates and policy making is limited. This is due among others to the fact that most MF work completed to date has shed light on the supply side (academic research, methodological and statistical work, development of MF accounts and derived indicators), and that most aggregated economy-wide indicators, that are in themselves more meaningful for communication purposes, are not always well understood and sometimes misinterpreted. Hence, feedback on the policy relevance of the various economy-wide MF indicators in use is seen as insufficient and further insights are needed to guide their further refinement.

Box 1. Main uses of natural resource accounts

| OECD countries’ experience with environmental accounting has shown that there are three uses of natural resource accounts (NRA) that are particularly relevant for decision-makers and policy analysis*. They can be used as a tool for: |
| Resource management: To be suitable for this purpose, the accounts must provide extensive and detailed information; this tends to require well-developed and large statistical bases and a relatively sophisticated accounting system, often at the substance level. |
| Policy analysis: This use is less information-intensive than the use for resource management. Two types of uses are distinguished: |
| Direct use of physical flow accounts: where NRA trace the flow of natural resources from the environment to the economy and within the economy, they provide information about the impacts of sectoral economic activities on the resource flows and stock and vice versa. |
| Indirect use of physical flow accounts through linking information from these accounts to economic information in the context of integrated environmental and economic accounting (hybrid flow accounts) or through introducing it into environment-economy models. |
| Indicator development: the construction of selected and/or aggregated indicators of resource use and pollution intensities is the least demanding application of resource accounts in terms of information requirements. |

* Seminar on Environmental Accounting for Decision Making, OECD, 1995, Paris

Links to economic aspects and environmental impacts

Whereas many countries point at the usefulness of MFA for linking economic and environmental information, important links, such as those between trends in material flows and trends in market prices for these materials, or trends in related resource rents remain largely unexplored. Two countries reported on related work concerning price signals to encourage efficiency in the field of
water use and waste (Australia) and concerning taxes on selected natural resources and chemical compounds (Sweden).

Academic research continues to better understand the implications of material resource use for environmental quality and to relate material flows to environmental impacts\(^8\),\(^9\), and hence to well recognised environmental policy concerns. This is done by combining material flow analysis (MFA) and life cycle assessments (LCA), by linking MF indicators to other environmental indicators or data describing pollution issues, by aggregating materials by common characteristics so as to reflect their environmental burden profile or by weighing the various material or substance flows according to their potential environmental impact or toxicity. Weighing materials for their toxicity or environmental impact requires sophisticated research (link to non-linear, multi-dimensional factors, temporal, etc.). As for other aggregated environmental indices, the use of such indicators requires a broad acceptance of the weighing methods used and a consensus about the validity of the conversion factors used\(^10\). Hence full empirical results for consideration at international level are not yet available, but could benefit from further exchange of experience among countries active in this area of work.

**Figure 1. Schematic representation of material flows, environmental impacts and policy uses**


\[^9\] See also the research project by the European Commission, carried out by CML (Leiden University), CE (Delft) and the Wuppertal Institute on decoupling and resource productivity indicators, including a weighted MF indicator reflecting the highest environmental impacts. The project covers the 25 member states of the European Union and three accession countries; draft results were made available in October 2004.


Material Flow indicators

Twenty one OECD countries have calculated and/or use one or several economy-wide MF indicators. These indicators generally describe economy-wide material use, as well as related intensities (e.g. resource productivity, eco-efficiency) and decoupling trends when linked to the relevant economic variables. Most of them are used to monitor the overall trends and to draw attention to key developments that will require further analyses. A few OECD countries have also calculated or use specific indicators focusing on particular substances or materials (6 countries), products (2 countries) or industries (7 countries).

Most OECD countries that have developed a national set of environmental or sustainable development indicators include in their set one or several indicators derived from natural resource or material flow accounting. In 14 OECD countries, MF indicators are part of proposed or agreed sets of environmental or sustainable development indicators (Austria, the Czech Republic, Belgium, Denmark, Finland, Germany, Hungary, Italy, Japan, Poland, the Slovak Republic, Spain, Switzerland, the United Kingdom).

Among the most common economy-wide MF indicators in use are:

- **Direct material input** (DMI, 19 countries).
- **Domestic material consumption** (DMC, 19 countries).
- **Total material requirement** (TMR, 14 countries).

Among other indicators in use or being developed are:

- **Domestic extraction** used (DEU, 4 countries);
- **Consumption indicators** such as total material consumption (TMC, 5 countries), raw material consumption (RMC, 1 country).
- **Trade related indicators**: Physical trade balance (PTB, 10 countries), raw materials trade balance (RMTB, 1 country), physical trade balance including indirect flows (PTBMI, 1 country), domestic resource dependency (DRD, 1 country).
- **Net additions to stock** (NAS, 4 countries).
- **Output indicators**: domestic processed output (DPO, 6 countries); total domestic output (TDO, 3 countries); direct material output (DMO, 2 countries), total material output (TMO, 1 country).

These indicators are often related to economic indicators to calculate material productivity and intensity indicators. Some are related to population or to area variables.

Germany distinguishes between biotic and abiotic materials, and uses an indicator on **abiotic raw materials productivity**. It is defined as the ratio between Gross value added (at constant prices) and the sum of domestic abiotic (i.e. non-renewable) raw material extraction (used) and imports. It has similarities with indicators on labour and capital productivity, and describes the efficiency with which "non-renewable raw materials" are used in the national economy.

In the Netherlands, research has concentrated on developing **dematerialisation indicators** that reflect potential environmental impacts. In this context, an **environmentally weighted material consumption** (EMC) indicator has been developed.

Austria has developed and uses a **domestic resource dependency** (DRD) indicator relating material exports minus imports to DMI. Eurostat uses the DE to DMC ratio to indicate resource dependency. These indicators measure the degree to which national and/or regional economies rely on net imports for different categories of materials.

An indicator representing a **Sustainable net Benefit Measure of production** (SBM) compared to Direct Material Flows (DMF) has been used in a research project "Measuring the Eco-efficiency of Welfare
Generation in a National Economy” published by Statistics Finland in 2001. The aim was to test factor 4 targets, i.e. a 75% reduction in material use and maintenance of at least the current level of welfare during the next 20-30 years.

At international level, an indicator for material consumption is included in the 2001 UN CSD List of Sustainable Development indicators. The OECD uses several indicators related to natural resources use in its sets of core and key environmental indicators (CEI, KEI), and has considered indicators on material flows and material resource use in the development of decoupling environmental indicators (DEI) and in work on waste prevention indicators.

In Europe, the European Environmental Agency (EEA) publishes estimates for Total Material Requirement (TMR) in its indicator report ‘Environmental Signals’. Eurostat regularly publishes material input and consumption indicators for all EU member states with time series from 1980 to the most recent year12. The indicators compiled include: DEU, DMC, DMI, DRD, and PTB. The calculation of TMR, domestic processed output (DPO) and net additions to stock (NAS) was abandoned in the most recent update. The underlying data series are produced by research institutes on behalf of the European Commission (Wuppertal Institute; IFF-Vienna). The preliminary list of sustainable development indicators for the EU includes a section on production and consumption patterns with indicators on material consumption and waste generation.

### Links to policy goals and objectives

In many OECD countries, goals and objectives concerning the efficient management and sustainable use of natural resources and materials have been embodied in national sustainable development strategies (NSDS) or environmental action plans. In a few countries, time-bound quantitative targets have been defined. In general, these targets are not mandatory and rather an expression of desired policy directions. Hence the publication of indicators to monitor progress towards the achievement of these targets often follows communication purposes, rather than policy purposes.

#### General policy goals and broad sustainability considerations

In six countries, MF indicators are associated to broad policy goals:

- **decoupling** natural resource use from economic growth (Belgium: Federal Plan for sustainable development; associated indicators: not yet defined; Flanders: goal to be among the top 10 regions concerning eco-efficiency by 2010 – using GDP/DMI and GDP/DMC among the indicators to follow up this goal)).
- Supporting eco-efficient measures (Czech Republic: NSDS includes a DMC/GDP ratio and other indicators reflecting the consumption of material and energy, and the generation of waste and pollution per unit of production and service);
- using resources more efficiently (Denmark: National sustainable development strategy; associated indicators: e.g. TMR/capita, total consumption of selected resources);
- improving resource efficiency (United Kingdom: UK Government framework for sustainable consumption and production; decoupling indicators among which DMC, “Stone, sand and gravel extraction”, fertiliser use, waste arisings and share recycled, freshwater abstractions, and domestic water consumption;
- improving the efficiency of natural resource use and energy through the full life-cycle (Finland: Government Programme for sustainable development; associated indicators: TMR);
- achieving non-toxic and resource efficient material cycles (Sweden: Swedish environmental quality goals).

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Quantitative objectives

In three countries MF indicators are associated to quantitative objectives of a general nature such as those aiming at:

♦ increasing resource productivity by a factor of 4 in the longer term (Austria: Strategy for sustainable development; associated indicators: DMI, DMC, DMC/GDP).
♦ achieving dematerialisation with a factor 2 to 4 by 2030 (Netherlands: 4th National Environmental Policy Programme; associated indicators: being developed, e.g. EMC).
♦ Maintaining the Total Material Requirement (TMR) per capita at 1998 level in 2006 (Spain: Basque Environmental Strategy for Sustainable Development)

Quantitative time-bound targets

In four countries, MF indicators are associated to quantitative time-bound targets on resource productivity or material resource use intensity:

♦ the German target to improve the productivity of abiotic raw materials by a factor of 2 between 2004 and 2020 (National Strategy for sustainable development).
♦ the Italian targets to achieve a reduction of the total material requirement (TMR) of 25% by 2010, 75% by 2030 and 90% by 2050 (Environmental Action Plan for sustainable development in Italy).
♦ the Polish targets to reduce the water consumption, material intensity and waste generation in the production sector by 50% between 1990 and 2010 (Second National Environmental Policy).

Among the most prominent examples of policy use of MF related information and indicators is that of Japan. In 2003, the Japanese government adopted its Fundamental Plan for Establishing a Sound Material-Cycle Society (SMS). The Plan includes three quantitative time-bound targets to be achieved by the year 2010 compared to 2000: (i) improve resource productivity (GDP/DMI) by 40%, (ii) improve the cyclical use rate by 40%, and (iii) reduce the final disposal amount by 50%. The targets build on a cabinet decision, and stakeholders are asked to make efforts to contribute to their achievement. The fundamental Plan is to be revised in 2008.
Figure 2. Examples of uses of MF information and links to policy goals

- France, Hungary, Slovak Republic, Spain, Switzerland.
- Belgium: decoupling resource use vs economic growth
- Czech Republic: supporting eco-efficient measures
- Denmark: using resources more efficiently
- United Kingdom: continual improvements in resource efficiency
- Finland: resource efficiency, life cycle
- Sweden: non-toxic and efficient material cycles
- Austria: resource productivity (factor 4)
- Netherlands: dematerialisation (factor 4)
- Italy: TMR (-25% by 2010; -75% by 2030; -90% by 2050)
- Germany: abiotic raw material productivity (factor 2, 2004-2020)
- Poland: material, water, waste intensity in production (-50% 1990-2010)
- Japan: 3 targets: -resource productivity GDP/DMI+40%; -cyclical use rate+40%; -final waste disposal –50%; 2000-2010

Resource efficiency/ productivity

Quantitative objectives

Quantitative time-bound targets

Netherlands: dematerialisation (factor 4)
- Italy: TMR (-25% by 2010; -75% by 2030; -90% by 2050)
- Germany: abiotic raw material productivity (factor 2, 2004-2020)
- Poland: material, water, waste intensity in production (-50% 1990-2010)
- Japan: 3 targets: -resource productivity GDP/DMI+40%; -cyclical use rate+40%; -final waste disposal –50%; 2000-2010

Table 1. Overview of main uses of basic EW-MF indicators

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Applications (research, publications, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1: Short term availability: Based on harmonised methods, well-established, frequently implemented, high data quality</td>
<td></td>
</tr>
<tr>
<td>DEU Domestic Extraction Used</td>
<td>AUS, AUT, BEL-LUX, CZE, DNK, FIN, FRA, DEU, GRC, HUN, IRL, ITA, JPN, KOR, NLD, NOR, POL, PRT, SVK, ESP, SWE, CHE, GBR, USA.</td>
</tr>
<tr>
<td>IMP Imports</td>
<td></td>
</tr>
<tr>
<td>EXP Exports</td>
<td>WRI Study on AUT, DEU, JPN, NLD, USA.</td>
</tr>
<tr>
<td>DMI Direct Material Input (= DEU + Imports)</td>
<td>Other countries: ROU, BRA, CHL, CHN, THA, SAU.</td>
</tr>
<tr>
<td>DMC Domestic Material Consumption (= DMI – Exports)</td>
<td>WRI Study on AUT, DEU, JPN, NLD, USA.</td>
</tr>
<tr>
<td>PTB Physical Trade Balance (= Imports – Exports)</td>
<td></td>
</tr>
<tr>
<td>DPO Domestic Processed Outputs (= emissions, waste)</td>
<td></td>
</tr>
<tr>
<td>Group 2: Medium term availability: Methods not yet harmonised, application on the case study level, less often implemented, lower data quality</td>
<td></td>
</tr>
<tr>
<td>NAS Net-Additions to Stocks</td>
<td>AUS, AUT, BEL-LUX, CZE, ESP, EU 25, WRI Study on AUT, DEU, JPN, NLD, USA.</td>
</tr>
<tr>
<td>TMR Total Material Requirement (= DMI + unused domestic extraction + indirect flows associated to imports)</td>
<td>CZE, DNK, FIN, HUN, ITA, PRT, ESP, SWE, CHE, GBR, EU 25, WRI Study on DEU, JPN, NLD, USA.</td>
</tr>
<tr>
<td>RMEm Raw Material Equivalents of exports</td>
<td>DEU, DNK.</td>
</tr>
<tr>
<td>Group 3: Longer term availability: Little or no applications</td>
<td></td>
</tr>
<tr>
<td>RME Imp Raw Material Equivalents of imports</td>
<td></td>
</tr>
<tr>
<td>RM C Raw Material Consumption (= DMC + RMEimp - RMEexp)</td>
<td></td>
</tr>
<tr>
<td>TMC Total Material Consumption (= TMR – indirect flows associated to exports)</td>
<td></td>
</tr>
<tr>
<td>DMO Direct Material Output</td>
<td></td>
</tr>
<tr>
<td>TDO Total Domestic Output</td>
<td></td>
</tr>
<tr>
<td>EMC Environmentally weighted material consumption</td>
<td></td>
</tr>
</tbody>
</table>
I. OVERVIEW OF MATERIAL FLOW RELATED ACTIVITIES IN OECD COUNTRIES – SUMMARY TABLES

Table 1a. Resource and material flow accounts: main characteristics and scope

<table>
<thead>
<tr>
<th>Type of activity (a)</th>
<th>Other closely related work (b)</th>
<th>Reference framework (c)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-MFA</td>
<td>PIOTs</td>
<td>SFA</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>X ad-hoc</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>x pilot</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>New Zealand</td>
<td>–</td>
<td>X NRA</td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>X</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td>X</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Iceland</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

Other: Material & Energy Flow Accounts - MEFA (energy, water, GHG) as part of the Canadian System of Environmental and Resource Accounts. Focus on individual accounts not full EW-MFA. Uses input-output framework.

Other: system of Economic and Ecological Accounts of Mexico (SEEAM)

EW-MFA: study by World Resources Institute SFA: Yale University (4 metals) / MF studies at State level / Other: Toxic release inventory (TRI); US life-cycle inventory (LCI) project

Other: case studies for industrial materials. NAMEA: Environmental burden accounts linked to Economic Input-Output tables.

Environment and material accounts (water, minerals, forests, fisheries, energy, GHG), not full material flow analysis. Australian Stocks and Flows Framework based on input-output approach.

EW-MFA: Eurostat


EW-MFA: pilot project. Other: case studies for industrial materials. NAMEA: Environmental burden accounts linked to Economic Input-Output tables.

EW-MFA: Eurostat & WR

PIOTs: methodology work. SFA, NAMEA and other specific MFA

EW-MFA: pilot project for 27 industries (1600 & 1800 products in 1990 and 2002). NAMEA: regular activity for energy, water, air, oil & gas reserves, waste (physical part).

NAMEA type aggregation of branches of industry. SFA: sectoral LCA for mining, forest, metals, packaging industries, energy, water, waste water treatment, paper, nutrients. NRA: forests

Full fledged Material & Energy Flow Information System (MEFIS) based on PIOTs (breakdown by 60 branches) by NSO. Calculation of Raw Material Equivalents. Plus research work by NSO and Wuppertal Institute.

Plans to use of MFA concepts in government policy making.

Other: Water flow accounting (link to energy) & some work on soil-erosion

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<table>
<thead>
<tr>
<th>Type of activity (a)</th>
<th>Other closely related work (b)</th>
<th>Reference framework (c)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-MFA</td>
<td>PIOTs</td>
<td>SFA</td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td></td>
<td>X NRA</td>
<td>No wide application of MFA: NRA: National fossil fuel flows account; Water flows account for one region; work in progress; next steps yet to be defined.</td>
</tr>
<tr>
<td>Italy</td>
<td>X</td>
<td>X NAMEA</td>
<td>PIOT: feasibility study done; pilot-exercise realised. NAMEA: resource intake and air emissions by industry</td>
</tr>
<tr>
<td>Luxembourg</td>
<td></td>
<td>X NAMEA</td>
<td>No official plans for MFA work so far.</td>
</tr>
<tr>
<td>Netherlands</td>
<td>ad-hoc X plot</td>
<td>X NAMEA, eIQ analysis</td>
<td>EW-MFA: joint international research project. SFA: many studies since 1990; heavy metals, nutrients, organochlorines. Other: NAMEA, Dematerialisation. Focus: energy content &amp; env. impacts of MFSF.</td>
</tr>
<tr>
<td>Norway</td>
<td>X plot</td>
<td>X NRA</td>
<td>EW-MFA: 2006-07 pilot project. SFA: energy, air, hazardous substances, waste.</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td></td>
<td>X NRA</td>
<td>EW-MFA: systematic work since 2005 (Minister Resolution) via a project-pilot of the EPA. Other: Individual accounts for water, mineral ores, raw materials, oil, coal, fuels, wood, construction materials etc. at national level.</td>
</tr>
<tr>
<td>Spain</td>
<td></td>
<td></td>
<td>Other: water, forest, air emission accounts. MFA also by Basque country government.</td>
</tr>
<tr>
<td>Sweden</td>
<td>X plot</td>
<td>X X</td>
<td>SFA: Air + water emissions (focus on metals) by universities &amp; municipalities at local level; ad hoc study by Chemicals Inspectorate (appr. 200 substances). Other: energy-related materials, hazardous substances (NAMEA framework).</td>
</tr>
<tr>
<td>Switzerland</td>
<td></td>
<td>X NAMEA</td>
<td>EW-MFA: yearly since 2003. NAMEA: pilot-project on CO2 emissions in 2002. SFA and regional or micro-level MFA: various studies by consultant firms, universities, research institutes (mostly related to waste management).</td>
</tr>
<tr>
<td>Turkey</td>
<td></td>
<td>X NAMEA</td>
<td>Other: SEEA supply-use tables (Irish water); NAMEA air; stand-alone study (1999-2002).</td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td>X NAMEA</td>
<td>EW-MFA: Wuppertal Institute pilot study; plus complete UK overview mass balance. PIOT: regional, product based using PRODCOM; ad hoc NGO work. SFA: studies by waste management industry as part of landfill tax credit scheme (Biffaward). NAMEA (air &amp; energy)</td>
</tr>
</tbody>
</table>

Notes:
Overview based on replies to the global survey of activities related to material flow analysis (by OECD and EEA) and on other country contributions. It should be noted that replies to the global survey are the respondent’s views, and may not reflect the country’s official position. Further details can be found in the descriptive country sheets.

a) EW-MFA: economy-wide material flow accounts or mass balances; PIOTs: physical input-output tables; SFA: substance flow analysis.
b) Other: all other relevant activities, including individual flow accounts and other natural resource accounts (NRA), National Accounting Matrix including Environmental Accounts (NAMEAs), etc.
c) SEEA: System of Integrated Environmental and Economic Accounting.
Source: OECD.
Table 1b. Resource and material flow accounts: status of work and lead agencies

<table>
<thead>
<tr>
<th>Country</th>
<th>Start date</th>
<th>Duration and periodicity</th>
<th>Status</th>
<th>Lead agency</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>early 1990s</td>
<td>X</td>
<td>X X</td>
<td>NSA</td>
<td>NSA: Canadian System of Environmental and Resource Accounts (MEFA). Varying periodicity; annual for GHG &amp; energy accounts. Participation in international work related to MFAcc (London Group, UN and OECD).</td>
</tr>
<tr>
<td>Mexico</td>
<td>1991</td>
<td>X</td>
<td>X X</td>
<td>NSA</td>
<td>NSA: Refers to system of Economic and Ecological Accounts of Mexico (SEEAM).</td>
</tr>
<tr>
<td>USA</td>
<td>mid 1990's</td>
<td>X EW-MFA</td>
<td>X</td>
<td>RES</td>
<td>RES: EW-MFA: WRI with government funding. No formal government-wide programme yet. SFA: Yale University (4 metals) and studies at state level</td>
</tr>
<tr>
<td>Japan</td>
<td>1992/2003</td>
<td>X EW-MFA</td>
<td>X X</td>
<td>MIN, RES</td>
<td>MIN, RES: MFA studies led by NIES with government funding. Many studies also by consultant firms., universities, research institutes (mostly related to waste management and the SRFs). Many partnerships and co-operation at international level (OECD, ConAccount). Regular government activity since FY2003.</td>
</tr>
<tr>
<td>Australia</td>
<td>2001</td>
<td>X NRA</td>
<td>X</td>
<td>MIN, NSA</td>
<td>MIN, NSA: Periodicity varies with projects (mainly NRA).</td>
</tr>
<tr>
<td>New Zealand</td>
<td>2001</td>
<td>X NRA</td>
<td>X</td>
<td>MIN, NSA</td>
<td>MIN, NSA: Periodicity varies with projects (mainly NRA).</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2000</td>
<td>X EW-MFA: annual</td>
<td>X PiotTs annual NAMEA</td>
<td>X X X</td>
<td>MIN, NSA, RES</td>
</tr>
<tr>
<td>Denmark</td>
<td>1997</td>
<td>X NAMEA</td>
<td>X</td>
<td>NSA</td>
<td>NSA: EW-MFA, PIOT: pilot projects by NSO. Funded by Research Foundation, EPA &amp; EU. Participation in work of London Group; contacts with Wuppertal Institute (Germany), IFF (Austria) and the EEA-ETCWMF.</td>
</tr>
<tr>
<td>Germany</td>
<td>1993</td>
<td>X annual except PIOTs</td>
<td>X</td>
<td>NSA, RES</td>
<td>NSA: Research work by NSO and Wuppertal Institute partly funded by EU.</td>
</tr>
<tr>
<td>Greece</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..: Refers to NRA. Periodicity varies.</td>
</tr>
<tr>
<td>Hungary</td>
<td>2001</td>
<td>X EW-MFA</td>
<td>X</td>
<td>MIN, NSA</td>
<td>MIN, NSA: EW-MFA: ad-hoc study by consultant firm SERI, funded by EU and part of governmental activity. RES: Budapest University of Technology and Economics, Corvinus University of Budapest.</td>
</tr>
<tr>
<td>Iceland</td>
<td>..</td>
<td>X</td>
<td>X</td>
<td>..</td>
<td>..: Refer to NRA. Periodicity varies.</td>
</tr>
</tbody>
</table>
## Inventory of country activities

### Measuring material flows and resource productivity

<table>
<thead>
<tr>
<th>Country</th>
<th>Start date</th>
<th>Duration</th>
<th>Regular activity</th>
<th>Ad-hoc project</th>
<th>Lead agency</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>2000</td>
<td>X EW-MFA</td>
<td>X NRA</td>
<td>X X</td>
<td>NSO</td>
<td>EW-MFA=annual, MF balances= every 5 years. PIOT: feasibility study done. NSO collaborates with the EPA, Ministry of Economy, and other institutions, incl. RES. MIN provided financial support and use EA figures. International participation: UNCEEA, London Group, Eurostat TF on MFA, CoreAccount network (coordinated by Wuppertal Institute).</td>
</tr>
<tr>
<td>Portugal</td>
<td>2000</td>
<td>X EW-MFA</td>
<td>-</td>
<td>-</td>
<td>RES</td>
<td>Stand-alone research study partly funded by government. Co-operation with NSO.</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>2005</td>
<td>X EW-MFA</td>
<td>-</td>
<td>-</td>
<td>MIN, EPA, NSO</td>
<td>EW-MFA: systematic work started in 2005 by the MIN and via a project-pilot from EPA (financed by government funding). NARA since 1993; annual updates. Other institutions involved: Ministry of Agriculture, Ministry of Economy and Mining Authority/Office.</td>
</tr>
<tr>
<td>Spain</td>
<td>late 1990s</td>
<td></td>
<td>X NAMEA</td>
<td>X X</td>
<td>NSO</td>
<td>MF work in Basque country region initiated in 2001: government work by university with Wuppertal Institute.</td>
</tr>
<tr>
<td>Sweden</td>
<td>2003</td>
<td>X EW-MFA</td>
<td>-</td>
<td>-</td>
<td>NSO</td>
<td>EW-MFA: ad-hoc studies only (late 1990s); no regular funding. NARA since 1993. SFA ad hoc study by Chemicals Inspectorate.</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1999</td>
<td>X EW-MFA</td>
<td>-</td>
<td>-</td>
<td>NSO (MIN)</td>
<td>EW-MFA: regular activity; yearly since 2003. Studies at regional or micro level by consultant firms, universities, research institutes: some funded by trade organisations &amp; other private institutions.</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1999</td>
<td>X annual</td>
<td>X</td>
<td>X X</td>
<td>NSO (MIN)</td>
<td>MF pilot by Wuppertal Institute, now NSO, DEFRA; complete UK overview mass balance completed in 2003. PIOT by NSO. International cooperation: Eurostat, London Group, OECD.</td>
</tr>
</tbody>
</table>

### Notes:

Overview based on replies to the global survey of activities related to material flow analysis and on other country contributions. It should be noted that replies to the global survey are the respondent’s views, and may not reflect the countries’ official position. Further details can be found in the descriptive country sheets.

a) MIN=ministry of the environment; NSO=national statistical office; EPA=environment agency; RES=research institute.

Source: OECD.
### Table 1c. Resource and material flow accounts: use and publication

<table>
<thead>
<tr>
<th>Country</th>
<th>Use of MF information to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Develop</td>
</tr>
<tr>
<td>Canada</td>
<td>EW, S,I</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>EW, S,P, I</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>EW, S</td>
</tr>
<tr>
<td>Korea</td>
<td>EW</td>
</tr>
<tr>
<td>Australia</td>
<td>-</td>
</tr>
<tr>
<td>New Zealand</td>
<td>-</td>
</tr>
<tr>
<td>Austria</td>
<td>EW, S</td>
</tr>
<tr>
<td>Belgium</td>
<td>EW</td>
</tr>
<tr>
<td>Finland</td>
<td>EW, S, I</td>
</tr>
<tr>
<td>Germany</td>
<td>EW, S, I</td>
</tr>
<tr>
<td>Greece</td>
<td>-</td>
</tr>
<tr>
<td>Hungary</td>
<td>EW</td>
</tr>
<tr>
<td>Iceland</td>
<td>-</td>
</tr>
<tr>
<td>Ireland</td>
<td>-</td>
</tr>
<tr>
<td>Italy</td>
<td>EW, I</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>-</td>
</tr>
<tr>
<td>Netherlands</td>
<td>EW</td>
</tr>
<tr>
<td>Norway</td>
<td>-</td>
</tr>
<tr>
<td>Poland</td>
<td>EW</td>
</tr>
<tr>
<td>Portugal</td>
<td>EW</td>
</tr>
</tbody>
</table>
### Use of MF information to:

<table>
<thead>
<tr>
<th>Develop</th>
<th>Support</th>
<th>Inform</th>
<th>Link</th>
<th>Monitor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF indicators (a)</td>
<td>Policy analysis</td>
<td>Modelling &amp; outlook activities</td>
<td>Decision making</td>
<td>PP: Key issues &amp; trends</td>
<td>Env &amp; Econ inform</td>
</tr>
</tbody>
</table>

| Spain | EW | - | - | - | X | - | - | X | ... | ... | ... | Yes | Publication on env. accounting & MFA (INE). |
| Sweden | EW | - | - | - | X | - | - | X | ... | ... | ... | No | |
| Turkey | - | - | - | - | - | - | - | - | - | - | - | No | - |
| United Kingdom | EW, I | X | X | X | - | - | - | - | - | - | - | Yes | Publication: Environmental Accounts- twice yearly publication Industry specific indicators: construction material extraction and output, supporting indicator for SD. |

### Notes:
Overview based on replies to the global survey of activities related to material flow analysis and on other country contributions. It should be noted that replies to the global survey are the respondent’s views, and may not reflect the countries’ official position. Further details can be found in the detailed country sheets.

(a) EW = Economy-wide; S = Substance or material specific; P = product specific; I = industry specific.

Source: OECD.
### Table 2. Material flow indicators: availability and use

<table>
<thead>
<tr>
<th>Availability of EW-MF indicators</th>
<th>Related policy goals (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type (a)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>in official indicator set agreed or proposed</strong></td>
<td><strong>Years</strong></td>
</tr>
<tr>
<td><strong>Canada</strong></td>
<td>–</td>
</tr>
<tr>
<td><strong>Mexico</strong></td>
<td>–</td>
</tr>
<tr>
<td><strong>USA</strong></td>
<td>DMI, DMC, TMR, Other (TDI, DPO)</td>
</tr>
<tr>
<td><strong>Japan</strong></td>
<td>DMI, DMC, TMR</td>
</tr>
<tr>
<td><strong>Australia</strong></td>
<td>–</td>
</tr>
<tr>
<td><strong>New Zealand</strong></td>
<td>–</td>
</tr>
<tr>
<td><strong>Austria</strong></td>
<td>DMI, DMC, Other (PTB, DDI, DAS), all related to population, GDP and area</td>
</tr>
<tr>
<td><strong>Belgium</strong></td>
<td>DMI, DMC, TMR, Other (PTB, DPO, DMO), related to GDP</td>
</tr>
<tr>
<td><strong>Czech Republic</strong></td>
<td>DMI, DMC, Other (TMC, DPO, DMO, NAS)</td>
</tr>
<tr>
<td><strong>Finland</strong></td>
<td>DMI, DMC, TMR, (TMC)</td>
</tr>
<tr>
<td><strong>France</strong></td>
<td>DMI, DMC</td>
</tr>
<tr>
<td><strong>Germany</strong></td>
<td>DMI, DMC, Other (abiotic raw materials productivity, DPO, PTB, NAS)</td>
</tr>
<tr>
<td><strong>Greece</strong></td>
<td>–</td>
</tr>
<tr>
<td><strong>Hungary</strong></td>
<td>DMI, DMC, Other (TMR, TMC)</td>
</tr>
<tr>
<td><strong>Iceland</strong></td>
<td>–</td>
</tr>
<tr>
<td><strong>Ireland</strong></td>
<td>–</td>
</tr>
<tr>
<td><strong>Italy</strong></td>
<td>DMI, DMC, TMR</td>
</tr>
</tbody>
</table>

- **Comments**: Indicators are available for selected resource and energy aspects for 1990-2003 through NSO website.
- **No precise objective, principle that “resources must be used more efficiently” in SD strategy.** Headline indicators (energy consumption, drinking water consumption & total waste volume) & specific set of 90 indicators.
- **No targets** for resource use efficiency and/or productivity adopted yet.
- **Proposed goal on decoupling use of NR from economic growth in draft Federal Plan for SD 2004-2008.** No indicators defined yet.
- **No targets** for resource use efficiency and/or productivity adopted yet.
- **The Fundamental Plan for Establishing a Sound Material-Cycle Society, includes time-bound targets by FY2010, 40% increase in Resource Productivity (GDP/DMI) and cyclical use rate, and 50% reduction of final disposal amount compared to 2000.** The plan will be revised in 2008.
- **Target to reduce TMR (-25% by 2010, -75% by 2030, -90% by 2050).**
<table>
<thead>
<tr>
<th>Country</th>
<th>Type (a)</th>
<th>in official indicator set agreed or proposed</th>
<th>Years</th>
<th>Lead agency</th>
<th>Policy plans, strategies</th>
<th>Objectives &amp; targets</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>Luxembourg</td>
<td>Other (TMC, PTB, PTBIF)</td>
<td></td>
<td></td>
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<td></td>
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<td>by 2050 in Env. Action Plan for SD approved by inter-ministerial committee in 2002.</td>
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<tr>
<td>Norway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Set of SD indicators developed, incl. natural resource indicators. Action plan for SD (part of report to the Storting) includes objectives partly related to material resource use and productivity.</td>
</tr>
<tr>
<td>Poland</td>
<td>DMI, TMR</td>
<td>Yes</td>
<td>1992-1999</td>
<td>MIN, EPA</td>
<td>X</td>
<td>X</td>
<td>MF indicators calculated by Wuppertal Institute (research project). National Env. Policy targets to reduce consumption of water, material intensity &amp; waste generation in production by 50% by 2010 compared to 1990.</td>
</tr>
<tr>
<td>Sweden</td>
<td>DMI, DMC, TMR (adhoc)</td>
<td></td>
<td>1993-1998</td>
<td>NSO</td>
<td>X</td>
<td></td>
<td>National system of indicators to measure SD includes &quot;total material flow/GDP&quot;. Regional level: the Canton of Geneva uses MFA to support the implementation of the local Agenda 21.</td>
</tr>
<tr>
<td>Switzerland</td>
<td>DMI, DMC, TMR, Other (PTB, material productivity &amp; intensity)</td>
<td>Yes</td>
<td>1981-2005</td>
<td>NSO</td>
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<td>Kingdom</td>
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Notes:
Overview based on replies to the global survey of activities related to material flow analysis and on other country contributions. It should be noted that replies to the global survey are the respondent’s views, and may not reflect the countries’ official position. Further details can be found in the detailed country sheets.

a) DMI: Direct Material Input; DMC: Domestic Material Consumption; TMR: Total Material Requirement; DEU: Domestic extraction used; DMO: Direct Material Output; DPO: Domestic Processed Output; DRR: Domestic resource dependency; NAS: Net Additions to Stock; PTB: Physical Trade Balance; PTBIF: PTB including indirect flows; RMTB: Raw Materials Trade Balance; TDO: Total Domestic Output; TMI: Total Material Input; TMO: Total Material Output.

b) Indicates whether goals concerning the efficient management and sustainable use of natural resources and materials exist in national sustainable development strategies or environmental plans, and whether related objectives have been defined.

BEL: Flanders: Goal (pact between government, organisations of employers and employees and env. NGOs): should be among the top regions on eco-efficiency (GDP/DMI, GDP/DMC). The Flemish Environmental Policy Plan 2003-2007 incl. a set of key indicators (incl. TMR) to evaluate env. policy in the long term.

Source: OECD.
## II. MATERIAL FLOW RELATED ACTIVITIES IN OECD COUNTRIES AND BEYOND - DESCRIPTIVE SHEETS

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<th>OECD AREA</th>
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<td>United Kingdom</td>
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<td>European Union – Commission of the European Communities</td>
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<td>Malta</td>
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<td>Brazil</td>
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<td>Colombia</td>
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<tr>
<td>Other Latin american countries</td>
<td>104</td>
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<tr>
<td>Africa</td>
<td>105</td>
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</tbody>
</table>
OECD AREA

CANADA

OVERVIEW

In Canada, work on material flows is part of the Canadian System of Environmental and Resource Accounts (CSERA) that builds on exploratory work in the late 1970s and early 1980s. Efforts focus on the development of individual material and energy flow accounts, rather than on economy-wide MF accounts. The lead institution is Statistics Canada. Among other institutions playing a role is the National Round Table on the Economy and the Environment (NRTEE), Environment Canada (EC) and Natural Resources Canada (NRC).

Canada participates actively in international work related to material flow accounting. Statistics Canada has been actively involved in the London Group on Environmental Accounting since 1997 and is coordinating the revision of Chapters 3 (Physical flow accounts) & 4 (Hybrid flow accounts) of the SEEA Handbook. Statistics Canada is also a member of the UN Committee of Experts on Environmental Accounting, and is the chair of the joint UNECE/Eurostat/OECD Working Group on Statistics for Sustainable Development. Representatives from Environment Canada, Natural Resources Canada and Statistics Canada have contributed to several of the OECD working groups related to material flow including the WGEIO, and the WGPR.

CHARACTERISTICS AND SCOPE

The first environmental and resource accounts, developed in the late 1970s - early 1980s, used the Stress-Response framework also used for organising physical data in Canada's Environmental Statistical System (Friend and Rapport, 1979; Friend, 1981)

The Canadian System of Environmental and Resource Accounts (CSERA), set-up over 1992-1997, uses the basic methods of the Canadian System of National Accounts (CSNA) to organise physical and monetary statistics. It has three components:

♦ the Material and Energy Flow Accounts (MEFA);
♦ the Natural Resource Stock Accounts;
♦ the Environmental Protection Expenditure Accounts (Statistics Canada, 1997).

The Material and Energy Flow Accounts (MEFA) record in substantial detail the annual production and consumption flows of materials and energy – in the form of resources and wastes – between the Canadian economy (industries, households, governments) and the environment. The accounts are structured according to the framework and sectoral classifications of the Canadian Input-Output Accounts, thus allowing environmental data in the MEFA to be directly and easily linked with economic data (hybrid flow accounts as defined in SEEA-2003). The Input-Output Accounts provide annual estimates of the production and consumption of 476 commodities by 113 industries and 120 categories of final demand. The MEFA build on this substantial detail by incorporating physical estimates of natural resource and waste flows into the accounting framework of the Input-Output Accounts.

MEFA have so far been produced for energy use, water use and greenhouse gas (GHG) emissions. Energy and GHG emission accounts are updated annually. As these accounts are based on I/O tables, the delay with respect to the reference year is four years. Data are available for 1990-2003. Work is currently underway to determine the feasibility of using synthetic input-output data to improve on the timeliness of the energy and GHG accounts. Water use accounts used to be updated every five years, but related surveys have been discontinued (data available for 1981, 1986, 1991 and 1996).

OUTPUTS AND USE

Publication: The following tables are produced and are made available electronically through the Statistics Canada website for the years 1990-2003: Energy use by sector, Direct and indirect energy use by industry, Greenhouse gas emissions by sector, Direct and indirect greenhouse gas emissions by industry. Analytical articles based on these data are published in a variety of publications including: Canadian Environmental Sustainability Indicators, Econnections: Linking the Environment and the Economy and Environmental Perspectives: Studies and Statistics.
Each year, NRC publishes the *Canadian Mineral Yearbook*, which reviews global trends for more than 70 minerals.

**Indicators:** MEFA provide the basis for some important *environment-economy indicators* that shed additional light on the nature of economic development in Canada. These are quantitative measures that define the extent to which the economy places demands on the environment as a source of raw materials and as a sink for waste materials, and provide important counterparts to the long-standing economic indicators published by Statistics Canada. Examples are:

- resource use/intensity of industrial output (water, energy, forest*, fish*).
- resource intensity of household consumption.
- waste intensity of industrial output (greenhouse gas emissions, solid waste*, wood waste*).
- waste intensity of household consumption.
- waste intensity of net exports.
- recycled proportion of total resource use.

* planned initiatives - not yet available

Environment Canada is also considering the incorporation of some of these material and energy flow indicators into their national state of environment reporting and indicators publication.

**Links to policies and objectives:**

The development of environmental and resource accounting in Canada has been closely related to policy development. A major turning point was in 1990 when the government released *Canada's Green Plan for a Healthy Environment* (Government of Canada, 1990), that initiated the development of the CSERA to quantify the links between the environment and the economy, and helped to make related funding available.

Data from the energy and greenhouse gas accounts are currently being used by Canada’s Department of Finance in their economic-environmental modelling. Their efforts are focused on the development of individual material flow accounts so that the data can be used in the development of specific resource policies (such as energy, climate or waste). As there is no national policy at this time in Canada with regards to sustainable resource use and/or resource productivity, there is no demand for the development of MFA data at the economy-wide macro-level.

**Use in research work:** MEFA data has been used for studies at STC on the potential availability of scrap metal in the economy as well as on a study of paper and wood fibre flows. University researchers that are accustomed to use Statistics Canada’s economic data and concepts have been able to easily incorporate material and energy flow data into their existing models, making them particularly useful for research purposes. Studies include: the potential impact of trade of goods and services on the environment, multi-factor productivity, eco-efficiency and energy/GHG intensities.
REFERENCES

Environment Canada, et al. (2004), Environmental Valuation Reference Inventory (EVRI), www.evri.ca.


St. Lawrence, J. and C. Gaston (n.d.), Input-Output Modelling of Scrap Metal Generation Based on Historical Final Demand, Statistics Canada, Ottawa, 19 p.
MEXICO

OVERVIEW

Mexico has not yet carried out work on material flows, but has good experience with integrated economic and environmental accounting. Environmental accounts are implemented since 1991.

The lead institution is the National Institute for Statistics, Geography and Informatics (Instituto Nacional de Estadística, Geografía e Informática - INEGI).

The System of Economic and Ecological Accounts of Mexico (SEEAM), covers environmental themes such as petroleum, forests, underground water, air and water pollution and soil degradation. It includes indicators such as the Net Ecological Domestic Product (NEDP), a GDP adjusted for depletion and degradations costs.

Publication: Results from the SEEAM are published regularly since 1991; the latest publication includes data for the period 1997-2002.

At academic level, a comparative EW-MFA of Mexico, Peru, Ecuador and Chile (1980-2000) has recently been carried out. An early version of this paper (accepted by the Journal of Industrial Ecology) and a paper on the EW-MFA Mexico (1970-2003) are actually available on the Economics Department website of the Autonomous University of Barcelona (UAB).

REFERENCES


UNITED STATES

OVERVIEW

The United States has no formal government-wide programme on material flows analysis, but has a long history of tracking mineral and energy flows, waste flows and toxic substances. Material flows related databases and analyses are well established in a variety of U.S. government agencies that gather material flows data relevant to their organisational missions and responsibilities.

Main institutions involved are the US Geological Survey (USGS), the US Department of Energy (DOE), the US Environmental Protection Agency (EPA), and the US Department of Agriculture (USDA).

MF studies have also been carried out at State level (Massachusetts, New York/New Jersey, Washington), and at the national level by private research institutes (World Resource Institute - WRI, economy-wide material flows) and by universities (Yale University, substance flow analysis with a focus on metals and a series on chlorine).

Together with Austria, Germany, Japan and the Netherlands, the United States has, via the World Resources Institute, actively participated in the joint international research project on material flows that led to two key publications by the World Resource Institute, et al. in 1997 and 2000.

As a result, there are many sources of data on material flows in the United States, although they are not co-ordinated or integrated for analysis or public policy-making purposes. In a recent study commissioned by the DOE, the EPA, the National Science Foundation and the USGS, the National Research Council recommended that a national-level effort be initiated to establish a comprehensive approach to material flows analysis building on "a structured material flow accounting framework that can accept and integrate existing and future data".

CHARACTERISTICS AND SCOPE

A research work carried out by the WRI in collaboration with the EPA, the USGS and other government agencies has focused on economy-wide MF studies and has so far generated time series data from 1975 to 2000. The data are classified by life cycle phase (Inputs, Uses, Outputs, Recycling), and characterised by mode of first release (M), quality (Q), and velocity (V) of flows. Current efforts concentrate on establishing a pilot database covering approximately 200 materials at various levels of details (macro- and micro-flows) and drawing upon data available from official sources (See box below).

Furthermore, the Stock and Flows (STAF) project at Yale University is a very active and important contributor to metal MFA studies and has published several papers on historical and current flows of copper, zinc and silver. Most of their studies concern national and global levels, but regional flows are also sometimes studied in finer detail. Research is now shifting from flows to stocks, which will feed back important information for flow studies. Current cycle analyses focus on nickel, tin, chromium tungsten and various steels. The STAF models of resource use are applied to predict several future technological scenarios and their environmental and economical impacts.

Examples of major material flow related studies and analysis generated by government agencies at federal level include the following:

- **Historical Statistics for Mineral and Material Commodities in the United States**: This interactive database, created and maintained by the USGS, is a compilation of historical US and world statistics on mineral and material commodities. This continuously updated database contains information on primary and secondary commodity production, imports, exports, and stock changes; reported and apparent consumption; and unit value (the real and nominal dollar value of a ton of apparent consumption) for approximately 150 commodities. For most of the commodities, data are reported as far back as 1900.

- **Flow Studies for Recycling Metal Commodities in the United States**: This 2004 publication presents material flow studies for 26 metal commodities. Each study covers issues from mining, through processing and consumption, to recycling. Overall, recycling accounts for more than half of the U.S. metal supply by weight and roughly 40 percent by value.

- **The Toxics Release Inventory (TRI)**: The TRI is a publicly available EPA database with information on toxic chemical releases and waste management activities reported annually by certain industry groups as well as federal facilities. It was established under the Emergency Planning
and Community Right-to-Know Act of 1986 (EPCRA) and expanded by the Pollution Prevention Act of 1990. It covers 650 chemical compounds; waste and emissions are tracked, but reporting is not designed to track fate of chemicals or materials through production and consumption activities.

- The **US life-cycle inventory (LCI) project** is a public/private research partnership aiming at creating a publicly available database on material and energy flows associated with a particular product or system. The project, sponsored by government agencies and private companies, was initiated in May 2001 and is steered by an advisory group of 45 government representatives, and of industrial, academic and consulting communities. A test version of the database is available.

- The **By-Product Synergy (BPS) project** is about creating and capturing value through matching producers of under-valued waste streams with users, and working with regulators to establish support for the process. BPS promotes a shift from a waste disposal system to a reuse methodology, saving energy and cutting emissions. EPA is supporting BPS projects in New Jersey and Kansas City.

Examples of **State level initiatives** include the following:

- The states of **New Jersey** (since the mid-1990s) and **Massachusetts** (since 1990) have established inventories that track substance-specific material throughputs at the facility level (amounts of materials entering the production process, and amounts released to air, water and soil). The focus is on toxic chemicals. The data are reported annually by firms that use more than a certain amount of listed toxic chemicals. New Jersey's law requires reporting of the same substances as the EPA's TRI, but with more detail regarding the flow characteristics.

- The New York Academy of Sciences (NYAS) has undertaken a multi-year study to identify and quantify the flows of specific contaminants into the **New York/New Jersey Harbour** from the regional watershed. This initiative was initiated by EPA's New York regional office and carried out by the NYAS and its associated Harbour Consortium of regional stakeholders. This consortium ensures the engagement of interested and affected stakeholders and includes states, local and federal governmental agencies, non-profit and environmental organizations, industry, labour, scientific organizations, academia and others. The project utilizes the principles of industrial ecology at the regional/watershed level, using material flow analyses, mass balances and economic assessments to develop inventories of contaminant use and release in the region and to identify the pollution prevention strategies that can have the greatest environmental impact and that are economically feasible.

- The state of **Washington** has used materials flow information and models in the development of its "Beyond Waste" project – a long term (30 years) plan for addressing solid and hazardous waste issues. The plan aims at decreasing solid and hazardous wastes, properly manage wastes that remain, and reduce the use of toxic substances by moving beyond waste to resource re-use and toxic-substance reduction.

**OUTPUTS AND USE**

**Publication:** There is no comprehensive official publication on material flows, but time series with US material flows data have been published by GS and WRI.

**Indicators:**

- Economy-wide MF information compiled by WRI as part of its research projects has been used to derive indicators such as Direct Material Input (DMI), Domestic Material Consumption (DMC), Total Material Requirement (TMR), Total Domestic Output (TDO), and Domestic Processed Output (DPO).

- Closely related indicators are included in other projects, e.g. **Micro Indicators of Environmental Stress** (dissipation of heavy metals into the environment, land disruption resulting from materials extraction, atmospheric releases of greenhouse gases); **Resource Efficiency Indicators** (recycling indices by economic sector, ratio of agricultural water consumption to food production, ratio of processed/raw materials).

**Links to policies and objectives:**

- In the states of **New Jersey** and **Massachusetts**, substance specific material flow information collected from industrial facilities is used for pollution control purposes and for encouraging industries to implement pollution prevention. It is also used for public communication purposes and can be accessed by anyone. In Massachusetts, this is done in the framework of the implementation of the Toxics Use Reduction Act (TURA) passed in 1989 to encourage a reduction in the amount of toxics used and the amount of toxic by-products generated by promoting more efficient industrial
operations. It involves in-plant changes that reduce, avoid, or eliminate the use of toxic chemicals or the generation of hazardous waste, emissions (to air or land), and by-products per unit of product manufactured.

- To date, five contaminants of concern for the NY/NJ Harbor have been studied, and action plans have been completed for mercury, cadmium, polychlorinated biphenyls (PCBs) and dioxins, with polycyclic aromatic hydrocarbons (PAHs) currently under study. Also upcoming is a synthesis report, summarizing key findings and lessons learned during this collaborative process.

- In the state of Washington, certain MF data is being used to measure progress in achieving the goals set out in the "Beyond Waste" project 30-year plans as required by a State law. However, the state is not currently pursuing comprehensive MF indicators because the necessary information is not all available.

The World Resources Institute (WRI) is an independent non-profit organisation carrying out research on environment related policy issues, including natural resource management and material flow analysis. Since the mid-1990s, the WRI has conducted three major studies on material flows and has published time series with material flow data for the USA in 1997, 2000 and 2004. Part of this work received financial support from the US government (e.g. EPA and USGS).

The first two studies were carried out together with research partners in Austria, Germany, Japan, and the Netherlands. The aim was to develop databases and indicators documenting the flow of materials through industrial economies in the late 1990's. The studies have produced two reports in 1997 and 2000. These reports, co-ordinated by the WRI, have shed light on the trends in materials throughput over the last several decades, and have contributed to the development of a standardized approach to materials flow accounting.

Current work began in 2002 and has focused exclusively on the United States. The aim is to compile a Materials Flow Accounts database for the United States and to advance the use of physical accounts of material throughput in the US economy as a tool for formulating national environmental and resource policies. This work will culminate in the publication Material Flows in the United States: A Physical Accounting of the US Industrial Economy, scheduled for publication by the end of 2007.
REFERENCES

Stock and flows (STAF) Project website, Yale School of Forestry & Environmental Studies, Center for Industrial Ecology, http://research.yale.edu/stafproject/index.html (see box below for additional references).
The United States Census Bureau (1997), The Materials Summary: Materials Used in Several Industrial Sectors, such as Manufacturing and Construction, US Department of Commerce, Washington DC.
The United States Environmental Protection Agency, Toxics Release Inventory, www.epa.gov/tri/.
Additional references from the stock and flows (STAF) project

Chromium

Copper
Lifset, R.J., R.B. Gordon, T.E. Graedel, S. Spatari, and M. Bertram (2002), Where has all the copper gone: The stocks and flows project, part 1, JOM 54 (10), pp.21-26.

Iron

Silver

Zinc
JAPAN

OVERVIEW

Japan initiated economy-wide MF studies in 1992 for a report on the quality of the environment, and has since then actively contributed to promote MF studies at international level.

The lead institutions are the National Institute for Environmental Studies (NIES) that produces annual MF data on behalf of the Ministry of Environment (MOE), and the MOE itself that is responsible for compiling MF indicators. Other bodies involved include the Japan Environmental Sanitation Centre (JESC), and the Fuji Research Institute Corporation (a consultant firm). In addition, the government provides funding for academic research projects (e.g. on Physical Input-Output Tables (PIOTs), Life Cycle Analysis (LCA)). Some private companies (e.g. Toyota Motor Corporation) and local authorities (e.g. Aichi Prefecture) are also very active in conducting MFA related activities.

Governmental research activities on Environmental and Resource Accounting including Material Flow Accounting (MFA) have been supported financially by the Global Environmental Research Fund (GERF), managed by the MOE. The first phase of the research project on environmental accounting started in 1991. Since then, four three-year-projects have been conducted by the NIES and collaborating institutions, including the Economic and Social Research Institute (ESRI), which is responsible for the SNA. A new project has been launched for FY2004-2006 with the participation of the NIES, the National Institute for Advanced Industrial Science and Technology (AIST), the National Institute for Material Science (NIMS), and six universities.

The results of these research projects have contributed to related international activities such as those carried out by the OECD and the ConAccount network co-ordinated by the Wuppertal Institute (Germany). Together with Austria, Germany, the Netherlands and the United States, Japan has, via its research activities, actively participated in the joint international research project on material flows that led to two key publications by the World Resource Institute, et al. in 1997 and 2000.

CHARACTERISTICS AND SCOPE

The work covers economy-wide MFA, Physical Input-Output Tables (PIOTs), and National Accounting Matrices including Environmental Accounts (NAMEAs).

- **Economy-wide MFA**: build on the Eurostat framework and methodology. Data are available from 1980 to FY2004 and are updated on an annual basis.
- **Physical Input-Output Tables (PIOTs)**: Japan has established PIOTs, linked to its economic input-output tables, as part of the national environmental statistical system. A trial edition of Japanese PIOTs was compiled by the NIES.
- **NAMEAs**: A Japanese NAMEA – linking environmental burden accounts to Economic Input-Output tables – was edited by ESRI.
- **Material System Analysis (MSA)**: case studies for a group of industrial materials, such as: timber, plastics, metals, recyclables, etc.

The current phase of the government's research projects (FY2004-2006) aims at developing indicators and methodologies to assess the performance of policy measures and technologies concerning sustainable production and consumption by using material flow models. The models are expected to be multi-scale so as to facilitate the linkages among material flow information at the macro-, meso- and micro- scales.

OUTPUTS AND USE

**Publications**: Two thematic data books related to environmental accounting have been published. They are available as paper copies with CD-ROM and via internet. The first one uses input-output tables and relates to embodied energy and emission intensity data (3EID); it contains sectoral emissions of CO2 and major air pollutants. The second one relates to material flow data "World resource flows around Japan"; it describes physical international trade flows on visual maps.

A third publication on material flows with PIOTs of harvested wood and related carbon flows have been published in March 2004. The publication of trial versions of PIOTs for other resources is under consideration.
The NIES also published an important collection of case studies related to MFA in 2006. This work highlights the purposes and/or uses, and the main outcomes of EW-MFA, MFA on materials and product, and MFA on meso- and micro-levels realised in Japan and in different organisations around the world.

**Indicators:** EW-MF information is used to derive MF indicators including Direct Material Input (DMI), Domestic Material Consumption (DMC), and Total Material Requirement (TMR).

**Links to policies and objectives:**

MF indicators are closely related to the Government’s policy as stated in Japan’s Fundamental Plan for Establishing a Sound Material-Cycle Society approved by Cabinet and enacted in March 2003 (implementing the Fundamental Law for Establishing SMS, Law No. 110 of 2000). As part of the Fundamental Plan, the Japanese government adopted three numerical time-bound targets on resource efficiency. The targets were defined on the basis of results from the above-mentioned research projects and are accompanied with indicators to measure progress.

The indicators and targets are defined as follows*:

- **Resource Productivity** (yen/tonne) = GDP / DMI
  Target: increase resource productivity to 390,000 yen/tonne by 2010 from 280,000 yen/tonne in 2000

- **Cyclical Use Rate** (in %) = amount of Cyclical Use / DMI + amount of Cyclical Use
  Target: increase cyclical use rate to 14% by 2010 from 10% in 2000

- **Final Disposal Amount** (tonnes)
  Target: decrease amount going to final disposal to 28 million tonnes by 2010 from 56 million tonnes in 2000.

The three indicators together with supplemental indicators (e.g. natural resource input broken down into several resource types; amount of import and export of waste) have been reviewed three times by the Central Environmental Council and a series of public hearings with various stakeholders (local governments, NPO/NGO, business community, academic community and general public). Every fiscal year, the results were reported at Cabinet meetings and reflected in the White Paper which was reported to the Diet meetings.

*The Fundamental Plan for Establishing SMS is to be revised by the Central Environmental Council by approximately March 2008. MF indicators referred to the above may be changed and new indicators may be introduced in the process of the argument at the council. The target setting process will include not only government officials but also other stakeholders and experts.

At **local and enterprise levels**, two examples of MFA related activities are to be mentioned:

- **MFA related activity in the Aichi Prefecture:**

  The Aichi prefecture is the centre of industrial production in Japan. MFA is used in support of the prefectural Plan for Establishing a Sound Material Cycle Society. The Plan focuses on extended producer responsibility and on the waste generator responsibility. It includes quantitative targets to be achieved by FY 2010, including general targets (40% increase in GDP; 20% increase in recycling rates; 58% decrease in waste going to final disposal), and specific targets for the government and the business sector, and for the public.

- **MFA related activity by the Toyota Motor Corporation:**

  Since 1998, Toyota has been promoting its environmental management programmes. The overall aim is to move towards “zero emissions” at all stages of car manufacturing and to encourage behavioural changes by employees. In practice, efforts focus on reducing the amounts of waste going directly to landfill by maximising recycling and reuse, optimising the effectiveness with which raw materials and energy are used in the production processes.
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KOREA

OVERVIEW

Current work on material flow accounts in Korea builds on research activities on environmental accounting initiated by the Korea Environment Institute (KEI) in 1994. The work is part of a ten-year master plan for the implementation of the System of Environmental-Economic Accounting (SEEA), which was launched in 2001 by the Ministry of Environment, in co-operation with the Bank of Korea and the National Statistical Office.

Research projects initiated in 2002 have been based on this ten-year plan and mainly funded by the Ministry of Environment. In the early phase of the plan, the priority was given to the development of ‘green GDP’. However, from 2004, the focus moved toward the compilation of physical accounts such as economy-wide material flow accounts (EW-MFA), National Accounting Matrix including Environmental Accounts (NAMEA), and Environmental Protection Expenditure Accounts (EPEA).

In 2005-2006, EW-MFA and NAMEA-air were compiled as pilot-studies following Eurostat's methodological guide. In 2007, the compilation method and data for both studies were examined and updated. Some important information based on indicators derived from EW-MFA (e.g. resource productivity) were made available to the public.

CHARACTERISTICS AND SCOPE

Economy-wide Material Flow Accounts: EW-MFA have been compiled according to "Economy-wide material flow accounts and derived indicators" (Eurostat, 2001). The collection of data set was concentrated upon the domestic extraction, imports, exports and ‘output to nature’ mainly due to the problems in data availability of the hidden flows.

The domestic extraction is composed of fossil fuels, minerals and biomass. Data on the domestic extraction are primarily available from statistical yearbooks independently published by the Ministry of Commerce, Industry and Energy, the Ministry of Construction and Transportation, the Ministry of Agriculture and Forestry, the Korea Forest Service, and the Ministry of Maritime Affairs and Fisheries.

Data on imports and exports available in the trade statistics are provided by the Korea International Trade Association. Imports and exports are classified into three material groups – fossil fuels, minerals and biomass – based on the division method in "Material use in the European Union 1980-2000" (Eurostat, 2002).

Air emissions of ‘output to nature’ include CO2, CH4, N2O, NOx, VOC, CO, TSP, NH3, CFCs and halons. Waste landfilled includes all waste categories. Emissions to water include BOD, TN, and TP. Dissipative flows include fertilisers, pesticides, and abrasion of tyres. Data on ‘output to nature’ are mostly collected from database systems managed by the Ministry of Environment. Data on greenhouse gases are acquired from the Ministry of Commerce, Industry and Energy.

Four material flow indicators (DMI, DMC, PTB, DPO) are derived based on statistical data mentioned above. Due to the limited availability, the data set on DMI, DMC and PTB only covers the period 1991-2005, and DPO 1991-2004.

NAMEA-air: NAMEA-air has been compiled according to NAMEA-air standard tables of Eurostat's compilation guide ("NAMEA for Air Emissions", draft version, 2007). NAMEA-air includes greenhouse gases (CO2, N2O, CH4, HFCs, PFCs, SF6) and other air pollutants (NOx, SOx, NH3, VOC, CO, PM10). Data on greenhouse gases are available from the Ministry of Commerce, Industry and Energy in charge of energy statistics. Data on other air pollutants are available from emission inventory of CAPSS (Clean Air Policy Support System) managed by the Ministry of Environment. The data set on greenhouse gases covers the period 1990-2004, while detailed information on other air pollutants emission sources has been released only from the year 1999. Industry classification of NAMEA-air is matched to national accounts, in which industrial economic data are grouped into 21 sectors.

MFA studies at industry-level and for specific material groups are being reviewed in depth for the improvement of material flow information. In addition, the feasibility study for physical input-output tables (PIOT) is underway.
OUTPUTS AND USE

Material flow indicators have recently been utilized in policy context. The Government adopted DMC as an indicator of material use in the baskets of National Sustainable Development Indicators in 2007. The Ministry of Environment currently plans to set up a policy target using material flow indicators.

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AUSTRALIA

OVERVIEW

In Australia, work on material flows is part of the country’s environmental accounting activities. Efforts focus on the production of individual material accounts in areas that are of particular relevance to the country and its economy, rather than on economy-wide material flow accounts.

This work is part of the government’s environmental reporting activities and of its official statistics. Lead institutions responsible for MFA and related activities are the Department of Environment and Heritage - from a policy perspective - and the Australian Bureau of Statistics (ABS) - from a statistical perspective.

Among other institutions involved is the Commonwealth Scientific and Industrial Research Organisation (CSIRO) that is in charge of the Australian Stocks and Flows Framework (ASFF).

At the academic level, MF related research work is carried out by the Griffith University.

In addition, the Australian Government has established a “Centre for Sustainable Resource Processing” as part of its Cooperative Research Centres Programme. The aim is to create a partnership of science and industry to improve the efficiency of its mineral and metals processing sector. Key areas for focus include: minimising energy consumption and greenhouse gas emissions; reducing process waste; reducing water consumption and efficiently using natural resources.

Apart from work on the ASFF, Australia is also looking to pricing signals to encourage more efficiency in areas such as water use and waste generation.

CHARACTERISTICS AND SCOPE

Australia’s work on environmental and natural resource accounts are developed as satellite accounts in accordance with the System of Integrated Environmental and Economic Accounting (SEEA). In addition, the standard Australian System of National Accounts (SNA) is disaggregated in a way that reveals links to national resource use.

Environmental and material accounts produced include: Water (new account released May 2004), Minerals, Forests, Fish, and Energy and Greenhouse gases. The focus is on the resource aspect, not necessarily on the full material flow analysis.

Australia’s Water Account

- Australia’s Water Account is compiled in accordance with the SEEA. It provides information on the supply and use of water in Australia, as well as on water stocks, environmental flows and water trading. Data are disaggregated by industry, State and source of water used.
- Australia’s Water Account has been developed because water is an important issue for Australia and its agricultural sector (less rainfall than any other continent except Antarctica; irregular supply – only 20% of Australia’s total runoff can be sustainably diverted; limited supply in major agricultural and urban areas). It is used to inform policy especially in pinpointing key users and areas of inefficiency. It also informs ongoing negotiations between States and key users on water allocation.

The Australian Stocks and Flows Framework (ASFF):

- The ASFF is a highly disaggregate data base and simulation model that keeps tracks of all physically significant stocks and flows in the Australian socio-economic system and interactions with the environmental compartments. It covers the complete economy, including service aspects, but incorporates only the physically significant elements of each sector. At the centre of the framework is an input-output model for the transformation of basic materials and energy types. Stocks have age profiles to inform their evolution. Uses of resources from the environment and emissions to the environment are observed. It is grounded with 50 to 60 years of historical data and can be used to run scenarios for the future up to 2100. Economic and social behaviour and technological progress are not modelled but entered as exogenous inputs.
- Results from the ASFF can assist decision making through creating and comparing scenarios. Policy analysis can suggest adjustments of chosen control variables and observe the model results. It does not typically employ automatic optimisation or resolution of tensions within and between sectors; usually analysis interact with the system to generate physically feasible scenarios and innovative solutions. In doing this, it can provide an integrated overview of the long-term physical consequences of economic and social choices made by Australians.
OUTPUTS AND USE

Information from Australia’s environmental and resource accounts is used in support of the National Strategy for Ecologically Sustainable Development and of national state of the environment reporting.

The Australian Stocks and Flows Framework (ASFF):

- The ASFF is being used in a range of policy areas including energy and greenhouse gases, oil depletion, land and water futures, grains industry, long-term population policy and fisheries management.
- It has been used in the 1996 and 2001 State of the Environment reports to assess the environmental impacts of human settlements. It enables an assessment of reducing resource requirement against maintaining/improving liveability. It was also used in the preparation of the 2006 State of the Environment report to describe physical stocks and flows of water, energy and wastes and other materials in the Australian economy. This was through a detailed study of the urban metabolism of three selected settlements in Australia. The selection of settlements was made so as to cover a range of characteristics – size (conurbation vs small town), location (coastal vs inland), pattern of growth (rapid vs slow) and climate.
- Information from ASFF has been used in the development of the sustainability policy for the state of Victoria. A higher resolution framework has been developed for this state. This has been used to study the interactions of demographics, land-use, water, energy and climate change.
- Data from the ASFF was used by the Federal Treasury for indicators of Australian environmental pressures in its second Intergenerational Report, which assesses the long term sustainability of Government policies.

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NEW ZEALAND

OVERVIEW

New Zealand does not carry out work on material flows, but has initiated work on natural resource accounts in 2001, with a focus on individual areas such as forestry, water, energy and fisheries. This is complemented with an experimental set of Environmental Protection Expenditure (EPE) accounts.

The lead institution is Statistics New Zealand.

At present there are no plans to produce a full system of environmental satellite accounts.

CHARACTERISTICS AND SCOPE

Natural Resource Accounts: The development of natural resource accounts by Statistics New Zealand builds on the System of Environmental and Economic Accounts (SEEA) and is directly linked to the System of National Accounts (SNA) used to produce NZL’s national accounts. For each resource an attempt is made to produce stock and flow accounts, in physical and monetary units. The flow tables are estimated as Supply and Use tables.

Tables and reports are being produced progressively for five resources, from late 2001 to mid-2004 as follows:

- Water accounts: annual water accounts (2004; 1995-2001 data; stock accounts only; data for producing flow accounts are not available in NZL)
- Land accounts: planned.

Environmental Protection Expenditure (EPE) accounts: EPE accounts have been produced for the fiscal year 2000/01 covering environmental protection activities and natural resource management. The EPE accounts provide data that are not available from other data sources, and give an indicative measure of sustainability. The EPE accounts will be developed further to be useful for monitoring and policy purposes.

OUTPUTS AND USE

An experimental report on New Zealand Sustainable Development Indicators (SDIs), called "Monitoring Progress Towards a Sustainable New Zealand" was published by Statistics New Zealand in August 2002. The report includes a chapter on consumption and resource use. In future, information and indicators from the natural resource accounts under development are expected to be used in such reports and in the monitoring of New Zealand's Programme of Action on Sustainable Development.

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AUSTRIA

OVERVIEW

Austria initiated activities on Material Flow Accounting in 1991 as part of the country's official statistics (work on Environmental Accounting) and following a request by the Ministry of Environment in 1989. Work is also carried out by academics. It covers economy-wide material flow accounts (EW-MFA), physical input-output tables (PIOTs), substance flow analysis (SFA) as well as National Accounting Matrix including Environmental Accounts (NAMEAs).

Lead institutions are Statistics Austria and the Institute of Social Ecology in Vienna (IFF-Vienna; University of Vienna and Klagenfurt). Other institutions involved are: the Federal Ministry of Agriculture, Forestry, Environment and Water Management; the Vienna University of Technology, and Sustainable Europe Research Institute (SERI), a private research institute.

Academic research work receives financial support from (i) the government, (ii) the European Commission (Eurostat, DG Environment) under the 4th, 5th and 6th framework programmes, (iii) the Jubiläumsfonds of the Austrian National Bank and (iv) foundations (the Anglo-German Foundation).

Austria also contributes to international work on MF within Europe (EEA, Eurostat) and beyond (OECD, UNEP), and participates in international research networks such as the ConAccount Network. Via SERI, it participated during the period 2002-2006, in the EU-funded research project "Modelling Opportunities and Limits for Restructuring Europe towards Sustainability" (MOSUS) (see box below). Together with Germany, Japan, the Netherlands and the United States, Austria has also, via its research activities, actively participated in the second phase of the joint international research project on material flows that led to two key publications by the World Resource Institute, et al. in 1997 and 2000. Research institutes, such as the IFF-Vienna, have further established many bilateral and multilateral relationships (case studies, training, technical assistance), with universities in Europe, South East Asia and Latin America.

CHARACTERISTICS AND SCOPE

Economy-wide MF accounts: EW-MFA are compiled in accordance with the Eurostat methodology and updated annually. Most recent data refer to 2004 (published March 2007). Concerning SERI, it is conceptionally and empirically working on indirect flows of traded products applying multi-regional input-output models.

Physical Input-Output Tables (PIOTs): Work on PIOTs is carried out by the IFF-Vienna. It includes the establishment of a highly aggregated PIOT for Austria, as well as conceptual and empirical work on physical input-output analyses and their applications (raw material equivalents and sectoral analysis). Some work on PIOTs has also been done by researchers at SERI on concepts and applications of PIOTs, in particular, to integrate PIOTs into monetary Input-output models.

Substance Flow Analysis (SFA): SFA has been done by Statistics Austria, different consultancy firms and the Group of Waste and Resources Management of the Vienna University of Technology. Initiated by government agencies, the following SFA of the Austrian economy were prepared (in brackets, the number of processes simulated to represent the whole economy): 1997 - Zinc (11); 2003 - Sands and stones (13), Iron ore and iron (11), Crude Oil (8), Coal (10), Wood and paper (9), Other biomass (9), Nitrogen (16), Aluminium (19), building materials (16) and the flows of the substance Aluminium, Iron, Carbon and Nitrogen in the building sector (16); 2006 - Copper (8).

Other related activities: NAMEAs by Umweltbundesamt and Statistics Austria; interlinked NAMEAs (covering output, value added, employees, material flows, final energy consumption, environmental protection expenditure for air and waste, air emissions, eco taxes and hazardous waste) by Statistics Austria and Input-Output (IO) tables. Specific MFA were conducted on timber, carbon, construction material, nitrogen and regional MFA.

OUTPUTS AND USE

Publication: Data from Material Flow Accounts are regularly published by Statistics Austria on its website: http://www.statistik.at/fachbereich_umwelt/materialfluss.shtml .

Indicators: Data from EW-MFA are used to derive selected MF indicators among which: Direct Material Input (DMI), Domestic Material Consumption (DMC), Domestic Resource Dependency (DRD; i.e. the relation of resource exports minus imports and DMI), Physical Trade Balance (PTB), and Net Additions to Stock (NAS) DMI, DMC and DRD are part of Austria's indicator-report for the monitoring of sustainable

**Links to policies and objectives:** Data and indicators derived from MFA are used to link environmental and economic information and to support modelling and outlook activities. They further support the monitoring of progress under Austria's **Strategy for Sustainable Development**, which was formally adopted by the federal government in April 2002 by a resolution of the Council of Ministers. The Strategy for Sustainable Development includes an official government objective for material resource use and resource productivity, under **Key Objective 9 - Successful Management Through Eco-efficiency**.

"... The key objective is to increase the productivity of resources together with higher economic growth in such a way as to achieve a further decoupling. **In the short term, absolute resource turnover should at least be stabilised**, and in the long term the objective must be to **increase the productivity of resources by a factor of 4**. Thereby, the prevention of raw material and energy consumption has absolute priority wherever this is technically feasible and economically reasonable, with the ultimate goal of achieving an absolute reduction in total resource consumption. ..." Among the indicators used to measure progresses are: DMI, DMC, DMC/GDP and DRD. A first indicator report on the implementation of the Austrian Sustainable Development Strategy was published in June 2004, and updated in June 2006. The next indicator report will be published by the end of 2007.

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The **Institute of Social Ecology in Vienna** (IFF-Vienna), Klagenfurt University, focuses on the interrelation of social and natural systems in the context of globalisation, global environmental change and sustainable development. The IFF Social Ecology has a rich experience in the development of concepts and indicators to monitor biophysical aspects of economic development. It has been involved in Material and Energy Flow Accounting (MEFA) since the beginning in the early nineties and contributed to developing international methodological standards.

In a number of European Union and Eurostat funded research projects it has established an extensive database on the long term development of material and energy flows in the 15 European Union countries as well as in South East Asian and Latin American countries. The institute contributed to the OECD MFA data set and quite recently established a comprehensive database on material and energy flows and land use for 160 countries in the world partly in time-series for the last 100 years. It also carried out conceptual and empirical work on physical and monetary IO tables and its application in MFA, and more recently started a project on calculating the Raw Material Equivalents of the Austrian foreign trade.

The Institute of Social Ecology is also involved in policy consultancy for the Austrian Government and Statistics Austria, the Eurostat MFA task force, the Statistical Offices of the EU member states, the OECD and UNEP, as well as various NGOs. In its university courses, the Institute of Social Ecology is teaching concepts and application of social metabolism and MFA to its Master and Doctoral students. Staff members are also regularly invited to teach courses abroad.

Major research and consultancy projects in the field of MFA:

- “Economy-wide material flow accounts and indicators of resource use for the EU” EUROSTAT Consultant Contracts 2001-2005.
- “ConAccount: Concerted Action on Coordination of regional and national material flow accounting for environmental sustainability” EU FP4 ENV 2C project, 1996-1998

Further research projects in the field of MFA:


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The **Sustainable Europe Research Institute (SERI)** is a Pan-European think tank exploring sustainable development options for European societies, set up in September 1999. Member offices are in Vienna (Austria) and Bad Oeynhausen (Germany), while the affiliated academics and researchers live throughout Europe. SERIs work includes two main research project integrating international MFA:

- **MOSUS**: Modelling opportunities and limits for restructuring Europe towards sustainability (2003-2006) – It developed and applied a global environmental-economic model to quantify the interrelations between socio-economic driving forces and the state of the environment. This model was then used to simulate different scenari towards sustainable development in Europe.
The model – It was the first such tool to directly integrate comprehensive biophysical data (material use, energy use and CO₂ emission) in a multi-country and multi-sectoral macroeconomic framework, including trade flows within Europe and between Europe and all other world regions. The model was used to perform simulations to the year 2020, putting them in relation to indicators of social and economic development.

The results – Together with three other partners, SERI developed the first global database for material inputs on the national level. The MOSUS MFA database covers 188 countries in 1980-2002 time series and builds on the Eurostat methodology on EW-MFA. Data sheets, in aggregated form, can be downloaded for all countries from www.materialflows.net.

In addition, MOSUS scenario results suggest that the implementation of policies primarily geared towards decoupling economic activity from material and energy throughput can actually be conducive to economic growth. This supports the view that increasing resource and energy productivity can actually improve the position of European industries on world markets and thus also lead to the creation of new jobs. From this perspective, environmental policy becomes one of the key strategies to reach the goals of the EU Lisbon Strategy. For more information, see: http://www.mosus.net/.

PetreE: Resource productivity, environmental tax reform and sustainable growth in Europe (2006-2009) – It examines the economic and environmental implications and impacts of environmental tax reforms and assesses the effectiveness of these reforms to improve the use of resources, including labour, and to raise welfare. The project is led by the Policy Studies Institute (United Kingdom) and has five other European partners, including SERI, which is responsible for work on "Global Dimensions of Sustainable Growth in Europe". This work investigates world-wide consequences of a European transformation towards sustainable growth, based on an environmental tax reform and on increased resource productivity. For more information, see: http://www.psi.org.uk/petre/.

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BELGIUM

OVERVIEW

In Belgium, economy-wide MF work is carried out by the regional governments of Flanders (since 2001) and Wallonia (since 2003).

- In Flanders, the lead institutions are the Flemish Environment Agency and, recently, the Public Waste Agency of Flanders. MF related data are compiled by the Centre for Sustainable Development, Ghent University.

- In Wallonia, the lead institution is the "Cellule de l'Etat de l'environnement Wallon". MF related data are compiled by the "Institut de Conseil et d'Etudes en Développement Durable" (ICEDD), an independent consultant and research institute, and the University of Liège.

Wallonia has established partnerships with the Wuppertal Institute (Germany).

At the academic level, ad hoc studies on substance flow analysis have been carried out by the Flemish Institute for Technological Research (VITO). In 2006, the VITO also launched a long term project on environmentally extended Input-Output-model (EE IO-model) with the Federal Planning Bureau. For the development of the EE IO-model, the FITR has established contacts with 2.-0 LCA consultants, IPTS – DG JRC (Sevilla, Spain) and TNO (Netherlands). Furthermore, the VITO is partner in the EU EXIOPOL project, which is a New Environmental Accounting Framework Using Externality Data and Input-Output tools for Policy Analysis.

CHARACTERISTICS AND SCOPE

Work on economy-wide MFA builds on the Eurostat methodology. MF data are updated on an annual basis and are used to calculate MF indicators.

- The Centre for Sustainable Development, Ghent University, under the authority of the Flemish Environment Agency, is investigating the possibilities for a sectoral breakdown of MF data and indicators and for relating MF data and indicators to environmental impacts.

- The ICEDD, under the authority of the Cellule de l'Etat de l'environnement Wallon, is calculating MFA Direct Material Input (DMI), Domestic Material Consumption (DMC) and Total Material Requirement (TMR) for specific sectors.

Work on Substance Flow Analysis by the Flemish Institute for Technological Research has focused on Al (1999), and Cr, Cd, N-compounds (1999-2002), and on the development of a model for dynamic substance flow analysis (2000-2004).

OUTPUTS AND USE

**Indicators:** MF data are used to calculate economy-wide MF indicators. Among these are: (i) DMI, DMC, TMR, Domestic Processed Output (DPO) and MF indicators related to GDP for the Flemish Region; and (ii) PTB, DMI, DMC and TMR, in relation to GDP, for the Walloon Region. These indicators are published regularly in a special chapter of the Flemish state-of-the-environment report (200, 2002, 2003, 2004, 2005), and in the 2004 Walloon State of the environment report (dashboard).

**Links to policies and objectives:**

At federal level, the Federal Plan for Sustainable Development 2004-2008 includes mandatory objectives to decouple the economic growth from the use of natural resources. The selection of indicators to be used for the monitoring of progress is not yet finalised.

In Flanders, a voluntary agreement (pact) has been concluded between the government, organisations of employers and employees and environmental NGOs. The aim is to promote eco-efficiency: by 2010, Flanders is expected to be among the top-regions concerning eco-efficiency by 2010. GDP/DMI and GDP/DMC are among the four indicators used to follow-up this objective. Furthermore, TMR is one of the key environmental indicators selected to evaluate the (environmental) policy in the longer term under the third Environmental Policy Plan (2003-2007) of the Flemish Government.
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CZECH REPUBLIC

OVERVIEW

In the Czech Republic, work on economy-wide material flow (EWMF) analysis was initiated in 2000 by the Ministry of the Environment as part of a research and development project*. The work was funded by the Ministry and the European Commission, and carried out by the Charles University Environment Centre (CUEC) in 2000-2001. Since then, the Czech Statistical Office (CZSO) collaborates with the CUEC in the compilation of EWMF indicators.

Some MF work has also been done as part of PhD studies in the CUEC. Research projects include work on input and output indicators since 2000 and a pilot-project on NAMEA for air emissions.

The Czech Republic participates, via the CUEC, to the 2003-2006 EU-funded research project "Modelling Opportunities And Limits For Restructuring Europe Towards Sustainability" (MOSUS). The CUEC further co-operates with the IFF-Vienna (Austria), the Sustainable Europe Research Institute (SERI, Austria) and the Wuppertal Institute (Germany).

The Governement Council for Sustainable Development has proposed to set up a new Working group on material flows led by the CZSO and consisting of delegates of ministeries and other institutions. The group would coordinate the processing of material flow accounts and indicators, material flow balances and material flow assessment (especially connected with the OECD Council Recommendation on Material Flows and Resource Productivity).

CHARACTERISTICS AND SCOPE

Work on economy-wide MFA is based on the Eurostat methodology and covers all major material balance variables. Data have so far been produced for the years 1990-2005 by the CUEC and the CZSO. Results, including an analysis of the relation between material productivity and economic performance, have been published in the scientific press.

Current projects by the CUEC include the following:

♦ Economy-wide material flow analysis – its application on regional and micro-economic level and its use in elaboration of sustainability indicators (2003-2004). This project was funded by the Czech Ministry of the Environment. The aim was to extend time series of material flow indicators in the Czech Republic up to 2002 and to develop a methodology on how to apply particular economy-wide material flow indicators or their components at sub-national and enterprise levels.

♦ State assessment of the environment by the material and energy flow analysis (...-2006). This project is funded by the Czech Grant Agency and focuses among others on analysing the indicator "net additions to stock" in the Czech Republic.

Further research work in the Czech Republic is expected to address two topics:

♦ Output flows, including waste flows, their relation to input flows and physical stocks of economies, and the issue of recycling (whether and how it can be dealt within EW-MFA).

♦ Upstream material flows related to domestic production and to foreign trade (which are crucial for assessing the environmental implications of trade and globalisation).

OUTPUTS AND USE


Indicators: The results of research work on MF have also been used to calculate EW-MF indicators such as: Total Material Requirement (TMR), as well as Total Material Consumption (TMC), Domestic Processed Output (DPO), Total Domestic Output (TDO), Net Additions to Stock (NAS).

Links to policies and objectives: Results from MFA work are now used on a regular basis in the government’s policy and reporting work, and are part of the country’s official statistics. The National Strategy for Sustainable Development of the Czech Republic (officially adopted by the Government at the end of November 2004) includes EW-MF indicators (but no official target yet) such as the DMC/GDP ratio.

* Methodology of state assessment and prediction of the environment by the material and energy flow, direct as well as hidden, balances.
and other indicators related to the decline in the consumption of material and energy, and generation of waste and pollution, per unit of production or service.

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Modelling Opportunities and Limits for Restructuring Europe towards Sustainability (MOSUS) Web site, www.mosus.net/. Research and development in the Czech Republic (information about projects which were supported from MoE), http://www.vyzkum.cz

DENMARK

OVERVIEW

Denmark has no formal programme on material flow accounting, but economy-wide material flows (EW MF) accounts have been compiled on an ad-hoc basis over the periods 1997-1999 and 2002-2006, with funding from the Danish Research Foundation, the Danish Environmental Protection Agency (EPA) and Eurostat. A detailed MF database, based on physical supply-use tables, was compiled in 2006 for the period 1993-2002. It is expected that Material Flow accounts will be published regularly as part of the Environmental Accounts starting by the end of 2007. Denmark has long experience with NAMEA type accounts for energy use (since the mid 1970s) and air emissions. Also, water flows are included in the Danish environmental accounts. Furthermore, Denmark has good experience with physical input-output tables.

Key institutions are Statistics Denmark (pilot work on MFAs and on Physical Input Output Tables (PIOTs), and the Danish EPA (calculation of MF indicators in connection with the national set of sustainable development indicators).

Denmark participates in international work steered by the London Group on Environmental Accounting. Contacts have also been established with the Wuppertal Institute (Germany), the IFF (Vienna, Austria) and the European Topic Centre on Waste and Material Flows (ETCWMF).

CHARACTERISTICS AND SCOPE

A number of relevant projects have been undertaken in line with the SNA93 and the SEEA. Current work aims at implementing the recommendations of the SEEA 2003 and SNA93 with respect to natural resource stock accounts for crude oil and natural gas.

Economy-wide MFA have been compiled according to the Eurostat methodology, with basic data taken from Statistics Denmark’s physical supply-use tables and MF database. Economy-wide MF data are available for the years 1997 (TMR) and 1993-2002 (DMI, DMC and PTB).

Physical Input-Output Tables have been compiled for the year 1990 for 27 industries based on physical supply-use tables with approximately 1600 products. Separate PIOTs have also been compiled for various groups of materials. In 2007, a PIOT have been compiled for 27 industries based on extended physical supply-use tables with approximately 1800 products. Furthermore, Danish PIOTs have been used to establish waste accounts by industries.

The Danish NAMEA is a “satellite accounting system” to the national accounts. The purpose of the NAMEA is to combine economic data with data concerning resources and pollution. NAMEAs have been compiled for energy, water, air emissions, and waste in physical terms.

OUTPUTS AND USE

Publication: Data related to material flow accounts and PIOTs for Denmark have been published on an ad-hoc basis. Statistics Denmark expects to publish Economy-wide MF indicators (DMI, DMC, PTB) on yearly basis starting with late 2007.

Links to policies and objectives: Denmark’s National Strategy for Sustainable Development, published by the Government, defines a set of objectives and principles among which "Resources must be used more efficiently". It is supported by a set of indicators that are used to monitor and report on the progress made in implementing the strategy and achieving the objectives. This includes a small set of headline indicators among which indicators on resource flows for 3 factors (energy consumption, drinking water consumption, and total waste volume) in relation to GDP, and a detailed, specific set of 90 indicators for each of the strategy's action areas among which Denmark's total consumption of selected resources (raw and ancillary materials).
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FINLAND

OVERVIEW

Finland has good experience with natural resource accounting, and has established a programme on environmental and resource accounting in the mid-1980s. This was stimulated by interest in ensuring sustainable use of forests, the most important natural resource in the Finnish economy.

Work on material flows was initiated in 1997 and is part of the country's official statistics. It covers various types of accounts, including economy-wide material flows and physical input-output tables, and is carried out by both government authorities and academics. A first project on economy-wide material flows "Eco-efficient Finland: Total Material Requirement and the Possibility to Reduce It in Finland", was carried out between 1998 and 2000 as part of the Environmental Research Programme of the Finnish Ministry of the Environment.

The lead institution for MFA is Statistics Finland together with the Thule Institute of the University of Oulu. Other organisations involved include the Ministry of the Environment, the Finnish Environment Institute, and the Finnish Nature Conservation Association.

A number of academic research projects have been carried out on behalf of the government and have benefited from financial support by the government and/or by Eurostat. Examples include the project "FINPIOT: material flows and balances in the Finnish economy" that was launched in 2000 jointly by Statistics Finland and the Thule Institute of the University of Oulu and was funded by the Finnish Ministry of the Environment. Related research work has also been carried out by the Finland Futures Research Centre of the Turku School of Economics and Business Administration (Environmental Kuznets Curves (EKC), material flow indicators such as Direct Material Input (DMI) and Domestic Material Consumption (DMC).

Finland participates in related international work carried out by Eurostat, the EEA, the OECD and the UN. Co-operation has been established between the Thule Institute and the Wuppertal Institute (Germany).

CHARACTERISTICS AND SCOPE

The work covers various types of MFA at various levels of detail (economy-wide material flow (EWMF) accounts, physical input-output tables, substance flow analysis) and is complemented with other environmental accounts (timber, energy).

Economy-wide MF accounts are compiled according to the Eurostat methodology and on the basis of materials from the Wuppertal Institut. As part of the project Eco-efficient Finland: Total Material Requirement and the Possibility to Reduce It in Finland, comprehensive Total Material Requirements (TMR) series for Finland for the period 1970-1997 were compiled by the Thule Institute and subsequently updated every two years. In future, these data will be updated annually by Statistics Finland as part of the country’s official statistics.

EW-MF accounts and balances make use of already existing basic data sources such as: industrial statistics (mining and quarrying, manufacturing industry, electricity, gas and water supply), energy statistics, agricultural statistics, forestry statistics, statistics and studies on consumption, statistics on foreign trade and statistics from industry associations.

Physical Input-Output Tables (PIOTs) have been compiled for the years 1995 and 1999 with a NAMEA-type breakdown by industrial branches. This was done as part of the research project "FINPIOT: material flows and balances in the Finnish economy". To facilitate the integration with national economic accounts, the same classifications (190 industries, 1300 products) are applied as in the monetary input-output tables (MIOTs) of Finland. The physical flows between the economy and the environment are constructed in such a way that they add up to the overall EW material balance.

A pilot study for Eurostat ‘Compilation and analysis of complete waste accounts in conjunction with general material flow accounts’ was finalised in 2006, by the Thule Institute and Statistics Finland. Reference year of the study is 2002.

A study on waste accounts was published in 2006 by the Thule Institute, the Finnish Environment Agency and Statistics Finland. The study focused on waste flows and intensities in 1997-2003.

Substance Flow Analysis has been applied to mining, forests, metals and packaging industries, energy generation and water supply, and waste water treatment systems (sectoral life cycle assessments), and to individual flows of paper and nutrients.
Other environmental accounts include timber material accounts and physical accounts for energy:

- **Timber material accounts** include physical measures of the forest balance (stock, growth, natural losses and harvesting, by wood type), use of the forest, and a wood mass balance that tracks the mass of wood products through the economy from harvesting to final consumption, including associated waste materials. The detailed structure of the accounts is compatible with the System for Environmental and Economic Accounts (SEEA), but reflects primarily an interest in supporting national forest management policy tools.

- **Physical accounts for energy** are based on input-output accounts and show the output of energy industries as inputs to 50 industrial branches and households for 11 fuel commodities.

### Outputs and Use

**Publication:** Time series on TMR and related indicators are reported in official publications such as:

- The annual Compendium of Environment Statistics,
- Annual report on Finland’s Natural Resources and the Environment, published by Statistics Finland and the Ministry of the Environment in conjunction with the State Budget, which also serves as an instrument for the Government policy on sustainable development as well as in special research publications.

**Indicators:** Data from MFA are used to calculate MF indicators such as DMI, DMC and TMR, as well as TMR/GDP and DMI/GDP (project ‘Eco-efficient Finland’), and TMC (Thule Institute). The TMR indicator is updated annually by the Thule Institute and Statistics Finland, and is part of the national set of sustainable development indicators.

An indicator representing a Sustainable net Benefit Measure of production (SBM) compared to Direct Material Flows (DMF) has been used in the research project "Measuring the Eco-efficiency of Welfare Generation in a National Economy" published by Statistics Finland in 2001. The aim was to test factor 4 targets, i.e. a 75% reduction in material use and maintenance of at least the current level of welfare during the next 20-30 years.

Data and indicators derived from MFA are used for monitoring the sustainability of material resource use, linking environmental and economic information and supporting modelling and outlook activities.

**Links to policies and objectives:** Strategic objectives and lines of action for material resource use are included in the Finnish Government’s programme for sustainable development that focuses on eco-efficiency in its third programme period (2003-2005). The general goals include the following: "promote changes in production and consumption patterns and minimize the exploitation of non-renewable resources; … safeguard the generative capacity of renewable resources, such as forests and land resources; etc. promote economic activity that increases financial and human capital while simultaneously safeguarding natural capital". The objective is to improve the efficient use of natural resources and energy taking into account the whole life-cycle. Material flow accounting will be developed for monitoring the use of natural resources as part of the national accounting system (2.6 Research and education, Line of action: 5).

The achievement of these objectives is not mandatory, but progress is monitored by the Finnish National Commission on Sustainable Development via a set of sustainable development indicators among which TMR.

Finland has also defined quantitative targets for promoting waste prevention and improving waste recovery rates as part of its national waste plans. The targets vary according to the type of waste concerned:

- Municipal waste, construction waste and industrial wastes: by 2005, a 15% reduction in waste generated compared to 1994, accounting for real growth in GNP, and an average recovery rate of at least 70%.
- Hazardous waste: by 2005, a 15% reduction in waste generated compared to 1992, and an average recovery rate of at least 30%.
- Contaminated sites: no quantitative target, but general goal to prevent the contamination of more sites.
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FRANCE

OVERVIEW

France has a long experience with environmental expenditure accounts (since 1975) and has been among the pioneers in the field of comprehensive natural resource accounting "Comptes du patrimoine naturel".

In recent years, efforts have been concentrating on the establishment of NAMEAs (e.g. air emissions, energy consumption, and to a minor extent water discharges). From 2007, NAMEA air and energy matrices are planned to be provided on an annual basis at the French Institute for the Environment (IFEN) that acts as the statistical service of the Ministry for Ecology and Sustainable Development (MEDD). In 2006, IFEN published a document promoting this tool.

Economy-wide Material flow studies have so far not yet been carried out with the exception of a one-spot study in late 2004 coordinated by IFEN and focusing on input data sources and net accumulation to stock (NAS). Data and derived indicators provided for France by the 2004 Eurostat/IFF study on the 1970-2001 period have been used in two synthesis documents published by IFEN in 2005-06: chapter dedicated to the sustainable use of resources in “L’environnement en France – édition 2006”, folder “the 10 key environmental indicators”.

In December 2006, IFEN has co-organized with the Sustainable Development Delegation and the Direction for economical studies and environmental evaluation of the MEDD, a national workshop dedicated to promote the interest, the development and the use of MFA tools and derived indicators. Following this workshop and in accordance with the National Strategy for Sustainable Development revised in October 2006, an EW-MFA activity started in 2007 on a permanent basis, with one person in charge of its development at IFEN. This development is carried out in cooperation with other national statistical offices, other national authorities and with the expertise of leading institutions in other OECD countries.

Some MF applications at more local scale are being carried out at academic level, mainly as part of PhD projects, as those carried out by the Centre de Recherche et d’Etudes Interdisciplinaires sur le Développement Durable (CREIDD) of the Université de Technologie de Troyes (UTT), or by other partners of the "Pôle français d’écologie industrielle" such as Auxilia NGO acting as technical assistant for MFA in Lille and Paris. In complement, ADEME, the French environment and energy management agency, promotes the use of its “Bilan carbone” methodology for any public or private institution to reduce its C emissions. The same agency supports the products approach and life cycle analyses (LCA).

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GERMANY

OVERVIEW

Germany is among the most experienced countries in MFA and has developed a comprehensive Material and Energy Flow Information System (MEFIS), based on a MFA framework and on physical input-output tables. Work is carried out by both the government and by academics. Government work was initiated in 1993 as part of the country’s official statistics and as part of work on Environmental Economic Accounting (EEA). Work on economy-wide material flow accounts started in 1993, mainly at the academic level.

The Federal Statistical Office (DESTATIS) and its Division for Environmental Economic Accounting is the lead institution responsible for MF accounts. The work is carried out in co-operation with non-governmental research institutes, such as the Wuppertal Institute for Climate, Environment and Energy, and has benefited from financial support by Eurostat. Among other institutions involved is the Federal Environment Agency (UBA). UBA is engaged in research on resource-indicators, derived from material flow (further information: see outputs and use).

Germany also contributes to international work steered by the London Group on Environmental Accounting and to collaborative work in Europe steered by EUROSTAT and the European Environment Agency and its Topic Centre on Waste and Material Flows. Together with Austria, Japan, the Netherlands and the USA, it has, via the Wuppertal Institute, actively participated in the joint international research project on material flows that led to two key publications by the World Resource Institute in 1997 and 2000. Bilateral co-operation in the field of Environmental Economic Accounting exists with Korea.

CHARACTERISTICS AND SCOPE

The German System of Environmental Economic Accounting (EEA) is fully compatible with the System of National Accounts (SNA) and with the System of Integrated Environmental and Economic Accounts (SEEA). The physical flow accounts, structured around physical input-output tables, are the most developed part of it.

The German system of physical flow accounts

- **Energy flow accounts**
  - Petajoules
  - Supply and use of Energy by economic activities (NAMEA-type breakdown) and type of energy carrier
  - 1991-2002

- **Primary material flow accounts**
  - Tonnes
  - Input of primary material (raw material from domestic extraction and imports) by economic activities (NAMEA-type breakdown) and type of material
  - 1993-2000

- **Regional accounts**
  - Breakdown by Federal States
  - Economy-wide material flow accounts NAMEA-type material flow accounts for energy, air emissions and water

- **Other NAMEA-type accounts**
  - Built-up and traffic area
  - Transport (e.g. person-kilometres, tonnes kilometres)
  - Env. taxes, env. expenditure...

- **Physical input-output tables (PIOT)**
  - Tonnes
  - Supply and use of raw materials, ecosystem inputs and products, material integration table by economic activities (NAMEA-type breakdown) and type of material
  - 1990, 1995

- **Air emission accounts**
  - Tonnes
  - Output of air emissions to the environment by economic activities (NAMEA-type breakdown) and type of air emission
  - 1991-2002

- **Waste flow accounts**
  - Tonnes
  - Supply of waste by economic activities (NAMEA-type breakdown) and type of waste
  - 1991-1995 (old classification)

- **Water flow accounts**
  - m³
  - Input and output of water, water flows within the economy by economic activities (NAMEA-type breakdown) and type of water
  - 1991-2001

- **Monetary input-output tables (MIOT)**
  - Euro
  - Supply and use of products, monetary integration table by economic branches (NAMEA-type breakdown)
  - 1991-2001
**Physical Input-Output Tables (PIOTs):**

The first German PIOTs, compiled in the mid-1990s with data for 1990, were also the first PIOTs ever compiled in the world (Stahmer et al. 1997). They mirror the monetary input-output tables (MIOTs) of the national accounts and broaden their scope by adding material flows between the economy and the environment.

The PIOTs are broken down by about 60 economic production and consumption activities and by type of materials. PIOTs are compiled for selected years only (i.e. 1990 and 1995) and are supplemented with a number of sub-modules that are updated annually.

These sub-modules include economy wide material flow accounts as well as a number of NAMEA-type accounts (energy flow accounts, primary material flow accounts broken down by 72 production branches and private households and by raw materials categories distinguishing biotic and abiotic materials, water flow accounts, air emission accounts, waste flow accounts (up to 1995 only), regional physical flow accounts).

This is further supplemented by a number of other NAMEA-type accounts covering for example built-up and traffic areas, transport (person-kilometres, tonnes kilometres), environmental taxes, environmental expenditure.

**Economy-wide MF accounts (EW_MFA)** have first been compiled in the mid-1990s for the years 1993-2000. They have recently been revised and complemented with accounts for 1960, 1970, 1980, and 1990 for the former territory of the Federal Republic of Germany, and with accounts for 1991-2002 for the current territory. Annual updates are planned in future.

The accounts cover the whole physical economy and their system boundaries are fully compatible with those for PIOTs. Conceptual differences with other European MF accounts were removed thanks to a study carried out with support from Eurostat. Lessons from this study have been grouped in a "National Handbook: Material Flow Accounts" that builds on the Eurostat guide and also covers the development and calculation of MF indicators (publication forthcoming).

**Outputs and use**

**Publication:** Data from MF accounts are regularly published by DESTATIS (various publications). MF indicators are included in "Environmental Data Germany" published jointly by the Federal Environment Agency (UBA), the Federal Statistical Office (DESTATIS) and the Federal Institute for Geosciences and Natural Resources (BGR) and will be freely available on the web. Various publications on specific issues related to MF accounts are also published by the UBA and the Wuppertal Institute. For instance, in early 2007, UBA published a study about the example of coltan extraction in the Democratic Republic of Congo, to explore how the demand for rare metals intensifies armed conflicts and presents possible solutions.

**Indicators:** Data from EW-MFA are used for compiling selected indicators among which: Direct Material Input (DMI), Domestic Material Consumption (DMC), Physical Trade Balance (PTB), Domestic processed output (DPO), Net additions to stock (NAS), and raw materials productivity (GDP/(DMI-biomass)). The indicators are calculated by the German Statistical Office and updated on an annual basis.

The indicator on "raw materials productivity" is defined as the ratio between Gross value added (at constant prices) and the sum of domestic abiotic (i.e. non-renewable) raw material extraction (used) and imports. It has similarities with indicators on labour and capital productivity, and describes the efficiency with which "non-renewable raw materials" are used in the national economy.

The DMI is derived by the simple addition of all raw materials provided for production and consumption, independent from the type of raw materials, measured in tonnes. In Germany, the minerals sand and gravel, while other environmentally relevant raw materials such as copper, whose total volume/weight is comparatively small, play a marginal role.

In 2006 the IFEU-Institute, Heidelberg, started a research project, commissioned by the German Federal Environment Agency (Umweltbundesamt). The objective of the research project is to further develop and supplement the existing indicator by considering the profiles of the environmental impacts associated with various raw materials. Furthermore, the improved indicator (indicator set) should guarantee more transparency and be practicably applied with respect to data availability and communication, resulting in a more effective information on the environment and sustainable development.

**Links to policies and objectives:** The raw materials productivity is one of the 9 indicators of the German Environment Barometer linked to quantitative targets and entering into the calculation of the German Environmental Index (DUX). The methodological approach of DUX is being reviewed in 2007/8.
It is also one out of 21 national key indicators for sustainable development defined in the National Strategy for Sustainable Development "Perspectives for Germany: Our Strategy for Sustainable Development" adopted by the German Federal cabinet in April 2002. The strategy outlines 21 targets or objectives to which the key indicators can be linked. The targets indicate desirable policy directions and their achievement is voluntary. One of these targets is the doubling of the raw materials productivity between 1994 and 2020.

"By 2020, we should aim for an approximate doubling of energy- and raw materials productivity in relation to 1990 and 1994 respectively. ... In the long term, the improvements in energy and raw materials productivity should be guided by the "Factor 4" vision."

The **Wuppertal Institute for Climate, Environment and Energy** is an interdisciplinary research institute focusing on applied sustainability research. The Wuppertal Institute develops guiding principles and concepts in areas such as: energy, transport, material flows and structural change, climate policy and eco-efficient enterprises.

The Wuppertal Institute is among the pioneers in the field of material flow analysis and of economy-wide MF indicators. The Institute has actively contributed to the international promotion of MF related studies, and has carried out MF projects for the European Commission (DG Environment, Eurostat) and the European Environment Agency (EEA) and its Topic Centre on Waste and Material Flows. Together with research partners in Austria, Japan, the Netherlands, and the United States, it has actively participated in the joint international research project on material flows that led to two key publications co-ordinated by the World Resource Institute in 1997 and 2000.

The Wuppertal Institute is the co-ordinator of **ConAccount**, "Coordination of Regional and National Material Flow Accounting for Environmental Sustainability", an international network of research institutions working on Material Flow Analysis (MFA). ConAccount was set up in May 1996 and supported financially by the European Commission (DG Environment) during the first phase of its existence until the end of 1997. The co-ordination of the ConAccount network is done in close co-operation with the Institute for Interdisciplinary Research and Continuing Education (IFF) in Vienna, the Centre of Environmental Science of Leiden University (CML), and Statistics Sweden.

The aim of ConAccount is to: (i) support the exchange of information between scientists and researchers developing MFA and users of MFA results, (ii) provide the basis for the development of a coherent framework of a MFA methodology, and (iii) promote the use of MFA for statistics and policy. A first R&D agenda was defined in 1997 and supported with technical workshops and conferences. Today, ConAccount has about 100 participants providing information about their activities. This is done through an interactive registration system whose current version was established (February 2000) with the support of the European Environment Agency.

Recent publications on MFA from the Wuppertal Institute include issues such as the Calculation of the Material Input Per Service unit (MIPS; 2003), Globalisation and the Shifting Environmental Burden (2004), Resource Use in European Countries (2005), the Sustainable Use and Economy-wide Management of Resources (2006), and the Sustainable Use of Biomass (2007).

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GREECE

OVERVIEW

No MFA related activities have been reported.

HUNGARY

OVERVIEW

Hungary has not yet initiated regular MF related activities, but has plans to use the MFA framework in government policy-making. If Hungary has not yet established any plan for sustainable consumption and production (nor related objective or targets), MF indicators are already used to inform decision making, and the public and policy makers about key issues and trends. More precisely, MF indicators are used to link environmental and economic information, to monitor the sustainability of natural resource use and the efficiency or productivity of material use.

Lead institutions are the Ministry of Environment and Water (MoEW) in charge of environmental indicators and the Hungarian Central Statistical Office (HCSO). The Budapest University of Technology and Economics and the Corvinus University of Budapest are also involved in MF related activities.

Economy-wide MFA for Hungary were compiled in 2001 for the years 1993-1997 by the Sustainable Europe Research Institute (SERI), according to the Eurostat methodology. Resulting from further work, the most recent EW-MF data for Hungary are available for 2003.

MF indicators (Domestic Extraction, Direct Material Input, Domestic Material Consumption, Total Material Requirement, Total Material Consumption, Physical Trade Balance) are published in official publications on environmental indicators since 2000 (Environmental Indicators of Hungary 2000; Environmental Indicators of Hungary 2002; Key Environmental Indicators of Hungary 2002; Main Environmental Indicators of Hungary 2003; Environmental Indicators 2004; Sustainable Development Indicators in Hungary [forthcoming]).

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ICELAND

OVERVIEW

Iceland does not carry out work on economy-wide MFA, but has developed individual natural resource accounts in areas of particular relevance to the country’s economy. This includes work on water input/output flows related to hydro-energy production, as well as research on underground water flows related to geothermal energy production. Some work has also been done on soil-erosion.

This work is closely connected to decision making in these areas, and is carried out by the Ministry of Environment, engineering bureaus, and energy agencies.

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IRELAND

OVERVIEW

Ireland has initiated a demonstration research project on MFA, focusing on the establishment of a national fossil fuel flows account and of a water flows account for a region. A first report on the results of this research project is expected to be available in autumn 2004. Further work on MFA and next steps will be informed by these results.

There is no lead institution or regulatory framework for work on MFA. Current research is being carried out by the Clean Technology Centre in partnership with the Irish EPA and the Central Statistics Office.

OUTPUTS AND USE

MFA has not yet been widely applied in Ireland. National policy however recognises the need to decouple resource use from economic activities and growth. No quantitative targets have been set in this regard.

As part of the National Waste Prevention Programme, the Irish EPA intends developing material flows indicators to illustrate progress towards the objectives of national policy. This work is at the earliest design stage and will be informed by the MFA demonstration research project that is nearing completion.

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ITALY

OVERVIEW

Italy has initiated work on material flow accounting in 2000, as part of the country’s official statistics and as part of its work on Environmental Accounting (EA). The work covers economy-wide MF accounts and related indicators, and Physical Input-Output Tables. Other related work is being done on NAMEAs (resource intake and air emissions by industry).

The lead institution is the National Statistical Office (Istat) in charge of environmental accounting, including in physical units. Istat cooperates with the Environmental Protection Agency (APAT) that provides basic data. Other institutions involved include the Ministry of the Environment that provided financial support for the development of EA activities at Istat and uses EA figures, including EW-MFA indicators, in its Report on the State of the Environment.

Italy contributes to international work steered by the UNCEEA and the London Group on Environmental Accounting and participates in the Eurostat task force on MFA and to the ConAccount network coordinated by the Wuppertal Institute (Germany).

CHARACTERISTICS AND SCOPE

Economy-wide MFA indicators are updated regularly by Istat on a yearly basis; the construction of full EW MF-Balances is foreseen for years at 5-year intervals, starting with 1997. Data for major MF aggregates (input indicators) are available for the years 1980 to 2004. A full sequence of flow accounts was compiled so far for 1997 only. The work is based on the Eurostat methodology.

Physical Input-Output Tables (PIOTs): Work on PIOTs has been carried out as part of stand-alone EU-funded project which ended in February 2007. A feasibility study has been carried out and a working group has been set up for its implementation. Tables have been realised based on a cross-classification of flows according to physical and economic concepts, but without any differentiation of production activities by industry.

OUTPUTS AND USE

Publication: The Ministry of the Environment publishes every two years a “Report on the State of the Environment”, containing some aggregates derived from environmental accounting. Data and indicators are used for monitoring the sustainability of material resource use and informing related decision making.

Indicators: Indicators derived from EW-MFA include Direct Extraction (DE), Direct Material Input (DMI), Domestic Material Consumption (DMC), and Total Material Requirement (TMR), as well as Total Material Consumption (TMC), physical trade balance (PTB), physical trade balance including indirect flows (PTBIF).

In general, information derived from environmental accounting is considered, along with sustainable development indicators, a necessary complement to economic indicators in the National Strategy for Sustainable Development. Chapter 2 “Environmental Action Tools”, states that “within national statistics, environmental accounting, indicators and statistics are being developed as new strategic tools”.

Links to policies and objectives:

The Environmental Action Plan for Sustainable Development in Italy, approved by the Inter-Ministerial Committee for Economic Planning (CIPE) in August 2002, includes a chapter on “Resource use and waste generation”, which states that “Italy as other developed countries, has reached and maintains such levels of consumption high enough to alter any ecological balance” and that “Environmental and economic reasons urge a substantial reduction in the use of resources, as well as in the flow of materials and pollutants discharged into the environment by human activities” by more efficient use of resource in industry and shift towards sustainable consumption and eco-efficient services.

The strategy includes a sequence of time-bound objectives to reduce TMR: -25% by 2010; -75% by 2030; - 90% by 2050. Due to the strategic nature of the document, the targets reflect desirable policy directions and are not binding. TMR is used as an indicator to monitor progress.
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NETHERLANDS

OVERVIEW

The Netherlands have a long history in the field of material flow accounting, even though most work has been carried out on an ad-hoc basis. Work has been covering economy-wide material flow accounting (EW-MFA), Physical Input-Output Tables (PIOTs), environmental input-output analysis, and substance flow analysis (SFA). Other closely related work includes the Dutch NAMEA (National Accounting Matrix including Environmental Accounts). Today, priority is given to the energy content and the environmental impact of material flows and substance flows, and to the development of dematerialisation indicators.

There is no lead institution for MFA, but many government and non-government institutions are active in this field. Among these are: Statistics Netherlands, the Ministry for Housing, Spatial Planning and Environment (VROM), research institutes such as the Netherlands Energy Research Foundation (ECN), TNO and the Netherlands Environmental Assessment Agency at RIVM, and universities (e.g. Leiden University, Institute of Environmental Science; Utrecht University - Copernicus Institute - Center for Energy and Environmental Studies; University of Groningen - Institute for Environmental Studies). TNO is participating in the EU EXIOPOL project. Work is also being done by private consultant firms mainly in the field of dematerialisation indicators. A number of these activities benefit from funding by the government and/or the Netherlands Science Foundation.

Together with Austria, Germany, Japan, and the USA, the Netherlands has, via the VROM and the Leiden University, actively participated in the joint international research project on material flows that led to two key publications by the World Resource Institute in 1997 and 2000. The Netherlands also contributes to international work steered by the London Group on Environmental Accounting. Dutch research institutes (Leiden University) participate in the ConAccount network co-ordinated by the Wuppertal Institute (Germany).

CHARACTERISTICS AND SCOPE

**Economy-wide MFA**: None, so far, with the exception of the contribution to the WRI led international research project. Efforts have been oriented towards developing alternative indicators reflecting environmental impacts of resource use.

**Physical Input-Output Tables (PIOTs)**: A few efforts have been undertaken, but are now largely outdated: Iron & Steel and plastics (for 1990 and 1997); paper and paper products, cement and cement products, zinc and non-ferrous metals (for 1990).

**Substance Flow Analysis (SFA)**: Dutch universities and research institutes (e.g. University of Leiden) have a good experience in SFA, often in connection with life cycle analysis (LCA). Since the early 1990s, many studies have been carried out at different levels. Most SFA studies have traced heavy metals (Cu, Zn, Pb, Cr, Hg, Cd) and nutrients (N, P); some have traced organochlorine compounds.

**NAMEAs**: The NAMEA system was developed and pioneered by the Netherlands in the early 1980s. It extends the System of National Accounts (SNA) with physical flow accounts, and is published by Statistics Netherlands every year. NAMEAs have been developed for environmental outputs (air pollutants, water pollutants, solid waste).

OUTPUTS AND USE

**Publication**: There is no official publication on material flows. The results of NAMEAs are published annually by Statistics Netherlands.

MF information is used in modelling and outlook activities and to link economic and environmental information. Information derived from SFA (e.g. Cadmium, Chlorine, Mercury) has proven to be useful when applied to chemical policy action in the Netherlands.

**Indicators**: Economy-wide MF indicators were developed and published as part of the international research project steered by the WRI (1997, 2000), but were not officially adopted as part of the country’s environmental or sustainable development indicator sets. Increased knowledge has resulted in an orientation towards developing alternative MF indicators i.e. dematerialisation indicators that would also reflect the environmental impact of material flows (e.g. EMC, environmentally weighted material consumption) as this more accurately fits policy needs. The work is funded by the Ministry of Housing,
Spatial Planning and the Environment and carried out by a consultant firm (CE - Solutions for environment, economy and technology) and the Centre of Environmental Science (CML) of the Leiden University.

**Links to policies and objectives:** Dematerialisation was put on the political agenda in 1999 after tabling a parliamentary motion to this effect. The 4th National Environmental Policy programme (NEPP4) adopted in June 2001 includes a number of proposals to promote sustainable use of biodiversity and natural resources among which a qualitative target aiming at achieving a dematerialisation of the Dutch economy by a factor 2 to 4 by 2030. The aim is to reduce the environmental impacts from resource consumption instead of resource consumption itself. The plan also asks for "a dematerialisation indicator to be created based on a material flows monitoring system that takes the degree of depletion of raw materials and energy supplies into account" as well as the environmental impacts from resource consumption. Based on the policy needs identified in NEPP4, an alternative indicator has been developed (the EMC) taking into account the environmental impacts from resource consumption based on LCAs.

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NORWAY

OVERVIEW

Norway has a long history in natural resource accounting. It carries out several activities related to material flow analysis with a focus on individual accounts such as waste accounts and flow analysis of individual substances. Economy-wide MF accounts have not been established although a pilot study was made in 2006-2007.

Lead institutions are Statistics Norway (waste accounts and energy accounts) and the Norwegian Pollution Control Authority (substance flow analysis, jointly with commissioned research institutes).

CHARACTERISTICS AND SCOPE

Waste Accounts: The Norwegian waste accounts are an abbreviated form of MF since the focus is on when products enter the waste stream rather than on the whole life cycle. The objective of waste accounts is to provide a comprehensive and clear statistical framework in which waste can be quantified and presented according to different characteristics. They build on individual waste accounts that are developed as a material balance between the generation and disposal of the various wastes. The accounts record waste amounts by material, type of product, source of origin (industry/sector) and type of treatment/disposal. Materials covered include e.g. paper, glass, wet-organic waste, metals, wood, plastic, sludge, concrete and brick, textiles. The waste accounts now provide an overall comprehensive picture of national waste flows. Data are available for 1995-2005.

Substance Flow Analysis: Beside a few ad-hoc studies by Statistics Norway (solvents, 1995; cadmium and phthalates, 1997; wood products, 1998), SFA is mainly carried out by the Norwegian Pollution Control Authority. The work started in the early 1990s and has since then covered many individual substances and products, from heavy metals to biocides and endocrine disruptors.

Energy balances and accounts: The energy accounts are one of the few natural resource accounts that were established in the mid-1970s that are still compiled and published on a regular basis. Since Norway is currently the third largest exporter of petroleum products, these supply and use accounts are very important. Data are available for 1976-2005.

OUTPUTS AND USE

Publication: Main results from the waste accounts and energy accounts are published annually together with other environmental and natural resource information in the report "Natural Resources and the Environment" prepared by Statistics Norway. Specific reports on results from substance flow analyses are available from the Norwegian Pollution Control Authority.

Indicators: A set of sustainable development indicators has been developed – energy use and fish are important natural resources included in the indicator set.

Links to policies and objectives: Norway does not have objectives or targets directly related to material resource use. However, the National Action Plan for Sustainable Development in Norway (Report no. 1 to the Storting, 2003-2004, National Budget 2004, Chapter 6) includes objectives that are related to natural resource management (energy efficiency, sustainable management of fisheries, forestry, agriculture and reindeer husbandry, etc.). The action plan is under revision, and a new plan is to be presented in October 2007 in Report no. 1 to the Storting, 2007-2008, National Budget 2008.

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POLAND

OVERVIEW

Poland has not yet initiated systematic reporting on material flows, but such work is under consideration to respond to information needs resulting from the National Environmental Policy adopted by the Government in 2000. Moreover, a workshop devoted to MF indicators, gathering representatives from many sectors, took place in June 2007 (see Outputs and Use).

An ad-hoc research project (ECOPOL) on economy-wide material flows in Poland was conducted in 1998-1999 by the Wuppertal Institute (Germany) in co-operation with the Warsaw Ecological Economic Centre of the Warsaw University and the Institute for Sustainable Development in Warsaw. Results were published in 2000.

CHARACTERISTICS AND SCOPE

Economy-wide MFA:
The Framework used in the ECOPOL project is a modified version of the approach followed in the WRI publication "Resource Flows". The project provided data on major MF variables for the years 1992-1997, as well as related MF indicators for Poland. It further included a comparison of the results with corresponding indicators calculated for some other countries: the Netherlands, Japan, Germany and the United States.

Other environmental accounts include an Air Emission Database (http://emissions.ios.edu.pl/)

OUTPUTS AND USE

Publication: Results of the research project: "ECOPOL: Ecological Economic Policy –Strategy for Poland in the 21st Century" conducted in 1998-1999 have been published in 2000 and are available on the Wuppertal Institute's website. Information on material management is also published annually by the National Statistical Office since 2002 (Gospodarka Materialowa).

In addition, the study "An assessment of possibility for calculation of material flows indicators on the basis of available national data" was prepared on the Chief Inspectorate of Environmental Protection's (CIEP) own initiative in 2006. The study includes the analysis of available data sources for direct material flows and unused domestic extraction, the assessment of possibility for calculation of MF indicators with suggestions about which indicators can be calculated first and the areas in which further research is needed (in the division of types of indicators), the instruction and recommendation for Polish governmental authorities.

Following this publication, the CIEP organized in June 2007 a workshop devoted to MF indicators, possible sources of funding pilot-projects and responsibilities sharing among governmental authorities in the area of MF. This workshop gathered representatives of the government (Ministry of Environment, Ministry of Economy, Ministry of Finance and Central Statistical Office), NGOs and research institutes carrying out studies in the area of MF as well as representatives of industry.

Indicators: As part of the ECOPOL project, MF indicators including Direct Material Input (DMI) and Total Material Requirement (TMR) were calculated. TMR has been included in the Polish sets of sustainable development and environmental indicators (Chief Inspectorate for Environmental Protection, Ministry of Environment).

Links to policies and objectives:
In its Second National Environmental Policy prepared by the Ministry of Environment (December 2002), the Polish Government has established a set of quantified and time-bound policy objectives related to the rational use of natural resources, in the areas of water use, material use, waste generation, and energy efficiency. The medium-term objectives, i.e. to be achieved by 2010, are as follows:

♦ to reduce water-intensity of production by 50% compared to 1990 levels (calculated per GDP and industrial sales value);
♦ to reduce the material-intensity and waste-generation of production by 50% compared to 1990 levels; and ensure their gradual abatement in individual production sectors so that at least average OECD levels are achieved (calculated per production unit, production value, or GDP).
The indicators used to monitor the implementation of the National Environmental Policy include among others the quantity of energy, materials and water consumed, and the volume of waste generated and pollutants emitted per GDP unit or the unit of production (expressed in physical units or by the value sold).

After the European Commission’s proposal of the EU Sustainable Production and Consumption Action Plan, Poland is going to draw up the national Roadmap that will specify the measures indicated in the ‘Strategy of changing production and consumption patterns to favour the implementation of sustainable development principles’, adopted in 2003, as an integral part of action taken in Poland, in particular to promote environmental technologies and Integrated Product Policy.

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Air Emission Database: http://emissions.ios.edu.pl/
PORTUGAL

OVERVIEW

Portugal has carried out work on MFA, mainly as part of case studies and pilot projects, some of them supported with government funding.

Most research work is done by two institutions: the National Institute of Engineering, Technology and Innovation (INETI) and the Centre for Sustainable Business Development, and the Technical Institute of the Technical University (IST/UTL). Other institutions involved include the National Statistical Office (INE, Instituto Nacional de Estatística) that carried out a pilot project on MFA in 2000.

INETI co-operates with the Sustainable Europe Research Institute - SERI (Vienna, Austria), and participates in the EU-funded MOSUS project ("MOSUS - Modelling opportunities and limits for restructuring Europe towards sustainability").

CHARACTERISTICS AND SCOPE

The studies have focused on economy-wide material flow accounts building on the Eurostat methodology. EW-MF data have been produced up to the year 2002. This includes MF indicators such as DMI, DMC, and TMR.

OUTPUTS AND USE

Links to policies and objectives

The final version of the Portugal’s National Strategy for Sustainable Development 2005-2015 abandoned the original objective aiming at a 1.5 factor reduction in resource consumption in industrial companies.

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SLOVAK REPUBLIC

OVERVIEW

The Slovak Republic initiated MF related activities in 1993 as a part of the country’s official statistics. The focus has long been on individual materials such as energy and water flows, and on substance flow analysis (SFA).

Systematic work on economy-wide material flow analysis started in 2005 with the minister resolution no. 52/2005 on Material Flow Accounting in SR and via a project-pilot study included in the Annual Work Plan of the Slovak Environmental Agency (financed by the fiscal budget of the Ministry of the Environment of the Slovak Republic). The main aim of this project has been to improve data, methodologies and measurement systems on material flows at the national level.

In 2006, a project titled “Material Flows in Slovakia – Analysis and Evaluation of Statistical Data Focused on Domestic Material Inputs” was realized. In 2007, work continued on the basis of the SEA approved Annual Plan of Activities; the project task titled “Material Flows in SR focused on input indicators and balance of material outputs” is linked up to material flow pilot study realized in 2006 as mentioned above.

The lead institutions are Ministry of the Environment, Slovak Environmental Agency working in close co-operation with Statistical Office. Other institutions involved include: Ministry of Agriculture, Ministry of Economy, and Mining Authority/Offices.

CHARACTERISTICS AND SCOPE

Part of the MF data is updated annually by the Statistical Office. The latest data available on energy and water flows refer to 2005.

Economy-wide MFA: Work on EW-MFA initiated in 2005 is based on the Eurostat methodology and cover all major MF indicators. It is expected that (i) the Eurostat Guide will be accessible (in Slovak) in electronic form via internet and (ii) the first set of consolidated MF indicators will be available for the Slovak Republic. This work will also identify information gaps regarding MF indicators. Cross-sectoral and inter-institutional co-operation has been established.

Material Flows in Slovakia – Analysis and Evaluation of Statistical Data Focused on Domestic Material Inputs” (2006): The project aim:

♦ evaluation of domestic material flows development from 1990 to 2002 according to the methodology of macro-economic accounting of MF.

Following activities were realized within the project task:

♦ specification of accessibility of statistic data for MFA in SR at macro-economic level and consequently derived indicators of sources utilization on the basis of EUROSTAT methodology focused on domestic material inputs;
♦ data collection concerning domestic raw materials exploitation was realized in co-operation with Statistical Office and State Geological Institute;
♦ data provided by Statistical Office on import and export of raw materials, semi-products and products were processed on the basis of Harmonised System Codes of foreign trade classification and prepared for further application;
♦ data collection concerning biomass from agriculture, forestry, fisheries and hunting was accomplished in co-operation with Statistical Office and Ministry of Agriculture;

In the report "Analysis of domestic exploitation", data obtained from the Statistical Office, the State Geological Institute and the Ministry of Agriculture were analyzed, and trends of utilisation of domestic exploited raw materials were evaluated.

In the report "Identification of unaccessible data and proposal of problem solving", the unaccessible data sources necessary for creating of complex material balance in SR were identified and possibilities of further problem solving were summarized. Project task outputs:

♦ Statistic data on raw material exploitation; time series: 1990-2004 – xls format file
♦ Statistic data on biomass – xls format file
♦ Report "Analysis of domestic exploitation" – doc. format file
Inventory of country activities
Measuring material flows and resource productivity

♦ Report “Identification of unaccessible data and proposal of problem solving” – doc. format file

“Material Flows in SR focused on input indicators and balance of material outputs” (2007) Data sets resulting from analyse and synthesis will be used to develop key aggregated input, output and effectivity indicators. Compiled indicators will be consequently evaluated in connection to macro-economic indicators. Project task outputs:

♦ Aggregated input indicators, i.e. domestic raw materials exploitation, will be completed with DMI and DMC indicators;
♦ Material outputs data sets – written report on waste, emissions, pollutants (into air and water) material outputs;

Outputs and use

Publication: Information on raw materials and other natural resources is regularly published in the country’s Statistical Office Yearbook and in the Raw Materials Yearbook.

Indicators: Indicators related to material and other natural resources are compiled by the Statistical Office and other relevant government institutions, and EW-MF indicators will be included in the country’s official set of environmental and sustainable development indicators.

Links to policies and objectives: Policy objectives related to material resource use are included in Slovakia’s National Sustainable Development Strategy (NSDS) adopted in 2001. Based on the NSDS and after having inserted the principles of sustainable development in individual sectoral strategies (economic, social, environmental, and information), the National Action Plan of Sustainable Development (NAPSD) was adopted by the Government resolution No.574 in 2005. Work on economy-wide MFA and related indicators is expected to support the preparation and implementation of key strategic documents closely related to MFA and to the tracking of eco-efficiency in individual sectors of the national economy (Waste Management Programme, National Strategy of Sustainable Development, the Raw Material Policy of the SR). It will further support the implementation of the EU Lisbon strategy at national level.

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One of the main short-term goals of the Raw Material Policy (RMP) of the SR directly relates to MF accounting – it is to create a unified statistical measurement system on the movement of raw materials in order to provide information about the quantity and type of individual commodities of raw material and related foreign trade. In this document it is possible to find out also information on:

- generation and use of mineral waste from the mining and processing of raw materials – belonging to „hidden flows” within the material flows account
- tables on export-import of raw materials needed for calculation of consolidated MFA
- tables on mining of raw materials („Domestic Extraction”) – with complement of socio-economic indicators. It further specified the lifetime of domestic geological and industrial reserves of raw materials – based on actual estimation of reserves of individual raw material of reserved deposits and actual domestic extraction quantities of raw material.
SPAIN

OVERVIEW

Spain has initiated work on economy-wide Material Flows (EW-MF) in 2002 as part of its activities on Environmental Accounting and as part of its National Statistics Plan 2001-2004. The lead institution is the Spanish Statistical Institute (INE).

Work has also been done at sub-national level in the Basque country region. It was carried out by the Institute of Public Economics of the University of the Basque Country in co-operation with the Wuppertal Institute, and funded by the Department of Land Use and Environment of the Basque government.

CHARACTERISTICS AND SCOPE

Work on economy-wide MFA builds on the Eurostat methodology (and on reference material by the Wuppertal Institute and the EEA) and has generated Material Flow Accounts and Balances for the years 1996 to 2000 and 2000-2004 (introducing changes in the Eurostat methodology). An effort has been made to develop, as far as data availability permits, a complete material flow analysis covering both input and output flows.

Basic data on a number of variables (domestic extraction, imports, exports, waste, emissions and dissipation of products) have been obtained through the Spanish official statistics, elaborated by INE or by the Ministry of Industry and the Ministry of Agriculture, Fisheries and Food.

Other relevant Environmental Accounts include:

Future work is expected to help to improve data quality and calculation methods in line with related international work, and to disaggregate the MF Accounts by economic branches, either through Physical Input-Output Tables or through resource use tables. Since water is an essential and scarce resource in Spain, interest in water flows analysis is high, especially as regards hidden water flows. To include water in the Material Flows framework is therefore an important issue.

Basque country government: Work in the Basque country has focused on economy-wide MFA and on physical input-output tables (PIOTs). EW-MF data are updated annually and are available for 1989-2002. Efforts have initially concentrated on developing a Total Material Requirement (TMR) indicator building on the Eurostat methodology with however a few amendments to adapt the method to the specific characteristics of the Basque Country. The main changes made are: the use of specific coefficients in calculating erosion due to agriculture; the introduction of a new method for calculating excavation due to the construction of infrastructure and buildings; and the estimation of imports from the rest of Spain (not covered in official trade statistics).

OUTPUTS AND USE

Publication: Information on material flows and resource use is published by INE together with other information from environmental accounts. It is available on the INE’s web site and as a paper publication. Results from work carried out in the Basque country were published in 2002.

Indicators: EW-MF studies include the calculation of a comprehensive set of MF indicators, including:
- input indicators (Direct Material Input (DMI), Total Material Input (TMI), Total Material Requirement (TMR), domestic TMR);
- consumption indicators (Domestic Material Consumption (DMC), Total Material Consumption (TMC), Net Additions to Stock (NAS)); and
- output indicators (Domestic Processed Output (DPO), Total Domestic Output (TDO), Domestic Material Output (DMO), Total Material Output (TMO)).

All indicators have been calculated in absolute terms and in relation to economic and demographic variables (GDP, population).
**Basque country government:** Work on MFA has led to the calculation of MF indicators including DMI and TMR, and direct material productivity (GDP/DMI). TMR per capita is included in the official set of sustainable development indicators of the Basque country.

**Links to policies and objectives:**

MF indicators are still under review to identify those that are most meaningful for inclusion in a set of sustainability development indicators to support the "Spanish Strategy on Sustainable Development", which draft has been adopted in 2005. The preliminary list of Sustainable Development Indicators includes DMC (level III) and TMC (level I) as proposed in the "Preliminary List of SDI" prepared by Eurostat (Revision 7, 28/10/2004). Another possible development would be to use MF indicators to monitor trends of resource use policies in accordance with the EU "Strategy on the Sustainable Use of Natural Resources".

The Basque Environmental Strategy for Sustainable Development (2002-2020) includes a target to maintain the Total Material Requirement (TMR) per capita at 1998 levels in 2006. The target is formally adopted by the Basque government.

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SWEDEN

OVERVIEW

Sweden has been developing physical environmental accounts since 1993 giving priority to environmental accounts for energy and certain emissions. Work on national level material flow accounts (EW-MFA) was initiated in the late 1990’s by the Swedish government as an ad-hoc project. So far, no decision has been taken as to the continuation of this work and related funding.

Current efforts focus on improving existing statistics that are used to populate and support material flow accounts (industrial and trade statistics, chemical products register, emission statistics), on getting a better understanding of user needs and on enhancing statistical co-ordination in the country. Further developments depend among others on developments at EU level and on future EU requirements for material flow statistics.

At the academic level, a number of research projects have dealt with substance flow analysis (SFA). The lead institution is Statistics Sweden (MFA; environmental accounts). Other institutions involved include the Swedish EPA, the Chemicals Inspectorate, the Royal Institution of Technology, the Likoping Institute of Technology, and local municipalities.

Sweden also contributes to international work through Eurostat and the OECD, and participates in the ConAccount network co-ordinated by the Wuppertal Institute (Germany).

Apart from accounting work on material flows, the Swedish EPA has also financed a study to: (i) evaluate the effectiveness and the efficiency of taxes on selected natural resources and chemical compounds; and (ii) analyse the potential for increased implementation of natural resource and chemical taxation in Sweden*. 

CHARACTERISTICS AND SCOPE

The accounting framework used for integrated environmental and economic accounting in Sweden is to a very large extent based on the National Accounting Matrix including Environmental Accounts (NAMEA) framework. Standard economic accounts are supplemented with physical data within the framework of input-output accounts. These data focus on waste flows: greenhouse gas and other air emissions, emissions of nitrogen and phosphorous and other waste flows from extraction and manufacturing industries categorised according to material, source and method of treatment.

Economy-wide MFA: The study on EW-MF, carried out by Statistics Sweden, included (i) a structure for collecting and presenting MF statistics for Sweden and (ii) a description of total material throughput building on international work available when the study was carried out (WRI and ConAccount). Variables covered include direct material inputs (DMI) in the society such as inputs from foreign trade, agriculture, forestry, mining and fuels, and outputs such as exports, waste, and air missions. The proposed structure for EW-MFA includes an attempt to couple MF information to environmental pressures in line with the System of Environmental and Economic Accounts (SEEAA), through a monetary input-output analysis. The aim is to use the knowledge derived from this information to work towards eco-efficiency by improving the resource productivity.

EW-MF data have been compiled for the period 1987-1998 and were used to estimate the resource productivity of the Swedish economy.

Substance flow analysis (SFA): Research work on SFA has been focusing on metals and nutrients on a local or national level, including water and air emissions (e.g. Cu, Pb and Hg). Ad hoc studies commissioned by the Swedish Chemicals Agency (KEMI) have so far covered about 220 substances.

Other MF activities include work on energy-related materials, on hazardous substances, etc.

OUTPUTS AND USE

Publication: First results from the study on EW-MFA were published in 2000.

Indicators: Data from the ad-hoc study on EW-MF have been used to calculate MF indicators such as DMI, DMC and TMR (for 1987-1998). DMC was included in the first Swedish set of sustainable development indicators published in 2001 by Statistics Sweden. None of these indicators has been updated since.

* “Extending the Environmental Tax Base: Prerequisites for Increased Taxation of Natural Resources and Chemical Compounds”
**Links to policies and objectives:** In 1999, the Swedish Parliament adopted 15 national environmental quality objectives that underpin the country’s environmental policy up to the year 2020 (“Swedish Environmental Quality Goals: An Environmental Policy for a Sustainable Sweden”, Government Bill 1997/98:145). Between 2001 and 2003, 71 interim targets (by 2010) were laid down to support the environmental quality objectives.

Resource productivity is not an explicit objective, but several of the environmental quality objectives are associated with products and necessitate the development of a strategy for an environment-oriented product policy if they are to be achieved (based on the need for: greater energy efficiency, non-toxic, resource saving ecocycles, environmentally sound products, efficient management of land and water resources). In May 2003, the Swedish Government put forward a bill "A society with non-toxic and resource-efficient ecocycles“ (Bill 2002/03:117), including objectives and measures to achieve such a society.

In April 2004, the Government presented a national strategy for sustainable development in which all ministries participated. It includes a chapter on sustainable economic growth and competitiveness with reference to production and consumption patterns.

At national level, SFA studies commissioned by the Swedish Chemicals Agency (KEMI) are closely linked to policy uses. At local level, municipalities such as city of Stockholm have shown interest in SFA in order to inform chemical policies. Stockholm participated in a research project covering stocks and flows of seven heavy metals in both the rural and the urban area of the city.

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SWITZERLAND

OVERVIEW

Switzerland has good experience with material flow related work such as substance flow analysis (SFA) and MFA applied to waste management mainly at research level and at local level. Economy-wide material flows accounting is a more recent activity and a feasibility study was carried out by the government in 2003-2004. Since 2003, the Statistical Office calculates on a yearly basis MFA indicators including the TMR.

The lead institution for economy-wide MFA is the Statistical Office, in co-operation with research institutes (ESU services (Uster); Wertstoffbörse GMBH (Zürich)). Other MF related work is being done by local agencies for waste management (e.g. in the Cantons of Zurich, Geneva, St. Gall and Thurgau) and research institutes such as the Swiss Federal Institute for Technology (Zurich, Lausanne) that also includes MFA in the subject matters of its bachelor and master studies, and the Swiss Federal Institute for Environmental Science and Technology. Related work is also carried out by private companies (e.g. Holcim) and environmental consultant firms (e.g. Geopartner; Sieber und Cassina; Infras; Wüest und Partner).

Switzerland participates via the Swiss Federal Institute for Technology in the ConAccount Network co-ordinated by the Wuppertal Institute (Germany).

CHARACTERISTICS AND SCOPE

**Economy-wide MF**: The Environmental accounts based on SEEA 2003 developed by the Statistical Office include economic accounts (SERIEE), physical accounts (MFA) and integrated accounts (NAMEA). The feasibility study on EW-MF builds on the Eurostat methodology and was carried out between August 2003 and September 2004. It demonstrated the feasibility of such accounts in Switzerland and highlighted some methodological problems. The study has generated data on Direct Inputs with time series for 1981-2001. Since 2004 the Statistical Office has consolidated the data, extended the time series up to 2005 and estimated the hidden flows for the calculation of the TMR. The next stages will consist in consolidating data on Outputs. The Statistical Office is producing regularly input indicators.

**Substance Flow Analysis or MFA at regional or enterprise level** are carried out frequently (though not regularly) as part of non-governmental research projects (universities, research institutes, consultant firms) and as part of governmental activities related to waste management at federal or cantonal level (Cantons of Zurich, Geneva, St. Gall, Thurgau).

A MF study carried out for the Canton of Geneva (between September 2002 and December 2003) has assessed the metabolism of economic activities in the region. The study covered all major MF variables for the year 2000 (input and output flows, stocks, consumption) broken down by type of materials including energy (electricity, motor fuels, heating fuels), construction materials (concrete and bricks, sand/gravel and asphalt concrete), food (including animal feed), metals (iron, copper, aluminium), plastics, wood (timber, paper, cardboard), and water.

OUTPUTS AND USE

**Publication**: First results on EW-MF were published early 2005 and the feasibility study is available on the website of the SFSO. A publication on EW-MF including the TMR will be available in April 2007. Numerous reports on SFA and MFA activities have been published on cantonal scale, mainly related to waste management.

**Indicators**: Total Material Requirement, Direct Material Input, Domestic Material Consumption, Physical Trade Balance, Material productivity and intensity.

**Links to policies and objectives**:
- At federal level, the proposed system of indicators to measure sustainable development (MONET) includes an indicator on the material efficiency of the economy (i.e. total material flow per GDP). The indicator is related to the postulate that "the environmental impact and risks emanating from production plants should be minimised, while energy and material flows should be optimised".
- At regional level, the Canton of Geneva uses MFA to support the implementation of the local Agenda 21 as defined in a law adopted on 23 March 2001 and revised in 2002 (loi sur l'action publique en
vue d’un développement durable - Agenda 21). The Agenda 21 Law includes 9 broad policy objectives to be achieved by 2006. Objective No.5 states that the state should take into account all possible synergies among economic activities so as to minimise their impact on the environment.

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TURKEY

OVERVIEW

Turkey does not carry out work on material flows per se, but has initiated a pilot study on supply-use tables for inland waters (based on the System of Environmental and Economic Accounts (SEEA) handbook).

The lead institution is the Turkish Statistical Institute. Other institutions involved include: the Ministry of Environment and Forestry, the Ministry of Energy and Mineral resources and the State Planning Organization.
UNITED KINGDOM

OVERVIEW

The United Kingdom has initiated work on material flows in 1999, when the UK Department for Environment, Food and Rural Affairs (DEFRA) in conjunction with the Office for National Statistics (ONS) engaged the Wuppertal Institute (Germany) to develop an economy-wide material flow account for the UK. The results of this research work, covering the period 1970 to 1999 were published in 2002 (‘UK National Accounts’, the ONS Blue Book).

The ONS has subsequently taken over responsibility for MF accounts on behalf of DEFRA, and MFA has become a regular activity as part of the country’s official statistics. This regular work is complemented with ad-hoc work on Physical Input-Output Tables (PIOTs) carried out by NGOs.

MF related work is also being carried out by the UK’s waste management industry that has commissioned a number of substance flow analyses under the Landfill Tax Credit Scheme.

The UK also contributes to international work steered by the London Group on Environmental Accounting, to the Eurostat material flows task force and to the OECD working group on material flows.

CHARACTERISTICS AND SCOPE

Economy-wide MFA: The framework used to develop EW-MFA follows the standards set out by Eurostat. The data are updated annually by the ONS on behalf of DEFRA and are available on the National Statistics website. The most recent data available refer to 2005.

Further research by the ONS aims at refining the estimates of indirect flows (many of the factors used so far will remain based upon one-off or country-specific studies and there is scope for more coordination of research internationally), and investigates methodologies for assessing the impacts in exporting countries of domestic consumption of imports. Some efforts have also been made to develop weights relating to toxicity or environmental impact, which could be used to weight material flow output indicators.

MF Mass balance: A complete mass balance of the UK was completed in 2003. Furthermore, Biffaward has yet funded more than 30 separate projects as part of its mass balance programme in the UK (for more information, see box below).

Physical Input-Output Tables (PIOTs): Ad hoc work carried out by the Stockholm Environment Institute and the Centre for Urban and Regional Ecology on the development of PIOTs (Regional, product based using Prodcom) resulted in the publication of four technical papers in 2005.

OUTPUTS AND USE

Publication: MFA data are regularly published by the ONS as part of the UK’s Environmental Accounts. MF data are presented alongside other data derived from natural resource accounts and other physical flow data (e.g. air and GHG emissions, waste, water).

Indicators: Indicators derived from MFA include Direct Material Input (DMI), Domestic Material Consumption (DMC), Total Material Requirement (TMR) and material productivity expressed as per capita GDP at real prices divided by per capita domestic Direct Material Consumption (DMC).

MF indicators are part of the country’s official set of sustainable development indicators (‘Quality of Life Counts’). MF indicators have been included as part of a proposed set of Sustainable Consumption and Production indicators for the UK, but have not yet been formally adopted. Up to now, MF data and indicators have been used to: inform the public and policy makers about key issues and trends; link environmental and economic information; monitor the sustainability of natural resource use; and, monitor the effects of trade and globalisation on material flows.

Links to policies and objectives: In September 2003, following the commitments at the World Summit on Sustainable Development, the UK’s Department for Trade and Industry and the Department for Environment, Food, and Rural Affairs published a framework document called “UK Government Framework for Sustainable Consumption and Production”. This document was accompanied by a consultation document setting out the Government’s initial ideas for a ‘basket’ of 12 “decoupling” indicators by which the effectiveness of the planned actions for sustainable consumption and production can be measured. The selected indicators were presented in the overall review of indicators for the UK SD Strategy completed in March 2005. Among these indicators, since then published yearly on the
Government sustainable development website, figure "domestic material consumption", "construction output and extraction of construction materials" and indicators related to freshwater abstraction, energy use and waste arising.

The UK does not have a specific target for resource use, but there is a commitment to promote continual improvements in resource efficiency, that is to make greater use of the resources extracted.

The Biffaward Mass Balance programme seeks to improve information about the environmental impact of resource use throughout the UK. Mass Balance UK is co-ordinating these projects with the aim of providing the most comprehensive picture of the mass balance of the UK to date. The project is being carried out by Forum for the Future on behalf of the Royal Society of Wildlife Trusts.

Yet, Biffaward has funded more than 30 separate projects as part of this programme. These projects are quantifying the movement of resources for the production of specific materials or through specific economic sectors or geographical areas as these resources are extracted/imported, manufactured into products, used and disposed of or recycled. The wastes generated at each stage of this sequence are also quantified and in this way the entire material flow is captured.

Find below the complete list of projects from the Biffaward Mass Balance programme:

<table>
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<tr>
<th>Material</th>
<th>Region</th>
<th>Sector</th>
<th>Waste Management</th>
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<td>♦ Benchmarking wood waste combustion in the UK furniture manufacturing sector</td>
<td>♦ Ecological Budget UK</td>
<td>♦ Agricultural Waste: Sustainable agricultural waste management</td>
<td>♦ EuroCharge</td>
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<td>♦ Carbon UK</td>
<td>♦ Isle of Wight: Island State</td>
<td>♦ Automotive</td>
<td>♦ Meeting Producer Responsibility Obligations: Resource Management &amp; Compliance Reporting</td>
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<td>♦ Glass Manufacture in UK</td>
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<td>♦ Iron, Steel and Aluminium: Economic Dimensions</td>
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<td>♦ Iron, Steel and Aluminium: Material Flow Analysis</td>
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<td>♦ Solvent Waste in Furniture Manufacturing</td>
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<td>♦ London: City Limits</td>
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<td>♦ South East: Taking Stock</td>
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<td>♦ National Health Service: Material Health</td>
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<td>♦ UK status report on waste from electrical and electronic equipment</td>
<td>Remanufacturing in the UK; A significant contributor to sustainable development</td>
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<td>♦ Sustainable Transport Resources and Waste (STRAW)</td>
<td>Waste Data Flow (On Line Data Capture Systems)</td>
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<td>♦ Thermal Methods of Municipal Waste Treatment</td>
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Note: For complete references of these projects, see Biffaward, The Mass Balance UK project website: [http://www.massbalance.org/projects/](http://www.massbalance.org/projects/).
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EUROPEAN UNION – COMMISSION OF THE EUROPEAN COMMUNITIES

OVERVIEW

The European Union has been carrying out work on MFA since 1993. The work covers economy-wide material flow accounts and indicators, as well as physical input-output tables. It is complemented with MF related modelling and research work (e.g. the MOSUS project) and with work on other environmental accounts, such as National Accounting Matrix including Environmental Accounts (NAMEAs) and environmental protection expenditure accounts.

The work also includes training and capacity building in the field of material flow accounts.

Lead institutions are Eurostat (methodological and statistical guidance, training, compilation of MF data); the European Environment Agency (EEA) and its Topic Centre on Waste and Material Flows (MF indicators and related guidance, policy and assessment reports), and the European Commission itself (policies and strategies, research). Other institutions involved include private and university research institutes that carry out projects on behalf of the European Union (e.g. the Wuppertal Institute, Germany and the IFF, Austria).

The European Union actively contributes to international work steered by the London Group on Environmental Accounting and participates in the work of the OECD, the UNSD (input to ESEA) and TF/Trainings with MS.

CHARACTERISTICS AND SCOPE

The Statistical Office of the European Commission, Eurostat, initiated work material flows as of 1993 with a project called "Materials balances for selected dangerous products and substances". The project included a first feasibility study on environmentally oriented material flow accounting, and was supported with expert meetings.

Since then, Eurostat has taken significant steps to harmonise methodological approaches of material flow accounting and derived indicators and has published a methodological guide in 2001. It has also commissioned several studies to provide MF data on the European Union and its member states. The data are updated annually and are available for the period 1970-2001 for the EU as a whole and for individual member states. The underlying data series are produced by research institutes on behalf of the European Commission (Wuppertal Institute; IFF-Vienna).

Current efforts focus on further promoting the development and use of MFA in member states, refining the methodological guidelines for MFA in co-operation with research partners and with other international institutions, and developing a simplified guide on MFA in support of work on MFA carried out by the OECD.

In 2001, the European Environment Agency (EEA) expanded the scope of work of its Topic Center on Waste to include material flow analysis and changed its name accordingly to European Topic Centre on Waste and Material Flows (ETC/WMF). This expansion was a result of EU policy developments in the area of sustainable use of natural resources in the context of the 6th Environmental Action Programme. Concerning material flow analysis, the objectives of the ETC/WMF include (i) the provision of data and information on material flows in Europe; (ii) the inclusion of such information and related findings in reports produced by the EEA; (iii) the contribution to the further harmonisation of methodologies in the area of MF accounting and indicators; and (iv) the provision of support to policy makers in developing policy strategies and measures concerning sustainable use of natural resources.

MF data and indicators produced so far by the ETC/WMF are available on the Topic Centre's website, as well as links to selected national and international MF related activities. The EEA uses MFA-based indicators in several key reports including 'Europe's environment - the Third Assessment (2003) and the Fourth Assessment (2007) and the 2005 State of Environment and Outlook Report.

In the course of the preparation of the 6th Environmental Action Programme (6EAP) and of the thematic strategy on the sustainable use of natural resources, the European Commission commissioned a number of studies on resource management, covering conceptual and policy issues.

♦ A first study, commissioned to the Wuppertal Institute via the European Topic Center on Waste and Material Flows (ETC-WMF), provided baseline data on material flows.
A study "Public private interface" carried out in 2003 by a consortium consisting of the Danish lead organisation of the European Topic Centre on Waste and Material Flows (ETC/WMF) and the Centre for Economic Analysis (ECON) under the lead of the Danish National Environmental Research Institute (NERI), reviewed policies, objectives and targets regarding natural resource and waste at EU-level or in Member States/accession countries; and examined the impact of existing taxes and subsidies on natural resources and wastes. The aim was to make proposals for target setting, instruments and best practices based on experience so far.

A study "Dynamic View on Resources", carried out in 2003 by Entec UK Ltd. assessed the feasibility of decoupling resource use from economic growth and developed a methodology to assess the dynamics of the use patterns of individual resources, including the relationship between the use and the environmental impacts, created at various stages of the life cycle. It reviewed the framework of resource regulation, economic structure and environmental impact related to two different resources, reviewed the impact of measures, such as material substitution, material recovery, and re-use/re-cycling, leap-frog technologies etc. and identified the best policy mixes, technological solutions, and other tools, through which the objective of de-coupling could occur.

A study "Policy review on decoupling and development of resource productivity indicators" was executed by the Institute of Environmental Sciences (CML) Leiden University, the Wuppertal Institute for Climate, Environment and Energy, and CE Solutions for Environment, Economy and Technology. The aim is to identify and explain the reasons for differences in material intensities and patterns of resource use of the EU and ACC; derive a weighted indicator of material flows that reflects the highest environmental impacts; identify a limited set of mass flow and land use indicators that are manageable; and assess whether one or more indicators could be used for benchmarking exercises. The project covers the 25 member states of the European Union and three accession countries. One of the major challenges of this study was the development of the environmentally weighed material consumption indicator, the EMC. The basic idea is simple: just adding an environmental weight to the material flow. Data and the methodology build on established tools and databases, such as LCA data. Some aspects limit its potential at the moment. One important problem is that of the weighting between environmental impact categories.

"Material metabolisms of the physical stock". The aim is to: describe and characterise the historically accumulated physical stocks (e.g. buildings, bridges, cars, etc.) in the EU and in accession countries; identify the dissipative material flows from the stocks due to corrosion, weathering, etc.; forecast the energy that is required for processing and transport of goods and materials related to the stocks and estimate the environmental pressures of these material metabolisms.

Between 2003 and 2006, the European Commission funded a 3-year EU-wide research project called "Modelling Opportunities and limits for restructuring Europe towards Sustainability (MOSUS)", within the Fifth framework programme of the European Union.

Twelve research institutions from seven European countries participated in the project: the International Institute for Applied Systems Analysis (IIASA), Austria, that acted as the project co-ordinator; the Gesellschaft für wirtschaftliche Strukturforschung mbH, Germany; the Sustainable Europe Research Institute (SERI), Austria; the Charles University Prague, Environmental Center (CUEC), Czech Republic; the London School of Economics, UK; the Austrian Institute of Economic Research (WIFO), Austria; the Institute for Sustainable Development, Poland; the National Institute for Engineering and Industrial Technology (INETI), Portugal; the Research Centre on the Portuguese Economy, Portugal; the Research Centre for Sociological Studies, Portugal; the University of Lodz, Poland; the Center for International Climate and Environmental Research, University of Oslo.

The goal was to quantify the interrelations between socio-economic driving forces and the state of the environment, by illustrating the physical growth of the global economy driven by the world-wide economic integration process of the past 25 years and presenting a world-wide distribution of environmental pressures associated with material extraction.

The project used the Eurostat guidelines for economy-wide MFA and built on an integrated (multi-country, multi-sectoral) ecological-economic input-output simulation model, GLODYM, developed by the German Institute of Economic Structures Research. The model covers trade and financial flows between all European countries as well as flows between Europe and other parts of the world.

Results include a complete compilation of trends (1980-2002) in direct domestic material inputs (including domestic hidden flows), energy inputs and land use for Europe as well as all economically important regions of the world, disaggregated by economic sectors and countries. The database covers 188 countries. The project covers major material groups (such as fossil energy carriers, metals,
industrial and construction minerals, and biomass). Most of the underlying data are derived from internationally available statistics and research reports. The physical extraction data are linked to socio-economic indicators, such as GDP and population, in order to assess different patterns of resource productivities and inequalities in per capita resource extraction between industrialised and developing economies. The project will further develop European and global scenarios of economic performance and their interaction with resource use and environmental deterioration (decoupling), and refine MF related indicators.

The Institute for Prospective Technological Studies in Seville, which is part of the Directorate General of the Joint Research Centre (IPTS - DG JRC) initiated the project 'Environmental Impacts of Products (EIPRO)', performed by the Netherlands Organisation for Applied Scientific Research (TNO), the Flemish Institute for Technological Research (VITO), the Centre of Environmental Sciences of Leiden University (CML) and the Danish Technical University (DTU). The study was published in 2006 and aimed to prioritize product groups on environmental impacts, including resource use. For this, it reviewed seven existing studies at national level, and developed an input-output database of 500 sectors with environmental extensions, the "CEDA EU25 model". All these sources differed substantially in their basic approach (LCA-based versus input-output approaches), geographical region, disaggregation of final demand, data inventory used, and method of impact assessment. Nevertheless, across all sources, a limited number of priorities emerged. The three main priorities (Housing, Transport and Food) account for more than 70% of the life cycle environmental impacts in most categories, while covering only 55% of the final expenditure in the EU25. At a more detailed level priorities are car- and most probably air travel within Transport, meat and dairy within Food, and building structures, heating, and electrical appliances within Housing. Given the very different approaches in the reviewed sources this result must be regarded as extremely robust.

As a follow-up of EIPRO, DG JRC IPTS launched a series of still ongoing studies on 'Improvement of environmental impacts of products', in short IMPRO. They focus on determining improvement options in one field of each of the three priority domains Housing, Transport and Food, namely housing, passenger cars and meat products.

In 2005, the European Commission published its Communication of the Thematic Strategy on the sustainable use of natural resources ("Resource Strategy"). This strategy calls for a further development of a set of indicators, building on the substantial work already undertaken in the fields of environmental accounting, material flow accounting and life cycle inventories. By 2008, the Commission will develop:

- indicators to measure progress in efficiency and productivity in the use of natural resources, including energy;
- resource-specific indicators to evaluate how negative environmental impacts have been decoupled from resource use, and;
- an overall indicator to measure progress in reducing the ecological stress of resource use by the EU (eco-efficiency indicator).

In this context, the Commission recently initiated two new studies:

"Potential of the Ecological Footprint for monitoring environmental impact from natural resource use". The objectives of this study are to:

- Provide an analysis of the potential of the Ecological Footprint as an aggregated indicator for resource-specific impacts as called for in the Resource Strategy;
- Provide an analysis on how other assessment tools (such as HANPP, SEEA, etc.) can complement the Ecological Footprint in order to monitor the impact of natural resource use on the environment;
- Identify elements for essential improvements of the Ecological Footprint methodology that can be addressed in the short to medium term (1 to 5 years).

"Strengthening the Knowledge Base for the implementation of the Thematic Strategy on the Sustainable Use of Natural Resources". The overall objective of this project is to start improving the information basis for decision makers in policy and other areas in order to support the implementation of the Resource Strategy. The objective comprises in particular to:

- Assess and make widely available knowledge on highly significant resource trade flows and their environmental impacts;
- Develop the initial elements for a world-wide contacts and reference inventory of expertise on natural resource flows and impacts;
Stimulate a wide expert discussion of the way forward in policy development for the sustainable use of natural resources.

Under the EU’s FP6 research program, the 4 year multi million project EXIOPOL was launched in March 2007, lead by the Fondazion Eni Enrico Mattei (FEEM) and TNO. Half of the project is dedicated to methodologies for external cost assessment. The other half of the project arguably builds the most comprehensive harmonized, global multi-regional trade linked input-output database with environmental extensions in the world (45 countries with more than 90% of the world’s GDP plus ‘dirty’ processes in the rest of the world, 100-110 sectors/products, 60-80 types of emissions and primary material inputs, traditional factor inputs, allowing the calculation of key environmental indicators such as the Ecological Footprint, LCIA themes, external costs and MFA indicators). The project builds further upon work of EEA, Wuppertal Institute and others on environmental accounting and related input-output frameworks, MFA studies and NAMEAs.

OUTPUTS AND USE

**Publication**: MF data and indicators compiled by and on behalf of Eurostat are regularly published and can also be downloaded from the web. Aggregated MF indicators for the EU are also regularly published in the EEA’s indicator reports "Environmental signals". MF data were also published in the Kiev report "Europe’s environment: the third assessment" under a chapter on material flows.

**Indicators**: MF information produced so far by Eurostat for the European Union as a whole and for individual member states has been used to derive MF indicators such as: Domestic Material Consumption (DMC), Direct Material Input (DMI), and physical trade balance (PTB). The calculation of Total Material Requirements (TMR), domestic processed output (DPO) and net additions to stock (NAS) was abandoned in the most recent update.

The preliminary list of sustainable development indicators for the EU includes a section on production and consumption patterns with indicators on material consumption and waste generation.

**Links to policies and objectives**: Natural resource use and resource efficiency were listed among the future key policy issues in the Review of the EU’s Fifth Environmental Action Programme (Decision N 2179/98/EC), and have been included in the 6th Environmental Action Programme (6EAP) 2001-2010 of the European Union.

The 6EAP called for the development of seven thematic strategies among which one on the sustainable use of natural resources. The natural resources considered include raw materials such as minerals and biomass, environmental media such as air, water and soil, flow resources such as wind, geothermal, tidal and solar energy and space (land area).

The European Commission published its Communication of the Thematic Strategy on the sustainable use of natural resources ("Resource Strategy") on 21 December 2005. The strategy states that a "more sustainable use of natural resources should lead over time to improved resource efficiency, together with a reduction in the negative environmental impact of resource use, so that overall improvements in the environment go hand in hand with growth. The overall objective is therefore to reduce the negative environmental impacts generated by the use of natural resources in a growing economy – a concept referred to as decoupling. In practical terms, this means reducing the environmental impact of resource use while at the same time improving resource productivity overall across the EU economy."

The renewed EU Sustainable Development Strategy confirmed the key objective to "promote sustainable consumption and production to break the link between economic growth and environmental degradation" and the important role the Resource Strategy can play, including "the measurement of resource efficiency".

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NON-OECD AREA

SOUTH-EAST ASIA

CHINA

OVERVIEW

In China, MFA studies are not a regular government activity, but the government has funded a number of related research studies. Further regular work on MF might be considered as part of future policies and plans related to economic and environmental management and to the establishment of a policy framework for promoting a "Circular Economy" in China.

China has initiated work on environmental accounting in June 2004 upon a request by President HU Jintao to study green GDP. The work is in its initial research phase and the government has commissioned research studies by various institutes.

Lead institutions are the Ministry of Environmental Protection (former State Environmental Protection Agency, SEPA) and the Chinese National Bureau of Statistics (NBS), with support from SEPA's affiliated institutions: the Chinese Academy of Environmental Sciences (CAEP), the Policy Research Center for Environment and Economy (PRCEE) and Renmin University. Work is also carried out at provincial level as pilot studies. Other institutions involved in the environmental accounting project include National Development and Reform Commission, and the Ministry of Science and Technology of China that provides part of funding for the project.

♦ The NBS is in charge of the compilation of the accounts. From 1998 to 2001, it has worked on the compilation of energy accounts and emission estimates for eight air pollutants as part of a cooperation project with Statistics Norway. Current work focuses on (i) the compilation of environmental-economic accounts based on environmental effects together with the State Environmental Protection Administration (SEPA), and (ii) the compilation of forest resource accounts with the State Forestry Administration and the Chinese Academy of Forestry.

In 2002, two pilot studies on industrial pollution and forest accounts have been launched at provincial level, one by Statistics Chongqing and one by Statistics Hainan. These two research studies have been completed in 2004 and 2003 respectively.

♦ The CAEP is in charge of drafting frameworks and guidelines for compiling environmental accounts, following the guidelines of the SEEA (2003). To date is has drafted two frameworks: A framework of Resources and Environmental and Economic Accounting for China, and A Framework of Environment and Economic Accounting for China. The drafting of technical guidelines for environmental accounting is in progress; this is to be followed by the selection of trial provinces. Economic valuation and environmental cost studies are also supported by the World Bank and other institutes, such as the PRCEE, Peking University, etc.

♦ Work to date on MFA has mainly been carried out by university research institutes (e.g. Tsinghua University, Peking University, Beijing Polytechnic University). A few universities have established contacts with research institutes in other countries, including the Wuppertal Institute (Germany), and the NIES (National Institute of Environmental Studies, Japan).

CHARACTERISTICS AND SCOPE

The development of environmental accounts by the government uses the SEEA 2003 as a general reference framework. Priority is given to the development of physical accounts for mineral, land, forest and water resources. The preparation of estimates of environmental protection expenditure is also considered, and the SEPA in collaboration with the World Bank sponsored a study to estimate environmental damage costs through modelling. The project is to be developed over a 3 to 5 years period.

Academic research work on MFA carried out to date covers many types of MF studies, most of them being supported with government funding.
A first pilot study on MFA for China, funded by the National Development and Reform Committee (NDRC), was carried out by the Tsinghua University (Energy, Environment and Economy Institute), covering the period 1992-2000. The study covered economy-wide MF, physical input-output tables for the year 1992, and substance flow analysis focusing on the use of iron in the Chinese steel industry. The results of the joint international research project on MF published by the WRI et al. in 2000 were used as a reference. The results of the study were used by the NDRC to calculate MF indicators such as DMI and TMR.

Another study carried out by the Tsinghua University (Department of Environmental Science and Engineering) and funded by the government, focuses on economy-wide MF (building on the Eurostat guidelines) and the establishment of physical input-output tables (PIOTs) at province level. The work on PIOTs covers more than 40 sectors, three natural resources and three pollution discharges. MF indicators calculated as part of the project include DMI and TMR (project duration: 2000-2004).

The Peking University (College of Environmental Science) carried out a project on MFA (between August, 2001 and December 2004) focusing on economy-wide MF accounts and on the material-energy metabolism and environmental impacts of the cement industry in the Beijing area. The project received government funding and followed the Eurostat guidelines. Work by the Wuppertal Institute and WRI et al. was used as a reference. MF indicators for China as whole, calculated as part of the project include Direct Material Input (DMI), Total Material Requirement (TMR), as well as TMR/capita, DMI/capita, and resource productivity indicators such as GDP/TMR and GDP/DMI. Data are available for the period 1997-2002.

The North-eastern University (Resources and Ecological Economics Research Centre) has, in January 2003, started a MF related research project, focusing on economy-wide MFA and using the concept of the Ecological Rucksack. The Eurostat methodological guide and work by the Wuppertal Institute are used as a reference. MF indicators calculated as part of the project include DMI, DMC and TMR as well as PBT. The most recent data available refer to 2002.

Provincial and city level MFA have been carried out, namely by Guiyang city and Tsingdao city, as demonstrations of the Circular Economy in China.

**Outputs and use**

**Indicators:** As part of the above described research projects, EW-MF indicators such as DMI and TMR have been calculated for China as a whole. Other related indicators produced as part of the government activities include indicators on water use, energy efficiency, industrial waste recycling, etc.

In 2007, NDRC, SEPA and NBS issued the indicator system for circular economy in China. This includes two sets of indicators: (i) economy-wide indicators for the circular economy, and (ii) sector based indicators for the circular economy in China.

**Links to policies and objectives:** China has many policy documents, plans and legal texts that relate to resource use, energy efficiency and sustainable development. Examples are the law on the promotion of cleaner production in China, the law on pollution control and prevention of solid waste, and the policy on comprehensive utilisation of resources. Some regulations also promote the development of the circular economy in China, as well as green public procurement, while others address electronic waste pollution control and prevention.

The Chinese government has approved a basic law for promoting a "Circular Economy", which integrates 3R as a basic principle. Great efforts have been made in the National programme on pollution abatement and energy efficiency in order to achieve the objectives of the Eleventh Five-Year Plan in China, led by the State Council with its members NDRC and SEPA, etc. Plans include a revision of the Environmental Protection Law of China and of related specialised laws and regulations so as to introduce or strengthen the 3R principle (reduce, recycle, re-use) in general and in specific sectors.
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LAOS

OVERVIEW
Laos has carried out ad-hoc research work on economy-wide MF accounts, energy flow accounts, and Substance Flow Analysis (SFA) with a focus on biomass from agriculture and forestry. This work has been carried out between 2001 and 2004 in the framework of a non-governmental interdisciplinary research project "South-East Asia in Transition" (SEATrans Project) funded by the European Union.  
The lead institution for the ad-hoc project was the National Statistics Center in co-operation with the National University of Laos, Faculty of Forestry and Faculty of Science, and the IFF-Vienna (Austria).

REFERENCES

PHILIPPINES

OVERVIEW
The Philippines do not yet carry out regular work on MFA, but have participated in related work under the interdisciplinary research project "South-East Asia in Transition" (SEATrans Project) funded by the European Union.

There is no one lead institution, as sectoral material flow tables are produced at the request of the National Statistics Coordinating Board (NSCB) for a fee. Partnerships exist with academic institutions throughout Europe (Netherlands, Italy, Austria) and South-East Asia (Thailand, Vietnam, Laos), and in particular with the IFF Social Ecology (Vienna, Austria) that co-ordinated the SEATrans project. Some academic work is also being carried out at the University of the Philippines at Los Banos.

MF work has been based on methodologies and training material from the IFF, and has focused on physical input-output tables (PIOTs). Data on resource use appears in the annual Philippine Statistical Yearbook.

The Philippine Council for Sustainable Development has published sustainable development indicators, which cover some aspects of material resource use.

VIETNAM

OVERVIEW
Work on MF in Vietnam so far has been restricted to a stand-alone study carried out between October 2000 and October 2003 under the interdisciplinary research project "South-East Asia in Transition" (SEATrans Project) funded by the European Union.

The work was co-ordinated by a Working Group of the University of Social Sciences and Humanities, (HCMC), with involvement by the Center for Natural Resources and Environmental Studies. The University has established close co-operation with the IFF Social Ecology (Vienna, Austria).

Information on material flows is published under the auspices of the General Statistics Organisation of Vietnam and of the Industry Ministry. MF data are used to calculate MF indicators such as DMI and DMC, but these are not included in any official set of indicators.

Information from MFA is seen as a useful tool to monitor the sustainability of material resource use, link environmental and economic information and to support modelling and outlook activities.

MF work was based on the Eurostat methodological guide and on training material from the IFF-Vienna.

16 Three-year project (2000-2003) carried out jointly by ten partners in the region and in Europe, including the IFF-Vienna (Austria) and the Leiden University (Netherlands). The project covered aspects related to social transitions, environmental impacts and policies for sustainable development.
EUROPE

BULGARIA

OVERVIEW

Bulgaria has carried out ad-hoc work on Material Flows. The work has a general scope and covers physical input-output tables (PIOTs) and Substance Flow Analysis (SFA).

The lead institution is the Bulgarian Executive Environment Agency, in co-operation with the National Statistical Institute. Some co-operation has also been established with the European Topic Center on Waste and Material Flows of the EEA whose documents were used to develop MF accounts.

MF data are available up to 1999. MF indicators have not yet been developed.

LATVIA

OVERVIEW

Latvia has recently carried out a pilot study (December 2003-December 2004) on economy-wide MFA. The lead institution for the pilot study was the Latvian Environment Agency. The Central Statistical Bureau of Latvia was also involved, along with selected sectoral and research institutions.

The Eurostat methodological guide was used as a framework when developing MF accounts. Data derived from the accounts have been used to calculate economy-wide indicators with focus on DMI and DMC. The most recent data available are from 2002.

Data and indicators derived from MF are seen as useful tools to monitor the sustainability of material resource use and inform related decision making as well as to link environmental and economic information.

National objectives regarding material resources include “increasing the sustainable use of natural resources” and “reducing waste production”. These are voluntary and are included in the Sustainable Development Strategy and the Environment Policy Plan.

MALTA

OVERVIEW

In Malta there is currently no work being undertaken in the field of MF, but an annual or biennial study cycle was due to start in 2005 as part of Malta’s official statistics.

The lead institution is the National Statistics Office.

Work was planned to focus on monitoring the sustainability of material resource use and also to link environmental and economic information. It is to be based on the Eurostat methodology.

SLOVENIA

OVERVIEW

Slovenia has initiated a feasibility study on MFA in January 2004. Plans for carrying out regular MF activities will depend on the results of this study.

The lead institutions for the study were the Statistical Office and the Environmental Agency of the Republic of Slovenia. The Ministry for the Environment, Spatial Planning and Energy also participated.

The work is based on the Eurostat methodology. Economy-wide MF data are available for the period 1992-2002.

Data derived from material flow work will be used to calculate MF indicators including DMI. Among the indicators already in use to monitor progress and of relevance to MFA are:
a Water Exploitation Index, Final Energy Consumption, Renewable Energy Resources, and Direct Material Input (DMI) used by the Ministry and the Environmental Agency (DMI has been included in the State of the Environment Indicator report, published late 2004 by the Environmental Agency).

- energy intensity, renewable sources and tree felling intensity used by the Institute of Macroeconomic Analysis and Development in its development report.

Data and indicators derived from MFA are planned to be used to monitor the sustainability of material resource use and inform related decision making and to link environmental and economic information.

Broad objectives for the sustainable use of natural resources are included in the National Environmental Action Programme (1999), and for the prudent use of natural resources in the Spatial Development Strategy (2004). More explicit objectives are expected to be included in the Strategy for the Development of Slovenia and in the updated National Environmental Action Programme (2004).
LATIN AMERICA

BRAZIL

OVERVIEW

In Brazil, a detailed Material Flows Analysis of the national economy has been carried out as part of non-governmental academic research projects, first as part of a PhD thesis, and second as part of an international research project funded by the EU (Amazonia21\textsuperscript{17}).

The lead institution for academic work on MF is the Institute of Advanced Amazonian Studies (NAEA) at the Federal University of Pará (UFPA) in Belém. Other institutions involved include the Federal University of Amazonas (UFAM) in Manaus and the UFF in Rio de Janeiro.

The NAEA further has co-operative agreements with the Universidad Autonoma Gabriel Rene Moreno, Centro de Investigacion y Manejo de Recursos Naturales (UAGRM-CIMAR Bolivia), the Universidad Central de Venezuela, Centro de Estudios Integrales del Ambiente (CENAMB Venezuela), the Universidad Nacional de Colombia, Instituto Amazonico de Investigaciones (IMANI Colombia). Co-operation also exists with the IFF-Social Ecology (Vienna, Austria), the Wuppertal Institute for Climate, Environment and Energy (Germany), the Vrije Universiteit Amsterdam, Institute for Environmental Studies (IVM, Netherlands), the Lews Castle College (United Kingdom), OEAR Regional Development Consultancy (Austria).

The first MFA study was carried out between October 1998 and July 1999 and covered the period 1975-1995. Data from the study were used to calculate economy-wide indicators (DMI, DMC, TMR), and to link environmental and economic information. They were subsequently revised as part of the Amazonia21 project, building on the Eurostat methodology, supplemented by reference material from the IFF in Vienna.

REFERENCES


COLOMBIA

OVERVIEW

In Colombia, most activities related to material flow analysis have been carried out at academic level as part of an international research project funded by the EU (Amazonia21\textsuperscript{17}).

Academic work is led by the Instituto CINARA at the Universidad del Valle (Sede Melendez). Other institutions involved include at the academic level, the Universidad Nacional de Colombia, Bogotá, the Instituto de Estudios Ambientales (IDEA), Bogotá, the Corporación Autónoma Regional de Risaralda (CARDER), Pereira, and at government level the Departamento Administrativo Nacional de Estadísticas (DANE), Bogotá and the Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM) of the Ministry of Environment.

\textsuperscript{17} Research project carried out by members of IFF-Vienna (Austria) in conjunction with researchers from Brazil, Venezuela, Colombia, and Bolivia. The project demonstrates the application of Material Flow Accounting (MFA) tools in the region of Amazonia.
Work has also been done as part of a masters and PhD thesis at the Autonomous University of Barcelona (UAB). The study covered the period 1970-2002 and MF indicators such as the Physical Trade Balance (PTB).

Data from material flow studies have been published by the IDEAM in its 2001 version of the Colombian state of the environment report "El Medio Ambiente en Colombia" (chapter "Flujo de materiales y de Energia en la economia colombiana").

MF work carried out is based on the Eurostat methodology, as well as on material from IFF-Social Ecology (Vienna, Austria) and the Austrian Ministry of Agriculture and Forestry, Environment and Water Management.

REFERENCES


OTHER LATIN AMERICAN COUNTRIES

OVERVIEW

In other Latin America countries, most activities related to material flow analysis have been carried out at academic level.

Amazonia 21, an international research project funded by the EU, was carried out by members of IFF-Vienna (Austria) in conjunction with researchers from Brazil, Venezuela, Colombia, and Bolivia. The project demonstrates the application of Material Flow Accounting (MFA) tools in the region of Amazonia, at national level (Bolivia, Brazil and Venezuela) and at local level (i.e. in three Amazonian communities from Bolivia, Brazil and Colombia).

Other academic works namely include: a study realised at Facultad Latino Americana de Ciencias Sociales (FLACSO) on direct material flows in Ecuador (1983-2003); a study on Columbian trade (1970-2002) realised at Universidad del Valle; and an input-output analysis of Chile realised at the Autonomous University of Barcelona (UAB). A SERI project also placed a special emphasis on the assessment of MF flows related to international trade of the Chilean economy (1973-2000). In addition, a comparative EW-MFA of Peru, Ecuador, Chile and Mexico (1980-2000) was carried out as part of PhD thesis at UAB.

REFERENCES


AFRICA

OVERVIEW

Some work including EW-MFA in Africa and regional comparisons were recently done by the IFF-Vienna. MF information on resource extraction (1980-2002) in African countries is also available on the Mosus MFA database produced by the Sustainable Europe Research Institute (SERI).

Works on copper stock and flows in Africa are issued from the Stock and Flows (STAF) project at Yale University (for more information on this project see the United States’ sheet).

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