Parallel Session B: MFA and the Provision of Policy Relevant Information

Environmental Pressure Information System (EPIS) Implementation for Austria

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1. Background

The Environmental Pressure Information System (EPIS) is a project funded by the European Commission, DG XI and EUROSTAT and is intended to provide the basis for the calculation of a set of comprehensive pressures and out of it pressure indicators. It is planned primarily as a data holding structure with the specific purpose to provide all statistical information needed to calculate indicators for a sectoral breakdown.

This paper presents one project from the second round of the EPIS project, where the statistical database shall now be implemented for the next four countries Finland, Spain, Sweden and Austria. Naturally this work bases on the reports and the conclusions of the pilot EPIS countries (Germany, France, the Netherlands and Italy) (Thomas 1997).

1.1 EPIS - A Database for the Calculation of Environmental Pressure on European Level

Main pressures of the production sector are related to the induced material flows, the consumption of raw material, energy carriers and water (and air) as Inputs as well as air and water emissions, waste and the products as Outputs. Besides environmental pressure caused by the use of area, by noise emissions etc. cannot be described by material flow data.

To cover a wide range of environmental pressure a stepwise approach will be carried out:

- Selection of the significant processes (environmentally and economically),
- Collection of input and output coefficients for the selected processes, and
- Calculation of pressures by means of economic activity and input/output coefficients.

The results of the actual project should contribute to the development of an environmental database of Eurostat (ENVSTAT) and the Member States.

1.2 Main Elements of a Typical EPIS Data Set

For the efficient use of the available personal and data resources it is recommended to focus on the main processes and material flows. Despite a broad coverage of the relevant environmental pressures is aimed at.

Table 1: Scheme of an EPIS data Set

INPUT					PROCESS	OUTPUT				Difference
Energy carrier	Calcul. figures	Materials & op. subst.	Air	Water	PROCESS	Product	Waste water	Waste	Air emissions	Difference

In the first row Table 1 shows the topics of an EPIS data set and differentiates these topics in the second row. Generally the structure of an EPIS data sheet consists of four parts: the Input and Output part, the process and difference part. In the input and the output part the material flow coefficients are recorded. These coefficients which are always related to the production of the main product play the crucial part in the EPIS approach. On behalf of the coefficients and the production mass which is recorded in the process part the annual flows (environmental pressures) can be estimated. The quality of the estimation depends on the correctness of the coefficients. An initial quality check done by comparing the sum of inputs with the sum of outputs for one process is proposed - this is only realistic for products and raw materials.

2. Selection of Processes and Data

To describe the environmental pressure caused by the production sector in Austria in a representative way a couple of important processes were selected to cover the main impacts. Criteria for the importance are high environmental relevance and high economic activity.

- Environmental RELEVANCE: In general all processes which are relevant on the national level are candidates for the registration in EPIS. Relevant means that at least one type of pressure resulting from all processes of the same type is quantitatively remarkable.
- ECONOMIC ACTIVITY: processes need to be of distinct importance in the public economy concerning the material throughput (raw material or production mass).

2.1 Environmental Criteria

Air emission relevance

Within the Corinair inventory processes with relevant air emission coefficients are documented. High emissions mainly result from high factors and high production mass so that some processes important on an international level don't have to be dealt with for Austria. The processes selected should have high Corinair emission factors and economic importance.

Water emission relevance

The Austrian waste water emission regulation covers main branches of industry with high environmental impact on water, these processes will be added.

Material relevance

As result of the "Austrian material flow accounting" (Hüttler/Payer/Schandl 1997) () processes with high raw material demand can be identified. High raw material consumption results either in high production masses, or high amounts of waste (in special cases high air emissions e.g. energy conversion).

2.2 Quality Criteria for the Data Sets

- COMPLETENESS: The data sets should allow summing up of nearly 100% of the input and of the output side for each process and, in consequence, the comparison of both sides for data checks. If a considerable quantity either on the input or on the output side is not recorded a data check is impossible.
- STABILITY OF THE MATERIAL FLOW COEFFICIENTS: The selected processes should have relatively stable material flow (also emission) coefficients. Unfortunately this is unrealistic for many processes due to fast technological development
- LOGICAL STRUCTURE: The flows recorded on the input and output side should either be environmentally meaningful - e. g. energy consumption or air emissions - or necessary for the understanding of the process and a prerequisite for correct balancing.

2.3 Processes Selected

A list of the selected processes can be found in the annex (table 1). Aim of the selection was a broad coverage of the whole sector at an adequate level of disaggregation, so that processes with high technological specialisation and high environmental impact are discussed in detail whereas the other processes are only dealt with roughly.

3. Methodology

A complete data set for an EPIS process consists of following data: production mass, raw material and energy consumption, air emissions, water emissions and waste. Depending on the availability and necessity data will be collected on different aggregation levels. The collection and processing of the environmental relevant data will be done at the most detailed level as possible. For assembling the data together to a process data set an appropriate aggregation level depending on the situation in the single pressure classes will be searched. This level shall then also be the basis for comparisons among countries, so that the availability of data in other countries should be included in the decision about the aggregates.

3.1 Production Mass

In the European Union the production mass is recorded following the international Prodcom nomenclature, generally in physical units and should be useable for EPIS demands. The system of Austrian Economic statistics was changed to this new structure when Austria joined the European Union 1995 and unfortunately until now there is no PRODCOM data available at ÖSTAT.

For this report a first approach was tried in transferring production data (1994) available for "Fachverbände" (industrial associations) to NACE-categories (2 to 4-digit depending on the processes). By means of the Austrian version of NACE (ÖSTAT 1994) the NACE Class (4-digit) relevant for the production of each single product was identified. Generally this assignment was quite clear and easy. The sum of the products classified as products of one NACE-class (4-digit) was used approximatively as production mass of this NACE class. Up from 1998 published PRODCOM data for 1996 are expected for Austria as well.

Although the statistics of the industrial production in Austria is of very good quality some production data is not available in mass units. A lot of products listed in "Industrie- und Gewerbestatistik" (ÖSTAT 1995a) have to be converted, the conversion is carried out by the multiplication of the production values with coefficients derived from artificial prices taken from the export part of foreign trade statistics (ÖSTAT 1995b). In case of the availability of other physical data (e.g. m3) mass units are derived by the use of physical coefficients (e.g. density). Units like pieces or meters are still posing a problem, here we need to use estimations.

3.2 Raw Material Consumption

Data survey on raw material consumption exists only in a few countries of the European Union. There are some discussions on a future annual survey of raw material consumption in Austria, which of course will provide best information, in the meantime we have to improvise, no general methodology can be recommended.

In the former structure of statistical surveys in Austria an annual collection of data on raw material consumption was carried out. In analogy to the products also a lot of raw materials need to be converted into mass units, where artificial prices from the import part of foreign trade statistics are used. The applicability of this data is discussed in (Angst 1996), Input/Output coefficients are reported for several economic activities at the level of "Fachverband" for the year 1991.

According to the results in the previous chapter the share out of one Fachverband to different NACE classes measured in tons (!), in some cases can be used for the estimation of the share out for the raw material masses. This conversion method can e.g. be applied if one "Fachverband" corresponds with one NACE class or in cases of a high aggregated consideration of the processes (some NACE classes are handled with together and correspond at least with one Fachverband).

The most actual data published in "Industriestatistik 1994, 2, Teil" will be used, if possible as discussed above. For some processes material flow data is available in literature. The selection of data will be discussed for each process seperately.

3.3 Energy Consumption

Energy consumption is surveyed within the monthly "Konjunkturstatistik". In analogy to production amounts there is no data available following NACE structure. The use of "Fachverband" data is limited to very homogenous units and high aggregated „processes“, in other cases a proportional division of "Fachverband" data to NACE classes might cause wrong results. Such an allocation of "Fachverband" data to Nace classes is tried within the NAMEA project with help of data on use-energy distribution.

3.4 Air Emissions

A conversion of Corinair data to NACE categories is tried within the NAMEA project in cooperation of ÖSTAT (Austrian Central Statistical Office) and UBA (Federal Environmental Agency). The results of the "Emission Inventory of Austrian Industry" (Windsperger/Turi 1997) which was based mainly on source data will be included. For the processes covered by the Corinair inventory the results of the NAMEA project will be used. This data will be supplemented with coefficients reported in international literature.

3.5 Water Emissions

There is no similar approach to the water field published like Corinair for air emissions. In a first approach emission limits from the austrian "waste water emission regulation" will be used if available. Generally the processes covered are those with the most environmental impact. Believing in the legal compliance of Austrian industry, the use of emission limits can help with a broad estimation of the actual load.

As the emission limits are generally given in concentrations (e.g. mg/l) and not as coefficients (mg/t product) or load (t/y), the volume of waste water is needed for calculation. In case of process specific data are available in international literature the consumption of process water can be used for the estimation.

3.6 Waste

The collection of data on waste on European level is often structured along waste categories but not along processes relevant for the "waste production". Moreover the definition and classification of "waste" is quite inhomogenous within the European Union.

The only available periodic waste data collection is the "Austrian waste data catalogue". It contains waste data split in waste categories. Municipal and similar industrial wastes are given together, so no identification of the single sources is possible. Hazardous waste is recorded in a lot of categories, some of them are indicating the origin so that the producing industrial branch can be identified. Unfortunately we have only very few examples for that. As some processes are reported in international literature, waste data from literature can be used additionally.

Theoretically the waste amounts could be derived form the difference between raw materials and products. In practise a lot of non reported in- and outputs affect the difference and prevent this possibility. Besides qualitative aspects could hardly be handled.

4. Conclusion

This EPIS-follow-up project shall provide a usefull data base for Austria. After the disaggregation of the production sector at an appropriate level, the processes concerned will be linked to economic sectors as a basis for the joint use of material flow and emission data.

A critical review of the processes, process definition and aggregation level given in the "EPIS-list" (which is still under development) by the criteria of completeness and practicability for Austria will be followed by a check of actual data availability in NACE-classification (Austria started data collection in NACE-categories 1995!).

As result a table (excel - spreadsheet) with the available and calculated environmental relevant data for the processes at the defined aggregation level and a documentation of the data sources will be produced. The results will be presented in absolute values (e.g. t/yr) or coefficients related to production mass (e.g. kg/ t P). The structure of this excel spreadsheet will be compatible with the envstat data base at EUROSTAT.

For the estimation of raw material demand coefficients derived from the Austrian „Industrie- and Gewerbestatistik“ structured along "Fachverband"-structure, will be used. Besides production data from national statistics air emission data from the Corinair survey and the Austrian NAMEA project can be drawn. As the availability of process data on water emissions and waste for Austria is poor, the water emissions will be estimated by using emission limits of the Austrian Water Emission Regulation. For estimating the waste amounts the Austrian Waste Data Collection will be used, supplemented by some sectoral inventories and by material balances of processes.

For comparison and for further use of the data, quality indicators will be needed. Such quality checks will be tried during the ongoing work and hopefully will lead to a check list, also applicable for the other projects.

Literature

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Thomas, J. (1997): The Environmental Pressure Information System (EPIS) and its Connection with the Sectoral Infrastructure Projects (SIPs); Internal Working Document, Statistical Office of the European Communities F3 Environment; April 1997.

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Table 1: List of selected processes

NACE		aggr. level suggested	National rel.	Data
1		Agricultural area fertilized		?
	15111140	Cattle		?
	15111330	Pigs		?
	15121271	Hens		?
	15121113	Broilers		?
	15111800	Horses, mules		?
5	501	Fishing	not relevant	
	502	Aquaculture	not relevant	
10	101	Hard coal	not relevant	
	102	Brown coal		IR
11	ex 111	Mineral oil extraction		IR
12		Mining of Uranium and Thorium ores	not relevant	
13	131	Mining of iron ores		?
	132	Mining of non-iron ores	not relevant	
14	14	Other Mining & Quarrying		?
15	151	Meat & meat products		?
	152	Fish	not relevant	
	155	Dairy Products		?
	1562	Manufacture of starches		?
	1583	Mnf of sugar		?
	1593	Wine		?
	1596	Beer		?
17	173	Finishing of textiles		?
19	191	Tanning and dressing of leather		?
20	202	Manufacture of veneer sheets, plywood, laminboard, particle board, fibre board and other boards		?
21	2111	Manufacture of pulp		?
	2112	Manufacture of paper and paperboard		?
22		Publishing, Printing etc.		?
23	231	Coke oven products		IR
	232	Manuf of refined petroleum products		IR
	233	Processing of nuclear fuel	not relevant	
24	to be discussed	Chemicals & chemical products		?
26	261	Manuf of glass and glass products		FR
	264	Manufacture of bricks etc in baked clay		FR
	2651	Manufacture of cement		FR
	2652	Manufacture of lime		FR
	2653	Manufacture of plaster		?
27	271	Basic iron & steel, +products		IR, FR
	2742	Aluminium mnf		?
	2743	Lead,zink and tin mnf		?
	2744	Copper		?
	2751+2752	Casting of iron & steel		?, FR
	2753	Casting of light metals		?, FR
	2754	Casting of heavy metals		?, FR
37		Recycling		?
40	401	Electricity/Hydropower		?
	401	Electricty/thermal		?
	403	Steam & hot water supply		?
45		Construction		?

IR data collected for the interim report

FR data for the final report, already available

? data collection not finished, availability uncertain

Material Flow Indicators for the Japanese Basic Environment Plan

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1. Introduction

At the last ConAccount Workshop in Leiden, January 1997, the author reviewed the outline of history and on-going activities on Japanese environmental and natural resources accounting in physical terms, presented preliminary Japanese Material Flow Accounts (Fig. 1) according to the framework of a four countries' joint study with Germany, the Netherlands and the United States, as well as some case studies about the implications of international material flows by trade. "Resource Flows : Material Basis of Industrial Economies", the first result of the four countries study, was jointly published in April 1997 by the Wuppertal Institute, the World Resources Institute, the Dutch Ministry of Environment, and the National Institute for Environmental Studies. In parallel with such international research activities, the author has been involved in indicators development for the Japanese national environmental policy and has contributed to apply the MFA concept to indicators of "sound material cycle", which is one of the four policy goals of the Basic Environmental Plan of Japan. A first proposal of an indicators set was published in July 1997, which includes several indicators derived from the MFA. This paper will present the recent progress in Japanese indicators development for national environmental policy, focusing on those related to material and energy flows.

2. Japanese Basic Environmental Plan and Indicators Development

In 1993, the law named "Basic Environment Law" was enacted as a new basic law for environmental policy in Japan. In 1994, this "Basic Environmental Plan" was established by cabinet decision based on the Basic Environment Law (see Annex 1). The plan mandated the government to develop comprehensive indicators for implementing the Plan and for reviewing policy performance towards four long-term policy goals set by the Plan, namely "sound material cycle", "harmonious co-existence" with nature, "participation", and "international activities" (see Annex 2). An expert advisory committee was established in the Environment Agency to elaborate the concept and to show options of indicators, drawing upon related activities in international organizations such as OECD and UNCSD, as well as those in other countries. The author has been involved in this process as an expert to support the secretariat of the committee. After seven times of plenary meetings of the committee since November 1995 as well as many meetings of subsidiary working groups, the committee published "A draft set of comprehensive environmental indicators" in July 1997. The draft set was disseminated to the related Ministries within the national government, local governments, academic societies, industries, as well as NGOs to invite their comments on the draft set and to improve it to establish a final set of indicators.

Out of the four policy goals of the Plan, the first one, "sound material cycle" has direct relevance for the MFA. Up-to-date information about international research activities for the MFA, e.g. those in Wuppertal Institute, was introduced in the early stage of discussions at the advisory committee. Another influential information was derived from PSR (DSR) framework by the OECD and the UNCSD. Such information was successfully reflected to the draft set. This contributed to make indicators set for sound material cycle more concrete and practical than those for the other three policy goals.

Table 1: Summary of "Draft set of comprehensive environmental indicators" for the Basic Environment Plan of Japan

<table>
<tr><td colspan="6">A: Sound Material Cycle
(1) Indicators set for material and energy flows</td></tr>
<tr><td colspan="3">Indicators for "Material" Flows
*Direct Material Input (total)
• DMI disaggregated by sector
• DMI per capita
• DMI per GDP in constant price
• Domestic Hidden Flows(Ecological Rucksacks)
• Imported Hidden Flows(Ecological Rucksacks)
*Total waste generation
• Waste generation disaggregated by sector
• Waste generation per capita
• Waste generation per GDP in constant price
*Recycle ratio of waste generated
*Recycle ratio of specific materials
(steel, aluminum, paper, glass, plastics)</td><td colspan="3">Indicators for "Energy" Flows
*Total Primary Energy Requirement
*Total Final Energy Consumption
• TFEC disaggregated by sector
*TPER per GDP
*TFEC per GDP
*Ratio of renewable energy to TPER
• Energy efficiency by sector

*: core indicators
-: supplementary indicators</td></tr>
<tr><td colspan="6">(2) Indicators set for sound water cycle</td></tr>
<tr><td colspan="6">Natural water cycle indicator = function (runoff ratio by type of ground surface, measures to enhance infiltration)
Man-made water cycle indicator = function (reuse of industrial water, public water and rainfall)</td></tr>
<tr><td colspan="6">(3) DSR Indicators for environmental issues associated with material and energy flows</td></tr>
<tr><td colspan="6">DSR indicators by 15 environmental themes (See table 2)</td></tr>
<tr><td colspan="6">B: Harmonious Co-existence with Nature
(1) State of the nature</td></tr>
<tr><td colspan="2">Driving force indicators:
Land use conversion</td><td colspan="2">State indicators:
Continuity of ecosystem
Degree of human disturbance to vegetation
Indicative animal species
Diversity, endangered species</td><td colspan="2">Response Indicators:
Protected areas</td></tr>
<tr><td colspan="6">(2) Access to the nature</td></tr>
<tr><td colspan="3">Actual:
Indicators for recreational use of the nature</td><td colspan="3">Potential:
Indicators of:
- Space for recreational use
- Demand for recreational use
- Support for access to the nature</td></tr>
<tr><td colspan="6">C: Participation</td></tr>
<tr><td colspan="6">Indicators for actions by national government
Indicators for actions by local government
Indicators for actions by industry
Indicators for actions by citizens</td></tr>
<tr><td colspan="6">D: International activities</td></tr>
<tr><td colspan="6">(1) Indicators for international partnership for global environmental policy
(2) Indicators for support to developing countries (fund & personnel)</td></tr>
</table>

Remark:This table is a tentative, not-authorized translation of Japanese original one.

3. Outline of Indicators Set and Relevance for MFA

A summary of the draft set of indicators for the four policy goals is shown in Table 1 and Table 2. The set is not based on a single consistent framework, but incorporates multiple different frameworks. The set of indicators for sound material cycle are subdivided into three subsets. The first is a subset of indicators for material and energy flows, which directly deals with material flows. The second is a subset for sound water cycle, which is also relevant to the MFA in broader sense. The third is a subset of indicators using D-S-R framework for environmental issues associated with material and energy flows.

The first subset indicators for material and energy flows stands for the recognition that the prevailing socioeconomic activities and lifestyles marked by mass-production, mass-consumption, and mass-disposal are essential sources of the burdens on the environment (see Annex 3 for reference). This subset is further subdivided into indicators for material flows and those for energy flows. Indicators for material flows include those for inputs of resources, outputs of wastes as well as recycling of materials. Needless to say, indicators in this field are strongly influenced by recent progress in international research activities for MFA. For example, not only direct material input (DMI) but also the concept of hidden flows (ecological rucksacks) is included in indicators.

The second subset tries to deal with cycle of water flows from two different perspectives. One is focusing on infiltration of rain water into the ground, which is essential to maintain sound natural water cycle. Another is on recycling of freshwater for public and industrial use. The third subset is structured on DSR framework, taking 15 environmental themes. Some of the themes are consistent with international frameworks such as OECD' environmental performance indicators, whereas others are included from national context. Because of the time constraint, technical difficulties and data availability, there still exist many blank cells where concrete indicators are to be determined, and "Response" indicators were not included in the draft set. As many of the "Driving Force" indicators are concerned with emissions of specific substances, emission inventories of major pollutants are essential as a part of the MFA.

4. Pending Issues of the MFA for Indicators Development

The concept and practical application of the MFA contributed much to the process of preparation of the draft set of indicators. Data compilation through international joint studies with Germany, the Netherlands and the United States was timely, which enabled us to present actual figures of historical trends of some indicators. However, there still remain many issues to be solved.

The first essential problem is data availability. A practical step of the improvement will be started for the output side of material flows, namely data on wastes. Another difficulty arises from poor data availability for estimating imported ecological rucksacks. Japanese part of the international joint study mostly relied on the data provided by the Wuppertal Institute, but we may have to collect our own country-specific data reflecting origin of natural resources imported to Japan.

Many other detailed technical questions arise from indicators of recycling. For example, definition of "recycle ratio of specific materials" is not simple. Denominator could be domestic production, supply including import, consumption, or consumption plus abandoned stocks. Numerator could be recovered, input of secondary material to production, production of refined material from secondary input, including/excluding imported secondary materials and/or materials refined from recycled materials.

Disaggregation of the MFA by industrial sectors and by type of materials is another important subject, in order to link indicators and policy measures to improve industrial activities. If this disaggregation of MFA is made consistent with the Input-Output table, it will provide us with further opportunity of economic analysis.

5. Conclusion

The outline of the draft set of indicators for Japanese Basic Environmental Plan and its linkage with the MFA was presented. Without recent collaboration with international partners, the inclusion of "rucksack" concept into the draft set could not have been realized. It might be too early to conclude whether this is a "success story" or not, but the author would definitely conclude that recent progress in the international MFA work was very influential for our domestic work on indicators development.

Table 2: List of D-S-R indicators by 15 environmental themes

Environmental Theme	Driving Force Indicators	State Indicators
Global warming	GHG emissions aggregated by GWP Emissions of individual GHGs (CO_2,CH_4, N_2O, HFCs, PFCs, SF_6, CFCs, HCFCs) CO_2 emission per capita	Concentration of GHGs
Ozone layer depletion	ODS emissions aggregated by ODP	Total ozone amount above Japan
Acidification	SOx and NOx emissions	Deposition of SO_4 & NO_3
Photochemical oxidant	NOx and NMHC emissions	Achievement rate of EQS for Ox Percentage of stations above alarm level of Ox
Urban air pollution	NOx emissions in specific polluted areas	Achievement rate of EQS for NO_2 and SPM
Hazardous air pollution	T.B.D	Achievement rate of EQS for hazardous air pollutants
Nuisance (Noise, Vibration and odors)	Traffic volume of trunk roads Traffic volume of bullet trains Areas exposed to aircraft noise	Population above specific level of Noise or Achievement rate of EQS for Noise
Organic pollution of water	(Rivers) BOD emissions (Coastal areas & Lakes) COD emissions Nitrogen emissions Phosphorous emissions	(Rivers) Achievement rate of EQS for BOD (Coastal areas & Lakes) Achievement rate of EQS for COD,N,P
Safety of water	T.B.D	Achievement rate of EQS for toxic substances
Marine environment	T.B.D	T.B.D
Soil pollution	T.B.D	Agricultural areas requiring measures Urbanized areas requiring measures
Ground subsidence	Drawn groundwater	Areas where subsidence is recognized
Solid waste	Amount of municipal wastes Amount of industrial wastes	Cumulative total of areas reclaimed by disposal of wastes
Toxic waste	T.B.D	T.B.D
Total risk of toxic chemicals	T.B.D	T.B.D

GHG:Green House Gas GWP:Global Warming Potential ODS:Ozone Depleting Substances
ODP:Ozone Depleting Potential NMHC:Non-Methane Hydro Carbons EQS:Environmental Quality Standard
T.B.D:To be determined

Remarks: Response indicators for all themes will be selected later. This table is a tentative, not-authorized translation of Japanese original one.

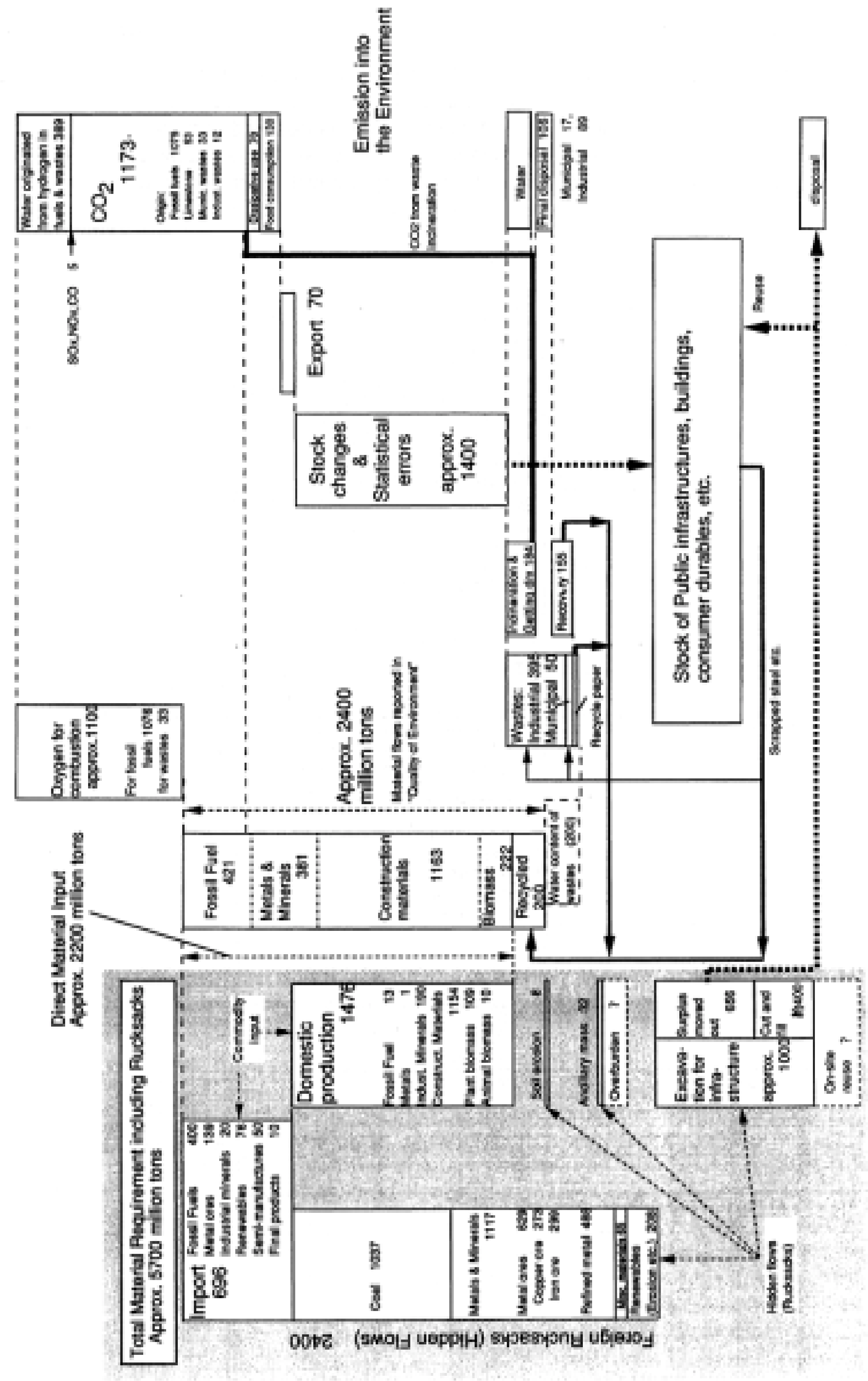

Figure 1: Extended Material Flow in Japan (1990) (Unit: million tons)

Annex 1: An Outline of the Basic Environment Plan

On December 16th 1994, the Japanese Government established the Basic Environment Plan. Following the provision of the Basic Environment Law (enacted in 1993), this Plan outlines the overall and long-term policies of the government in environmental Conservation.

In January 1994, the Prime Minister requested the Central Environment Council to draft and submit a Report on the Plan. The council deliberated intensively on the subject and submitted a Report to the Prime Minister on 9 December. The Cabinet made its decision on the Plan in accordance with this final Report.

Responding to today's environmental problems, the Basic Environment Plan sets the long-term objectives of Environmental Policy, foreseeing through the middle of the 21st century. It also provides a systematic base for government policies in the period towards the early part of the 21st century, and sets out expectations for the activities which should be carried out by local governments, corporations, citizens and private organizations in the same period, in order to achieve those objectives. In particular, it specifies the role of each party and the appropriate instruments for policy implementation.

Now, the Environment Agency and other ministries concerned are implementing specific measures for environmental conservation in accordance with the Plan. Local governments, corporations, citizens and other parties in society are also expected to voluntarily and actively engage themselves in activities which protect the environment in accordance with the Plan.

The Plan sets the following four long-term objectives:

Sound Material Cycle:

in order to minimize the burdens on the environment generated at various stages of socioeconomic activities, to establish a socioeconomic system fostering environmentally sound cycling of substances through reexamining the current system dominated by mass production, mass consumption and mass disposal.

Harmonious Coexistence:

in order to ensure that the blessings of the environment will be enjoyed by both present and future generations, to maintain or restore the sound ecosystems and to ensure harmonious coexistence between nature and human beings.

Participation:

to build a society where all parties, including the central and local governments, corporations, citizens and private organizations, participate voluntarily and actively in environmental conservation activities, cooperate, and share burden fairly.

International Activities:

to promote international environmental efforts in cooperation with the other countries that share our common global environment.

Annex 2: Statement for Developing Indicators in the Basic Environment Plan

Part II. Principles of Environmental Policy

Section 3. Developing Comprehensive Indicators

The Basic Environment Plan sets long-term objectives for building a sustainable society, to attain a socioeconomic system of "sound material cycle", "harmonious coexistence" with nature, "participation" and "international activities", and provides future direction of measures to achieve these objectives. It is desirable to specify comprehensive indicator/indicators which show the progress of these objectives and the relation between the objectives and measures, in order to ensure effective implementation of the measures. Whereas studies and research have been carried out extensively both domestically and abroad, at this point, there are not enough results to incorporate the indicators in this Plan. Therefore, the Government will immediately begin working on the development of comprehensive indicators and utilize the results in implementing and reviewing the Plan.

Annex 3: Forword of the Basic Environment Plan

Humankind can enjoy healthy and cultured living, depending on the abundant blessings of the Earth's environment. Recently, however, it is becoming a common recognition that the global environment, the very basis of humankind's continued existence, is at risk of being damaged. There is a growing need to reconsider our values placing too much emphasis on the pursuit of material wealth, and the prevailing socioeconomic activities and lifestyles marked by mass-production, mass-consumption, and mass-disposal. It is the present generation's obligation to pass on to the future generations a well conserved and healthy environment, both globally and domestically. This obligation applies to all humankind. As for Japan, we must change our society to a sustainable one that generates little burden on the environment, while at the same time promoting international activities for conserving the global environment.

Based on these considerations, the Government hereby establishes the Basic Environment Plan, in accordance with the provision of Article 15 of the Basic Environmental Law (Law No. 91, 1993).

The Basic Environment Plan prescribes four long-term objectives. These are 1) to build a socioeconomic system fostering environmentally sound material cycle, where environmental load by human activities are minimized, 2) to secure a harmonious coexistence between humankind and diverse wildlife and natural environment, 3) to enhance participation of all the members of society in environmental conservation activities, and 4) to enhance their international activities. The Plan also provides for the outline of policies, roles of each sector of society, and the direction for implementing various policy instruments, toward the achievement of these objectives.1

Remark: Conversion of fonts to bold and italic is applied by the author to emphasize relevance to the MFA.

Experiences with SFAs on the National Level for Hazardous Substances in Denmark

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Introduction

In Denmark SFAs on the national level for hazardous substances have been carried out for almost two decades. The commissioning institution has in all cases been the Danish EPA illustrating that the Danish EPA takes SFAs to be an important tool in the task of protecting the environment.

The author of this paper has been assisting the Danish EPA within the field of SFA and other issues almost since the introduction of SFA in Denmark. However, the information stated in this paper should be taken as the personal experience of the author and does not necessarily in all detail reflect the opinion of the Danish EPA.

1. SFAs Undertaken in Denmark

In Denmark SFAs on the national level for hazardous substances have been carried out for almost two decades, starting with an analysis for mercury back in 1978. Since then SFA has been performed for several heavy metals as well as organic compounds (reference is made to table 1). It should be noted, that the list in table 1 covers full scale SFAs only, and does not include investigations limited to certain applications (like e.g. batteries).

For each of the substances mentioned in table 1, the year covered by the SFA has been stated. For some substances more than one SFA has been undertaken for the purpose of updating. For the heavy metals mercury, lead and cadmium as well as for CFCs (which has updated annually since 1989), the updating exercise has actually been a way of monitoring development trends regarding consumption and disposal of the substance in question. For nickel and phthalates the updating process has also served the purpose of improving the standard of the SFA to an acceptable level for policy considerations, as the first SFA in both cases has been of overview standard only.

In all cases the objective of the SFA has been to provide the Danish EPA with the relevant knowledge regarding fields of application and sources for emission to environment for the substance in question. However, the precise scope and focus of the SFA have differed slightly depending on the actual issue of concern initiating the SFA. The role and outcome of SFAs may likely best be illustrated by the cadmium story.

Table 1: Substances covered by SFAs on the national level in Denmark (figures indicate the year covered by the SFA).

Heavy Metals	Organic Substances	Other substances
Arsenic - 81	AMPA (Sources for) - 97	Chlorine and compounds - 87
Cadmium - 80, 90	Chloroparaffins - 91	Aluminium - 94
Chromium - 81	Chlorophenols - 85	
Cobalt - 81	CFCs - 86, 87, 88 etc.	
Copper - 94	Formaldehyde - 83	
Lead - 85, 94	Halons -86	
Nickel - 81, 94	PCBs - 81	
Mercury - 78, 83, 93	PCTs - 81	
Tin - 94	Phthalates - 82,94	

2. The Cadmium Story from the Danish Point of View

Considerations regarding risk minimisation actions with respect to cadmium in Denmark were initiated in the end of the 70ties. The background for these considerations was the knowledge on cadmiums toxicity especially on humans combined with investigations on:

- The content of cadmium in the kidneys of Danes.
- The content of cadmium in food, drinking water and air leading to intake of cadmium by Danes.
- The balance for cadmium in the top soil of Danish farmland and behaviour of cadmium in Danish agricultural soils leading to the conclusions that the levels of cadmium were raising and would lead to increasing levels of cadmium in Danish food thereby increasing the risk for Danes to be exposed to kidney damages.
- Important sources for supply of cadmium to agricultural included atmospheric deposition as well as commercial fertiliser and sewage sludge.

This was taken to be an unsustainable development. The Danish EPA responded to this development by preparing the Danish Cadmium Review from 1980. As an important part of the fundament for this review the first Danish SFA on cadmium was initiated in 1979. The objective of the SFA was to find out:

- What were the sources for release of cadmium to the environment in Denmark (and especially for contamination of agricultural soils) and what could be done to eliminate/minimise these sources.

The SFA showed i.a., that sewage sludge was contaminated by industrial emissions (plating etc. and cadmium in zinc) while important sources for emissions to air were waste incineration (likely due to the use of cadmium in plastics and batteries) and coal power plants.

Table 2: The story of Cadmium

Year	Action	Background/Consequence
1980	First Danish SFA on Cadmium	Background for Cadmium review, identifying sources for pollution
1980	The Danish Cadmium Review	Arguing the need for effort on cadmium due to - increasing levels in topsoil leading to - increasing levels in human food and - increased risk for kidney damages.
1983	Survey of net import of Cadmium with plastics and plated metal	Knowledge on cadmium import with finished goods inadequate
1983	The Danish Cadmium Ban	Ban on pigments and stabilisers in plastics and plated surfaces - with exemptions
1984	Survey on battery use/disposal	Batteries a growing field
1985-1990	Misc. studies on batteries, sources for contamination of iron/steel scrap, fertiliser etc.	
1993	Second Danish SFA on Cadmium	Monitoring purposes
1994	Assessment of potential for collection of nickel-cadmium batteries	Voluntary collection inadequate/The collection set-up was reorganised.

However, the SFA was not perfect, as we at that time had little knowledge on the content of cadmium in finished goods like automobiles imported to Denmark. Furthermore, many figures were established on expert judgements, since monitoring data from e.g. incineration plants was not adequate. A new investigation focusing on imported finished goods was conducted in 1983. An important outcome of this investigation was that it was clear that the emission to air from burning of car wrecks has been seriously underestimated in the SFA from 1980.

The results from the SFAs were used to establish the Danish cadmium ban from 1983, which focused on pigment, stabilisers, solders and plating purposes while the batteries were left out. Parallel to this initiatives were taken to reduce emissions from incineration plants, sewage treatment plants, coal power plants etc., partly by introducing thresholds for cadmium emissions. The monitoring activities related to observing these thresholds indirectly also served the purpose of providing more reliable monitoring data concerning emission of cadmium.

A new Danish SFA on cadmium was carried out for 1990. This SFA served the purpose of monitoring the development regarding consumption and emissions within the different fields, and emphasised the need for an effort directed towards nickel-cadmium batteries.

Along the road studies have also been carried on special issues like consumption and collection of NiCd-batteries, sources for cadmium in iron and steel scrap for secondary steel production, content of cadmium in commercial fertilisers etc.

One should conclude, that the efforts on risk minimisation for cadmium carried out in Denmark, have to a significant extent been based on the results of SFAs.

One may also conclude, that the Danish strategy of relying on substitution as an important risk minimisation action for cadmium as well as for other substances (that will say to fight the problem at the source) originates from the use of SFAs, as an important strength of SFA is to link the emissions monitored with the applications causing the emissions.

3. The Current Position of SFA Related to Hazardous Substances

In Denmark today, SFAs are taken to be a standard tool in the process of identifying important sources for release of hazardous substances to the environment and the applications of the substances responsible for these releases (reference is made to table 1).

Table 3: Standard checklist/procedure within the Danish EPA for substances, which are considered hazardous to humans or the environment to the extent that use restrictions are considered appropriate.

Health assessment Environmental assessment EU risk assessment Monitoring
Substance Flow Analysis Goal definition Strategy considerations Substitution assessment Recycling assessment Economic assessment

It is a typical procedure to initiate a SFA for all substances which have been identified as actual or potential hazardous to humans or the environment. The results of the SFA will subsequently form the fundament for considerations by the Danish EPA related to the need and instruments for risk minimisation for the substance in question. More precisely the results of the SFA are used for:

- Initiating risk minimisation actions like bans or negotiations, cleaner technology development etc., if deemed necessary.
- Adjusting previous actions
- Reporting to international organisations like Eurostat, OECD, The Marine Conventions etc.
- Identifying needs for further work

The SFA initiated will normally be a detailed SFA according to the standard format (reference is made to the paradigm by Hansen & Boisen, 1993). This SFA may then be improved along the road by further studies on special issues to compensate for data gabs identified by the first detailed study. A new detailed full scale SFA will typically first be conducted after approximately 10 years.

An upcoming field for SFA seems to be the issue of conservation of non-renewable mineral resources like metals. In this context, the objective of the SFA is to identify uses of the metal causing the metal to be lost to landfills and other kinds of depots or to be dissipated into the environment, thereby leading to resource depletion for the metal in question. An ongoing SFA for aluminium scheduled for finalization in 1997 is based on this objective.

References:

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Using SFA Indicators to Support Environmental Policy

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Abstract

In order to improve the link from SFA studies to environmental policy, a translation is made from the SFA overview of flows and stocks into a limited set of indicators. This set is designed to evaluate a region's substance regime with regard to environmental quality and sustainable development, including problem shifting in time and space.

1 Introduction

MFA studies are meant to support environmental decision-making. Although in practice such studies have been carried out succesfully (a.m.o. Adriaanse et al., 1997; Tukker et al., 1995), the issue of connecting with the world of policy has arisen frequently (for example Brunner et al., 1997). Researchers may find the results of MFA studies clearly speaking for themselves, but for policy makers this often is not so self-evident. Apparently, researchers would be doing a good thing in paying closer attention to the translation of MFA results into policy relevant terms. Three issues may be important: the basic principles, the terminology and the complexity.

Regarding the basic principles, it is often a matter of debate whether it is useful at all to investigate societal metabolism. Policy makers often feel that knowing emissions and extractions is sufficient. Many publications have been devoted to the importance of studying societal metabolism since the publication of the concept of industrial metabolism by Ayres (1989) and the political awareness of the role of societal flows and stocks as the instigators of the environmental ones is slowly growing in the working out of policy principles such as „integrated chain management“ (Anonymus, 1991).

Terminology is always a tricky subject in a relatively new area of investigation. Even among scientists there is no established terminology when it comes to MFA, which often leads to confusion. On top of that, there is the lack of coherence between the scientific and the policy vocabulary. We can see for example that the concept of „sustainability“ has found its way into MFA research, but this has become such a very broad concept that it covers virtually everything and therefore has been stripped of any real meaning. In order to close the gap between policy and science, a more specific connection must be made: MFA scientists may point out more clearly for which policy areas their results are relevant, and what they mean in terms of policy means and ends.

The third hurdle is the complexity of the MFA results. These results are, in most cases, comprised in an overview of flows and/or stocks connected with a considered region. Often, such an overview is too complicated to distill precisely the relevant information. A further interpretation of the overview data is then required, also to avoid the risk for rather coincidental outcomes. In the MFA framework as presented by Udo de Haes et al. (1997), this is the third element after „goal and systems definition“ and „inventory and modelling“. This third step has received relatively little attention so far in a methodological sense. This paper is dedicated to this third element of the MFA framework. A choice has been made to elaborate this by defining a set of indicators. A further specification is made by zooming in on a specific brand of MFA, the substance flow analysis or SFA. SFA describes the metabolism of a region with regard to one specific substance or a limited group of substances (Van der Voet, 1996). By doing so we hope to achieve different aims at the same time: reducing complexity and a better connection with the language of policy.

2 Indicators for Substance Chain Management

Indicators play an important role in the interpretation of environmental data for environmental policy. The general idea is, to aggregate the rather large and ungainly lot of data into a limited set of measures or yardsticks relevant for environmental policy. Policy uses indicators widely, to measure developments in the state of the environment, the human influence on the environment and the effectiveness of chosen policy measures. The concept "indicator" is not strictly defined, and in practice many widely different things may serve as indicators. Several attempts have been made towards a classification of indicators (a.o. Opschoor & Reijnders, 1991; OECD, 1993a and 1993b).

The indicators in this paper are meant to provide information with regard to a substance's flows and stocks, relevant for an integrated substance chain management policy. Substance chain indicators must be constructed in such a way that they provide

- information on the state of the stocks and flows of a substance on a given moment in time,
- early warning for future problems,
- information on the changes in flows and stocks over time,
- information on the influence of policy measures,
- information on various types of problem-shifting.

These demands imply the need for the definition of reference values indicating a desired or „sustainable“ level for the indicators.

In addition, requirements can be defined for the indicators as a group. The indicators as a group must be usable for the evaluation of an SFA overview for a specific year, but also for the evaluation of changes in flows and stocks over the years and modifications therein, for example as induced by environmental policy. Therefore, a comparison between different regimes must also be possible.Three types of indicators are distinguished:

- indicators concerning the SFA environmental subsystem,
- indicators concerning the SFA economic subsystem
- indicators concerning the relation of the SFA economic sy,stem to its surroundings.

Indicators from the first group are related to the core issue of most substance-oriented policies: environmental quality and the human influence on that. Indicators of the second group refer to the society’s metabolism, and therefore can be regarded as indicators for (sustainable) development. In view of the environment, they may fulfill an early warning function. Indicators of the third group say something about the broader impacts of the society’s metabolism and therefore may have a function in detecting problem shifting.

The set of indicators presented below is developed for application in a case study concerning a group of metals (Udo de Haes et al., 1992). Most of the indicators can be used also for other substances. However, it is likely that other substances with different hazardous qualities and different environmental and economic properties would require additional indicators, while some of the indicators presented in this paper may be irrelevant. A more elaborate presentation of the indicators, including the details on how to calculate them from the overview of flows and stocks, can be found in a background report (Van der Voet et al., 1997).

3 Indicators Concerning the Environmental Subsystem

When we look at the environment, the key issue is not the environmental flows themselves, but the resulting environmental damage in the sense of health damage, ecosystem deterioration or loss of functions. Such information, however, is hard to come by and moreover highly site specific. Therefore such information can hardly ever be used as a basis for a (supra)national environmental policy. Indicators must be defined that are a measure for this damage, without pretending to predict whether this damage will actually occur. Five measures for the risks linked to the environmental flows are proposed here:

1. concentration, i.e. the average concentration of the substance in the environmental compartments within the region
2. daily intake, i.e. the average daily intake of the substance by humans in the region
3. environmental accumulation, i.e. the increase in environmental stocks within the region
4. total emissions, i.e. the total amount of emissions from the economic subsystem into the environment of the region
5. depletion rate, i.e. the contribution of a region to the depletion of global resources

Indicator 1: Concentration

The indicator is the concentration of a substance in an environmental compartment. It is a translation of the substance's stock. In addition, a concentration rise is a translation of the stock's increase or accumulation (see Indicator 3.)

The significance of the indicator: The calculation of the concentration of a substance in an environmental compartment is a measure for the (potential) loss of environmental quality. It may indicate a human health risk through specific exposure routes, it may indicate a loss of economic functions, for example agriculture or recreation, and it may also indicate a deterioration of the ecosystem. For the several functions or values, separate reference values may be defined.

Method of calculation: The concentration of a substance in an environmental compartment can be obtained through dividing the stock (in kg) by the volume of the compartment (m3) (or its weight in kg, if so required). In addition to the overview of flows and stocks, information is required regarding the „amount of environmental compartment“ in the region under study. Generally, this information is available.

Interpretation for environmental policy: The introduction of reference values in the shape of concentration limits opens opportunities to evaluate flows in an absolute sense.

Indicator 2: Daily Intake

The indicator is the average daily intake of the substance through all different routes by humans.

The significance of the indicator: The daily intake may serve as an indicator for human health risk.

Method of calculation: With the help of methods of risk assessment, environmental concentrations can be translated into an average daily intake of the substance for humans (for example, Paustenbach 1989). Such methods calculate the intake as a result of the various exposure routes, so that all environmental compartments are included. For other species, the intake may be calculated likewise.

Interpretation for environmental policy: The human daily intake can be compared with ADI or TDI values, such as defined by the WHO. These values refer to a maximum acceptable intake level, any transgression of these indicates a health risk.

Indicator 3: Environmental Accumulation

The environmental accumulation is the increase of a certain environmental stock over the year. It can be defined either on an aggregate (total environmental accumulation) or on a detailed (accumulation in one specific stock or compartment) level.

The significance of the indicator: Environmental "sinks", i.e. stocks wherein substances tend to accumulate, are soil, sediment and groundwater. Accumulation seldom indicates a specific environmental problem. What it does indicate however is the fact that under the current substance management regime the environment is off balance. If this regime is continued over the years, the environmental concentration will rise, eventually transgressing quality standards. Moreover, the outflow out of such a growing stock often tend to increase and lead to problems in other environmental compartments. In the end, the situation will stabilize at a new (possibly undesirable) steady state.

Method of calculation: This indicator can be extracted directly from the overview of flows and stocks.

Interpretation for environmental policy: In general, it can be stated that the larger the accumulation is, the more severe is the state of imbalance, and the higher the risk for future problems. As a reference value, a zero accumulation may be adopted following from the „less is better" adagium. In some cases, a negative accumulation (stock decrease) might even be desirable. However, we may find ourselves entangled in the problem of chemical time bombs (Stigliani & Salomons, 1993): a stock decrease might imply the increasing availability of substances formerly locked safely away in stocks. A further possibility is establishing the time involved in transgressing concentration limits, as done for example by Moolenaar et al. (1997).

Indicator 4: Total Emissions

The indicator is the total amount of emissions within the region. Below, several indicators are defined regarding the relative amount of leakages or cycle losses, which is relevant information from the point of view of formulating policy measures. However, it is the absolute amount that is indicative for the environmental problems created by a certain chain management. For this, the total amount of emissions may serve as an indicator.

Significance of the indicator: It depends on what exactly counts as an emission, what the significance of this indicator is. In a strict sense, any transgression of the economy/environment border is an emission. However, generally a narrower definition is adopted: the emissions are the emissions into the atmosphere and surface water as well as the diffusive emissions into soils. When we consider environmental quality, the latter definition may be preferred, since this excludes the landfill sites where generally large amounts are stored but relatively little disperses from the location.

Method of calculation: The emissions can be extracted directly from the overview of flows and stocks.

Interpretation for environmental policy: For the interpretation, emission targets may be used if available. It may be necessary to break down the total emissions into categories, emissions to the various environmental compartments. Often, emission targets do not exist. In that case, "less is better" could still be used to compare alternatives. It could be argued that using emission targets is merely a less sophisticated way to approach the environmental problems involved. On the other hand do emission targets often include policy objectives apart from environmental concern, for example political considerations.

Indicator 5: Depletion Rate

The indicator is the amount of extraction of a substance from the environment on behalf of a region, compared to the global extraction of that substance.

The significance of the indicator: The indicator specifies the contribution of the region to the global resource depletion. It provides information with respect to the depletion of global resources as a result of the substance management within the region.

Method of calculation: The requirement of virgin material is determined by the region's consumption, i.e. the use flow (see indicator 7) and by the amount of recycling (see indicator 8).

On that side, the information is already available from the other indicators. This information must be combined with information on the global extraction of the resource to put it in perspective. Even more perspective can be obtained by calculating this indicator on a per capita basis and then compare with the global per capita average.

Interpretation for environmental policy: For this indicator, it is very difficult to define a reference value. Once again the "less is better" criterium can be used. For the per capita variant, the global average may be used as a reference value.

4 Indicators Concerning the Economic Subsystem

Indicators for flows and stocks in the economic subsystem bear no direct relation to environmental problems linked with the substances. This does not mean that such indicators are meaningless. In the first place, they provide information regarding the "tidiness" of the societal chain management: regardless of environmental problems, it still seems a good idea to keep the house in order by avoiding leakages. In the second place, these indicators offer information directly relevant for actual policy measures. For example, it may become apparent whether a certain targeted emission reduction can be obtained by technical emission reduction, or that a source-oriented policy is required. In the second place, here too the concept of risk may be introduced: certain societal ways of using a substance may serve as an early warning of future environmental problems. Five indicators for chain management and early warning are proposed:

6. efficiency, i.e. the efficiency of the economic processes within the region,
7. use level, i.e. the amount of the substance being used by the region's population,
8. recycling rate, i.e. the fraction of waste being recycled within the region,
9. economic accumulation, i.e. the increase in economic stocks during the year within the region,
10. economic dissipation, i.e. the fraction of the substance's applications being trace applications.

Indicator 6: Efficiency

The indicator is the efficiency of the economic processes within the region. The efficiency in fact is the reverse of the leakages: it is the fraction of the inflow that ends up in another economic process.

The significance of the indicator: The efficiency of a comprehensive group of processes indicates the appropriateness of the processes and techniques involved. The factors determining the "appropriateness" vary with the life cycle stage. For production processes, it indicates the possibilities for closing the cycle by technical means: the adoption of more efficient production techniques, or a better application of the current ones. For the use of products, the efficiency is related to two aspects: the life span of the applications, and the percentage of the household waste that is collected to be treated further in one way or another. For waste management, the efficiency is determined by the amount of the substance recovered as secondary materials, and by the amount degraded or immobilized.

Method of calculation: Process efficiency is mostly calculated as OUT/IN, whereby the losses to the environment are extracted from OUT. A choice is made to establish efficiency for four subsystems, representing life cycle stages: (1) extraction and refinery, (2) production and manufacturing, (3) use and consumption, and (4) waste management. For each subsystem an efficiency percentage can be calculated. (For a justification of this choice and for a further elaboration on the method of calculation and the interpretation, see Van der Voet et al., 1997).

Interpretation for environmental policy: As a general rule, it can be stated that - quite apart from economic considerations - the higher the efficiency of the processes is, the better it is. An efficiency of 100% therefore, although this can never be realized, may serve as a target. Furthermore, the life-cycle stage which is responsible for the largest losses can be identified. In various case studies, it has been shown that the largest leakages no longer occur in the production stage, but in the use or waste management stage, depending on the substance and the application. Also the efficiencies of different sectors within the economy or of the chains of different substances can be compared.

Indicator 7: Level of Use

The indicator is the amount of the substance being used within the region.

The significance of the indicator: The total amount of use within a region determines, directly or indirectly, all other economic flows. It is therefore a measure of the total economic throughput.

Method of calculation: For the use level, a choice must be made for either the total use flow, which is the flow of newly produced goods into the use/consumption stage, or the total use stock. Both can be derived from the overview of flows and stocks directly. It depends on the substance, or rather on the application, which one makes the most sense.

Interpretation for environmental policy: No reference value can be defined regarding the level of use. For this indicator, again the "less is better" adagium can be adopted, since in accordance with ideas of dematerialization less use generally means less input, and therefore less emissions. For certain substances, a volume policy can be imagined, which goes hand in hand with the definition of a volume reduction target. Such a target could be applied to the use level, either stock or flow.

Indicator 8: Recycling Rate

The recycling rate within the region refers to the relative amount of generated waste which is, in one way or another, transferred into a useful input for an economic process.

The significance of the indicator: The recycling rate - or its counterpart the discarding rate - of waste materials, indicates the leakage percentage of the economic cycle as a whole, and, vice versa, the potential for a further "closing of cycles" policy.

Method of calculation: The indicator can be calculated in two ways, (1) determine the fraction of secondary materials of the total input into the economic subsystem, and (2) determine the fraction of waste materials that is being transferred into resources once again.

Interpretation for environmental policy: The recycling rate may serve as a measure of the efficiency of the economic system as a whole. As a target level, a 100% recycling can be said to completely prevent both depletion and pollution problems. In practice, this will never be attained. As a relative indicator for the economic cycle, the lower leakage percentage may be interpreted as the better one.

Indicator 9: Economic Accumulation

The indicator is the increase in the economic stocks in the region over the year. Accumulation of substances in the economy takes place in materials, products and in waste materials.

The significance of the indicator: In itself, accumulation in materials and products does not constitute a problem: there is no leakage to the environment. What accumulation does mean, though, is a lack of equilibrium in the economic system. Growing stocks indicate a risk of leakages and/or waste volumes growing in magnitude in the future. Accumulation in the economy thus functions as a warning signal of future environmental problems.

Method of calculation: This indicator can be extracted directly from the overview of flows and stocks. Specific stocks may be chosen, but the indicator can also be defined on an aggregate level. This latter option may be preferred since it is difficult to indicate „key“ stocks within the economic system.

Interpretation for environmental policy: In contrast to environmental accumulation, economic accumulation cannot be translated directly into policy relevant terms with the help of environmental quality standards. It can be stated that in otherwise comparable systems a higher accumulation means a less stable (i.e. more different from the steady state) situation, and therefore a larger risk for increased emissions in the future. The indicative value is thus relative, not absolute.

Indicator 10: Economic Dissipation

The indicator is the fraction of the applications in the user phase that can be called trace applications.

The significance of the indicator: Dissipative applications are becoming increasingly important as pollution sources. Perhaps the most dissipative applications of metals is the application as a trace element in products. A large part of these applications in fact are non-intentional: the occurrence as product pollutants in, for example, phosphate fertilizer or fossil fuels. Product policies, such as for example the Cadmium Directive (Council of the European Communities, 1991), are directed against such trace applications, the intentional as well as the non-intentional ones. As a result of waste management policies however, the trace applications increase: waste materials such as manure, fly ash, compost and sewage sludge, wherein metals tend to accumulate, are increasingly re-used. Thus, discarded metals start a second economic life-cycle in dissipative applications, as a contaminant of such secondary materials.

Method of calculation: This indicator requires information that does not show out of the overview of flows and stocks, but is used in the process of quantifying the overview: the breaking down of either the use flow or the use stock into the separate products, and the composition of those products. Based on that information, a classification can be made into trace and bulk applications.

Interpretation for environmental policy: Since trace applications are much more difficult to recycle, and emissions from trace applications are much more difficult to prevent compared with bulk applications, it could be concluded that the lower the share of trace applications is the better it is for the prevention of chain leakages.

5 Indicators Concerning the Relation of the Economic Subsystem to its Surroundings

Two indicators are proposed within this category:

11. pollution footprint, i.e. the total amount of emissions anywhere on the world, on behalf of consumption and use within the region
12. disturbance rate, i.e. the magnitude of the economic cycle compared to the natural cycle.

Indicator 11. Pollution Footprint and Pollution Export

The pollution export indicator is the problem-shifting away from the region in relation to developments within the region. Several studies show the process of the "cleaning up" of regions during the last decades (Ayres & Rod, 1986; Stigliani & Anderberg, 1992). One of the possible side effects of the cleaning up of a region is the shifting of environmental problems to other areas. Especially in regions with rather strict environmental regulations, the more polluting stages of the life cycle may be relocated outside the area. On the global level this may even lead to more pollution.

The significance of the indicator: The pollution export is a measure of the occurrence of the benefits and the problems of the use of a substance within the same area, or, in other words, the (implicit) problem-shifting practices of a region.

Method of calculation: In specifying a region's substance life cycle there are two possible points of departure, each resulting in a different idea of what does and what does not belong to the cycle. The two approaches can be characterized as "regional" and "functional" (see also Van der Voet, 1996). It is precisely the difference between those definitions that is relevant for the pollution export indicator.

Taking the regional approach, a picture emerges of the pollution occurring within the region, identical to indicator 4 (total emissions). The functional approach starts from consumption in a given region and specifies all processes connected with that, whether they take place within the region or outside. This approach has a certain resemblance to what Wackernagel & Rees (1996) call the ecological footprint. They refer to the fact that an urban area requires much more space than its actual territory in order to provide for its inhabitants. In the case of the pollution footprint, "space" must be taken metaphorically.

Interpretation for environmental policy: A reference value of a 0% pollution export, indicating that the region's pollution footprint matches the pollution occurring within the region, would seem a logical choice. However, the problem-exporting or problem-importing practices of a region cannot be judged absolutely. Another possibility is the "less-is-better" approach: the smaller a region's footprint, the better it is.

Indicator 12: Disturbance Rate

The indicator is the amount of emissions entering the environment compared to the natural generation of the substance within the region.

The significance of the indicator: The indicator is defined to provide information with regard to the risk that the natural substance cycle will be disturbed by human activity, in the shape of the economic substance cycle. Two ways of approaching this risk are presented below.

Method of calculation: The extent to which the natural cycle is disturbed by human interference can, as a first possibility, be expressed by relating the natural "virgin" generation of the substance (by formation or erosion) to the anthropogenic adding (by emission). A second way to provide an indication for the risk of disturbance of the natural cycle is to compare the respective magnitudes of the economic and the ecological inputs. Relatively large economic inputs then constitute a large risk for disturbance of the natural cycle by unwanted or unavoidable losses. A third possibility is making the comparison on the basis of anthropogenic versus natural use.

Interpretation for environmental policy

For all calculation procedures of the indicator, a higher figure indicates a larger disruption risk. A standard, based on an 'allowable' emission, is missing. A zero disruption risk may serve once more as an ideal, never to be reached reference value. For metals, this indicator has little relevancy.

6 Discussion and Conclusions

Below, the twelve indicators described above are summarized. In the table is indicated

- whether or not the indicator can be linked to a "sustainable" level, i.e. a reference value,
- what information the indicator provides on the state of the flows and stocks and the changes therein,
- what information the indicator provides regarding the shifting of problems,
- whether or not the indicator provides a direction for the management of the substance.

	reference value1	information on state & changes	early warning & problem shifting
ENVIRONMENT			
1. concentration	standards	pollution	
2. daily intake	standards	pollution	
3. environmental accumulation	0	pollution	time
4. total emissions	targets; 0	pollution	
5. depletion rate	0	depletion	location
ECONOMY			
6. efficiency	100%	management	
7. use level	-	management	
8. recycling rate	100%	management	
9. economic accumulation	0	management	time
10. economic dissipation	0	management	time
RELATION TO OUTSIDE			
11. pollution export	0	pollution	location
12. disruption rate	0	disruption	time

1Reference values such as "0" or "100%" indicate that no targets have been set by environmental policy, and that common sense or common agreement indicates that "less is better", or in some cases "more is better". Sometimes, it will not be possible to set standards or targets while in other cases it would be possible but has not been done so far.

Referring back to the introduction, the first question to be discussed concerns the completeness of the set. Are all relevant aspects covered? The set is designed to cover both sustainable development and environmental quality. Indicators 1-5 refer to the environment and our interference with it, and therefore can be stated to address environmental quality. Indicators 6-12 are about the societal metabolism and therefore are related to (sustainable) development. For both environmental and economic indicators a "sustainable level" may be introduced as a reference value. From the above, it has become apparent that such reference values are at present very rare: they exist only for the concentrations in the environmental compartments and for the daily intake by humans. For some of the other indiators, more specifically for the environmental ones, it would seem to be possible to define substance-specific reference values, provided the necessary knowledge regarding fate and degradation is available. For others this is not possible, at least not without a number of specific additional assumptions. For example, a „sustainable“ use level cannot be defined without having information regarding production processes and waste management practices, in other words, is very much dependent on technology assumptions. Such indicators therefore only can be used in a relative sense, to compare different regimes („less is better“), or they can be used to derive management options (efficiency boost vs volume policy, for example).

Such a set may provide adequate information regarding a region's substance management from a "physical economy" point of view. It should be kept in mind that this point of view does not address all relevant issues. Problem-shifting, for example, to other substances will not become apparent, nor will changes in energy use or environmental damage by physical interventions. Moreover, even within the scope of a region's substance management there is the problem of weighing contradictory indicators: in such cases, which indicators must prevail? Ultimately, this may well be a subjective matter which cannot be answered scientifically. Do we prefer a cleaner environment now at the possible expense of the future? Is it acceptable to locate our waste processing in other countries? This problem of weighing the relative merits of the indicators would be pressing indeed if our aim was the integration of the set of indicators into one value or index for the integrated environmental risks of an economic substance chain regime. At present, no attempt is being made to do so. In the future, however, this will almost certainly return as an important issue.

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MARKAL: Lessons From MFA Experiences in the Netherlands

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Introduction

The MARKAL (MARKet ALlocation) model has been succesfully applied for two decades for the analysis of environmental impacts of national and regional energy systems. The model has been used in many countries for ex-ante studies concerning acid rain and greenhouse gas emission abatement. Both environmental problems are closely related to energy flows.

MARKAL is an operational linear programming model that is based on a cost minimisation algorithm. The method is similar to approaches that have been suggested for MFA by other authors (Foxon/Leach 1997, Heijungs 1997). The model is used for the identification of promising emission mitigation options and the development of scenarios for energy policies and energy related environmental policies for the next decades. In recent years, MARKAL has been extended for materials modeling (Gielen 1995). The model can now be used for integrated energy and materials system modeling. The interaction of environmental impacts of energy and material flows concerns mainly bulk materials. These bulk material flows in the economy have been included in the analysis. The model has been used for analysis of CO2 emission mitigation strategies in the Netherlands and is currently applied for assessment of greenhouse gas emission mitigation strategies for Western Europe.

The difference between energy and materials is a matter of definition. For example wood and plastics are materials that can also be used for energy purposes. Energy carriers represent themselves a bulk substance flow: total apparent energy consumption in Western Europe amounts to approximately 1000 Mt per year. Table 1 compares the energy flows to the flows of some other bulk materials and substances. The term materials will further on be used for all matter flows in the economy.

Table 1: Consumption of selected bulk materials/substances in Western Europe, 1990's (van Duin 1997)

	[Mt per year]
Water	310,000
Sand/gravel	>1,000
Fossil energy carriers	1,000
Cereals	200
Wood	200
Cement	175
Iron and Steel	150
Bricks	66
Plastics	30
Glass	25
Synthetic fertilizer	20
Aluminium	7
Synthetic fibers	4

The relevance of these material flows depends to a large extent on the environmental problem that is considered. Emissions of toxic substances, SO2 and NOx emissions, and greenhouse gas emissions, are to some extent linked to these materials. These emissions can significantly differ per weight unit of material. As a consequence, different materials must be considered for different environmental problems. The link of materials consumption to sustainability is unclear, as a proper operationalisation of the sustainability concept is still lacking. Only very general statements can be made, like a ceteris paribus reduction in consumption of one or more materials will increase sustainability. Comparisons of the apparent materials consumption of individual countries is complicated by international trade, materials substitution, and the different industrial structure. The complex relation between the economic structure and environmental degradation is vividly illustrated by the current debate concerning the existence of the so-called environmental Kuznets curve (see e.g. (Enkins 1997). A bottom-up approach may provide more insight than the top-down approach.

Comparison of Markal and Conventional MFA

The following discussion will focus on experiences with dynamic ex-ante material flow accounting with MARKAL for development of materials related greenhouse gas emission reduction strategies. The method differs to some extent from 'common' MFA (Material Flow Accounting). The time boundaries differ, because the interactions between current materials consumption and future waste release are considered (see Figure 1). MFA focuses on one time period, MARKAL considers a set of time periods and the relations between the flows in these different time periods. Moreover, MARKAL is primarily used for the identification of improvement options, whereas MFA for bulk materials on the national level is nowadays primarily used as accounting tool. The characteristics of MARKAL and conventional MFA are compared in Table 2. MFA has been succesfully applied for materials that are themselves environmental problems, like heavy metals and chlorinated compounds. Its use for accounting of environmental problems that are related to bulk flows has recently received a lot of attention.

The following discussion focuses on the use of materials strategies in a situation where the environmental problem is related to the material (greenhouse gas emissions are linked to the energy use for materials production etc.).

Table 2: Comparison of MARKAL and conventional MFA characteristics

Characteristic	MARKAL	Conventional MFA
Time boundary	Set of linked time periods	1 time period
Spatial boundary	Economy of 1 region	Region/sector (may include both economy and environment)
Goal	Selection of improvement options	Accounting; analysis
Method	Systems optimisation	Materials balance
Focus	Improvements	Flow analysis
Scope	Materials, energy, and products	Materials
Environmental impacts	Greenhouse gases (can be extended)	Optional
Costs	Considered	Not considered
Time horizon of analysis	>10 years	<10 years

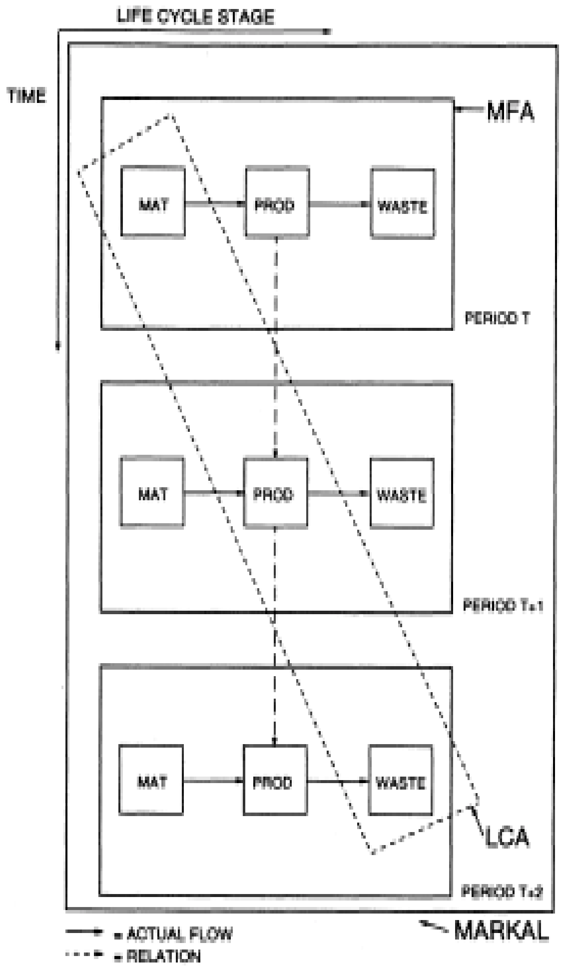

Figure 1: Schematic characterisation of the time system boundaries for MFA, LCA, and MARKAL

Barriers for Succesful Use of MFA Results

Experiences with MARKAL in the Netherlands showed:

- Many potential clients exist for environmental policy strategies, but each client requires a different MFA perspective. Policies for sustainability, for climate change, for energy supply problems, are scarce or even non-existent (this is a specific MFA problem). Succesful applications exist in areas where policies exist: energy efficiency, industrial policy, RD&D policies.
- MFA represents not sufficient information for policy making in cases where the material is not the environmental problem itself. MFA can be extended to dynamic integrated models, but at the expense of complex models and huge data requirements.
- Policy makers do not accept counterintuitive answers from complex models that cannot be checked by the policy makers themselves. In such cases, simple tools and simple (but often misleading) answers are difficult to beat (not a specific MFA problem).
- Materials represent generally only a part of the source of environmental problems. For example one third of the CO2 emissions can be allocated to the materials cycle, the remaining two thirds can be allocated to (passenger) transportation and heating of (residential and commercial) buildings.

- Long term planning has a long tradition in the energy sector, but not in materials producing industries. Planning over a period of decades is limited to the largest materials producing industries.
- Bulk materials are generally produced by a few large companies. Their political influence is a main obstacle for MFA based policy making (a specific MFA problem).
- Materials policies will often affect the industrial structure. However structural policy is a non-issue in the current drive for free markets (a specific MFA problem). Generic instruments like substance deposits or taxes may pose effective instruments to overcome these problems. Recent suggestions to include materials efficiency in the existing industrial energy efficiency convenants may also pose a viable option (van Dril).
- Bulk materials production is an essential part of the Dutch economy. This policy area is governed by the Ministry of Economic Affairs and by the Ministry of Agriculture, which are both primarily interested in a buoyant economy (a specific MFA problem). A recent Dutch white paper on the environment and the economy contains few new policies, but opts for the technology strategy as solution for environmental problems (Dutch Parliament 1997). Regarding greenhouse gas emission reduction, the potential of materials policies for greenhouse gas emission reduction has been acknowledged by the allocation of significant R&D funds to several projects where natural organic materials and feedstocks will be developed (Dutch Government 1997). However actual policy goals for emission reduction beyond 2000 are still missing (Ministry of Housing, Spatial Planning and the Environment 1997). In conclusion, unpopular policy choices are still avoided.
- Policy making is complicated by free international trade (a specific MFA/LCA problem). The costs and benefits of environmental impacts are not evenly distributed. International compensation mechanisms could be developed, but may result in major administrative problems.

Solutions to Increase the Policy Relevance

In order to overcome the problems of international trade, the system boundaries of MARKAL have been extended from the Netherlands to Western Europe (Dielen/Kram 1997). Western Europe represents a much more closed materials system. As a consequence, the conclusions may have a higher policy relevance. While the studies have up till now primarily focused on greenhouse gas emissions, an upcoming study will focus on the optimisation of land use options for biomass production for enhanced sustainability. Addition of more environmental impacts is considered of paramount importance for succesful use of MARKAL for MFA purposes.

Recommendations

The following recommendations are made in order to increase the political relevance of MFA for bulk materials:

- MFA methods must be internationally scientifically validated and accepted, so policy makers cannot easily dismiss results and conclusions.
- MFA for bulk materials and for environmentally harmful substances should be dealt with separately, because they require different analysis tools.
- Current MFA for bulk materials should be further developed to dynamic multi-material life-cycle models focusing on more environmental problems. Relevant costs and employment effects of materials policies should be included in the analysis.
- Further development of MFA should increasingly focus on the ex-ante analysis of improvement options instead of its use as an ex-post/status quo accounting tool. For example

Design-For-Environment methods (DFE) can be linked to current MFA practice. MFA should not be promoted for target setting, which is primarily a political process.

- MFA cannot succesfully be applied for policy making in situations where the political willingness or the political power to set targets is missing. The potential use of MFA results should be critically reviewed before a study commences. Negative messages will often be blamed on the messenger.
- MFA should not be communicated as a “new” policy tool that solves all policy making problems with LCA etc.. Its benefits and limitations should be better communicated.

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