

Resource Efficiency and the Environment: Identifying Key Resource Flows
Summary of Workshop Sessions

Opening and introduction

Decoupling economic growth and environmental degradation is a growing concern for both scientists and policy makers. It is increasingly understood that an efficient use of resources is of vital importance for achieving sustainable consumption and production patterns, with benefits for the economy and the environment. 'Doing more with less', or satisfying growing consumer needs using fewer resources and causing less pollution is the underlying driving force for initiatives such as the G8's '3R' programme, the UN's Marrakech Process, China's Circular Economy, the EC's Thematic Strategy on the Sustainable Use of Natural Resources and the OECD's programme on Material Flows and Resource Productivity.

Scientists and policy makers therefore need to come to a common ground on concepts, definitions, methodologies, tools, strategies and indicators. Key questions to date include whether or not an identification and prioritization of key resource flows is needed, and if so, on what level (global, regional, national) and applying which criteria or methodology for prioritization.

The United Nations Environment Programme (UNEP) is currently setting up an International Resource Panel which will address the challenge of decoupling environmental impact from economic growth from this resource perspective. The panel will provide scientific/technical assessment on the environmental impacts of the use of resources (renewable and non-renewable) over the full life cycle. There has been an on-going consultation process with scientists and governments with regard to the scope of the Panel.

Objective of the Workshop

The workshop is part of this consultation process and will provide an opportunity for experts to exchange their views, serving to build an understanding of the needs and ways of identifying key resource flows and their efficiency through different approaches. The workshop will compile basic knowledge on the environmental impacts and socio-economic relevance of resource flows and will draw a first approximation of key resource flow issues that will be assessed in detail by the panel.

This workshop is organized a day before the OECD-Japan Seminar on "Material Flows and Resource Productivity From Knowledge to Practical Policies" in order to allow for a broad international information exchange between ongoing initiatives. The participants will include international experts in the field of resource efficiency, material flows and environmental impact analysis from a life cycle perspective.

The **specific objectives** of the workshop are to:

- Exchange information on the needs and ways of identifying key resource flows based on existing scientific methodologies of resource efficiency and environmental impacts of resource use from a life cycle perspective;
- Compile basic knowledge on the environmental impacts and the socio-economic relevance of resource flows based on existing scientific assessments for material flows and products; and
- Explore linkages between the work of UNEP, the work of the OECD on Material Flow Analysis, and other international initiatives. The outcomes will be used to refine the scope of a joint OECD-UNEP conference on this issue, and to contribute to the work programme of the Resource Panel.

The workshop is organised by UNEP with the support of the EC and in collaboration with OECD and the Ministry of Environment of Japan.

Session 1: Needs and ways of identifying resource flows

The needs and methods for identifying resource flows will be presented from the perspectives of EU, OECD, BRIC and developing countries. This session will discuss how the International Resource Panel could identify and assess key resource flows while taking stock of existing approaches.

Need for assessing key resource flows: The EU Thematic Strategy on the sustainable use of natural resources, Werner Bosmans, DG Environment, European Commission

Resources are the backbone of the economy, but increasing global demand puts ever greater pressure on the environment. Improving resource efficiency and making our production and consumption patterns more sustainable will deliver environmental benefits while improving our economic performance and competitiveness.

An important change in European resource use took place. Raw materials extraction in Europe has decreased while imports have increased, resulting in a shift of environmental pressures related to resource extraction to other regions. The fact that emerging economies are using natural resources at an accelerating pace, stresses further the need to take account of the global dimension of resources use as well as the importance of life-cycle thinking.

As a policy response, the *EU Thematic Strategy for the sustainable use of natural resources*¹, launched on 21 December 2005, aims at reducing environmental impacts associated with resource use in a growing economy – called decoupling.

New initiatives are called for at all levels of governance – at national, EU and international level – if this strategy is to be successfully implemented. At EU level, this will entail amongst others a concerted effort to build the knowledge base, to develop indicators that can be used in policy discussions and to launch sectoral initiatives with economic operators. Given the strong global dimension of resource use and the need for policymakers to take this into account, the European Commission and the United Nations Environment Programme (UNEP) are establishing an international panel on the sustainable use of natural resources.

Concrete policy actions should focus on resource uses with the most significant impacts. In order to assess which impacts and resource uses to tackle with priority and to define any targets, there is a need to bring together and to analyse state-of-the-art scientific information from all regions of the world regarding the use of natural resources, and to translate these findings into actions that can be readily taken by decision makers at various levels of government and other organizations.

Options for assessing resource flows: The OECD work on material flows and resource-productivity, Yuichi Moriguchi, National Institute for Environmental Studies, Japan

The OECD has a significant history in its work on natural resource accounting and environmental accounting since late 1980's. More recently, special focus was put on material flow analysis/accounting (MFA) and derived indicators. In 2003, the Heads of G8 adopted an Action Plan on Science and Technology for Sustainable Development, which referred to the role of OECD in continuing work on material flow and resources productivity indicators. The OECD Council recommendation on material flows (MF) and resource productivity (RP) was adopted in April 2004, and the work program on MF/RP has supported the implementation of the council recommendation. A series of OECD guidance documents on measuring MF and RP is being compiled to support policy work and analysis.

¹ See: http://ec.europa.eu/environment/natres/pdf/com_natres_en.pdf

These guidance documents provide guidance on methodological and measurement issues related to MFA, including the development of material flow accounts and related indicators. The main objectives are to provide an accessible guide to the measurement of MF and RP for those involved in constructing and interpreting such measures, to identify desirable characteristics of MF and RP measures in accordance with policy questions and uses, and to improve international harmonization and convergence so that results are coherent and can be used in international work.

The first volume of the guidance documents includes an overall framework for MFA, a description of different kinds of measurement tools, a discussion of those issues and policy areas to which MFA and MF indicators can best contribute, and guidance on how to interpret MF indicators. It is illustrated with practical examples from countries' experience. It is accompanied with technical and methodological documents on material flow accounting and its implementation, being developed in co-operation with other Intergovernmental Organizations such as UNSD and EUROSTAT.

Some diversity in the implementation of MFA is expected, for example in terms of the coverage of natural resources or materials, because economic and environmental importance of a given resource or material flow is varying among different countries.

This is a first step towards better information and knowledge, but the experience so far shows that more needs to be done to better cover indirect and unused flows, trade flows in general including origin and destination, specific flows of materials (e.g. recyclables) and to better characterise the environmental impacts of material resource use.

Material flow analysis and development of circular economy in China,
Guomei Zhou, State Environmental Protection Administration (SEPA), China

China's rapid economic growth has generated social welfare as well as resource and environmental challenges. In order to address the challenges, China has adopted a new industrialized road and development model, which is different with traditional one. Recently China has launched the 11th Five Year Plan. In this plan, strong emphasis was placed on a harmonious society. Resource efficiency, global responsibility and reduced environmental destruction are three cornerstones of the new plan. Therefore, quantitative objectives of energy efficiency and pollutant reduction have been set up. In order to fulfil this goal, circular economy is identified as a key national strategy for establishing a resource efficient and environmental friendly society. 3R (reduce-reuse-recycle) has been adopted, as the main principle for developing circular economy in China, and Material Flow Analysis is an important tool for achieving circular economy in China.

According to the draft Law on Circular Economy (CE), China is trying to set up an indicator system for CE's development and performance review, which is based on the MFA approach. However, due to constraints of data availability, MFA's application in China is still very limited. But China is realizing the importance of MFA for improving and promoting 3R and CE. Some case studies of MFA at national level, at local level and for some industrial sectors, such as fossil fuels, as well as for some important substances, such as coppers, have also been conducted. In order to transfer knowledge of MFA to practices and decision-makings in China, some policy recommendations have been proposed.

Materials and the Environment: An Approach to Identifying Key Resource Flows,
Derry Allen, US Environmental Protection Agency, USA

In 2002, the U.S. Environmental Protection Agency (EPA) and a group of state government environmental officials published a report, "Beyond RCRA: Waste and Materials Management in 2020," sometimes known as the "RCRA Vision" Report. That report envisioned a transformation from waste management to materials management. It viewed waste as a missed opportunity and looked towards sustainable materials use.

Five years later we still have a long way to go to realize this vision.

Thus a task force from EPA and several state government agencies has begun an effort in 2007 to identify key actions by governments and others that are necessary to realize a materials management society. The task force has started by looking for materials and products that deserve priority attention. The task force expects to complete its work in 2008. This presentation introduces the effort.

Session 2: Basic knowledge on the environmental impacts and the socio-economic relevance of resource flows

Environmental impacts of significant natural resource trade flows into the EU, *Nick Dale, Metroeconomica (with AEA Energy and Environment), UK*

A European Commission project titled "Strengthening the Knowledge Base for the Implementation of the Thematic Strategy on Sustainable Use of Natural Resources" is currently being undertaken by AEA Energy and Environment, and Metroeconomica UK. The thematic strategy stresses the need to take account of the global dimension of EU resource use and associated environmental impacts. To address the global dimension of implementing the strategy, this project aims to improve the information basis for decision makers in policy and other areas by assessing the current state of knowledge on the environmental impacts of highly significant natural resource trade flows to the EU.

The selection of 40 highly significant natural resource trade flows to the EU will be outlined, the type of information which is being compiled on their environmental impacts, and the presentation of this information in a way that can be readily applied by decision makers. Some example trade flows will be used to illustrate the approach. Conclusions will be given on project findings to date.

Global material recycling: The case of metals

Kohmei Halada, National Institute for Materials Science, Japan

A forecasting is introduced regarding the consumption up to 2050 of following metals: Fe, Al, Cu, Mn, Zn, Cr, Pb, Ni, Si, Sn, rare earths, Mo, Li, Sb, W, Ag, Co, In, Au, Ga, Pt and Pd. The forecasts are based on the linear decoupling model of the relation between per capita metal consumption and per capita GDP. The models of each metal are applied to the economic development model of BRICs and G6 countries. According these forecasts, the overall consumption of metals in 2050 will be five times greater than the current levels, and demand for metals, such as Au, Ag, Cu, Ni, Sn, Zn, Pb, and Sb, is expected to be several times greater than the amount of their respective reserves. Demand for iron and platinum, which is considered to be optimistic about the resource exhaustion, will also exceed the current reserves. And, further analysis by using TMR (total material requirement) accounting indicate that we need to reduce materials' consumption less than eighth part of current consumption at the resource-end in order to avoid materials risk. In other words, "factor 8" is required to us. Urgent measures are needed to find alternatives from common resources and to shift into sound materials circulation society.

Recycling is one of the effective solutions to avoid the risk. However, the promotion of recycling of metals in the world is sluggish. The recycling rate of Pb, Al, and Zn are broadly flat since 1990s, around 45, 25 and 20 percent respectively. The recycling rate of Cu and Sn are decreasing from 40% to 25% and from 18% to 8% respectively.

The effect of recycling on the impact of resource use can be estimated about the reduction of total materials requirement (TMR), which is equivalent of ecological rucksack, and CO₂ reduction of mining and extractive metallurgical processes. The calculation in Japanese recycling case suggests us that we need material flow analysis. Material flow patterns in recycling have four different types, life-cycle loop type, midway loop type, spiral loop type and one way type. The deference between life-cycle loop type and midway loop type is whether

main scrap flow comes from post-consumer-scrap (EOL scrap) or pre-consumer-scrap (process scrap). A higher value of recycling rate in midway loop type does not mean the reduction of impact of resource consumption. We need more detailed material flow research in each country and all over the world in order to pursue effective recycling to reduce the resource risk.

Hazardous recyclables: Challenges and opportunities for environmentally sound resource management in India, Vijaya Lakshmi, Development Alternatives, India

Globally, and especially in developing economies such as India, the demand for certain minerals is growing very fast, due to increasing levels of consumption, infrastructure needs and general growth in the industrial economy. In India coal contributes to 80% of mining activity and the remaining 20% is in various metals and other raw materials such as gold, copper, iron, lead, bauxite, zinc and uranium. Since India is not endowed with all the requisite mineral resources there has been rise in imports to meet the current demand. A case in point is the rising demand supply gap in Lead metal due to sharp rise in automobile production, photovoltaics, substantial increase in use of lead batteries for inverters, UPS and Computers.

While consumerism is driving the economic growth, it is also contributing to mounting waste problems. Growing demand for electronic goods such as mobile phones, computers etc., and improper management of resulting waste materials such as Lead, Mercury, Cadmium, Chromium etc., can pose potential environmental and occupational health hazards when present even in minute quantities.

However, due to their intrinsic property of maximum recoverability at the end of the product life cycles, metal scraps containing gold, lead, copper etc., are offering new business opportunities for recyclers from both domestic and overseas markets. In spite of Basel Ban to regulate trans-boundary movement of hazardous material, strong domestic regulations in the case of Battery handling, Hazardous waste management etc., a flourishing, and unorganised, informal recycling sector came into existence not just in India but in the South Asia due to weak enforcement of regulations. The challenge is how to reorient the informal sector as part of the supply chain, without compromising the health, environmental, productivity and livelihood concerns associated with waste recycling.

It is imperative that the 3R principles, design for environment principles needs to be adopted both in letter and spirit along the life cycle of the product, by involving all concerned stakeholders for achieving efficiencies in material flows. The key challenges lies in designing appropriate policy support, technological innovations, and infrastructure support that is essential for balancing the economic development, livelihood generation and environmental requirements.

One of the criteria for identifying key resource flows at the global level is to understand their life-cycle-wide environmental and socio-economic impacts. This needs to be based on a systems perspective that will help minimise shifting of impacts from one region to another and between competing functions.

Environmental weighting of resource use, Ester van der Voet, CML Leiden University, Netherlands

The extraction and use of resources is the cause of environmental problems. Policies on resource use aim to decouple economic development of societies from environmental pressure. This is double decoupling: economic growth from resource use, and resource use from environmental pressure. It opens up different strategies for such a decoupling: on the one hand, dematerialization in its various shapes (decoupling growth from resource use: 3R), on the other hand, reducing environmental impacts (decoupling resource use from environmental impacts: substitution, shifting resource base).

The development of overall indicators to measure decoupling is a first step in an overall resource strategy. The demands to such indicators are very high: they should be aggregate, yet

contain the relevant information at a detailed level, so as to avoid problem shifting as a result of a too narrow view in defining policy measures. This implies necessarily an indicator that is composed out of a lot of information, and therefore subject to complexity and the need for aggregation. Although problems related to data and methodology are many, it is possible to arrive at such indicators: life-cycle based and including a broad scope of environmental impacts. One of those indicators is the Environmentally-weighted Material Consumption (EMC). Application already shows some interesting phenomena. For example, that a major shift towards a biomass-based economy will not lead to a decoupling. Such indicators should be used with care, however, and be supplemented with other information. The challenge at hand is to define and develop a knowledge base for a sustainable resource use. Some elements are already present in the EU Resource Strategy.

The case of renewable resources, Stefan Bringezu, Wuppertal Institute, Germany

"Renewables" are usually deemed a pre-requisite for sustaining resource use. However, naturally renewable resources – i.e. biomass – are globally to a large extent overexploited, and the high aspirations to supply a significant share of cultivated biomass also for non-food purposes such as biofuels will face trade-offs in the form of negative environmental impacts (also with regard to climate) and increasing competition of with other types of land use. In the medium to long term, renewable energy will be more efficiently provided through technologies such as photovoltaics, solar thermal power plants and wind turbines which have a higher output and less environmental impact than biomass. Nevertheless, those technologies are mineral based (i.e. their production requires naturally non-renewables) and they differ with regard to resource efficiency, content of hazardous compounds, and the potential for recycling ("technical renewability").

Thus, a key question for sustainable use of "renewables" will be in how far they require non-renewable resources, and which material and energy supply systems are most appropriate to increase overall productivity while minimizing the life-cycle-wide environmental impacts in a socially acceptable manner.

Opportunity of using the LCA tool for natural resources management in Africa, Toolseeram Ramjeawon, University of Mauritius, Mauritius

Sustainable Consumption and Production in Africa need to be put into the specific context of the continent and the overall priority should be that the basic needs of the poor are being met and natural resources are being managed sustainably. Africa's abundant natural resources hold the key to poverty eradication on the continent, but only if they are used carefully and managed to improve people's living standards. An "unsustainable" use of Africa's natural resources could lead to an erosion of its wealth, forcing the continent to slide deeper into poverty.

Africa produces nearly 80 percent of the world's platinum, more than 40 percent of the diamonds and more than a fifth of global gold and cobalt, yet the continent's industrial base remains insignificant. Africa is currently producing and consuming little, but the little it is producing and consuming is already unsustainable. There is need for Africa to move from being a major exporter of primary resources to being one with a vibrant industrial and manufacturing base and hence it is an appropriate point in history to redirect its production and consumption to be sustainable.

Consumer markets in Africa are still small in relation to world markets and in terms of impacts environmental issues are thus dominated by production than by consumption. As a consequence, impact assessments have tended to be project and site focused. As yet there is little incentive to use LCAs at a national level. Industry and governments are still slow to realize the benefits of LCAs as tools to support sustainable development. Common problems for LCA application relate to the LCA methodology itself (system boundaries, allocation, etc) and to problems specific to Africa (data availability and quality, relevance of impact assessment methodologies, capacity building and limited capacity for critical review).

Industrial Ecology and Conservation of the Congo Basin Forest,
Evans Kituyi, University of Nairobi, Kenya

The Congo Basin Forests are the second richest ecosystems in the world after the Amazon. They are home to over 50% of the continent's animal species and the world's lowland gorillas. Furthermore, they are sources of food, materials, and shelter for over 20 million people in the eight country. However, about 1.5 million hectares of these forests are lost annually and it is predicted that two thirds of these will be lost over the next 50 years if illegal logging continues at current levels.

In this presentation, the flow of logs from these forests to European and other markets is examined, the impacts on the environment of these material flows are discussed and the finally, the influence of international markets, political, economic and social systems on these illegal logging are elucidated. It offers an industrial ecology perspective on the sustainable management of the politically explosive issue of the Congo Basin Forest conservation.

Session 3: Challenges and Way Forward

This session aims to outline some elements that the Resource Panel needs to take into account when developing its first work programme by linking different needs and ways of identifying key resource flows and their associated environmental and socio-economic impacts.

Determining the criticality of materials, *Thomas Graedel, Yale University, USA*

Some materials are abundant, and some are not. In the latter case, governments and businesses try to protect themselves against shortages by special purchase arrangements, stockpiles, hedging, and so forth. This is difficult and expensive, and immediately raises the question "How can I tell if a material that appears to be of concern is "critical" or not?" An intelligent response to this question involves an accurate determination of the size of the resource, the availability of that resource, the degree to which suitable substitutes are available for the major uses of the material, the importance of those uses, and the likely evolution in demand over time. Each of these topics will be discussed to some degree; together, they provide the answer to the question of the criticality of a particular material.

Impacts of consumption, products, production and resource use: Assessing causal factors and opportunities for realizing Sustainable Consumption and Production
Arnold Tukker, TNO, The Netherlands

In the EU, a variety of studies has been done or is in progress that develop(ed) an analytical toolbox for a coherent assessment of the sustainability impacts of consumption, products, production and resource use, and allows for analyzing the drivers behind unsustainability and the options for improvement. It concerns e.g. EIPRO (Environmental Impacts of Products), EIRES (Environmental Impacts of Resources), and EXIPOL (A New Environmental Accounting Framework Using Externality Data And Input-Output Tools).

These studies have shown convincingly that an accounting system that is based on supply-use (SUT) or input-output tables (IOT) with environmental extensions (EE) allows to analyse drivers of environmental impacts with one single coherent data set, from a final consumption, product, industry and resource use perspective. And where traditionally EE IOT or EE SUT just maps monetary relations in the economic system, the same accounting framework can be used equally well to include data on physical resource flows. EE IOT and EE SUT are suitable for 3 main applications:

1. Problem analysis (typical questions: pollution embodied in final consumption, pollution embodied in trade, etc.). For this, a static table for a specific year is sufficient.
2. Monitoring (typical question: did dematerialization or decoupling of environmental impacts and economic growth take place, and was this caused by changes in final demand,

changes in emission or resource use factors, or structural change in the production system). For this, time series of data are needed, and via techniques such as decomposition analysis the factors driving changes in environmental pressure can be identified.

3. Foresight and scenario analysis. For this, a policy scenario can be 'imposed' on the table, which for such purposes then usually is used with a dynamic model.

The EU funded EXIOPOL project (2007-2011, 5 Mio Euro) will produce the first global multi-regional EE IOT, covering the most important economies and their links via trade. This database will allow for excellent analysis of the relations between consumption, resource use, and environmental impacts, at a global level. It will hence be a vital informative instrument for the future UN International Panel on the Sustainable Use of Natural Resources.

Rapidly industrializing economies and global resources efficiency,
Sangwon Suh, University of Minnesota, USA/Korea

In recent years a number of developed economies have laid out national policy goals to decouple materials use from economic development. In particular European countries and Japan have set quantitative targets to improve materials and resources efficiency as a part of their national policy objectives. It is also these particular nations where material flow statistics are widely collected, and MFA research is actively conducted.

With the increasing importance of international trade in the global economy, however, an analysis of materials and resources flows within a national border exhibits limited applicability in understanding the fundamental relationship between the society and the nature. Imports by EU25 member states, for instance, have been doubled since 2001. During the same period, the portion of imports from developed economies has been constantly decreased to about 30%, while the portion of imports from other countries, especially China, Russian Federation, South Korea, Brazil and Romania, has been rapidly increasing. Furthermore, rapidly industrializing economies in Asia, Latin America and Eastern Europe supplies semi-finished and finished products, of which resources productivity behind them is difficult to measure as compared to primary resources. In this sense, these economies present hubs of natural resources flows in the world economy, and the involvements of these economies are crucial in improving resources efficiency world-wide. So called BRIC countries (Brazil, Russian Federation, India and China), 6 new accession countries to OECD since 1994 (Czech Republic, Hungary, South Korea, Mexico, Poland and Slovak Republic) and the 12 new accession countries to the European Union since 2004 generally cover these rapidly industrializing economies.

Resources productivity is not only an issue of natural resources conservation or environmental protection but also an issue of competitiveness and security of industrial production especially for these rapidly industrializing economies. An international coordination and a framework for accounting and analysis that can adequately address these issues involving rapidly industrializing economies are essential to collectively improve resources productivity of global economy. The form of international coordination and the requirements for such a framework for accounting and analysis are suggested and discussed.

Conclusions and next steps

UNEP will provide a summary of the discussion during the workshop and indicate the next steps in the establishment of the International Resource Panel. The panel will be launched during the World Science Forum in Budapest on 9-10 November 2007. The inaugural panel meeting will take place on 9 November.