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International Panel for Sustainable Resource Management

UNEP

International Panel
for Sustainable
Resource Management

Exploring Elements for a Workplan (2008-2010)

Background papers for the meeting of the international panel for sustainable resource management

Meeting of the International Panel for Sustainable Resource Management,
Hungarian Ministry of Environment & Water Building

Budapest, Hungary, 8-9 November 2007

Introduction

The overall objective of the International Panel for Sustainable Resource Management (Resource Panel) is to provide independent scientific assessments on the environmental impacts from the use of resources (both renewable and non-renewable) over the full life cycle. The Panel contributes to a better understanding of ways to reduce these impacts by decoupling resource use and environmental impact from economic growth. It takes into account economic development, resource productivity and supply security issues.

UNEP DTIE as secretariat of the Resource Panel has carried out a consultation process since mid 2006 in order to identify elements of a work programme that corresponds to the overall objective. Apart from a multitude of bilateral meetings, conferences and workshops, this included the organisation of a pre-Panel meeting in December 2006 in Brussels and a workshop in September 2007 in Tokyo. Reports of the meetings can be found in annexes 1 and 2.

The Secretariat has identified the following elements which the Panel might wish to consider in their deliberations on an initial work programme:

- Scientific understanding of decoupling and related methodologies and indicators
- Prioritization of products and resources from an environmental point of view
- Scientific assessment of global metal flows from a sustainable management perspective
- Scientific assessment of biofuels from a sustainable resource management perspective
- Capacity building in developing countries and economies in transition

Background papers that introduce each programme element and pose some questions to the Panel have been prepared. The background materials may be used as a starting point for discussions by the Panel and its Steering Committee. The following five background papers and three annexes are included:

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2. UNEP workshop report: Resource Efficiency and the Environment: Identifying Key Resource Flows (Tokyo, 25 September 2007) Page 43
3. Strengthening the Knowledge Base for Sustainable Use of Natural Resources Page 50
(A study by AEA Energy and Environment and Metroeconomica for DG Environment, EC)

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Disclaimer
This document is not for distribution and is not an official UNEP document. It has been prepared as background for discussion at the meetings of the International Partnership for Sustainable Resource Management (Panel and Steering Committee), held in Budapest, Hungary, 8-9 November 2007.

Background Paper 1

Introducing the concept of decoupling

Background Paper 1 for the meeting of the International Panel for Sustainable Resource Management, Budapest, Hungary, 8-9 November 2007

Introduction

It looks like the world will not be able to sustain economic growth indefinitely without running into resource constraints or putting pressure on the environment that goes beyond the Earth's carrying capacity. If environmental impact and resource consumption are not decoupled from economic growth then it will be even more difficult to reach sustainable development. To achieve decoupling it will be necessary to reflect seriously, select science-based policy responses and assess the status of resource use and related environmental impacts diligently on a regular basis.

This paper, prepared as background for the first meeting of the international panel for sustainable resource management, reflects on the concept of 'decoupling'. The Panel is expected to contribute to the overall policy goal of decoupling through 'definitions, indicators, and methodologies'. Therefore, the paper highlights some relevant political aspects, and scientific progress to date to define and measure decoupling. It concludes by posing some questions the Panel might wish to consider.

The term decoupling refers to breaking the link between economic growth and environment degradation. It is not generally considered to extend to the third pillar of sustainability (social issues). International pressure to 'decouple' is mounting in the face of conflicting priorities to grow economies (and hence reduce poverty) and to protect the environment (e.g. climate change). Some see this in the light of criticism of traditional measurements of human progress such as gross domestic product (GDP). More robust and encompassing measures of society's wellbeing such as the genuine progress indicator (GPI)[1] are proliferating.

> *"Business-as-usual, it is widely accepted, will exceed the Earth's carrying capacity in an alarmingly short space of time. In simple terms, we need to learn to use the world's rapidly depleting resources in a significantly more efficient manner."*
>
> **Ernst Ulrich von Weizsäcker et al., The Wuppertal Institute in *Eco-Efficiency and Beyond (2004)***

Conventional economic growth generally puts added pressure on the environment. As economies grow, demands for resources, materials and goods accelerate.

That is why there is increasing national, regional and global debate on and action to reconcile these conflicting priorities. Decoupling is a centrepiece of international initiatives such as the World Summit on Sustainable Development inspired Marrakech Process on Sustainable Consumption and Production (SCP)[2]. It is the driver for the European Commission's (EC) Thematic Strategy on the Sustainable Use of Natural Resources which supports the Lisbon Strategy and the EU's sustainable development strategy. At the national level, several governments are pursuing policies of decoupling, often reflected in initiatives to promote resource efficiency, sustainable consumption and production or sustainable development. Resource efficiency is promoted by the G8 Initiative on 3R (reduce, reuse, recycle) and in the work carried out by the OECD on material flows and sustainable materials management. It is not just a concern of the developed world economies. Major developing economies such as China accept the importance of encouraging *green growth* to ensure a sustainable future (e.g. China's Circular Economy approach).

> *"We need to move to dematerialisation of our economy if we want to achieve a development that will last."*
>
> **Jacqueline Aloisi de Larderel, Former Assistant Executive Director, UNEP**

Tackling resource, material and product efficiency in a life cycle perspective is widely recognised as a major challenge. Without proper understanding of the scientific basis for and measurement of

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[1] For more information see http://www.rprogress.org/sustainability_indicators/genuine_progress_indicator.htm

[2] See http://www.unep.fr/pc/sustain/10year/home.htm

decoupling it will be difficult to achieve any lasting success.

Decoupling for the future

Growth versus the Environment

For decades our society has been driven by an inherent desire to grow economies at a rapid rate. Since 1950 the global economy has quintupled. In fact, humankind has consumed more natural resources in the past five decades than in all previous human history (e.g. Brown et al. 1999). This growth has fuelled a world consumer class of more than 1.7 billion people – with almost half residing in developing economies like China and India (Bentley 2003).

To the detriment of the natural environment, political and economic actors continue to make decisions and measure *progress* based on the traditional national accounting system - gross domestic product. GDP has many flaws. According to Venetoulis and Cobb (2004) of the Redining Progress initiative, it includes only a portion of economic activity, leaving out much that people value such as unpaid work in households. It also leaves out the contribution of the natural world, such as clean air and water, fertile soil and moderate climate.

Economic growth is still seen by many policy makers and economic scholars as the key to addressing major problems such as poverty. It is said that through growth comes development which leads to a gradual – and in the case of the BRICS rapid – reduction in the number of poor people. However, according to, for example, the ecological footprint theorists, growth that does not consider the environmental and social wellbeing of people and the planet cannot be sustained indefinably (e.g. Wackernagel and Rees 1996). The WWF points out that "effectively, the Earth's regenerative capacity can no longer keep up with demand – people are turning resources into waste faster than nature can turn waste back into resources (WWF 2006).

Green Growth

There is evidence that some quarters of society are adopting new lifestyles that consider the quality of life more important than material accumulation. The abundance of literature on 'post-materialism' and the release of new sustainable consumption teaching curricula in the past few years reflect the growth of this contemporary movement (Ryan et al. 1997; De Graaf et al. 2002; Gardner et al. 2004). Of course, there is a wide range of theoretical arguments and also some survey data that needs to be considered. The advent of 'downshifting' by many people in developed economies is one such example of this pursuit of happiness over material wealth (e.g. Hamilton 2003).

In parallel, alternative methods to measure wellbeing are being developed. Indicators such as the GPI, the Human Development Index (HDI) and the Human Wellbeing Index (HWI) [3] are three such examples. These are complemented by several national and community-based studies on wellbeing and happiness. According to de Leeuw (2005), "the old slogan *doing more with less* is getting the new, ambitious, and perhaps crazy meaning of *more units of happiness with less damage*".

A wide group of stakeholders is starting to take notice. For instance, the Beyond GDP conference in November 2007, hosted by the European Commission, European Parliament, Club of Rome, OECD and WWF will aim to clarify which indices are most appropriate to measure progress, and how these can best be integrated into the decision-making process.

Decoupling definitions

Simply speaking, decoupling equates to a desire to break the link between economic growth and environmental degradation. However, there is some difference in opinion on how to define and measure this.

As highlighted in its Resource Strategy, the EC considers that decoupling specifically

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[3] See http://www.sustainability.ca/index.cfm?body=chunkout.cfm&k1=351

implies that the goals of economic growth and decreased environment damage are achieved concurrently.

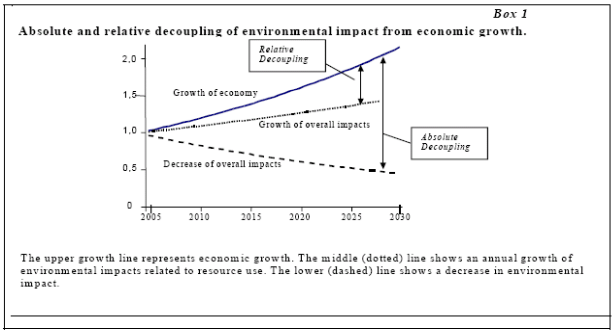
The OECD has been quite active on decoupling initiatives in the past few years, including work on sector-based studies and decoupling indicators. The OECD believes decoupling occurs when the growth rate of an environmental pressure is less than that of its economic driving force (e.g. GDP) over a given period. Its main point of departure from the EC definition is that it focuses on the *pressure* on the environment rather than the *quality* of the environment.

> *Successful policies and the use of improved technologies have resulted in some environmental improvements […]. OECD countries are using less natural resources and materials and are generating less pollution and waste per unit of product produced and consumed. However, for many issues the volume effects of total increases in production and consumption have resulted in net increases in environmental degradation. Decoupling environmental pressures from economic growth, with a view to ensuring that continued economic growth is accompanied by enhanced environmental quality, is needed.*
>
> **OECD Environment Strategy for the First Decade of the 21st Century, 2001**

One can also refer to *double decoupling*, where economic growth is first decoupled from resource use and then resource use is decoupled from environmental degradation.

Absolute or relative decoupling

Decoupling can be absolute or relative. Relative decoupling occurs when the rate of environmental degradation is less than the rate of economic growth, but still greater than zero. Absolute decoupling occurs when the rate of environmental degradation is zero or negative. These phenomena can be depicted in a graph where the economic and environmental indicators are plotted separately in a time series (see Figure 1). This makes it simple to determine whether there has been a decoupling trend (UNEP 2005). Many decoupling indicators use this form of presentation, as will be shown in the next section. Alternatively, an index can be used where the rate of environmental impact is divided by the rate of economic impact.


Box 1

Absolute and relative decoupling of environmental impact from economic growth.

The upper growth line represents economic growth. The middle (dotted) line shows an annual growth of environmental impacts related to resource use. The lower (dashed) line shows a decrease in environmental impact.

Figure 1: Absolute and relative decoupling (EC 2003)

Decoupling equation

The Swedish Ministry of Environment suggests analysing decoupling patterns and trends through a highly aggregated mathematical equation (see Figure 2). It can cover the national or world economy depending on the system boundaries chosen (Azar et al. 2002). Information on population and utility measured as GDP are usually delivered by statistical agencies. An overview of structural changes might be obtained through time lines of Input-Output Tables (IOT). Information on the mass flows linked to the consumption and production patterns can be provided by Material Flow Accounting (MFA), while impacts of the life cycle of materials are accessed in an aggregated way based on sound science by the Life Cycle Impact Assessment (LCIA) approach initially developed by the Institute of Environmental Sciences at Leiden University (CML).

I	=	*I*	x	*M*	x	*u*	x	*P*
(Total impact)		*(impact / Kg)*		*(kg / utility)*		*(utility / capita)*		*(capita)*
Strategies		Transmaterial-isation		Dematerial-Isation		Structural Changes		

Figure 2: Decoupling equation

It seems that in the future these supply-use or input-output tables with environmental extensions could allow analysing drivers of environmental impacts with one single coherent data set, from a final consumption, product, industry and resource use perspective. This would allow for an assessment of whether dematerialization or decoupling of environmental impacts and economic growth had taken place as well as carrying out scenario analysis with dynamic models. (Tukker 2007)

Many different variables are currently used to communicate decoupling without giving the full picture. The *economic variable* might be GDP or population growth, among others. The quantifiable *environmental indicators* used vary widely. Inputs into the economy, such as energy use, are commonly used as proxy indicators, as are outputs to the environment, such as CO_2 emissions.

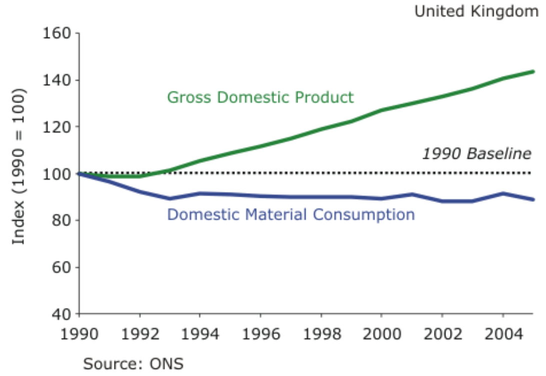
Environmental Kuznets Curve

Several scholars argue that a decoupling of environmental degradation occurs naturally as economies mature (Panayotou 2000; Azar et al. 2002). According to Azar et al., as economies become richer, the need for new infrastructure decreases and consumer preferences for a cleaner environment grows, leading to decreased demand for environmentally harmful products. This implied 'inverted-U relationship' between environmental degradation and economic growth has become known as the "Environmental Kuznets Curve". This phenomenon, however, is not considered completely natural by many scholars, who point to the considerable political efforts made by governments to encourage environmental protection. A serious flaw with the assumption is that although some environmental concerns seem to improve, growing CO_2 emissions and solid waste generation, for example, continue to put added pressure on the environment as economies mature.

So, are we decoupling?

Relative decoupling is widespread in OECD countries, according to the OECD decoupling indicator study from 2002. Absolute decoupling is also occurring, but is less common. For example, the graph below indicates that since 1990 there has been an absolute decoupling of domestic material consumption (DMC) and GDP in the UK (see Figure 3).

On the European level, according to studies completed by Eurostat (2005) the absolute amount of domestic material consumption remained fairly stable (and according to van de Voet et al.) rose slightly between 1990 and 2001 while GDP grew constantly over that time, indicating a relative decoupling of material use from economic growth.



Source: ONS

Figure 3: Domestic Material Consumption and Gross Domestic Product, 1990 to 2005 Source: UK, SCP indicators

Some decoupling is possibly due to a shift of environmental burden from developed countries to developing countries. There is also little evidence of decoupling trends in developing countries. However, some general trends are visible in the case of the 'carbon intensity indicator', which takes the dimension of the number of tons of carbon dioxide per unit of economic output (tons of CO2 per unit of GDP). Between 1980 and 1996, for example, carbon intensity decreased in Chile, Argentina and China, whereas it increased in many developing countries such as India and Malaysia (ISAE, 2005).

Global patterns indicate an increase in resource efficiency, though this has largely been counter-balanced with increases in total volume of outputs. However, further analyses and monitoring mechanisms need to be established before accurate reporting on decoupling can be assured.

Limitations of the decoupling concept

The relative simplicity of decoupling makes it attractive. Graphs that depict a relative or absolute decoupling can be powerful tools of communication particularly for business and political leaders. However, decoupling has the potential to mask certain important actualities.

First, even if decoupling is occurring, in reality environmental damage may be increasing unsustainably. In other words, the decoupling concept has no automatic link to the environmental limits, and in that sense the indicators that are used to measure decoupling are often only considered as directional and not absolute indicators. This limitation in many respects at least makes the concept of *relative* decoupling appear unacceptable. Linking ecological footprint data to decoupling indicators may be one solution to this problem since the ecological footprint methodology tries to take the carrying capacity of the Earth into account. (UK DEFRA 2007).

Second, the decoupling concept applied at the national level takes no account of the changing balance of international trade or related social impacts. In particular, it does not consider the cross-border flow of environmental externalities, since they are not captured by most country-based indicators (OECD 2002). In principle, the analysis of global material flows, using LCIA indicators that are weighted with environmental costs, would be a way to address this.

Third, the relationship with the main driver is not always well established. In other words, the relationship between the economic driving force and the environmental pressure or impact is regularly quite complex. According to the OECD, "most driving forces have multiple environmental effects, and most environmental pressures are generated by multiple driving forces, which in turn, are affected by societal responses. The PSR/ DPSIR model [4] will not reveal all such linkages and hence the need to use decoupling indicators within a more complete analytical framework."

What goes unmeasured gets ignored

Decoupling indicators and their methodologies

Indicators are valuable tools for tracking progress on set priorities and targets. Quantitative indicators can help to gauge whether we are moving closer to or farther away from sustainability (UNEP 2007). They also contribute to accountability and public transparency in programme implementation. Indicators are an important tool for stimulating debate and focusing attention (in this case on decoupling).

Indicators do have certain drawbacks however. Decoupling indicators, like all other types of indicators, shed light on particular aspects of a complex reality but leave out other aspects (OECD 2002). Measuring some of the dimensions related to decoupling is difficult and overcoming the stated limitations also a major challenge. Data reliability and availability is also an obvious concern, particularly in developing countries. It is also sometimes hard to reach consensus on the right indicators and methodologies to be used.

Decoupling can be measured by decoupling indicators that have an environmental pressure variable for numerator and an economic variable as denominator (OECD 2002). Several international and regional sets of sustainable development indicators include some decoupling indicators. These include the UN-DESA set of sustainable development indicators and the European Union's sustainability indicators. In 2002, the OECD developed a detailed framework of 31 decoupling indicators covering a broad range of environmental issues. Several individual countries such as Australia, Canada, Sweden and the UK have also introduced decoupling indicators in their indicator frameworks. These indicators are generally concerned with measuring a decoupling of economic growth (GDP) from natural resource use, greenhouse gas emissions or energy and water use.

A brief discussion of two more advanced methodologies for decoupling indicators follows. However, clearly further research in this area needs to be undertaken.

Material Flow Accounting (MFA)-related indicators

Material flow accounting (MFA) is a mass balance method that enables the modelling

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[4] PSR=Pressure-State-Response, DPSIR=Driving Force-Pressure-State-Impact-Response

of flows and stocks of materials through a spatially and temporally defined system (Brunner et al. 2002). An MFA on its own does not make a statement about sustainability; it is merely a physical quantification process. A variety of indicators can be used to communicate MFA results (OCED 2007). The most commonly used consumption indicators are the Domestic Material Consumption (DMC) and the Total Material Consumption (TMC). The TMC is more comprehensive than the DMC in that it considers indirect material flows associated with imported and exported commodities, i.e. induced resource requirements to foreign economies. Evaluation methods, such as Life Cycle Impact Assessment and Ecological Footprint, can be used to link the MFA results to environmental context.

Environmentally-weighted Material Consumption (EMC) indicator

There are major differences in environmental impacts between different resources or materials. A kilogram of sand does not have the equal impacts as a kilogram of copper, or meat, or coal (van der Voet et al. 2005). Not only the weight and volume of the use of materials and resources, but also their potential environmental impacts should be considered. According to van der Voet et al., it should be the actual environmental pressures or impacts decoupled from economic growth, rather than their use per se.

CML, in conjunction with the Wuppertal Institute and CE Delft developed the environmentally-weighted material consumption indicator. The indicator combines information on material flows with information on environmental impacts.

The EMC is calculated using LCIA methodology, where the flows of individual materials are multiplied by a characterisation factor from well established LCA databases. The flows are summed and aggregated into the single figure, just like the Domestic Material Consumption results in a single *kg* figure.

Key Questions for the Panel

1. How will the Panel define the concept of decoupling?

2. What further assessments on decoupling are required?

3. How is the concept of decoupling to be measured?

List of abbreviations

3R	Reduce, Reuse, Recycle
BRICS	Brazil, Russia, India, China, South Africa
CML	Institute of Environmental Sciences at Leiden University
CO_2	Carbon Dioxide
DEFRA	Department of Environment, Food and Rural Affairs (UK)
DESA	Department of Economic and Social Affairs (UN)
DMC	Domestic Material Consumption
DPSIR	Driving Force-Pressure-State-Response-Impact
EC	European Commission
EMC	Environmentally-weighted Material Consumption
EU	European Union
GDP	Gross Domestic Product
GPI	Global Progress Indicator
HDI	Human Development Index
IOT	Input-Output Tables
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
MFA	Materials Flow Accounting
OECD	Organisation for Economic Co-operation and Development
PSR	Pressure-State-Response
SCP	Sustainable Consumption and Production
TMC	Total Material Consumption
UNEP	United Nations Environment Programme

References

Australian Government (2006). Decoupling Indicators in *Australian Bureau of Statistics, Environment: Issues and Trends.*

Azar, C., J. Holmberg, & S. Karlsson (2002). “Decoupling – past trends and prospects for the future”, Goeteborg

Bentley, M. (2003). “Sustainable Consumption: Ethics, National Indices and International Relations”. Ph.D. Thesis. Paris: American

Graduate School of International Relations and Diplomacy (AGSIRD).

Bentley, M., J. Fien and C. Neil. (2005). *Sustainable Consumption: Young Australians as Agents of Change*. Canberra: Australian Government.

Bringezu, S., H. Schuetz, S. Steger, J. Baudisch (2004). “International comparison of resource use and its relation to economic growth – The development of total material requirement, direct material inputs and hidden flows and the structure of TMR”, *Ecological Economics*, 51 pp. 97-124

Brown, L. R. et al. (1999). *State of the World 1999*. New York: Norton.

Brunner, P., and H. Rechberger (2004). “Practical Handbook of Material Flow Analysis – Advanced Methods in Resource and Waste Management”. London: CRC Press LLC.

De Leeuw, B. (2005). “The World Behind the Product” in *Journal of Industrial Ecology*, Volume 9, Number 1-2, Winter/Spring 2005.

De Graaf, J. et al. (2002). *Affluenza: The All-Consuming Epidemic*. US: Berrett-Koehler Publishers.

EC (2000). European Union’s Lisbon Strategy. See http://ec.europa.eu/growthandjobs/key/index_en.htm

EC (2002). “Analysis of Selected Concepts on Resource management. A study to support the development of a Thematic Community Strategy on the Sustainable Use of Resources”, March 2002.

EC (2003). *Towards a Thematic Strategy on the Sustainable Use of Natural Resources*. Brussels: EC.

Eurostat (2005). *Measuring Progress towards a more sustainable Europe: Sustainable development indicators for the EU.* Brussels: EC.

Galeotti, M. (2003). "Environment and Economic Growth: Is Technical Change the Key to Decoupling?," Working Papers 2003.90, Fondazione Eni Enrico Mattei.

Gardner, G. & E. Assadourian (2004). “Rethinking the Good Life” in Worldwatch Institute (2004) *State of the World 2004*. US: W. W. Norton and Company.

Hamilton, C. et al. (2003). *Downshifting in Australia: A Sea-change in the Pursuit of Happiness.* Number 50, Discussion Paper, 2003, Australia Institute.

Heyerick, A. and B. Mazijn (2005) “The Need for Indicators to Monitor and Evaluate (un-) Sustainable Production and Consumption Patterns” Centre for Sustainable Development, Ghent University, Belgium

ISAE (2005). “Towards a Sustainable Globalisation.” ISAE Report 2003 on Public Finance and Redistribution. Rome: ISAE.

Japanese Society of Non-Traditional Technology (SNTT) (2005). “Research on the Development and Utilisation of Indicators for Sustainable Consumption”. Tokyo: SNTT. See http://www.sntt.or.jp/sntt/SC/top.html

OECD (2001). *Environment Strategy for the First Decade of the 21st Century*. Paris: OECD.

OECD (2002). *Indicators to measure decoupling of environmental pressure from economic growth*. Paris: OECD.

OECD (2005). “Decoupling transport impacts from economic growth – Status report on phase 2 of the OECD decoupling project”

OECD, sustainable consumption indicators, see http://www.oecd.org/document/58/0,3343,en_2649_34289_2397498_1_1_1_1,00.html

OECD (2007), *Measuring material flows and resource productivity: An OECD guide*, Paris: OECD

Panayotou, T. (2000). “Economic Growth and the Environment”. Center for International Development at Harvard University (CID).

Prescott-Allen, R. (2001). *Wellbeing of Nations.* Washington DC: Island Press.

Ryan, J. et al. (1997). *Stuff: The Secret Lives of Everyday Things*. US: NWEW

Sabrina, A., L. Becchetti & R. Luca (2006). "Testing crucial model assumptions: the income/willingness to pay for the environment nexus in the Environmental Kutznetz Curve," Departmental Working Papers 239, Tor Vergata University, CEIS.

Sachs, W. and T. Santarius (editors) (2007). *Fair Future: Resource Conflicts, Security and Global Justice*. US: Zed Books.

Tukker, A. (2007), EXIOPOL project, TNO, Delft.

UK DEFRA (2007). Information provided by the UK Department of Environment, Food and Rural Affairs.

UN DESA, sustainable development indicators, see http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm

UNDP (1998). *Human Development Report, 1998*. New York: UNDP.

UNEP (2002). *Global Environment Outlook 3*. London: Earthscan.

UNEP (2003). “Life-Cycle Approaches to Sustainable Consumption and Production”, Workshop paper, 3 March 2003.

UNEP (2005). “International activities on decoupling environmental degradation from economic growth by changing unsustainable flows of natural resources”, draft paper, UNEP DTIE, Paris.

UNEP (2007). Guidelines for National SCP Programmes, draft report, UNEP DTIE, Paris.

UNEP (2007*). Life Cycle Management. A Business Guide to Sustainability*. Paris: UNEP.

UNEP–CI (2002, 2004). *Tracking Progress: Implementing Sustainable Consumption Policies*. Paris: UNEP–CI.

United Kingdom Government (2006). Sustainable Consumption and Production indicators, see http://www.sustainable-development.gov.uk/progress/national/consumption-production.htm

Van der Voet, E. et al. (2005). "Policy Review on Decoupling: Development of indicators to assess decoupling of economic development and environmental pressure in the EU-25 and AC-3 countries". Leiden: CML.

von Weizsäcker, E. U. et al. (2004). *Eco-Efficiency and Beyond: Towards the Sustainable Enterprise*. Germany: The Wuppertal Institute.

Venetoulis, J. & C. Cobb (2004). *The Genuine Progress Indicator* (2004 update), *Measuring the real state of the economy*. San Francisco: Redefining Progress.

Wackernagel, M. & W. Rees (1996). *Our Ecological Footprint: Reducing human impact on the Earth*. Philadelphia, PA: New Society Publishers.

WWF (2006). *Living Planet Report 2006*. Geneva: WWF.

Yale Centre for Environmental Law and Policy, Yale University (2005). *2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*, see www.yale.edu/esi

Background Paper 2

Prioritisation of products and resources from a sustainability point of view

Background Paper 2 for the meeting of the International Panel for Sustainable Resource Management, Budapest, Hungary, 8-9 November 2007

Abstract

This background paper gives a short review of recent studies into priority setting of materials on the resources side and products on the consumption side, from an environmental perspective. In developed economies, products related to consumption expenditure in the areas of housing, food and mobility tend to be responsible for over 75% of the life cycle impacts from just 50% of final consumption expenditure. Studies focusing on the impacts of resource use generally identify the following priorities:

- The use of fossil fuels and "global warming potential" and "potential acidifying effect".
- Use of specific metals, where there is a clear and linear relationship to environmental impacts from metal extraction, refining and use.
- Area occupation, where it is the resource use itself that is of environmental concern. A reduction in area occupation will reduce the pressure on biodiversity.
- Construction materials, where the resource use drives the waste stream, albeit mostly with a significant delay corresponding to the lifetime of the constructions.

Studies tend to favour an accounting framework based on economic input-output tables with environmental extensions since they are best suited to give a comprehensive picture at macro level. They also answer questions on priority setting of products, consumption, sectors and resources, in principle all different perspectives in the economic system, via one coherent data set.

Introduction

One of the key questions that a policy maker dealing with the environmental impacts of resource flows and products has to answer is where to start. After all, there are dozens of key resources and millions of products. Which consumption activities and which resource uses cause the greatest environmental impacts? What are the driving forces? This paper summarises the results of some recent studies into these questions, and concludes with a view on how structural data gathering for this purpose may be set up.

Environmental impacts of resources

Two different approaches

A key debate in the Material Flow Analysis (MFA) community is if indicators should be used that simply account for the primary material demand of society, or that somehow a differentiation has to be taken into account according to (potential) environmental impacts related to the use of the resource. In the first approach one simply sees total societal material demand as a measure for unsustainability. In the second approach one would concentrate on material flows with relatively high potential impact[5].

Relating impacts from products to the primary material

For those interested in using impacts related to material use as a measure for priority setting, a further complication is at stake. Materials are transformed (e.g. iron ore into iron, or fossil fuels into plastics), and after that end up in a great diversity of products. To what extent can impacts related to such products still be allocated in a meaningful way to the original primary material? For instance, where at first sight it seems not reasonable to allocate the emissions of a car to the steel used in that car, but just to fossil fuels, one has to acknowledge that the same car could have been made of lighter materials, leading to lower emissions. So in a way the use of heavy steel could be seen as responsible for at least part of such emissions.

In 2004, on assignment of the European Commission’s Joint Research Centre, a

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[5] Example: the use of cadmium , that may generate emissions during its life cycle that are highly toxic.

group of EU based institutes reviewed a variety of studies into the environmental impacts of resources (EIRES, see box 1). The studies considered cover a broad range of methodological approaches, ranging from “top-down-approaches” where impacts are determined from National Accounts Matrices extended by Environmental Accounts (NAMEA) to “bottom-up-approaches” where environmental impacts are determined from Life Cycle Assessments (LCAs).

Knowledge gaps exist

With the exception of Moll et al. (2004), the studies did not analyse explicitly the correlation or causal relationships between indicators of resource use and indicators of environmental impact. This is clearly a gap that may warrant attention from the Panel. However, the studies reviewed did allow for identifying some straightforward relations between environmental impacts, and thus a more obvious consideration for policies aiming to reduce the environmental impacts from resource use could include:

- The use of fossil fuels and "global warming potential" and "potential acidifying effect".
- Use of specific metals, where there is a clear and linear relationship to environmental impacts from metal extraction and refining. A reduction in use of these metals will lead to a direct reduction in the associated impacts.
- Area occupation, where it is the resource use itself that is of environmental concern. A reduction in area occupation will reduce the pressure on biodiversity.
- Construction materials, where the resource use drives the waste stream, albeit mostly with a significant delay corresponding to the lifetime of the constructions.

In addition, environmental impacts directly related to resource extraction are relevant. This is particularly the case for biotic resources, such as fish, (tropical) forests, and the like, and water in regions with water scarcity (e.g. Nijdam and Wilting, 2003).

Box 1: Example studies into impacts of resource use

Labouze E, Monier V, Puyou J-B (2003). Study on external environmental effects related to the life cycle of products and services. BIO Intelligence Service and O2 France for the European Commission, Directorate General Environment.

Moll S, Acosta J, Villanueva A (2004). Environmental implications of resource use – insights from input-output analyses. Copenhagen: European Topic Centre on Waste and Material Flows. Draft manuscript, January 2004.

van der Voet E, van Oers L, Nikolic I (2004). Dematerialisation: not just a matter of weight - Development and application of a methodology to rank materials based on their environmental impacts. Leiden: Centre for Environmental Studies at Leiden University. CML report no. 160.

Phylipsen D, Kerssemeeckers M, Blok K, Patel M, de Beer J (2002). Assessing the environmental potential of clean material technologies. Institute for Prospective Technological Studies, Joint Research Centre (DG JRC), European Commission. Report EUR 20515 EN.

Nemry F, Thollier K, Jansen B, Theunis J (2002). Identifying key products for the federal product and environment policy. Final report. Institut Wallon de développement économique et social et d’aménagement du territoire ASBL and Vlaamse Instelling voor Technologisch Onderzoek (VITO) for the Belgian Federal Services of Environment, Department on Product Policy.

Dall O, Toft J, Andersen TT (2002). Danske husholdningers miljøbelastning (Environmental impacts of Danish households). Danish Environmental Protection Agency. (Arbejdsrappport 13). In Danish.

Nijdam DS, Wilting H (2003). Milieudruk consumptie in beeld (A view on environmental pressure on consumption) RIVM report 7714040004). In Dutch.

Kok, R, Falkena H-J, Benders R, Moll HC, Noorman KJ (2003). Household metabolism in European countries and cities - Comparing and evaluating the results of the cities Fredrikstad (Norway), Groningen (The Netherlands), Guildford (UK), and Stockholm (Sweden). Toolsust Deliverable No. 9. Groningen: Center for Energy and Environmental Studies, University of Groningen.

Environmental impacts of products

Bottom-up or top-down approaches?

In the 1970s, energy analysts had already taken up the question of what final consumption activities drove most of the demand for energy. With the advent of life cycle assessment (LCA) of products in the 1990s, authors started to analyse this point from a perspective of a broader set of impact categories. A problem for LCA based approaches was that consumers buy thousands of products, for which an individual LCA could never be performed. Often data for a specific product LCA had to be extrapolated to a product category, which poses obvious problems. Another problem with LCA is that it is virtually impossible to follow all of the supply chains: at some point, ‘cut-offs’ have to be introduced. Though each cut-off can be small, there are many of them, and research has shown that up to a few dozen percent of the impacts may be neglected. Approaches based on economic input-output databases with environmental extensions pose fewer complications in this respect; they simply are able to allocate the total environmental impacts to final consumption expenditures. There may be some errors in allocation, but impacts are not ‘forgotten’.

Recently, Hertwich (2005) and the Journal of Industrial Ecology (Tukker, 2006) have published comprehensive reviews of studies into the environmental impacts of final consumption expenditure. Table 1 summarises the results of 8 studies reviewed in the Journal of Industrial Ecology. The table shows clearly that for all studies the total contribution of expenditures on Classification of Individual Consumption According to Purpose (COICOP) categories, namely food, mobility and housing is 70% or more, where these COICOP categories are just some 55% of the total household and government expenditure in the EU25 (Huppes et al., 2006). Given the very different approaches followed in each of these studies this result must be regarded as extremely robust. Where Table 1 focuses on energy related indicators, a deeper analysis shows that similar conclusions are valid, also when other indicators are used. Studies for the US (e.g. Suh, 2004), and other developed countries show a similar pattern.

Environmental Impact of Products (EIPRO)

Objective:
The Joint Research Centre in Seville, Spain, launched a study in 2005, with the objective to identify those products that have the greatest environmental impact throughout their life cycle, from cradle to grave.

Methodology:
The methodological approach for this study was to take the results of existing studies and combine them with new research. This way, full advantage could be taken of existing research and knowledge of impacts, and the understanding could be developed further in key areas to close knowledge gaps. As part of the new research, an environmentally extended input-output model was developed that allowed a systematic and detailed analysis (distinguishing several hundreds of products). The analysis used the following eight environmental impact categories: abiotic depletion, acidification, ecotoxicity, global warming, eutrophication, human toxicity, ozone layer depletion and photochemical oxidation.

Results:
The study identified products in the following three areas as having the greatest impact: food and drink; private transport, and housing. Together they are responsible for 70 – 80% of the environmental impact of consumption, and account for some 60% of consumption expenditure.

Next steps:
The model adapts the latest model developed with United States sectoral data to Europe. The resulting EU-25 Products and Environment model covers all resource use and emissions in the production, use and disposal phases of all products consumed in the EU-25. As a next step, it would be good to develop a global database covering the most important economies. Such an input-output model would allow for excellent analysis of the relations between consumption, resource use and environmental impacts at a global level. The modelling needs particularly to be extended to the regional level to take into account the particular situation of regions like Africa and Latin America.

Relevance to developing countries

A main point is that the studies discussed in this paper have mainly been done for developed economies. It is not clear if the conclusions can be directly translated to many non-OECD countries, which still rely heavily on agriculture, tend to have just limited transport activities, and where consumption activities like leisure/package holidays may be almost completely absent. Another issue to consider is that developing and emerging economies have a special place in the global economic system. Many of them are home to high impact activities like mining, of which the products usually are exported to developed countries. Therefore, consumption in developed countries may drive environmental impacts in developing countries.

Preauthorisation at the global level?

In the past few decades, a clear shift has taken place in the location of where consumer products are produced. China and other Asian countries have become the ‘factory of the world’, again leading to a situation where developed countries may have ‘exported’ much of their ‘impact generating’ industries abroad. All this implies that an environmental-economic accounting system at the national level and even at the level of entities of the EU quickly looses its value. Since the structure of industry is changing, one cannot make sound assessments on the national level if, for example, decoupling of economic growth (or better: final consumption) and environmental impact is at stake. For this, one needs to have insight into the environmental impacts related to the supply chains abroad, or better, have insight into the ‘embodied pollution’ in products traded between (groups of) countries.

Table 1: Contribution per COICOP category to energy-related impact indicators in different studies

			1	2	3	5	6	7	8	9	10
COICOP	**Study**	**% of total expenditure in EU25 (Tukker et al, 2005)**	**Collins et al.(2006)**	**Dall et al. (2002)**	**Labouze et al. (2006)**	**Moll et al. (2005)**	**Jansen and Thollier (2006)**	**Nijdam and Wilting (2005)**	**Palm et al. (2006)**	**Peters and Hertwich (2006)**	**Huppes et al. (2006)**
	Geographical focus	EU25	Cardiff	Denmark	EU15	Germany	Belgium	Netherlands	Sweden	Norway	EU25
	Indicator		Footprint	Energy	GWP	Energy	GWP	GWP	CO2	CO2	GWP
	Main approach		Top-down/ hybrid	Bottom-up	Bottom-up	Top-down	Bottom-up	Top-down	Top-down	Top-down	Top-down
CP01-02	Food	19,3%	21.0%	26.2%	7.0%**	13.0%	3.6%**	22.1%	7,7%	12,2%	31.0%
CP03	Clothing	3,1%	0.8%	1.3%	3.3%	2.2%	1.3%	6.5%	0,7%	10,3%	2.4%
CP04-05	Housing	25,1%	30.8%	40.8%	58.8%	54.3%	53.5%	33.4%	29,1%	23,0%	23.6%
CP06	Health	3,9%	0.3%	n/a	n/a	1.8%	0.3%	0.3%	1,0%	1,1%	1.6%
CP07	Transport	14,1%	22.4%	19.5%	29.6%	18.3%	32.9%	17.3%	15,5%	35,9%	18.5%
CP08	Communication	4,0%	0.5%		0.0%		2.9%	0.0%	1,7%	2,1%	2.1%
CP09	Recreation	9,1%	8.3%	7.2%	0.0%	8.1%	n/a	15.1%	0,5%	0,5%	6.0%
CP10	Education	1,4%	0.3%	n/a	n/a	1.8%	n/a	0.7%	0,3%	0,1%	0.5%
CP11	Restaurants	9,6%	11.0%	n/a	n/a	n/a	n/a	2.8%	1,8%	1,3%	9.1%
CP12	Miscellaneous	10,3%	4.5%	5.1%	1.3%	0.4%	5.4%	1.8%	6,6%	13,1%	5.2%
Other	Refined petroleum products / Direct household energy*								35,0%		
	TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

* Palm et al. (2006) reported energy use by households as a separate category. To be distributed over housing and transport

** Nemry et al. (2002) did not include food in their study; this value is related to packaging for food. Labouze et al. (2003) under-addressed food for a variety of reasons in their work.

n/a: not visible as a specific category in the study at stake.

Suggestion for an accounting system

The studies highlighted in this paper used two basic approaches to assess impacts related to resource use and final consumption: bottom-up (extrapolating existing product LCAs) and top-down (using environmentally extended IO analysis). It seems that the review points to the superiority of the second approach. This model can easily reach a level of detail of 60 consumption expenditure categories, which is more than that achieved in the bottom-up studies reviewed (see Annex 3). It is inherently more complete, consistent and systematic in allocating environmental impacts to final expenditure categories. Once the model is constructed it can be relatively easily updated with new emission data and structural economic data (when available from emission registration systems and statistical bureaus). A clear framework for this approach already has been developed in SEEA (2003) for example. It has the additional advantage that such an EE I-O database, preferably one that differentiates between the most important countries or regions in the world, covers all economic processes and their relations. It is hence possible to use such data from different perspectives: a consumption/product perspective, a sector perspective, and a resource input perspective. This, in turn, implies that one coherent data set is suitable for answering questions related to each of these perspectives.

List of abbreviations

COICOP	Classification of Individual Consumption According to Purpose
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
MFA	Materials Flow Analysis
NAMEA	National Accounts Matrices extended by Environmental Accounts

Key Questions for the Panel

1. Are methodologies and practices for prioritising resources and products useful? Are there any knowledge gaps?

2. If so, would such a system of prioritisation be constructive / relevant on the global level?

3. What specific needs and characteristics of developing countries and countries with economies in transition can be identified, and what capacity building activities would be needed?

References

Chertow, M.R. (2000). The IPAT Equation and its Variants. Changing Views on Technology and Environmental Impact. Journal of Industrial Ecology, Vol. 4, No. 4: 13

De Bruyn, S. (1998). Dematerialisation and rematerialisation. In: Vellinga, P., F. Berkhout and J. Gupta, Managing a Material World, Kluwer Academic Publishers, Dordrecht/London/Boston

Ehrlich, P. and J. Holdren (1971). Impact of population growth. Science 171:1212-1217

EU (2003) Communication: "Towards a Thematic Strategy on the Sustainable Use of Natural Resources. COM (2003) 572 Final, downloadable from

Hertwich, E. (2005). Life Cycle Approaches to Sustainable Consumption: A Critical Review. Env. Sc. Tech., Vol. 39, No 13, p4673

Huppes, G., A. de Koning, S. Suh, R. Heijungs, L. van Oers, P. Nielsen, J.B. Guinée (2006). Environmental Impacts Of Consumption In The European Union Using Detailed Input-Output Analysis. Journal of Industrial Ecology 10.3

Jansen, B. and K. Thollier (2006). Bottom-up LCA Methodology for the Evaluation of Environmental Impacts of Product Consumption in Belgium. Journal of Industrial Ecology 10.3

Joint Platform 'European and International Environmental Policy' (2003), Position Integrated Product Policy, Comments on the methodology used in the Belgian study, September 2003 (Members of Joint Platform are industry federations FEB, UWE, UEB, VEV)

Kok, R., H.J. Falkena, R. Benders, H.C. Moll and K.J. Noorman (2003): Household metabolism in European countries and cities. Comparing and evaluating the results of the cities Fredrikstad (Norway), Groningen (The Netherlands), Guildford (UK), and Stockholm (Sweden). Toolsust Deliverable No. 9; Center for Energy and Environmental Studies, University of Groningen, Netherlands. Available from. http://www.toolsust.org/documents/Toolsust-IntegrationWP2deliverable9final.pdf

Labouze, E., V. Monier, Y. Le Guern and J.-B. Puyou. (2003), Study on external environmental effects related to the lifecycle of products and services – Final Report Version 2, European Commission, Directorate General Environment, Directorate A – Sustainable Development and Policy support, BIO Intelligence Service/O2 France, Paris, France

Moll, H., K.J. Noorma, R. Kok, R. Engstrom, H. Throne-Holst and C. Clark (2005). Pursuing More Sustainable Consumption by Analyzing Household Metabolism in European Countries and Cities.

Moll, S., J. Acosta, and A. Villanueva (2004). Environmental implications of resource use – insights from input-output analyses, prepared by the European Topic Centre on Waste and Material flows (ETC WMF), Copenhagen, Denmark

Moll, S. and J. Acosta (2006). Environmental Implications of Resource Use – NAMEA based environmental Input-Output analyses for Germany. Journal of Industrial Ecology 10.3

Nemry, F., K. Thollier, B. Jansen, J. Theunis. (2002), Identifying key products for the federal product & environment policy – Final report, for Federal Services of Environment Department on Product Policy, Institut Wallon de Développement Économique et Social et d'Aménagement du Territoire ASBL/Vlaamse Instelling voor Technologisch Onderzoek, Namur/Mol, Belgium.

Nielsen, P.H., A. Tukker, B.P. Weidema, E.H. Lauridsen and Ph. Notten (2004). Environmental Impact of Natural Resources. ESTO/EU DG JRC – IPTS, Sevilla, Spain.

Nijdam D S, Wilting H. (2003). Milieudruk consumptie in beeld [A view on environmental pressure on consumption] Bilthoven: RIVM. (RIVM rapport 7714040004).

Palm, V., A. Wadeskog and G. Finnveden (2006). Swedish experiences of using environmental accounts data for integrated product policy (IPP) issues. Journal of Industrial Ecology 10.3

Peters, G.P. and E.G. Hertwich (2006). Measuring Household Environmental Impacts: The Case of Norway. Journal of Industrial Ecology 10.3

Suh, S., (2004b). Missing Inventory Estimation Tool (MIET) 3.0 User's Guide, included in the SimaPRO software package, PRe consultants, Amersfoort, the Netherlands.

Tukker, A., G. Huppes, S. Suh, T. Geerken, B. Jansen, P Nielsen (2006). Environmental Impacts of Products. Literature review and input-output analyses on 500 product groupings for the EU's Integrated Product Policy. ESTO/IPTS, Sevilla,

Wackernagel, M., Rees, W.E. (1996) Our Ecological Footprint. Reducing Human Impact on the Earth (New Society Publishers, Gabriola Island BC).

Wiedmann, T., Minx, J., Barrett, J., and Wackernagel, M., forthcoming. Allocating Ecological Footprints to Household Consumption Activities by Using Input-Output Analysis. Accepted for publication in Ecological Economics.

Weidema, B.P., A.M. Nielsen, K. Christiansen, G. Norris, P. Notten, S. Suh, and J. Madsen (2005): Prioritisation within the integrated product policy. 2.-0 LCA Consultants for Danish EPA, Copenhagen, Denmark

UNEP/IRM/RP/0711/04

Background Paper 3

Scientific assessment of global metal flows from a sustainable management perspective

Background Paper 3 for the meeting of the International Panel for
Sustainable Resource Management, Budapest, Hungary, 8-9 November 2007

Introduction

Consumption and production of metals impact on the environment in different ways. Understanding the structure of international flows of metals can help determine the extent and location of the environmental pressure. It can also help identify the affects on the efficacy of national recycling systems and additional pressures on supply. This paper provides an overview of key issues and identifies some questions that the Panel might wish to consider. The paper looks at the entire life cycle of metals, in a sustainable management perspective, from extraction via production and use to recycling and disposal.

Most of the metal ores in Europe and in countries like Japan and Korea are imported. In Europe, the total metal ore consumption was about 220 million tons in 2001, but only 20 % of this was produced domestically. Domestic extraction of metal ores declined from 150 million tons in 1971 to 43 million tons in 2001 (EEA 2005).

The metals with the highest consumption rates in the world include steel and iron, zinc, copper and lead. Iron is dominantly used to produce steel which is mainly used in the construction and motor vehicle manufacturing sectors. In 2001, 1050 million tons of iron and steel was produced. The biggest consumers were China (22 %) and the EU-15 (19 %) followed by the US (13 %) and Japan (10 %) (IISI 2002).

Metals are naturally non-renewable, but technically renewable through recycling. There are various ways of reducing the consumption and environmental impacts of the use of metals. One option is to decrease the pressures arising over the whole life-cycle of a resource, from extraction to waste. This includes more efficient production or improved efficiency of use, as in the case of aluminium cans with thinner sides. Another possibility is to extend their life-cycle, by maintenance, reuse, and recycling. The substitution of some non-renewable resources with renewable resources can also be an option (e.g. increased use of wood in the construction sector). However, this may be limited by the reproductive capacities of nature and the space available to produce renewable resources and should be carefully assessed to avoid problem shifting (Moll et al. 2005).

Environmental impacts in a life cycle perspective

Different metals, different impacts

Trends in use and in the related environmental impacts vary from one metal to another. The main problems for steel and aluminium are the volumes used and energy consumed. For lead and cadmium it is eco-toxicity and health impacts. While for copper and precious metals the amounts of waste generated during production are of main concern (EEA 2005).

All phases of the life-cycle of metals, from mining through production and manufacturing to use and final disposal are environmentally relevant. Extraction processes can be very damaging to landscapes. In certain parts of the world, waste from mining is the largest waste stream. A number of metals, such as gold, nickel and copper, are extracted with environmentally-intensive mining technologies, resulting in large quantities of waste, contamination of soils, landscape destruction and negative effects on natural water cycles (e.g. Kippenberger 1999; IIED/ WBCSD 2002; Ayres 2003; Miranda et al. 2003).

The stages of processing, i.e. concentrating and refining crude metal ore, smelting, forming, etc., are very energy-intensive. In general, other non-renewable resources are used (e.g. fossil fuels) and this leads to air emissions, which contribute to environmental problems such as climate change, air pollution and acidification. The environmental impacts of the use phase are determined mainly by the final product in which the metal is embodied, and have less to do with the nature of the metal itself. Life cycle assessment (LCA) studies show that the energy used by the end product is relevant, for example for heating buildings, fuelling transport vehicles, or providing electricity for refrigerators, electric and electronic equipment. However, there are still methodological difficulties in setting up clear system boundaries and allocation rules to account for the environmental impacts of metals over the entire life cycle. For some metals, such as copper, zinc and tin dissipative losses and corrosion during use may be also of concern (EEA 2005).

Identifying environmental hotspots using LCA

An example of a life-cycle based analysis to address the "environmental hot-spots" of metals is the study by Moll et al. (2005). It focuses on the iron and steel flows along the production-consumption chains in the EU. The study illustrated in Figure 2 shows that the environmental pressures of primary steel exceed those of secondary steel significantly (ore versus scrap based supply). The analysis, however, revealed that, even complete recycling (i.e. 100% of the currently generated scrap) would not fulfill current demand for steel and that scrap levels would not meet the level of iron and steel demand before 25 years in the future (an insight that would not have been reached without a material flow model). The results suggested technology improvements and indicated the need for higher materials efficiency in the sectors that use iron and steel as a base material.

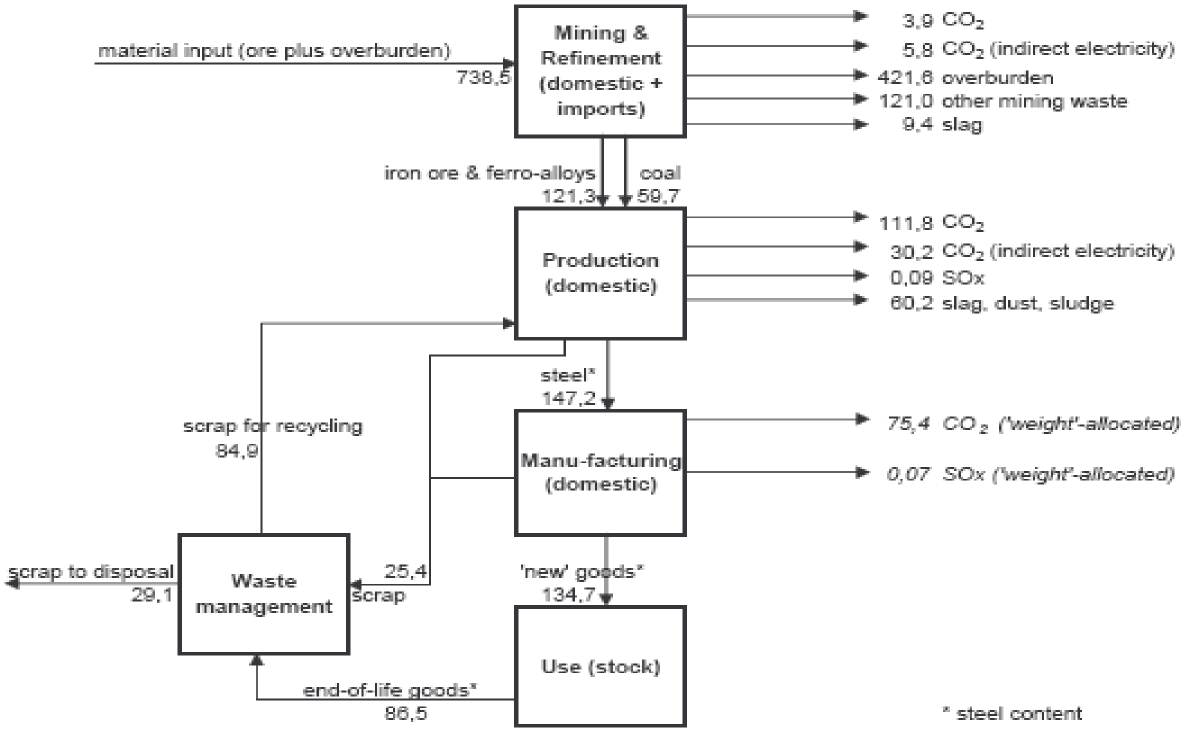
Recycling and resource productivity

Recycling versus landfill

Recycling is the most common way of extending the life-cycle of metals. It saves primary raw material inputs, reduces the extraction of crude metal ores and the associated environmental impacts and avoids emissions due to landfill. According to UNEP (2005) over 1 million tons of electronic waste still goes to landfill every year. This is one of the most widely used methods of waste disposal. However, it is common knowledge that landfills leak. The leachate often contains heavy metals and other toxic substances which can contaminate ground and water resources.

Recycling metals is an alternative treatment method. For instance, the recycling of 15 metal cans saves 1 kg of CO_2 in comparison to the production of these cans from primary feedstock as highlighted by Eco-Emballages

Figure 1: *Overview of the "environmental hot-spots" of the iron and steel system, European Union, 2000 [million ton] (Moll et al. 2005)*



(2007). The reason behind this saving in CO_2 emissions is the advantageous difference in the energy requirement for primary versus secondary feedstock for steel and aluminium production (Sinclair 2003).

In this way, recycling contributes to increased resource productivity (greater output or value added per unit of resources). Resource productivity has an affect on the production process and on economic growth through impacts on capital stocks, and through impacts on costs, especially in resource-intensive countries. At the same time, improved resource productivity is likely to be crucial in easing environmental constraints and in delivering greater welfare, as long as efficiency gains outweigh increases in demand (OECD 2007).

Recycling for the future

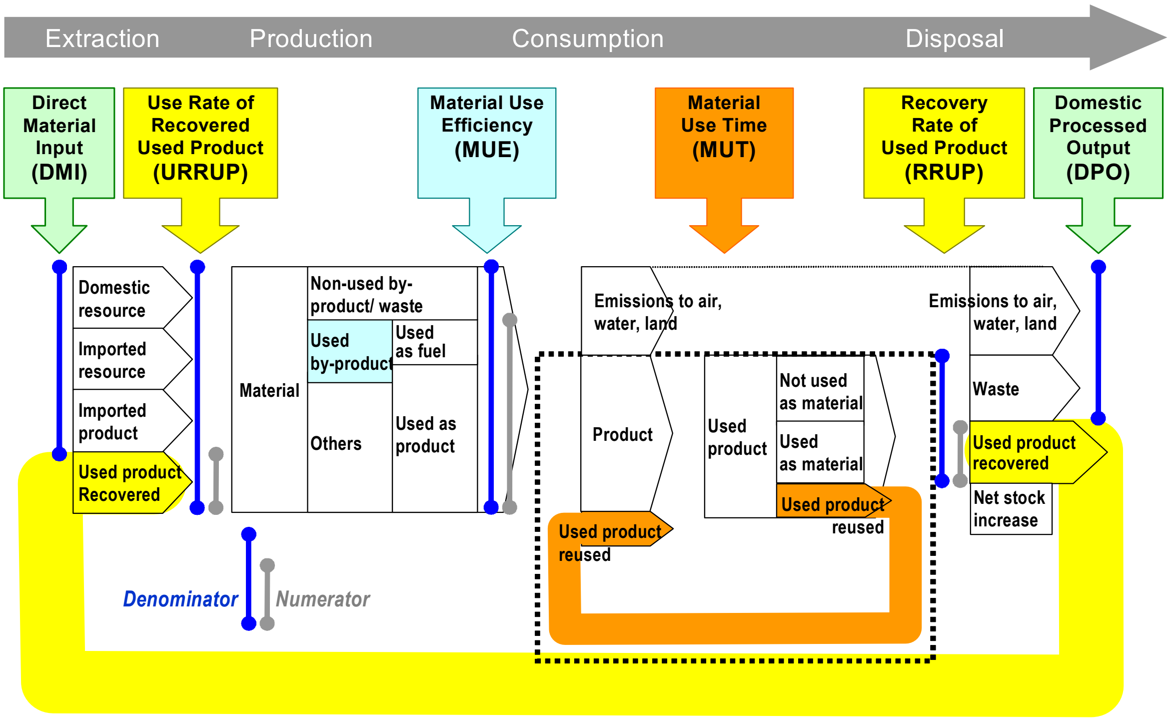
For some metals, high recycling rates have already been achieved. For example, the share of the secondary fraction (the share of scrap in the total input to production/smelting) for silver, copper and lead exceeds 50 % and is about 35–50% for steel, aluminium and zinc. The amount of metals currently being recycled cannot substitute for all primary metals because of the continuing increase in demand. In this context, the large amounts of metals stocked in buildings, infrastructure and durable goods may be seen as future metal sources, rather than future wastes. To increase the recycling of metals adequate product design is required. This facilitates the dismantling of products after their useful life (e.g. end-of-life vehicles, electrical and electronic equipment, machinery). But economic feasibility and environmental benefits need to be carefully analysed (EEA 2005).

The monitoring of recycling is not as straightforward as one may expect. Many indicators are used, including the composition of scrap reused in secondary smelters, the fraction of reused material per total amount of waste produced, the recycling rate of old scrap, and the amount of old scrap used for the production of metals. Several ways of measuring recycling rates are used based on material flow analysis (MFA) as shown in Figure 2 (Bringezu et al. 1995).

Figure 2: *Waste and recycling indicators derived from MFA (OECD 2007)*

Three material cycles are distinguished, each of them contributing to the objectives of a sound material cycle (i.e. preserving natural resources and minimising the environmental burden 🟩):
1-reuse of used products 🟧,
2-recovery of by-products (as material and heat) 🟦, and
3-recovery of used products (as material and heat)🟨.

Source: Hashimoto and Moriguchi (2004), Resources, Conservation and Recycling.



Identifying optimal recycling rates

Recycling rates per se may not be an indicator of progress towards sustainability. Additional information may be necessary to make an informed judgment since there is a growing debate on the benefits and drawbacks that metal recycling can put on the environment and human health, in particular in developing countries. In some cases, recycling may be associated with a higher burden on the environment than the route of primary processing. High recycling rates are counterproductive in such cases. From an environmental point of view there is a break-even point for an optimal recycling rate in the same way as from an economic perspective. In some developing countries, waste electronics, batteries, etc. are usually processed by "backyard" industries under less sophisticated processes. For example, circuit boards are treated in open acid baths next to rivers to extract copper and precious metals. Wires are collected and burned in open piles to recover re-saleable copper. Open fires release dangerous pollutants like POPs and burn with a lack of oxygen, forming carbon monoxide, which poisons the blood when inhaled (UNEP 2005).

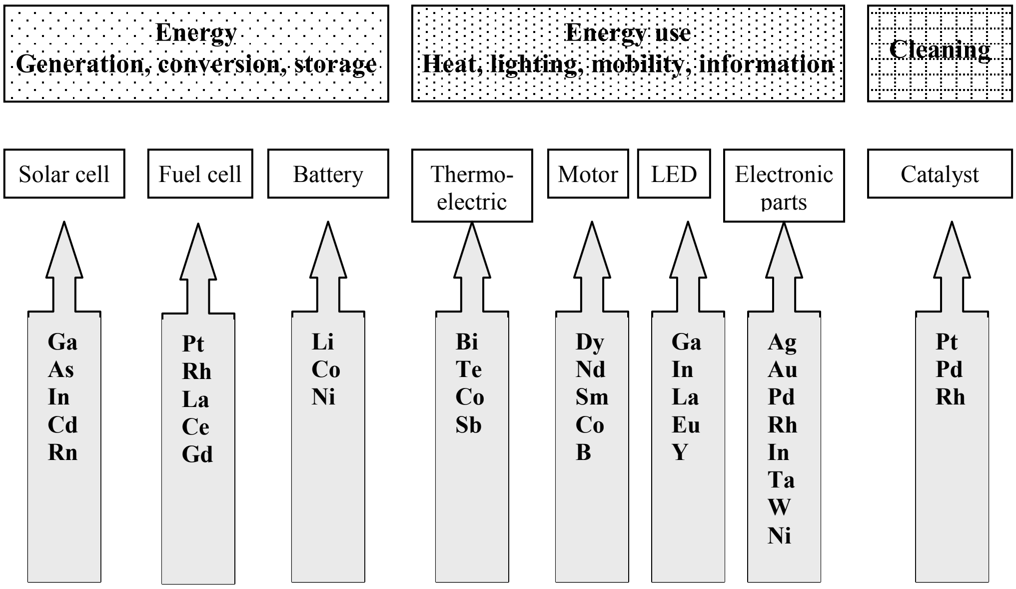
Supply security and resource economics

Growing dependence on recycled metal

How do we use metals? Should we worry about the sustainability of supply? To study these questions, the anthropogenic metals cycles have recently been quantified for several of the common engineering metals. It is clear that the world is moving from exclusive use of virgin ore towards fuller dependence on the recovery and use of recycled metal. (Graedel 2007)

In the future development of renewable energy systems, which are needed to mitigate climate change, such as thin-layers, new dye materials, novel photo-semiconductors and other technological innovations are expected. Light, strong composites and friction-less bearings are required for more efficient wind electricity. Heat resistant materials are critical to geothermal energy. Advanced catalysts and novel biochemical resistant materials will expand the possibilities of bio-energy use. Fuel cells will allow for the use of hydrogen energy. These new technologies need precious metals which require a considerable amount of energy to be produced and generate an enormous amount of waste when they are extracted and

Figure 3: *Rare metals which are required in eco-innovation (Halada 2007)*



processed. Figure 3 illustrates the metals that are required in the various fields of eco-innovation. (Halada 2007)

Is there any sign of a decoupling?

Halada (2007) analysed material consumption up to 2050 using a decoupling model from a certain stage of development (i.e. when GDP/ capita is less than a certain level, material consumption increases linearly with GDP/ capita; when GDP/ capita goes beyond a certain level, dematerialisation occurs). Decoupling had occurred in Japan for the case of Au, Sn, W, Cr, Zn, Cu and Pb. The forecast was made with the assumption that BRIC countries will follow Japan's path, using GDP growth predictions made by Goldman Sachs. The annual consumption of iron would be about 2.5 billion tons in 2050, and more than three quarters of this would be consumed by China and India. The accumulated consumption over time would be more than 100 billion tons and in 2050 close to the amount of current reserve estimates, which however would be far from depletion rates. The study by Halada (2007) came to the following conclusions:

- Metals that will be close to the level of reserves by 2050: Fe, Mo, W, Co, Pt, Pd
- Metals that will require several times the level of reserves by 2050: Ni, Mn, Li, In, Ga
- Metals that will run over the reserve base by 2050: Cu, Pb, Zn, Au, Ag, Sn

Reduce, reuse, recycle

According to Halada (2007), although Indium was currently considered to exceed the reserve base, it was not classified in the severest group because drastic new resource reserves are currently being investigated. Even so, many crucial metals are included in this final group. Copper is indispensable for electronic equipment. Silver and gold are heavily used in electric circuits like mobile phones and computers. Zinc is necessary for rust protection of motor vehicles. That means, if no new resource reserves were explored or reclaimed – including recycling – the world would face a crisis of supply security by 2050. In order to reduce overall risk for supply security Halada argues that it is important to improve resource productivity and to implement the 3R (reduce, reuse, recycling) principle. A factor 8 was seen as a good target of dematerialisation by Halada (2007).

Resource economics theories suggest that the functioning of the market should be the most important determinant of sustainable resource management. According to theory, resource use would be sustainable if: i) correct prices are applied to resources; ii) an economic rent is imposed on privately operated extractions; iii) the external costs of all stages of resource use are internalised; iv) sufficient competitiveness is ensured; v) all 'perverse' subsidies are removed. Ideal theoretical conditions, however, hardly apply to real markets. In reality, market prices are often distorted by subsidies and taxes; and actual prices do not include the external costs. Under such conditions, prices and price changes do not necessarily signal scarcity as the theory would assume. (EEA 2005)

Furthermore, analysing the economics of mineral extraction, Reynolds (1999) pointed out that improved extraction technologies and processes lead to lower prices, despite increasing resource scarcity. This might lead to market participants' expectation of continuing low prices for metals. Actors expect low prices because they are used to them, and because prices are shaped by different factors, not just physical scarcity of supply.

Concluding remarks

Preliminary discussions in the process of setting up the Resource Panel have identified the need to gather and assess existing scientific knowledge on the environmental impacts and resource productivity - including recycling - of metal flows and the risks for supply security. Policy makers need guidance on global recycling rates, supply security and environmental impacts associated with selected material flows to inform technology development.

Key Questions for the Panel

1. Is the extraction of virgin metals or the recycling of used metals better for the environment?

2. What are the gaps in knowledge that need to be filled with respect to the sustainable management of global metal flows?

3. What are the barriers and consequences that exist?

List of abbreviations

3R	Reduce, Reuse, Recycle
BRIC	Brazil, Russia, India and China
CO2	Carbon Dioxide
EEA	European Environment Agency
GDP	Gross Domestic Product
IIED	International Institute for Environment and Development
IISI	International Iron and Steel Institute
LCA	Life Cycle Assessment
MFA	Material Flow Analysis
OECD	Organisation for Economic Co-operation and Development
POP	Persistent Organic Pollutant
UNEP	United Nations Environment Programme
WBCSD	World Business Council for Sustainable Development

References

Ayres E. (2003). The Hidden Shame of the Global Industrial Ecology. World Watch Magazine January/ February 2004.

Bringezu, S., R. Behrensmeir, H. Schuetz (1995). Material Flow Accounts Part I: General Aspects, Aluminium, National Overall Accounts. Final Report of Phase I of the EUROSTAT Project 'Material Flow Accounts of Selected Products and Substances Harmful to the Environment'. EUROSTAT Doc. MFS/97/6.

Eco-Emballages (2007). Advertisement on recycling of metal cans, Paris.

EEA (2005). Sustainable use and management of natural resource. EEA Report No 9/2005.

Graedel (2007). Metal Stocks, Flows and Sustainability. Contribution to the R’07 World Congress on Recovery of Materials and Energy for Resource Efficiency.

Halada (2007). Eco-materials go into the Next Stage. Proceedings of the 8th International Conference on Eco-Materials – ICEM8.

IEED/WBCSD (2002).Breaking New Ground: The Report of the Mining, Minerals and Sustainable Development Project (MMSD). Earthscan Publications Ltd, London and Sterling, VA.

IISI (2002). World steel in figures, Brussels.

Kippenberger, C. (1999): Stoffmengenflüsse und Energiebedarf bei der Gewinnung ausgewählter mineralischer Rohstoffe - Auswertende Zusammenfassung. Geologisches Jahrbuch der Bundesanstalt für Geowissenschaften und Rohstoffe, Sonderhefte Reihe H, Heft SH10.

Miranda M., P. Burris, J.F. Bingcang, P. Shearman, J.O. Briones, A. La Viña, S. Menard, S. (2003): Mining and Critical Ecosystems: Mapping the Risks. World Resources Institute.

Moll S., S. Bringezu, H. Schuetz (2005). Resource Use in European Countries. Wuppertal Institute.

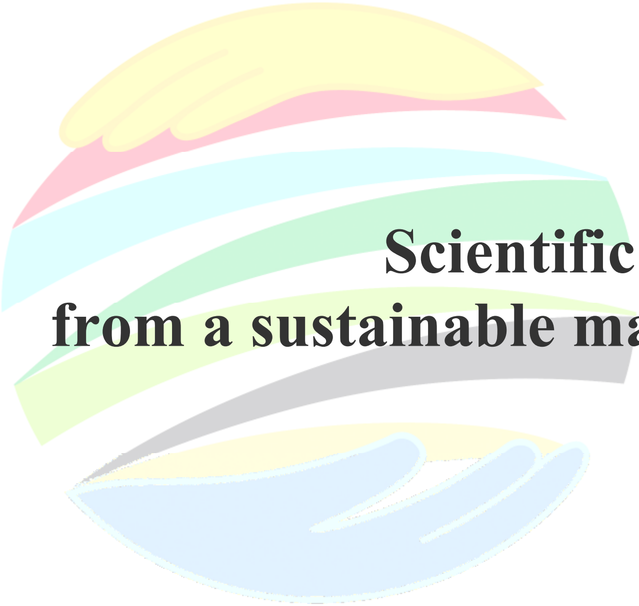
OECD (2007). Measuring Material Flows and Resource Productivity: An OECD guide. Working Group on Environmental Information and Outlooks. OECD document ENV/EPOC/SE(2006)1/REV2.

Reynolds, D.B. (1999). The Mineral Economy: How Prices and Costs can Falsely Signal Decreasing Scarcity. In Ecological Economics, Vol. 31, No. 1, pp. 155–166.

Sinclair R. (2003). Enhanced recycling. Canadian minerals yearbook.

UNEP (2005). Why tackle e-waste? Background document for IAA Interad Competition on e-waste.

Background Paper 4



Scientific assessment of biofuels from a sustainable management perspective

Background Paper 4 for the meeting of the International Panel for Sustainable Resource Management, Budapest, Hungary, 8-9 November 2007

Introduction

This paper points to some social, economic, and ecological sustainability issues due to the rapid development of biofuels. It considers the entire biofuels value chain, in a sustainable resource management perspective from production to use. The paper is based upon the most recent UN publication on bioenergy and includes excerpts from the document (UN-Energy (2007).

The paper focuses on modern biofuels, principally in the form of liquid and gaseous fuels. However, in order to sketch the whole picture, other bioenergy systems are also referred to (such as solid biomass use for electricity and heat generation).

The issues that stem from biofuels development are complex and highly dependent on local circumstances (climatic, agronomic, economic, and social). This paper is intended to give an overview of some principal trade-offs involved in biofuels development, and identify some questions that the Panel might wish to consider.

Recent and expected future developments of biofuels in the energy sector

Increased biofuels technologies

Modern biofuels technologies that produce transport fuel, in particular ethanol and biodiesel, are advancing rapidly. Biofuels has become one of the most dynamic and rapidly changing sectors of the global energy economy. The United States and Brazil are global players in the global biofuels industry, and many other governments are considering the appropriate role for biofuels in their future energy portfolios.

Biofuels production is on the rise

Global production of biofuels alone has doubled in the last five years and will likely double again in the next four years. Among countries that have enacted new biofuel policies in recent years are Argentina, Australia, Canada, China, Colombia, Ecuador, India, Indonesia, Malaysia, Malawi, Mexico, Mozambique, the Philippines, Senegal, South Africa, Thailand, and Zambia.

> *"The gradual move away from oil has begun. Over the next 15 to 20 years we may see biofuels providing a full 25 percent of the world's energy needs."*
>
> **Alexander Müller, Assistant Director-General for the Sustainable Development Department, FAO**

Oil demands and pressures

In the past three decades, oil-dependent economies have been affected by three dramatic oil price increases—in the mid-1970s, the early 1980s, and the current period (2004–07). Unstable and unpredictable oil prices have complicated economic planning around the world, and market analysts expect this pattern to persist. Oil production has already peaked in long list of major oil producing countries such as Indonesia, Mexico, Norway, the UK and the US.

Oil imports now consume a large share of the foreign exchange earnings of many developing countries, in some cases offsetting gains from foreign debt elimination agreements. Recent oil price increases have had important effects on many of the world's developing countries, some of which now spend six times as much on fuel as they do on health.

> *Senegalese President Abdoulaye Wade has described Africa's current oil crisis as "an unfolding catastrophe that could set back efforts to reduce poverty and promote economic development for years."*
>
> **Source: UN Energy, 2007**

For countries that obtain 50–100 percent of their energy demand from an increasingly unstable world oil market, the arguments for supply diversification are strong. Many of these nations lie in tropical zones where relatively low-cost biofuel crops, such as sugar cane and oil palm, grow. In this context, 12 African countries joined Senegal in forming the Pan-African Non-Petroleum Producers Association, aimed in part at developing a robust biofuels industry in Africa. The idea behind such efforts is to divert a portion of the money now being spent abroad on oil to local agricultural and manufacturing sectors, where it would strengthen economies and generate employment.

Limited experience with associated economic, environmental and social impacts

The rapid development of biofuels worldwide clearly presents a broad range of opportunities, but it also entails many trade-offs and risks. Experience with the associated economic, environmental, and social impacts is limited, and the types of impacts will depend largely on local conditions and on policy frameworks implemented to support biofuels development. Agricultural policy, including the availability of rural infrastructure, credit, and land tenure, will determine the scale and distribution of economic benefits. At the international level, efforts to reduce agricultural subsidies in developed countries and to allow free trade in agricultural commodities are inextricably linked to the development of first-generation [6] biofuels which have become the fastest growing segment of the world agriculture market. Trade reform efforts will both have powerful effects on and be subject to sizable impacts from biofuels expansion.

The development of new biofuels industries could provide energy services to millions of people who currently lack them, while generating income and creating jobs in poorer areas of the world. But rapid growth in first-generation biofuels production, for example, will raise agricultural commodity prices and could have negative economic and social effects, particularly on the poor who spend a large share of their income on food. In many countries, the current structure of agricultural markets means that the bulk of the profits go to a small portion of the population. Unless ownership is shared more equitably, this could become as true for energy commodities as it is for food commodities today.

Thus, the economic, environmental, and social impacts of biofuels development must be assessed carefully before deciding how rapidly to develop the industry and what technologies, policies, and investment strategies to pursue. Accelerated interest in biofuels in the coming years will place great demands on decision makers to evaluate and guide the development of these new industries. They will need to address structural problems in agriculture, forestry, and the economy as a whole so that the economic benefits to the poor outweigh the losses.

Key sustainability issues: a short overview

The sustainable bioenergy publication of UN-Energy (2007) identifies the following seven key sustainability issues in addition to the impacts on climate change, biodiversity, human health and resource management:

1. Ability of modern bioenergy to provide energy services for the poor

In many developing countries, small-scale bioenergy projects could face challenges obtaining finance from traditional financing institutions, since such initiatives generally have a less favourable risk rating compared to more well-established energy technologies. Although these projects could be critical in providing modern energy services to populations currently lacking access, they will likely require an effective microcredit delivery mechanism.

2. Implications for agro-industrial development and job creation

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[6] Some distinguish between first generation biofuels (fuels made from sugar, starch, vegetable oil, or animal fats using conventional technology) and second generation fuels (made from lignocellulosic biomass feedstock using advanced technical processes).

In the short-to-medium term, bioenergy use will depend heavily on feedstock costs and reliability of supply, the cost and availability of competing energy sources, and government policy decisions. In the long term, the relative economics of bioenergy will improve as agricultural productivity and agro-industrial efficiency improve and carbon markets mature and expand. At the same time, technological advancement will reduce costs and foster the emergence of a variety of new products, including advanced biofuels like cellulosic ethanol.

Successful bioenergy industries bring significant job-creation potential, with positions that include highly skilled science, engineering, and business-related employment; medium-level technical staff; low-skill industrial plant jobs; and unskilled agricultural labour. Because the vast majority of bioenergy employment occurs in farming, transportation, and processing, most of these jobs would be created in rural communities where underemployment is a common problem. The operation of these facilities generates additional rural economic activity, since the weight and volume of most biomass crops usually makes it necessary to locate collection and conversion facilities close to where the feedstock is grown. Jobs are being created in bioenergy agro-industries in rich and poor countries alike.

3. Gender implications

The most significant gender-differentiated and health benefits from modern bioenergy use relate to household applications. Smoke inhalation from cooking with traditional biomass indoors is one of the leading causes of disease and death in the developing world, responsible for more fatalities each year than malaria. The impacts, typically on women and girls, of walking long distances, carrying heavy loads, and collecting fuel in dangerous areas could also all be reduced by increased reliance on biofuels. While biofuels free women from collecting firewood, however, they could also generate additional work if women produce the biomass to make the fuel, such as for biogas.

4. Implications for the structure of agriculture

An important issue that needs to be addressed in the local context, is which crops are most promising. International capacity building is particularly critical at this stage of the bioenergy industry, where the expertise unique to bioenergy cropping practices, such as carbon-cycling cropping considerations, is concentrated in only a few countries (see Annex 3 for example).

5. Implications for food security

The availability of adequate food supplies could be threatened by biofuel production if land and other productive resources are diverted away from food production. Similarly, if biofuel production drives up commodity prices, as appears to be the case for corn and sugar in 2006 and early 2007, food access could be compromised for low-income net food purchasers. On the other hand, the market for biofuel feedstock offers a new and rapidly growing opportunity for agricultural producers and could contribute significantly to higher farm incomes. Modern bioenergy could make energy services available more widely and cheaply in remote rural areas, supporting productivity growth in agriculture or other sectors with positive implications for food availability and access.

6. Implications for Government Budget

To date, large government subsidies have been provided to biofuels. These subsidies are considerably larger that the benefits of potentially lower greenhouse gas emissions that arise from switching to biofuels. Because the magnitude of the subsidies provided to maintain a domestic biofuel market is very large, governments should examine alternative uses of the budget set aside for subsidizing biofuels to ensure that the objective of welfare maximisation is not seriously compromised. This is especially important in low-income countries where limited government resources compete for basic needs. The economics of bioenergy are situation specific, and each country will produce different results.

7. Implications for trade, foreign exchange balances, and energy security

In the case of energy, a relatively small number of countries dominate exports, while most countries import most of the fuels they consume. Diversifying global fuel supplies could have beneficial efforts on the global oil market. By some estimates, rising production of biofuels could meet most of the growth in liquid fuel demand in the next decades, particularly if second-generation technologies are available and if simultaneous investment in more-efficient transport limits the growth rate.

Agricultural commodities dominate the export earnings of many poor countries, but these earnings are limited by the fact that agricultural subsidies and other protectionist policies in industrial countries have reduced international agricultural prices and limited access to the world's wealthiest markets. Unlike with energy, most agricultural commodity prices today are well below the real price of 20 years ago. The linking of agriculture commodity prices to the vicissitudes of the world oil market clearly presents risks, but it is an essential transition to the development of a biofuels industry that does not rely on major food commodity crops. Rising prices for maize and sugar are a major new incentive to develop second-generation cellulosic technologies for biofuels.

The United States and the European Union have coupled subsidies for biofuels with import tariffs that ensure that these subsidies will benefit domestic farmers rather than those in other countries. This has led to the strange irony of virtually unimpeded trade in oil, while trade in biofuels is greatly restricted. Most experts agree that opening international markets to biofuels would accelerate investment and ensure that production occurs in locations where the production costs are lowest. Poor countries in Central America and sub-Saharan Africa are among those likely to benefit. Realising the full economic benefits of biofuels development, and minimizing the risks, will depend on building the human and infrastructure capacity to support it at the national level (see Annex 3).

Spotlight on the environment

From an environmental impact and resource management perspective, one of the greatest benefits of using biomass for energy seems to be the potential to significantly reduce the greenhouse gas (GHG) emissions associated with fossil fuels. One of the greatest risks, however, seems to be the potential impact on land used for feedstock production and harvesting (particularly virgin land or land with high conservation value), and the associated effects on habitat, biodiversity, and water, air, and soil quality. Additionally, changes in the carbon content of soils, or in carbon stocks in forests related to biofuels production, might offset some of the GHG benefits.

> *"Bioenergy provides us with an extraordinary opportunity to address several challenges: climate change, energy security and development of rural areas. Investments, however, need to be planned and managed carefully to avoid generating new environmental and social problems, some of which could have irreversible consequences. Measures to ensure sustainability of bioenergy include matching of crops with local conditions, good agricultural management practices and development of local markets that provide the energy poor with modern energy services."*
>
> **Achim Steiner, Executive Director of UNEP from UN Energy, 2007**

A better understanding is needed to fill gaps in knowledge regarding life-cycle GHG emissions (including nitrous oxide emissions) and other heat-trapping emissions associated with biomass production and use. Full life-cycle GHG emissions of bioenergy vary widely based on: land use changes; choice of feedstock; agricultural practices; refining or conversion process; and end use practices.

In general, crops that require high fossil energy inputs (such as conventional fertilizer) and valuable (farm) land, and that have relatively low energy yields per hectare, should be avoided. It is also critical to reduce if not eliminate the harvesting of non-renewable biomass resources, a problem in much of the developing world. However, even the planting and harvesting of "sustainable" energy crops can have a negative impact if these replace primary forests, resulting in large releases of carbon from the soil and forest biomass that negate any benefits of biofuels for decades.

Research on the net life-cycle GHG emissions associated with biofuels production and use is still under development, and estimates vary widely due to variations in circumstances. Results are highly sensitive to assumptions on land use changes, the effects of fertilizer application, and by-product use. With regard to transport fuels, the vast majority of studies have found that, even when all fossil inputs throughout the life cycle are accounted for, producing and using biofuels from current feedstock result in increased supply security and some reductions in GHG emissions.

In the future, "cascading" biomass over time, that is, using biomass materials for various uses and then recycling the wastes for energy, could maximize the CO_2 mitigation potential of biomass resources. It is possible to displace more fossil fuel feedstock, and thus derive a far greater carbon benefit, by first using biomass to produce a material (such as plastic) and subsequently using that material, at the end of its useful life, for energy production. Studies of the climate and economic impacts of cascading biomass have concluded that this practice could provide CO_2 benefits up to a factor of five.

Ultimately, the problems associated with land use for biofuels production (particularly virgin land), including deforestation, biodiversity loss, soil erosion and nutrient leaching, seem likely to remain the most complex and deserve the most attention. Depending on the type of crop grown, what it is replacing, and the methods of cultivation and harvest used, biofuels can have negative or positive effects on land use, soil and water quality, and biodiversity.

In the future, second-generation technologies could significantly reduce land requirements for biofuels production. At the same time, it is important to recognize that agricultural and forestry residues are necessary for maintaining soil and ecosystem health and that a certain amount must remain on the ground.

Health risks associated with the production of biomass are similar to those of modern agriculture, including exposure to pesticides (if used) and the operation of hazardous machinery. At the same time, biodiesel has positive health impacts due to reduced particulate emissions as compared to regular diesel, and use of ethanol to increase the octane level of gasoline can help lead phase out. Agricultural water could also be a serious concern especially where water is scarce and highly variable throughout the year.

More research seems necessary to determine which crops and management practices can best minimize impacts and maximize benefits. Unless new policies are enacted to protect threatened lands, secure socially acceptable land use, and steer biofuels development in a sustainable direction overall, the environmental and social damage might in some cases outweigh the benefits.

The Global Bioenergy Partnership (GBEP), which emerged from a commitment made by the G8 at the Gleneagles Summit in 2005, is focusing initially on two main areas: trade and the sustainability of bioenergy. To ensure that bioenergy can achieve its potential benefits, sustainability of the entire life cycle should be assured. Thus, GBEP partners, in particular UNEP, are in the process of defining sustainability criteria and suggestions for decision makers in both industry and government that aim to reduce risks as the bioenergy market develops. Issues for which criteria will be developed include: climate change, local air pollution, biodiversity, water, soil, land use, food security, and labour issues.

The Resource Panel might wish to contribute to this criteria development through its scientific assessment of biofuels from a sustainable resource management perspective.

Key Questions for the Panel

1. What are the comments of the Panel on the vision of sustainable bioenergy described in the UN-energy publication?

2. What is the current status of knowledge, according to the Panel, on perspectives for the crop production and trade flows for biofuels as well as the sustainability impacts of the production and use of these fuels for a set of global biofuel supply chains?

3. Should the Panel contribute to the development of sustainability criteria for biofuels and if so how?

List of abbreviations

CO2	Carbon Dioxide
GHG	Greenhouse Gas
GBEP	Global Bioenergy Partnership
UNEP	United Nations Environment Programme

References

UN- Energy (2007), Sustainable Bioenergy: A Framework for Decision Makers, United Nations Publication

Background Paper 5

Capacity building and international knowledge exchange

Background Paper 5 for the meeting of the International Panel for Sustainable Resource Management, Budapest, Hungary, 8-9 November 2007

Introduction

The Resource Panel identifies knowledge, data and capacity gaps in developed, developing and emerging economies, and suggests options to overcome barriers by means of capacity building, demonstration projects and international knowledge exchange. In this way and through the geographical balance in the composition of Panel members, capacity will be developed in the countries where it is most needed.

Link to UNEP's existing mechanisms

Overall, the strong need for capacity building in Africa and other developing regions was underlined during the entire consultative process. It was suggested to link training on topics on material flows and resource efficiency to ongoing capacity building efforts by UNEP on life cycle assessment within the UNEP/ SETAC (Society of Environmental Toxicology and Chemistry) Life Cycle Initiative (see Box 1). Training should include the statistical agencies in developing countries and economies in transition.

Addressing critical needs

It is important that people in all regions and all sectors are able to contribute to sustainable resource management in their local settings and more widely. Capacity building can therefore help all actors to achieve sustainable development outcomes. The capacity building work area may address needs related to:

- Motivation: which is present in organisations, if the perceived benefits exceed the costs.
- Awareness: which could be promoted in a traditional "top down" fashion via publicity. More effective is word-of-mouth publicity from one user to another prospective user, when it addresses the motivation question directly by speaking about tangible benefits based on real experience.
- Ability: promotion of which does not require that all actors become specialists in the area of sustainable resource management. It simply requires that persons in positions to provide and/or use knowledge on sustainable resource management are able to do this. Modest but targeted peer-to-peer training and technical assistance in demonstration projects could be seen as crucial.

Concluding remarks

International knowledge exchange on sustainable resource management is broader than the primary activities of the Resource Panel. It includes any enterprise, government or organisation that is reporting basic data (pro-actively or otherwise) that gets used in sustainable resource management and that takes action on the basis of this information on impacts throughout product life cycles. It also includes actors whose actions are promoted in the favour of sustainable resource management (economically or otherwise) by decision makers elsewhere in the supply chain.

Key Questions for the Panel

1. How will the Panel assess the state of knowledge and capacity for sustainable resource management in developing countries?

2. Should the Panel's work on capacity building in developing countries be linked to ongoing UNEP mechanisms such as the Life Cycle Initiative?

3. What other capacity building initiatives should be instituted?

Box 1: What is being initiated under the UNEP/ SETAC Life Cycle Initiative Work Area "Life Cycle Approaches for Capability Development?"

Facilitating education and awareness:

- Support of international and regional conferences
- Global dissemination of the "train the trainers program for Life Cycle Managers" through UNEP & SETAC channels, stakeholders and regional networks
- Preparation of e-learning tool

Clearinghouse:

- Translation of key documents in 4 UN languages
- Maintenance of a webportal with all available materials (reports, guides and training materials)
- Facilitating the access to commercial tools and databases

Facilitating the creation of regional networks and centres of excellence:

- Regional networks for Africa, Asia, Eastern Europe and Latin America
- Centre of excellence in Brazil

LCA Award for Non OECD Countries:

- Support of the development of case studies on life cycle approaches supported with free advanced commercial tools and databases

Annex 1

International Panel on the Sustainable Use of Natural Resources ("Resource Panel")

Pre-Panel Brainstorming Meeting: A Summary
DG Environment, Brussels, 8 December 2006

Introduction

A pre-panel meeting was organized as the first main activity of UNEP and European Commission (EC) led project titled "International Panel on the Sustainable Use of Natural Resources (Resource Panel)". The aim of this meeting was to brainstorm with experts on potential topics for consideration by the Panel.

A total of 18 participants were present at the meeting, with ***12 experts from Ethiopia, Peru, Germany, Austria, Brazil, Japan, Canada, China, European Environment Agency (EEA) and the Organization for Economic Co-operation and Development (OECD)*** taking part in the discussions. The meeting was chaired by the European Commission (EC) with UNEP acting as the facilitator and rapporteur.

Mr. Timo Makela, EC's Director of Sustainable Development and Integration from Directorate General (DG) Environment, opened the meeting with a brief explanation of the project background. This was followed by a roundtable introduction of pre-panel participants (see Table 2 for the full list of participants) and a debriefing of the Bruges conference on Sustainable Resource Management, held on 6-7 December 2006 (please refer to conference website http://www.coleurope.eu/template.asp?pagename=chairtoyotaconfbruges2006). The informal brainstorming exercise with the pre-panel experts immediately followed, which continued until the end of the meeting (see Table 1 for meeting agenda and annotated agenda).

This summary report crystallizes the main points discussed during brainstorming segment of the pre-panel meeting.

Issues for Consideration by the Panel

Country	Views and Comments
Japan	• Interested in circulation of materials: natural resources management linked to recycling policy in Japan. • Prefers that the Panel does not focus too much on intangible aspect of resources (such as biodiversity and ecosystem services), but rather on tangible flows (such as metal, minerals etc.). • Need a common understanding of fundamental underlying concept, principle and vision when considering natural resource use. • Scientific assessment of environmental impact important for both primary and secondary resource use, hence the importance of recycling. • There is a need for better internationally compatible database (improved basic statistics).
Austria	• Vision of systematic perspective needed (socio-economic). Focus initially on energy, material and water, their inter-relation at the technical level and economic level. A key sector that has to change is infrastructure which is part of sustainable production and consumption related work. This will also link public and private sectors. • Elements of consideration that would cross-cut all topics include natural resource security, identifying link between use of natural resources and economic development (quality of life), environmental impacts and equity issues.
Brazil	Suggested topics can be grouped into three categories: 1) *Technical issues* • Important to include soil into the analysis in ways that address the maintenance of soil quality (as it affects productivity) and the relationship between soil and water (considered important in the desertification process). • The sustainable use of the underground water, which should include overexploitation, contamination and the replenishment of aquifers. 2) *Social and geographical trends* • Consider examining the relationship between the use of natural resources and social conditions of countries. Does increased resource efficiency and economic growth go in parallel with poverty alleviation? In this vein, biofuel and biodiesel ("social fuel") topic is of great interest. Should perhaps consider involving Petrobras in the biofuel work. • Analyze international trade and consumption of natural resources to identify where and how the externalities (positives and negatives) are occurring. 3*) Vision of the future* • Need to go beyond just providing scientific assessment and policy advice and develop a kind of a vision of the future, suggesting alternative ways of producing and consuming and pointing towards a new form of economic development. Measuring progress (indicators) will also be an important element to this work.

Country	**Views and Comments**
Germany (Wuppertal)	• Need to develop a future vision on ways in which development takes place. Panel experts need to provide a positive future vision. • Topic focus is necessary but on the other hand systematic perspective is needed that would help avoid shifting impacts. Use of integrated assessment tools is needed in this regard. • Biofuel topic needs a systems analysis approach (real impact with regard to climate mitigation, competition of land use, biodiversity etc.) • Forward-looking /alternative scenarios should be suggested. • Capacity building in development countries.
Ethiopia	• Resource use and extraction are linked to poverty issues (number of jobs etc) in the African continent as well as social stability especially in resource rich countries (such as Angola, Sierra Leone, Congo, and Nigeria). • Topics that the Panel could look into include biofuels, waste recycling, eco-labelling, eco-design and biodiversity (Africa is a hotspot for biodiversity).
China	• Circular economy framework in China aims to achieve resource efficiency while decreasing environmental load. Legislation on circular economy has been launched by the National Peoples Congress with focus on resource use and extraction and application of life-cycle thinking. • EC-funded project titled “PRODEV” is currently being implemented in Guiyang city that aims to develop a policy package geared to implement the circular economy framework at the local level. • Policy analysis that spells out different options (scientific scenario analysis). • Supports capacity building efforts in developing countries
Canada	• Geographical balance in the Panel needed. • Industry representative should be included in the Panel.
Peru	• Outreach and education important for next generation. • Need to connect with existing institutions (e.g., environmental conventions) so that the Panel fills the gaps and not duplicate already ongoing work.
EEA	• Information flow exists in multiple layers. • Capacity building should be a key activity (within the 30 EU country context) • EEA is ready and willing to support the works of the Resource Panel • Challenge will be working with many different levels of the issue (scientists, businesses, governments etc) • Systematic approach encouraged: combine national capital (tangible) with ecosystem services (intangible) when assessing environmental impacts. • Use of resources linked to consumption patterns (mainly household but public consumption also an issue). • Panel should focus on concrete short-term topics and at the same time provide an outlook for long-term.

Country	Views and Comments
OECD	• Economic thinking is important for policy dimensions. • OECD's work will fit well with Resource Panel activities which can build from the kind of work OECD is doing to a global level. The Panel should aim to provide a blueprint for an international framework on relevant topics. • Need to include in the overall package, namely the economic aspects (pricing of natural resources and internalizing externalities etc. which can influence consumption patterns). Linked to the concept of natural resources rent etc. • Short-term: focus on flow of metals. • How to construct a viable (economically) recycling investment framework, nationally and internationally. • How to reduce distortion and obstacles to supply, trade and demand of materials.

Conclusion and follow-up

The outcome of the pre-panel brainstorming session directed the work of the Panel on two levels:

First, to ***focus on a few issues that have immediate international policy relevance, such as biofuels and global material recycling, so that once scientific case has been made, it can be picked up by policy-makers***.

Second, to ***outline systematic approaches to establishing a global vision on alternative socio-economic development paths*** (with linkage to existing national/regional and global initiatives) based on sustainable use and management of natural resources. This would constitute a longer-term work of the Panel.

In the course of the next few months leading to the second pre-board meeting scheduled in March 2007, the secretariat will engage in the following:

Administrative Aspects	Resource Panel	Outreach
Draft administrative and organizational aspects of the functioning of the secretariat with roles and responsibilities of the Panel members, Secretariat and Board.	Draw up a first comprehensive list of potential Panel members for selection. Number of Panel members for inaugural meeting is set to maximum 15.	UNEP GC24 side event (consider "co-organizing" the event with governments of Brazil, Japan, Canada and China) on 8 February 2007.
Look into setting up of a Resource Panel trust fund.	Resource Panel strategy document: as a first step, outline modalities for addressing suggestions made by pre-panel experts.	Organize bilateral meetings with government high-level officials at GC and other venues.

TABLE 1: PRE-PANEL MEETING MINUTES

Agenda	Minutes
Item 1: **Opening of the Meeting**	Timo Makela (TM), Director of Sustainable Development and Integration at DG Environment opened the meeting at 10:00, 8 December 2006.
Item 2: **Opening remarks by Chair and Secretariat**	TM introduced the EU Thematic Strategy on the sustainable use of natural resources (COM(2005) 670 final) and how EC fits into the overall establishment of the set up of the International Panel on the Sustainable Use of Natural Resources ("Panel"). Bas de Leeuw (BdL) from UNEP supported TM's introduction by explaining how UNEP can support the works of the Panel, and informed the participants that UNEP will host the Panel's secretariat.
Item 3: **Roundtable introduction of pre-panel participants**	TM asked the participants to introduce themselves. The pre-panel participants include a mixture of experts and government officials (see Annex 2 for list of participants).
Item 4: **Debriefing of Bruges conference and discussions**	Dr. Stefan Bringezu, Director of the Research Group Material Flows and Resource Management, Wuppertal Institute, gave a debriefing of the Bruges conference titled "Sustainable resource management, raw materials security, Factor-X resource productivity – tools for delivering sustainable growth in the European Union" which was held from 6-7 December 2006 in Bruges. He summarised the conference as a whole with emphasis on issues pertaining to non-renewable resources. This will be followed by a debriefing of the "Beyond Europe" session by Dr. Yuichi Moriguchi, Director of the Research Center for Material Cycles and Waste Management, National Institute for Environmental Studies where Japan's 3R platform was introduced. In addition to Dr. Stefan Bringezu and Dr. Yuichi Moriguchi, Dr. Valentin Bartra from Peru, Mr. Hiroaki Takiguchi from Japan and Dr. Guomei Zhou from China were also present at the Bruges conference.

Agenda	Minutes
Item 5: **Informal brainstorming on priority issues/topics for the Resource Panel**	The informal brainstorming exercise with the experts was the main segment of the pre-panel meeting. The objective of this brainstorming session was to: • seek general comments from pre-panel participants on the setting up of a Resource Panel; • seek reactions/feedback from pre-panel participants on the suggested topics/issues in the background/discussion document; • explore linkages with on-going international initiatives (such as the 3R and circular economy); • draw a common recommendation on some of the priority areas/issues that the Resource Panel should include in the first few years of its work programme; and • ask for recommendation of experts and organizations to invite as Panel members. UNEP's Inhee Chung (IC) introduced the distributed discussion/background document to initiate reactions/discussions from the pre-panel participants. The floor was then opened for comments and suggestions from the pre-panel participants (please see summary report for details of this discussion). In the absence of TM, MR. Klaus Kögler (KK), Head of Sustainable Production & Consumption unit at DG Environment chaired the afternoon brainstorming session, with BdL facilitating the discussions.
Item 6: **Next steps and other business**	Following the brainstorming exercise, IC asked the participants to send additional inputs after the meeting. IC also briefed the participants on the upcoming 24th session of the UNEP Governing Council (GC) scheduled in February 2007 where UNEP plans to have a side event. IC asked for support especially by participants from governments.
Item 7: **Closing of the meeting**	With no other business, KK closed the pre-panel meeting.

TABLE 2: LIST OF PARTICIPANTS

Name	Nationality	Affiliation
Dr. Getachew ASSEFA	Ethiopia	Royal Institute of Technology, Stockholm, Sweden.
Dr. Valentin BARTRA	Peru	Universidad Nacional Mayor San Marcos, Instituto Andino, Lima, Peru
Dr. Stefan BRINGEZU	Germany	Wuppertal Institute for Climate, Energy and Environment
Dr. Marina FISCHER-KOWALSKI	Austria	University of Klagenfurt; Institute of Social Ecology at the Faculty for Interdisciplinary Studies (IFF)
Dr. Luiz Fernando Krieger MERICO	Brazil	Ministry of Environment, Brazil
Dr. Yuichi MORIGUCHI	Japan	National Institute for Environmental Studies (NIES), Japan
Mr. Hiroaki TAKIGUCHI	Japan	Ministry of Environment, Japan
Mr. Eric ROBINSON	Canada	Mission of Canada to the European Union (BREU)
Dr. Guomei ZHOU	China	State Environmental Protection Administration (SEPA), China
Dr. David STANNERS	EEA	European Environment Agency (EEA)
Mr. Lars Fogh MORTENSEN	EEA	European Environment Agency (EEA)
Dr. Christian AVEROUS	OECD	Organization for Economic Co-operation and Development
Mr. Timo MAKELA	EC	European Commission
Mr. Klaus KÖGLER	EC	European Commission
Ms. Anne-France WOESTYN	EC	European Commission
Mr. Werner BOSMANS	EC	European Commission
Mr. Bas de LEEUW	UNEP	United Nations Environment Programme (UNEP)
Ms. Inhee CHUNG	UNEP	United Nations Environment Programme (UNEP)

Annex 2

UNEP workshop report

Resource Efficiency and the Environment:
Identifying Key Resource Flows

Tokyo, 25 September 2007

Opening remarks and Session 1 on Needs and ways of identifying resource flows

The presentations in the first part of the workshop indicated that there were synergies to expect with regard to geographic scope and the working approach taken between the ongoing activities of OECD on material flows, resource productivity and sustainable material management and the upcoming efforts of UNEP in the context of the international resource panel. The presentations about the OECD work showed that the OECD had set the ground for international guidance on material flow methodology and was now moving from knowledge to policies and individual material flows like steel and iron, aluminium, etc. The OECD work had been initiated largely for reasons linked to waste economics and had over time developed towards more focus on materials. UNEP had been working on environmental impacts in life cycle assessment, had developed together with UN DESA the Marrakech Process on Sustainable Consumption and Production and was now looking at how to achieve decoupling of environmental impacts from economic growth. The Resource Panel would carry out scientific assessments of consumption and production with a life cycle perspective, comprising material flows from the extraction of resources to final waste disposal. One of the overall aims of both OECD and UNEP was to internalize external costs along the value chain. Equally, synergies between these initiatives and both EC and US policy were striking. See Table 1 for a full list of meeting participants.

For all governments presenting in Session 1, the area of Resource Efficiency and the Environment belongs to their work on 3R (reduce, reuse, recycle) or circular economy. Waste was seen as a "wasted resource". In this context, governments were in particular interested in overall resource productivity and recycling rates for key material flows. Recycling was considered to reduce environmental impacts and to increase supply security. Related material flow studies had been carried out in all countries presenting in the first session, especially for the metal sector. Globally recognised scientific assessments, however, were still missing.

Participants agreed on the need for identifying key resource flows and product groups and on the need for shifting the economy to more environmentally friendly types of material use. As a particular important challenge the move from an economy based on energy from fossil fuels to an economy using renewable resources such as biomass, water, wind and sun was highlighted. Material flow related analyses were seen as a way that could help in the identification of key resource flows. A system-analytical perspective would help recognise interconnectedness of environment and economy. Emphasising actions in the early stages of material life cycles would facilitate the change towards more environmentally friendly products and their key compounds. Therefore, it would be important to share concrete experiences at the international level, which could be replicated and for which suggestions for improvement could be exchanged.

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

In Session 2 a variety of studies contributing to basic knowledge on the environmental impacts and the socio-economic relevance of resource flows was presented. The presentations reached from attempts to address the environmental impacts of resource flows via comprehensive studies on metal flows and its impacts in developing countries to questions such as which renewable resources were problematic for energy supply in Africa and in particular in the Congo region.

With regard to trade flows of resources and materials it was said that data were available. These would indicate that usually only a small number of source countries accounted for a large share in the imports to the EU of particular trade flows. Recent international developments like those affecting WTO arrangements, EU directives on particular products (e.g. biofuels) and consumer issues (e.g. GM soybean) could be easily detected in trade data.

For the case of a computer CPU (Central Processing Unit) it was demonstrated that 100 times more material was consumed at the resource end than at the consumer end. Therefore, it would be important to take the hidden material flows (the "ecological rucksack") into account. This means in particular for countries that import most of the raw materials that the Domestic Material Input (DMI) is not sufficient as an indicator for resource efficiency, but that the Total Material Requirement (TMR) should be used.

With regard to environmental impacts three approaches were mentioned: environmental footprint, life cycle impact assessment and site specific environmental impact information (with quantitative data or as qualitative descriptions). It was highlighted that there were data gaps, and data discrepancies. There were also some key unanswered questions on methodologies, for instance on how to compare impacts across different trade or material flows, on how to provide one indicator for all environmental impacts by weighting, and on how to come up with at least one indicator for each policy area like Climate Change, Resources, Human Health and Biodiversity. Due to differences in policy regimes (regulation, monitoring, and enforcement) and the nature of production (scale of production and local sustainability issues) there would be differences in impacts per unit of output between countries with resource extraction and material production.

As a first step forward the Environmentally weighted Material Consumption (EMC) approach was developed, which combines information on mass flows (DMC or TMC) with information on environmental impacts, using Material Flow Analysis (MFA) databases for mass flows per material or resource and a standard Life Cycle Assessment (LCA) database for environmental impacts per material or resource. EMC was developed to ensure a double decoupling of both environmental impact and resource use from economic growth. While material flow balances were dominated by high volume construction materials, with the EMC approach medium volume flows had high impacts: Greenhouse gas emissions were dominated by fossil fuels and land use by agriculture, especially animal farming. For the low volume flows a high impact originated from metals.

It was indicated that metal prices would continue to increase together with the total consumption in line with GDP growth until 2050 (i.e. no absolute decoupling), if no adequate actions were taken. Gold and copper were used as examples of metals which would be consumed at an unsustainable rate leading to a depletion of the known resources by 2050, hence causing risk for supply security in the future. Therefore, a resource-efficiency gain of factor 8 would be needed. Recycling of both production and post consumer waste could help to achieve this. It was, however, commented that this was a rather critical statement, as many authors argue that the reserves are flexible and increase when the prices increase.

Severe health problems of lead battery recycling with high exposure concentration to lead were reported in developing countries. Due to unfavourable economics, backyard smelters would continue to thrive in countries like India. A way forward was seen in the 3R efforts linked to Extended Producer Responsibility (EPR) and better environmental sustainability targets through a certification system. It was agreed widely that strategies for preventing hazardous emissions from recycling in developing countries were needed.

With regard to the question on which renewable resources were problematic for energy supply it was articulated that biomass was an inefficient means to use solar energy and that photovoltaic energy supply would be more efficient. The question of the usefulness of biomass for non-food purposes, in particular as bio-fuels (1st and 2nd generation), would deserve a detailed scientific assessment, using a comprehensive systems perspective through an integrated MFA and LCA approach. LCA studies showed an increase of impacts on eutrophication, acidification and land use and gave a mixed picture with regard to greenhouse gas emissions. However, LCA methodology could not cover impacts via changes of land use pattern (e.g. biodiversity). Moreover, the competition issue between food and cropping area would need particular attention. Recent analyses show that business-as-usual, fostering the use of biofuels in countries like Germany, will lead to an expansion of global arable land, and thus to increased global warming and loss of biodiversity.

It was highlighted that minerals and metals (including those that were very rare elements) would be needed for renewable energy solutions using flow resources (water, wind and sun). Hence, there would also be a need to analyse and optimise material and energy systems of metals and minerals with regard to life cycle environmental impacts, recycling rates and supply security. is important to mention that the required metals are often very rare elements, which makes this aspect even more critical

Lack of water availability and low quality were mentioned as major limiting factors for development in Africa. Other key environmental impacts for Africa were biodiversity and deforestation since Africa was a hotspot for biodiversity and Africa had the highest rate of deforestation anywhere in the world. An unsustainable use of Africa's natural resources could lead to an erosion of its wealth, forcing the continent to slide deeper into poverty. Sustainable consumption and production policies in Africa with the aim of contributing to the Millennium Development Goals would mean to take the challenge of meeting basic needs into account.

Participants were aware that environmental impacts of materials were only one of the required inputs for setting priorities. In addition, economic development perspectives, supply security, resource constraints (e.g. land and water) and social impacts like food security, working conditions and trade issues were among the other relevant factors mentioned for decision-making on prioritisation.

Biofuels were seen as an opportunity for rural development in Africa, considering, however, environmental and social risks. In principle, at least in certain parts of Africa a well established agro-industry was available that would be ready for diversification. In particular sugar cane would have a huge potential as an energy efficient crop. However, LCA impact categories with problems due to biofuels were euthrophication and water consumption, and any extension of arable land would have to be done carefully.

Industrial Ecology was presented as a framework that could be applied to the Congo region and help this zone by quantifying the material flows in Congo Basin Forests and the environmental impacts associated with these flows. Logging (legal and illegal practices) was seen as driving the other impacts. In addition, gaps in political, social, regulatory, market interventions were to be identified. This information might help sensitizing decision makers and could be integrated into programmes by regional governments, trading blocs and political institutions.

Overall the strong need for capacity building in Africa was underlined. It was suggested to link LCA and MFA training. Ongoing capacity building efforts by UNEP on LCA within the UNEP/ SETAC (Society of Environmental Toxicology and Chemistry) Life Cycle Initiative might be strengthened. Training on MFA should include the statistical agencies in developing countries.

Session 3 on Challenges and Way Forward

In addition to environmental impact, supply security was clearly identified as another factor to take into account when identifying key resource flows. Supply risk was defined as including geologic, regulatory, technical, geopolitical and social availability. Half of the periodic system was needed to produce one mobile phone. So it was important to know about the supply risks and in particular the reserves. How much of the material is still left? How much is in use? Where it is going to? And where are the reserves geographically located? It was emphasised that these questions would be of interest for governments and companies. The impact of shortage would have consequences on product development and manufacturing limitation. Since most product designers were not aware of these risks, dissemination of the lessons to product developers was needed.

It was pointed out that recent developments in the area of material flows using input-output analysis had allowed prioritizing product groups with regard to their overall environmental impact in relation to their contribution to economic growth. The EIPRO (Environmental Impacts of Products) study had identified for the EU-25 the following three products group as having the greatest impact: i) food and drink, ii) private transport and iii) housing. Together they were responsible for 80% of the environmental impact but accounted for only some 60% of consumption expenditure.

These studies were considered to show that an accounting system based on input-output tables (IOT) with environmental extensions (EE) allowed analysing drivers of environmental impacts with one single coherent data set, from a final consumption, product, industry, and resource use perspective. Where traditionally EE IOT just mapped monetary relations in the economic system, the same accounting framework could be used equally well to include data on physical resource flows. EE IOT would be suitable for three main applications: i) Problem analysis (typical questions: pollution embodied in final consumption, pollution embodied in trade, etc. - for this, a static table for a specific year would be sufficient); ii) 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 were needed, and via techniques such as decomposition analysis the factors driving changes in environmental pressure could be identified); iii) Foresight and scenario analysis (a scenario could be ‘imposed’ on the table, which for such purposes then usually would be used with a dynamic model).

Finally the role of the rapidly industrializing economies for global resource efficiency was discussed. Several developing countries had shown that resource efficiency could be improved even during periods of rapid economic growth. In general, theses countries would move up the Kuznet curve from agriculture via manufacturing to services and thereby improving the resource efficiency from step to step. However, while resource efficiency could be reduced in a country (within national boundaries) it was not clear if at the same time this would not generate an increase outside the country and thus at the global level. This would be due to induction of domestic consumption into other countries which would absorb delocalised agriculture and manufacturing. This question would deserve a global assessment. It became evident that global IOT would be necessary for such studies.

Conclusions

At the end of the workshop, UNEP thanked the participants for their valuable contributions and concluded that the workshop had helped the Secretariat of the Resource Panel in developing elements of a work plan for the Panel.

The following elements were identified:

i) Development of a **scientific understanding of decoupling** and related methodologies and indicators;
ii) Scientific **assessment of key resource flows** with integrated MFA and LCA methodology, probably looking first at selected metal flows and at an appropriate moment in time also at bio-fuels;
iii) Scientific study on the **prioritisation of materials** on the resource side end and of products on the consumption side, using static EE IOT;
iv) Need for **capacity building in developing countries** and economies in transition was again underlined

As said at the beginning of the workshop, contributing to a scientific understanding of decoupling environmental impact and resource use from economic growth was the overall aim of the Panel. The workshop clearly demonstrated that therefore on the one hand the available **indicators** would need to be discussed. This would include on the economic side to explore if it would be possible to go beyond GDP and on the environmental side and resource side to see if there was an overarching indicator or which group of indicators could be used. On the other hand, an adequate methodological framework for scientific assessment and scenario analysis of decoupling opportunities would have to be developed at one point. From the workshop it looked like EE IOT might offer some possibilities in this respect.

From the workshop it appeared that a scientific assessment of **metal flows** with regard to environmental impacts, supply security and recycling rates would be an area of broad interest. Much scientific information would already be available and an agreement on the methodology (integrated MFA and LCA) to apply would largely exist. The supply of metals was considered of strategic importance for any country and its importance was considered to increase in the future due to the expected changes in energy production towards renewable sources, in particular flow resources such as wind and sun. At the same time, it was said that precious metals would belong to those materials that had the highest ‘environmental rucksack’ per kg output. The major task for the Panel would be to contribute to enhancing resource efficiency and fostering global recycling.

Another topic that was mentioned by several governments as being the priority flow for them for further scientist assessment was **biofuels**. The challenge would be to come to a good balance of issues such as the global expansion of arable land, minimize competition between food and non-food use and to optimize the use of. In this area, the Panel would have a number of recent scientific studies to review. Although methodological questions with regard to a global assessment of situation-dependent water and biodiversity impacts in a life cycle perspective might need to be tackled, the Panel could have an immediate added value in strengthening the scientific base for this important policy area.

A scientific study on the prioritisation of materials and products, using static EE IOT, was by many seen as a promising first step to **assess current resource use** in an integrated way - including all material flows at once. As a first step, a framework for the scientific methodology behind the assessment studies would have to be prepared. Then, as a second step, the available scientific information with regard to the resource use and environmental impact of material flows and their contribution to economic growth could be summarised in an assessment report indicating priority production sectors and consumption product groups on the global level and opportunities for decoupling and resource-efficiency gains. The assessment might have to be extended to the regional level to take into account the particular needs of regions like Africa and Latin America.

TABLE 1: LIST OF PARTICIPANTS

Name	Nationality	Affiliation
Graham Turner	Australia	Stocks and Flows Frameworks, CSIRO Sustainable Ecosystems
Nina Eisenmenger	Austria	IFF - Faculty for Interdisciplinary Studies, University Vienna
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Tomas Hak	Czech Republic	Environment Center, Charles University
Jan Kovanda	Czech Republic	Ministry of the Environment
Ole Gravgård Pedersen	Denmark	Statistics Denmark
Werner Bosmans	Europe	DG Environment, European Commission
Jörg Alexander Hanauer	Europe	DG EUROSTAT, European Commission
Pawel Kazmierczyk	Europe	European Environment Agency (EEA)
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Name	**Nationality**	**Affiliation**
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Arnold Tukker	Netherlands	Innovation and Environment TNO Built Environment and Geosciences
Ester van der Voet	Netherlands	CML, Leiden University
Julie Hass	Norway	Statistics Norway
Christian Avérous	OECD	Environment Directorate
Myriam Linster	OECD	Environment Directorate
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Guido Sonnemann	UNEP	Division of Technology Industry & Economics
Derry Allan	USA	US Environmental Protection Agency
Thomas Graedel	USA	Industrial Ecology, Yale University
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Annex 3

AEA Energy & Environment
From the AEA group

METROECONOMICA
Economic and Environmental Consultants

Strengthening the Knowledge Base for Sustainable Use of Natural Resources

A study by AEA Energy and Environment and Metroeconomica for DG Environment of the European Commission[7]

1. Introduction

European and other major economies depend on natural resources for their prosperity, but current patterns of increasing resource use are causing environmental pressures and environmental degradation globally. In order to tackle this issue, the European Commission has developed a "Thematic Strategy on the Sustainable Use of Natural Resources[8]" with the overall objective of decoupling economic growth from environmental degradation through improved resource efficiency **and** reduced environmental impact of resource use.

As for most developed regions, the EU is highly dependent on resources coming from outside Europe, and as such is in effect exporting environmental impacts. This study aims to assess the current state of knowledge on highly significant trade flows into the EU and their environmental impacts in order to improve the information basis for decision makers in policy and other areas. It will further develop a related database of worldwide contacts and expertise. It also aims to stimulate expert discussion on the way forward in policy development for sustainable use of natural resources. The final stage of the project will be to assess and make recommendations on which of the resource flows analysed should be tackled with priority. As the EU trade patterns have similar environmental impacts as most developed regions, the results of this study should be highly beneficial for the future work of the International Panel for Sustainable Resource Management.

The study began in January 2007 and will be completed by April 2008. This note summarises progress in the project to date and provides some early, provisional findings from the analysis.

2. Selection of highly significant trade flows

The study is examining forty trade flows, split between renewable and non-renewable raw materials covering the broad sectors of food and non-food agricultural products, fossil fuels, and metals and minerals (Table 1). The selection of specific trade flows followed definitions of commodities used in standard trade statistics classifications. Data for 2005, the latest year for which comprehensive trade reporting was available, was taken from the United Nations Commodity Trade Statistics database (Comtrade) and the Eurostat External Trade Database. A level of aggregation was used which is compatible with the study of environmental impacts and policy level recommendations.

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[7] Judith Bates, AEA Energy and Environment, judith.bates@aeat.co.uk, + 44 (0)870 190 6411; Nick Dale, Metroeconomica, nickdale@metroeconomica.com +44 (0)1225 318360; Werner Bosmans, DG Environment, +32 2 296 7282

[8] COM(2005) 670 final. 'Thematic Strategy on the Sustainable Use of Natural Resources'

Selection of the first 20 trade flows focused on primary products. The most significant commodity *groups* (for example, Cereals and Cereal Preparations for the food agricultural sector) for each sector were identified in terms of economic value and physical volume of trade into the EU. From these groups specific significant *commodities* (for example, Wheat) were chosen to represent the groups. Selection criteria for the second 20 trade flows included economic importance, as well as environmental impacts and policy relevance (using simple multi-criteria analysis methods).

For the trade flows examined to date it is clear that extra-EU imports can account for a significant proportion of total global trade (for example, around 35 per cent in the cases of bananas and crude palm oil). There is usually a clear group of three to five leading source countries that account for most extra EU imports (Figures 1 to 4 shows these for the first twenty commodities examined). For the selected trade flows a diverse range of leading source countries are represented in terms of geographical region, level of development and policy regime. This diversity is apparent even within single commodities, for example suppliers of iron ore include Brazil, Russia and Canada. In a few cases one country dominates all others, such as Mauritius for raw cane sugar. To some extent the leading countries reflect long standing trading partnerships and historical links with specific EU countries. However, there are examples of recent international developments severally affecting EU trade with particular source countries. Clear examples are the reduction in soybean imports from the United States due to GMO issues and the reduction in cotton imports from Uzbekistan due to yield reductions and changes in trading relations. There has also been great volatility over recent years in some minerals and metals markets, as well as for sugar, resulting in significant year by year changes in the import values from leading source countries.

Table 1: Significant trade flows to the EU examined in the study

Food Products	**Non-Food Agricultural Products**	**Minerals and Metals**	**Fossil Fuels**
Bananas*	Bioethanol	Aggregates	Coal*
Bovine meat*	Chemical wood pulp	Aluminium	Crude petroleum*
Cocoa	Cotton lint *	Bauxite*	Gas*
Coffee	Cotton fabrics, woven	Cadmium	Liquefied gas
Fish (crustaceans, molluscs etc.)	Leather	Cement	Petroleum oils other than crude
Fish (fresh, chilled, frozen)*	Natural Rubber	Copper ores and concentrates*	Synthetic Rubber
Maize	Palm Oil*	Gold *	
Milk Products	Soybean Oil*	Iron and steel	
Rice	Tobacco*	Iron ores and concentrates*	
Soybean*	Wood, simply worked*	Mercury	
Sugar *		Phosphate rock	
Tea		Zinc ore and concentrates*	
Wheat and wheat flour*			

* Trade flows analysed to date

Figure 1: Top source countries for EU imports of food products

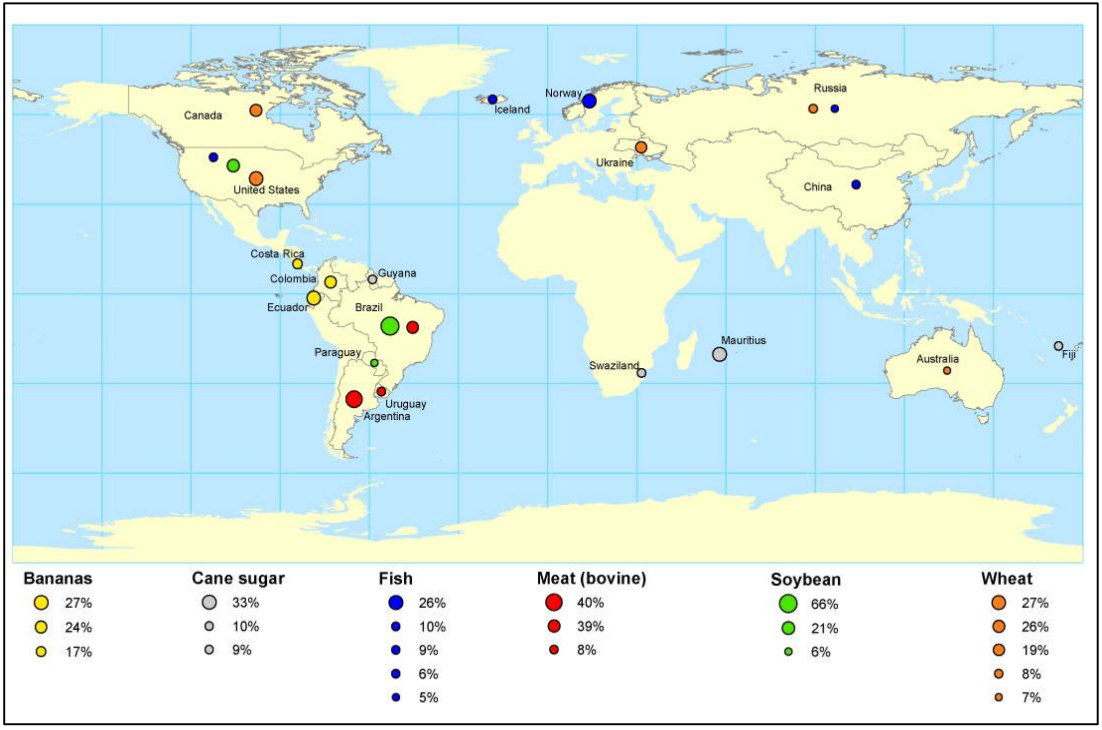


Figure 2: Top source countries for EU imports of agricultural products

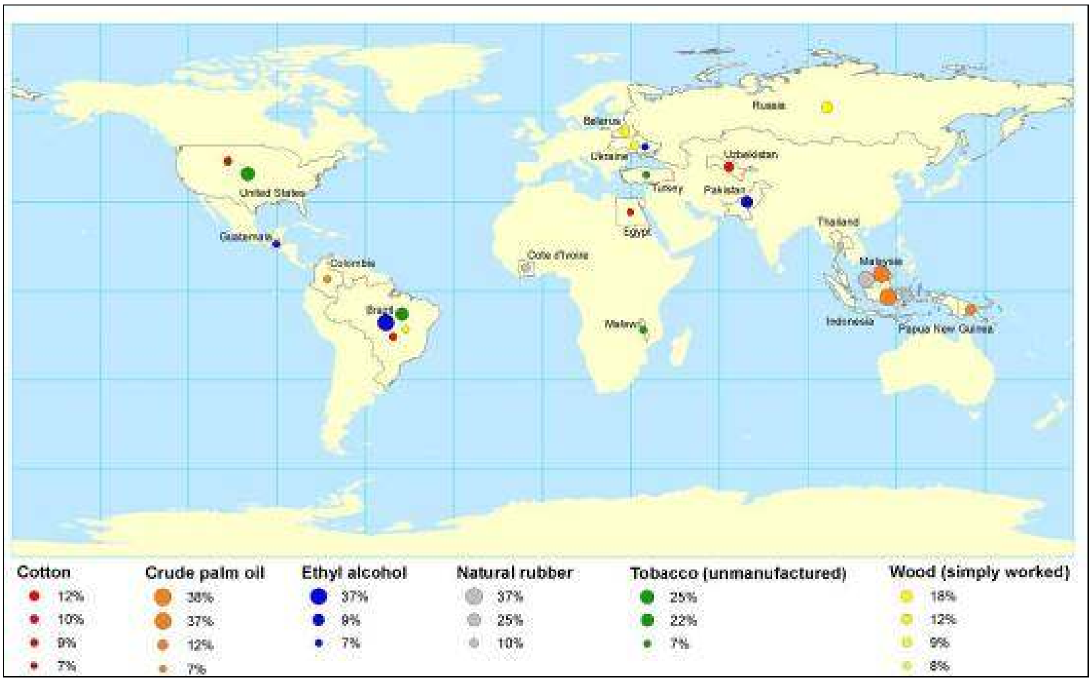


Figure 3: Top source countries for EU imports of minerals and metals

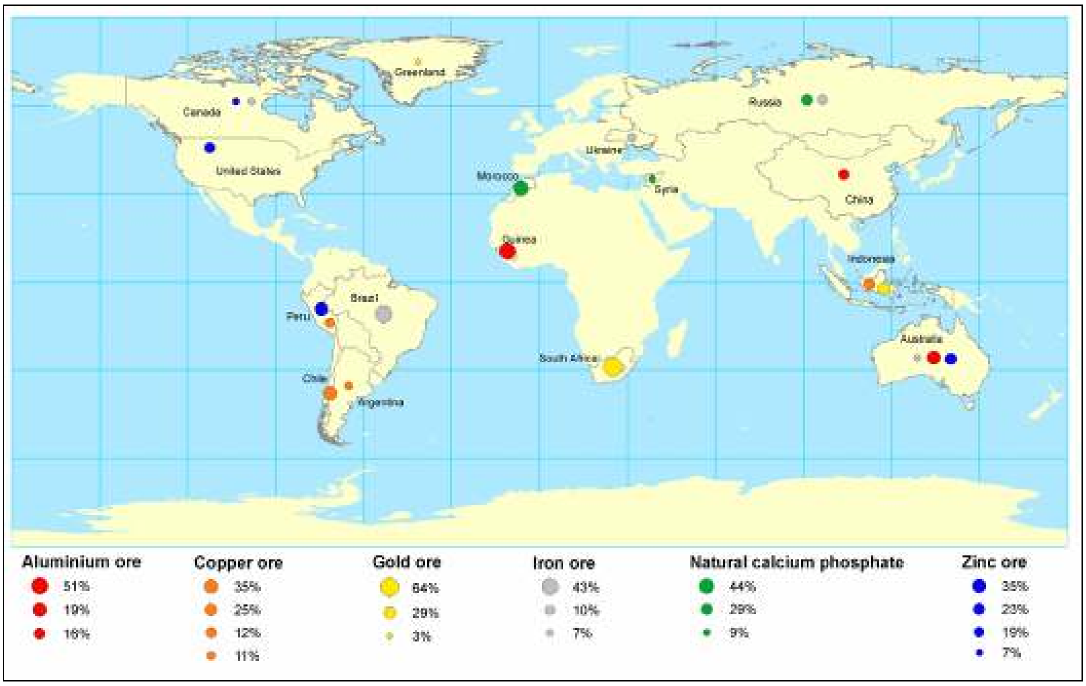
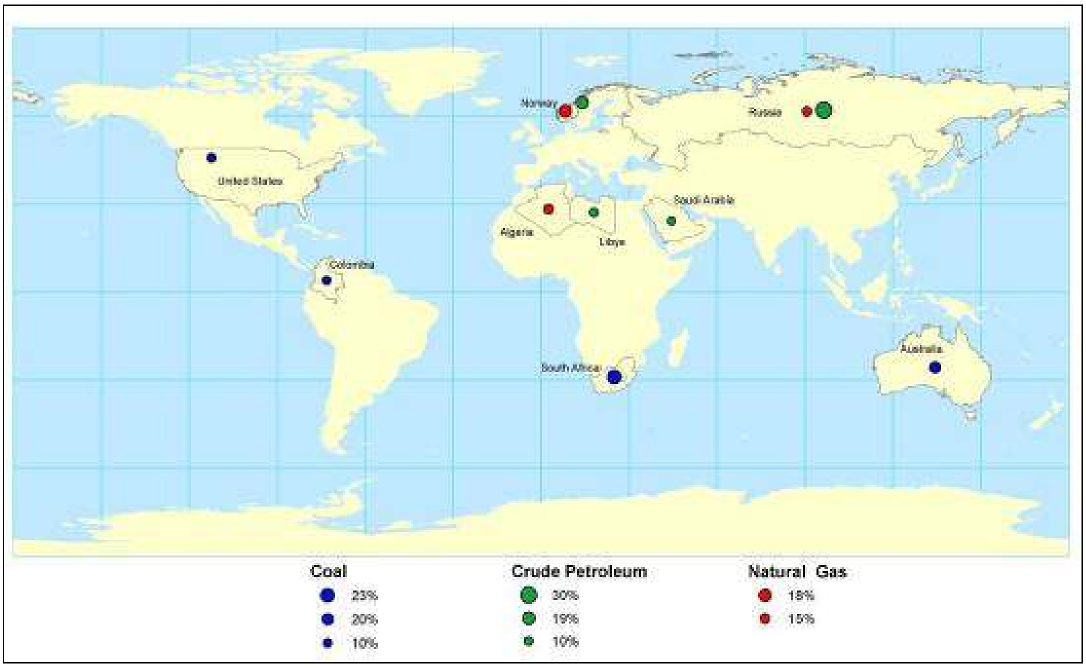


Figure 4: Top source countries for EU imports of fossil fuels



3. Environmental Impacts

The study covers the impacts of production of commodities in their country of origin, and from their transport to the EU. This is in contrast to other studies which have taken a more life cycle based approach and looked at the impacts from resource extraction to incorporation in a final product. The focus of the study on impacts associated with production of the commodity, and in the case of intermediate products primary processing overseas, allows a more detailed examination of these impacts and the variation in impacts between source countries. For materials which are not 'consumed' i.e. minerals and metals and some non-agricultural products, the disposal/end of life phase of the production is also briefly considered as this influences opportunities for recycling of the commodity and the possibility of reducing imports of the commodity.

Information on a wide range of environmental impacts is being collected (climate change, air and water pollution, soil quality, biodiversity), with country specific data being collected for the top three sources wherever this is available. This suggests that the severity of particular environmental impacts can vary significantly by location for a number of reasons including:

- **Availability of natural resources** necessary to sustain commodity production (e.g. in areas where rainfall is not sufficient to support cotton production, there are severe impacts on water resources affecting both biodiversity and the local people);
- **Patterns of existing habitats and land use**; whenever land use change is required for commodity production, impacts on biodiversity are very dependent on the existing land use;
- **Production mode**: smaller scale production can reduce environmental impacts for some commodities (e.g. by preventing large areas of monoculture), but may also increase impacts due to less efficient production methods, or poorer regulation (e.g. small scale gold mining).
- **Level and quality of environmental regulation;** regulation of extraction and production activities and regulation of use of e.g. herbicides and pesticides in agricultural production may vary significantly between countries. Good regulation and proper monitoring of impacts can lessen the severity of impacts.

In general, more information was found during the literature review on environmental impacts of minerals and fossil fuels, than for the other commodities. Only limited information on the impacts of producing some food commodities (e.g. bananas) was found, although for others, e.g. sugar impacts, appear to be well researched. Further work is being carried out to try and establish whether this is because there are no or relatively few impacts for these commodities, or whether there is a data gap. Quantitative data is being collected wherever it is available but data is quite often qualitative, particularly for impacts such as biodiversity.

For each of the commodity groups examined, there are often some generic issues, which are applicable to all or many of the commodities in the group. For example, a large number of common impacts were found for the minerals examined to date - large volumes of waste, acid drainage leading to water pollution and fugitive dust causing health problems. All of the agricultural products considered to date have impacts on biodiversity either from habitat destruction due to clearing of land to expand production, or from use of herbicides and pesticides. However there are also some specific impacts associated with some commodities, e.g. the large amount of water needed for cotton production, which is causing water resource problems in some source countries.

The information on environmental impacts is being used to gauge the impacts of commodity production in the four key areas identified in the EC's 6th Environmental Action Plan of climate change, human health, biodiversity, and resources. Examples of a mineral (iron ore) and agricultural commodity (cotton) are shown in Table 2 below. The 'ratings' for the severity of impacts in each category are tentative at present, and key challenges are to develop a methodology to ensure consistent ranking of the environmental impacts across commodities, and a way to take into account the quantity of the trade flow.

Table 2: Impacts of iron ore and cotton production in four priority areas
(Key: ✱ Minor; ✱✱ Significant)

	Cotton	**Iron**
Climate	* Limited impact from cultivation and harvesting: use of agrochemicals which are relatively energy intensive to produce	* Limited impact from extraction of iron ore
Biodiversity	** Impacts on wetland and river ecosystems from water depletion) in some source countries; loss of native species.	** Acidic discharges containing heavy metals can pollute water courses and have severe effects on ecology. Deforestation from open pit mining and pollution of coastal waters from spillages (e.g. in Brazil)
Health	** Health impacts from deterioration in quality of water sources (e.g. from pesticides)	** Impacts from air pollution and potentially from water pollution
Natural resources	** Large volumes of water required for irrigated cotton: causing depletion of water resources in some source countries e.g. Aral Sea in Uzbekistan	* Soil contamination Large land take from open pit mining

4. Database

The project is also developing a database for use by DG ENV to allow relevant experts and centres of expertise to be identified. The database will include expertise on trade and material flows, commodity production and environmental impacts (e.g. human health impacts, deforestation). Resource based entries in the database will give a description of resource production and processing, key producer countries for the EU and a summary of environmental impacts. Expertise based entries will include contact details, areas of expertise, regional coverage etc. The database will be searchable by country, area of expertise and by commodity.

5. Development of Recommendations

The final stage of the project will be to assess and make recommendations on which of the resource flows analysed should be tackled with priority by new or reinforced existing policy initiatives. This will take into account (i) overall environmental impacts in source countries informed by analysis undertaken in the earlier tasks of the project, (ii) relative contribution of the analysed EU trade flows to overall global impacts and (iii) existing policy architecture relating to the analysed trade flows and the scope for intervention. The focus of policy recommendations will be primarily at EU and international level policy such as the International Panel for Sustainable Resource Management. The recommendations will also identify where methodological and data availability issues stated above in the analysis of environmental impacts should be further addressed in order to improve the assessment of policy priorities.