Dematerialisation, Resource Use and Economic Growth

With a focus on dematerialisation in Europe, this case study concentrated on resource use at global, European, and national scales and looked into driving forces, dynamics of change and policy options for dematerialisation. One goal was to provide tools for forecasting material resource use and identifying feasible policy options.

Global level

On a global scale this MATISSE case study performed a metabolic study of the evolution and the current patterns of global production and consumption of four materials: copper, aluminium, cadmium and zinc. The criteria for the selection of metals were environmental, strategic and economic relevance in the past, available information and expected increase of use in the future.

The scoping stage focused on identifying the key sustainability issues of the social metabolism of metals. From a world history perspective, the evolution of per capita metals use has been tremendous. For example, copper, which is one of the oldest metals in use, an increase in per capita consumption from prehistoric times to the time of the ancient agrarian civilisations by a factor of 10 and again by a factor of 50 from then to the present day can be observed. Considering that high levels of metal production are a typical characteristic of an industrialised economy and that the majority of the world's

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population is only at the beginning of a transition from an agrarian to an industrialised society, we can expect a further substantial increase in the demand for metals.

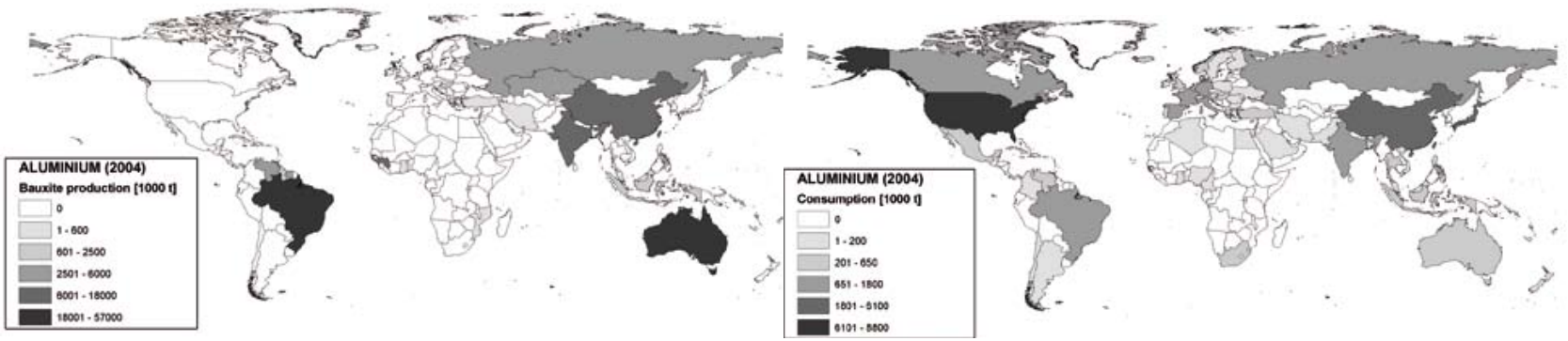
For the industrial metabolism, the flows of material between economy and biosphere, metals are prime strategic raw materials. Their manifold and valued material qualities make them essential and partly non-substitutable components of numerous industrial products and inputs to manufacturing. There are two main *sustainability concerns* related to metals use that dominate the literature: the environmental impacts associated with the industrial metabolism of metals and the potential of resource scarcity or even depletion[1 2 3]. Although less often addressed, a third aspect concerns the social impacts of metals use, especially mining activities, including violent conflicts over access to land and resources. *Adverse social effects* of the metals industry are serious as well, though less often analysed. They are most severe in densely populated developing countries.

What was done?

One focus of the case study was to build up a database to consolidate existing data covering:

- historical time series on production and consumption of the selected materials, for roughly 100 countries in the world that represent some 90 percent of the world's population and GDP; and
- traded commodities.

To get some insights into trade flows, we focussed on the European Union and established a *dataset on imports and exports of metals and derived products* differentiated according to trading partner. The traded products include basic commodities, semi-manufactured and high-manufactured goods of the particular metals and thus cover different stages in metal processing. Finished goods were not considered in the analysis because of the unknown mix of different materials, which would distort the



material balance approach. Data for European trade flows were taken from the Eurostat trade database 'Comext'.

Findings

Total metals consumption in the EU increased constantly from 1970 to 2004 by 130 percent for aluminium, 50 percent for copper, and 60 percent for zinc. Figures for per capita consumption reveal the same trends: aluminium consumption doubled from 10 kg/capita to 20 kg/capita, copper increased from 7 to 9 kg/capita, and zinc rose from 4 to 6 kg/capita. Only cadmium consumption decreased. The decrease over the period was from 24 to 14 kg/capita.

To give a more detailed example, Bauxite production and Aluminium consumption patterns with a focus on EU-15 are discussed here.

As on the global level, aluminium consumption grows at the same rate as economic value-added is produced. No decoupling is visible for this metal at all, in contrast to what one would expect for an industrialised region. Unlike consumption figures, bauxite extraction follows a decreasing trend from 5 million tonnes in 1970 to 3 million tonnes in 2004. The only EU-15 country, where bauxite is still extracted is Greece. Bauxite mining in France, Italy, and Spain ended during the 1980s. The next steps of processing, i.e. alumina production as well as production of aluminium, is nevertheless growing from the 1970s to the 1990s, after which production levelled off. Despite growing aluminium production, total consumption already exceeded domestic production in the 1970s. The resulting demand for bauxite and also for processed alumina and aluminium is met by increased imports from other world regions. Aluminium imports to the EU-15 come mostly from Africa and to some extent Australia and New Zealand.

The following conclusions can be drawn from analysing the data:

1. Absolute material use: There is no decrease in use of aluminium or copper, either on the global scale or in the EU.
2. Recycling: The recycling shares are growing and thus relieving uses of natural stocks. However, recycling rates are growing slower than overall consumption.
3. Sourcing: There is a clear trend towards decreasing raw material extraction and concurrent increasing imports of higher manufactured products in the EU.
4. Total waste generation: Few major technological innovations were developed over the period covered by our analysis to provide for a reduction of related waste flows. Continuing depletion of natural stocks is resulting in the mining of ores of increasingly lower grade with higher amounts of waste flows.

Main findings from the statistical analysis are given here for the example of copper. This analysis focused on the relation between copper use, developmental stage and economic dynamics.

A cross-country correlation analysis was performed for all countries and each year on the relation between copper consumption levels and income levels. There are three clear groups of countries:

1. Countries where copper consumption levels strongly correlate with income levels.
2. Countries that maintained a persistent low copper consumption level at various levels of income.
3. Low income countries that had a large range of copper consumption levels.

Over the years only a few countries changed group; for the vast majority the pattern remained stable for more than 30 years.

A stakeholder meeting with the international copper association was held, where our findings regarding copper were presented and discussed in terms of the implications for future sustainable use of metals.

European level

The European strategy on a sustainable use of resources aims at a double decoupling; a decoupling of economic growth from resource use and a decoupling of resource use from its environmental impacts. At present DG Environment envisages developing targets and indicators for both resource productivity and environmental impacts of resource use. Whereas an indicator for aggregated environmental impacts of resource use still has to be developed, indicators for resource use itself are established and available. The challenge for scenario analysis lies in integrating parameters for resource use into appropriate econometric models (see also pages 35 - 38).

What was done?

Together with colleagues from Cambridge Econometrics we integrated material flow data for all European countries in their E3ME model, which basically involved a sectoral disaggregation of domestic extraction and physical imports.

The following four scenarios (up to 2030) will be modelled and analysed with respect to their impact on material use, energy use and CO_2 emissions:

1. *Ecological tax reform:* increasing taxes on resources and CO_2 emissions, decreasing taxes on labour (see also page 14).
2. *Time instead of money:* Gains in labour productivity are paid back to the labour force partly in money, partly in time.
3. *Lifestyle changes:* Different exogenously introduced changes in lifestyle (expressed in different private consumption patterns) are analysed with respect to their effects on resource use.
4. *Means and feasibility to achieve dematerialisation targets:* The fourth scenario combines the previous ones and will investigate if, under which conditions, and by which combinatio of instruments, specific dematerialisation goals (e.g. Factor 4) can be achieved.

Overall these scenarios aim at identifying promising points of intervention that could have a significant impact on future resource use levels.

National Level

Within this case study there was a focus on the Czech Republic. In collaboration with the case study on environmental technology the extraction and consumption patterns of this new EU Member State were analysed. The results were discussed with stakeholders and used the modelling of the case study (see pages 35 - 38).
The experimental stage of this sub-case study focused on quantification of direct and upstream energy requirements and carbon emissions related to the production system in the Czech Republic. These flows were then linked to domestic final demand for commodities, as well as to their exports and to imports. The quantification of total energy requirements and carbon emission flows was carried out for 1999 and 2003.

Results show that while total energy requirements for domestic final demand remained stable between 1999 and 2003, there was an increase in energy requirements for exports by approximately 9 percent. An increase in energy requirements for total final demand, which

amounted to 4 percent between 1999 and 2003, was therefore driven by consumption abroad rather than by consumption in the Czech Republic.

Total energy requirements of imports went up by 6 percent. This suggested an increase in pressure exerted abroad by the consumption in the Czech Republic between 1999 and 2003. As total energy requirements for exports also went up, there was a simultaneous increase in pressure exerted on the environment in the Czech Republic by the consumption of other economies. The balance between energy imports and exports remains positive and on the same level for both years. This means that, with respect to its foreign trade and energy requirements, the Czech Republic exerts pressure on the environment abroad rather than other economies exert pressure on its environment. Total carbon emissions related to domestic final demand went up by 12 percent. As there was only a very slight increase in total energy requirements for domestic final demand, this increase indicated that more carbon-intensive energy carriers were burnt when producing commodities for domestic final demand in 2003 compared to 1999. The opposite seems to be true for exports and imports, as in spite of an increase in energy requirements, total carbon emissions went down by 7 percent for exports and almost 40 percent for imports.

Prospects for ISA

The results of this study provide the background for the scoping stage of a full-scale ISA. It provides the basis for scoping the unsustainability problem and paving the way to identify possible solution options to explore with stakeholders, concerning how the key relationships in this area might be manipulated, for example through substituting for some metals, reducing their use in some applications, improving recovery rates and recycling rates and reducing demand by selling services rather than selling products.

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[2] Ayres, R.U., Ayres, L.W. and Rade, I. (2002). The Life Cycle of Copper, its Co-Products and By-Products. IIED and WBCSD,

[3] von Gleich, A., Ayres, R.U. and Gößling-Reisemann, S. (2006). Sustainable metals management. Securing our future - steps towards a closed loop economy. Springer, Dordrecht.

Further Reading

Eisenmenger, N., Weisz, H. and Ayres, U.A (forthcoming). Global socio-metabolic patterns of selected metals. Past trends and future options..

Kovanda, J., Havranek, M. and Weisz, H. (forthcoming). Accounting for direct and up-stream energy requirements and carbon emissions related to the production system in the Czech Republic.

Pollitt, H., Eisenmenger, N., Schaffartzik, A., and Weisz, H. (forthcoming). The future of resource use in Europe.

Weisz, H. and Schandl, H. (eds). (forthcoming in 2008.) Material use across world regions: Inevitable pasts and possible futures. Special issue of the *Journal for Industrial Ecology.*

Weisz, H., Krausmann, F., Eisenmenger, N. and Steinberger, J. (forthcoming). Evolution of material use in the European Union 1970 to 2004.