Key Elements for Economy-wide Sustainable Resource Management (1)

It is getting tighter on our globe. A growing world population is getting richer and demands more and more products which require natural resources and create various environmental impacts from mining to final waste disposal. The competition on rarer metals let some countries prohibit exports containing such raw materials. The rising demand for food and non-food biomass, such as feed-stocks for biofuels, and harvests fluctuating severely, due to more frequent weather extremes, triggered land grabbing in foreign countries, particularly in developing regions. Without mechanisms moderating resource consumption, abiotic and biotic resources will be depleted, mining and refining will devastate and pollute more and more places in remote areas, agriculture will expand into the remaining natural forests, and conflicts about land use and clean water will increase.

By Stefan BRINGEZU*

The growing demand for natural resources leads to price fluctuations and interim shortages of supply. Higher food prices affect households and metal manufacturing is faced with more and more volatile markets.

One key strategy is resource efficiency, ie. to make more out of less, to generate more wealth and well-being with less input of natural resources. For industry, higher material and energy efficiency is a chance to reduce costs and enhance competitiveness. The search for eco-efficient technologies is thought to trigger innovation. Unsecurity of foreign supply may be reduced by mitigating material losses in the production and use chain.

A growing number of countries have already defined targets to increase resource productivity of their economy. The European Commission is developing a road map to increase resource efficiency EU wide, and various member countries like Germany have established first institutions and instruments to foster material and energy efficiency in companies and households.

National governments together with industry and societal groups are challenged to develop programmes for economy-wide sustainable resource management. This is requested by the Thematic Strategy for the Sustainable Use of Natural Resources (CEC 2005). As European countries are increasingly sourcing from other world regions, such programmes need to consider the use of both domestic and imported resources and their environmental and socio-economic implications. Designing a robust and effective policy framework for sustainable use of natural resources also requires knowledge on the long-term dynamics of the socio-industrial metabolism and the key strategies, technologies and institutions to develop the physical basis of the economy sustainably.

Resource management at different scales

Local resource management

Managing a farm field, a forest or a fishing ground in a way to gain a reasonable harvest while minimizing economic and environmental costs has been the oldest form of resource management. The idea of sustainability was actually created at the beginning of the 18th century from the need to generate a more continuous long-term income from the use of forests which had been largely depleted in Germany. Nowadays, guidelines of good agricultural and forestry practise advise farmers and foresters on how to keep up soil fertility, minimize erosion and nutrient losses, etc. Nevertheless, worldwidely, the extension of degraded land is growing, and the growing consumption of food and non-food biomass is supplied by a more and more intensified industrial-type agriculture which is challenged to find the proper balance between increased yields and environmental side-effects.

Product chain management

Manufacturers and final consumers become increasingly aware of their responsibility and market power. Demand for products which are produced in an environmentally and socially responsible manner is growing. As a consequence product labelling and certification plays a relevant role in informing industry and households also on the conditions of cultivation and harvest in the fields and forests where the raw materials and final products stem from. However, labelling and certification is usually applied only for selected market segments. Moreover, it cannot control the overall demand of products and the resulting global resource consumption.

River basin management

Communities and states living along the course of rivers have learned since centuries that up-stream actors have to consider the effects of their activites downstream, and downstream actors have developed the interest to cooperate, but also become less dependant from up-stream pressures. The EU Water Framework Directive is a supreme example, how the water quality of water bodies within a river basin can be improved through the consistent involvement of various relevant actors like farmers, companies, fresh water suppliers and waste water utilities. Nevertheless, although cross-sectorally designed, the approach does not affect the waste flows to deposits or the atmosphere, nor the consumption of products and related trade flows to regions outside the river basin.

Regional and national land use planning

Land use planning has been developed in civilized societies since long in order to minimize internal land use conflicts. A prime function from its very beginning was to secure the supply with domestic resources, mapping the farm and forest area, and channeling the growth of urban areas to land where no geological deposits have been located. In recent times land use planning plays an important role in mapping the areas for nature conservation, and land management within Europe has been rather successful to maintain species rich forests and wetlands. However, regional, national and EU land use planning has had no influence on the consumption of products and related resource requirements drawn from within or from outside Europe.

Economy-wide sustainable resource management

At the national and European level, programmes for sustainable resource management need to be developed which act economy-wide, and:

- ✔ integrate climate and resource conservation, and supply security,
- ✔ consider biomass and mineral use for all purposes,
- ✔ build the bridge between economy and ecology,
- ✔ use comprehensive indicators and targets for long-term orientation,
- ✔ account for domestic and foreign resource use (materials, land),
- ✔ minimize problem shifting (between regions, different pressures, or over time).

Trends of global resource use

There are «Three Big» environmental pressures worldwide which are going to increase:

- ✔ the emissions of green house gases inducing climate change,
- ✔ the extraction of abiotic resources leading to landscape change and ending up in waste disposal,
- ✔ the change of land use, in particular expansion of built-up and agricultural land at the expense of natural ecosystems.

Land use change, mineral extraction and GHG emissions are interconnected and also linked with other environmental pressures like water consumption and pollution which vary within regional contexts.

Whereas the climate issue has been well described and is widely acknowledged (IPCC 2007), the relevance of resource extraction and land use change has received less attention so far.

The extraction and harvest of abiotic and biotic resources is expected to nearly double between 2000 and 2030 under business-as-usual conditions, from 52 billion tonnes to over 100 billion tonnes (FoEE 2009) (2). This comprises the used extraction of fossil fuels, metals, minerals and biomass, but does not entail the unused extraction. The latter constitutes, for example, the earth excavation for infrastructures, extraction waste of mining and quarrying and the erosion linked to agriculture. The unused extraction adds double to triple amount to the used extraction. The extraction and refining waste is particularly high for metals. Because the concentration of metals in ores is declining in many cases, the consequence will be growing amounts of primary extraction, higher volumes of mining waste, water discharge and landscape change (see e.g. Mudd 2007, Norgate 2010).

The total material requirement (TMR) is an indicator measuring the domestic and foreign resource extraction, which is directly and indirectly linked to all production and consumption activities of a country. The TMR of the EU has been increasing in between 2000 and 2007, from 43 to 46 tonnes per capita. Whereas the domestic extraction and harvest remained rather constant, the resource requirements of the imports increased, even to a higher level than those of the exports (Figure 1).

Fossil fuel and mineral resources made up the highest portion of the domestic TMR, whereas metal resources dominated the resource requirements of imports and exports (Figure 2).

Global land use change is characterized by two key developments: the expansion of built-up land and the extension of agriculture land, both at the expense of shrinking forests worldwide.

In 2005, the «built environment» was accounted for with 306 Mha worldwide. Without policy intervention it is expected to grow by up to nearly 250 Mha (or 81%) by 2050 (Electris et al. 2009). According to Seto et al. (2010) urban area alone might expand altogether between 40 and 143 Mha from 2007 to 2050. Holmgren (2006) assumes that 80% of urban expansion occurs on agricultural land.

Whereas forest area in Europe is even growing slightly, forests in particular in tropical regions are increasingly being degraded and deforested. This is not only a result of growing demand for forestry products, but also a

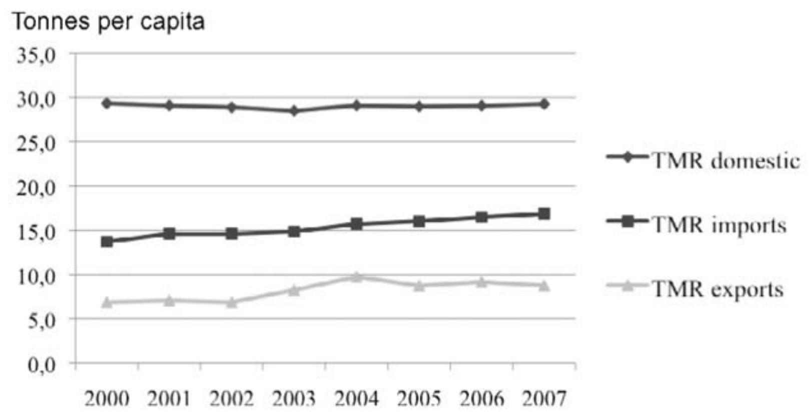

Figure 1: Total material requirement (TMR) of the European Union (EU27) from domestic sources, and TMR of imports and exports.
Source: data base of the Wuppertal Institute, compilation by H. Schütz

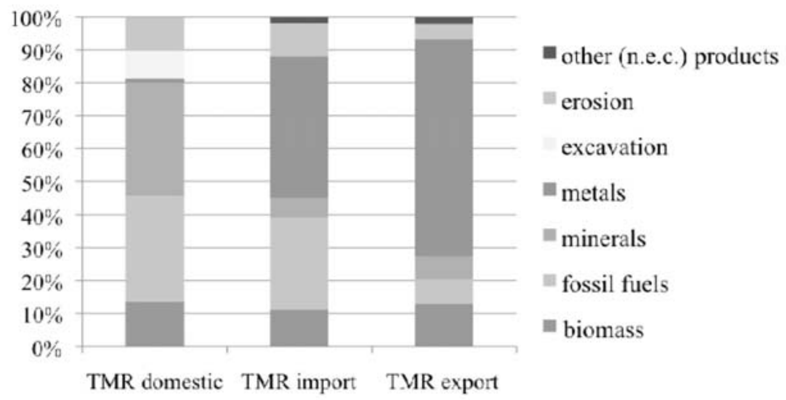

Figure 2 : Composition of the EU´s TMR in 2005.
Source: data base of the Wuppertal Institute, compilation by H. Schütz.

consequence of growing demand for agricultural commodities.

Until 2030, global cropland will probably be expanded only to feed a growing world population with changing diet pattern (Bringezu et al. 2009a). Any prognosis towards this end is based on rather uncertain development of agricultural yield increases. If one assumes a rather conservative global average increase of about 1% p.a., this equals about the rate of population growth. At the same time, however, developing countries will significantly increase their consumption of protein rich food, ie meat and dairy products. And in order to feed the required animals, more cropland will be needed. Global cropland may then be expanded by 10-20% from 2004 to 2030, ie between about 150 to 300 million hectare.

Any additional demand for non-food biomass from agriculture will add to the pressure on the expansion of cropland into grasslands, savannahs and forests. Associated with this development will be a loss of biodiversity and most probably increasing GHG emissions, which in the case of 1st generation biofuels may even render any mitigation effect negative for the coming decades (Bringezu et al. 2009a, Ravindranath et al. 2009).

Global land use accounts (GLUA) measure the global land use of equivalent land use categories associated with the domestic consumption of goods and services (Bringezu et al. 2009b, 2009c). $GLU_{agriculture}$ accounts for the global land use for domestic consumption of agricultural goods, for food, materials and energy. Analogously, $GLU_{cropland}$ and GLU_{forest} can be determined. In each case, imports and exports are calculated based on real land use for the production of their feed-stocks.

$GLU_{agriculture}$ is about 30 mill. ha larger than the domestic agricultural area of the EU27, clearly indicating that the EU is a net importer of land (Figure 3). While the domestically used agricultural land is slightly declining, the land used in foreign countries has been growing.

As mentioned before, the expansion of global cropland is a key driver for the loss of biodiversity (MEA 2005). $GLU_{cropland}$ of the EU27 for the overall consumption of agricultural goods was 0.31 ha per capita. This is one third more than the globally available cropland per capita of the world population. Starting from today's roughly 0.24 ha per capita cropland for the world population, the trend may lead to only 0.21 ha per capita in 2030 (van Vuuren and Faber 2009, trend scenario).

Following a strategy which aims at halting biodiversity loss due to land use changes and calls for ending expansion of agricultural land from 2020 (van Vuuren and Faber 2009, challenge scenario), one would arrive at 0.19 ha cropland per capita in 2030. In any case, the current EU consumption of about 0.31 ha per capita would clearly exceed the globally available cropland for each world citizen. Even a further yield increase of 1% p.a. on average would not suffice to keep EU´s consumption below global mean use of cropland. A further increase of non-food biomass demand, for instance for biofuels or biomaterials would increase the disparity of EU´s demand and global availability and probably lead to increased pressure on land use change, in particular in tropical regions.

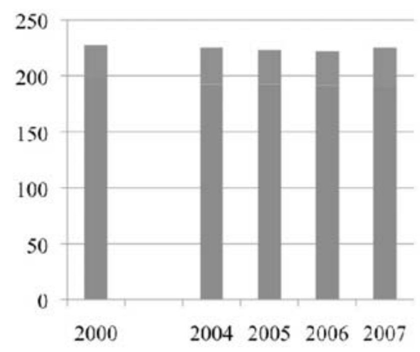

Figure 3 : Global land use for domestic consumption of agricultural goods of EU-27 (in mill. ha).
Source: data base of the Wuppertal Institute, compilation by H. Schütz.

Long-term dynamics and future options of the socio-industrial metabolism

In ancient history, humans started to use biomass for food, material and heating. They «roomed» away forest spots for living space and timber. Wooden biomass was the main energy source also during bronze and iron era and medieval times which lead to largely cleared forests in the middle mountains of Western Europe. Discovery of coal and the steam engine allowed forests to recover; however, it was the starting point of a larger-scale side effect in the form of climate change. Nowadays, humankind is at least partly returning to ancient ways of supply by large-scale forest clearings, particular in the tropics, and the use of biomass for fuel purposes.

In future, carbon feed-stocks and all other resources will need to be used much more efficiently within production and consumption. After use, the carbon containing organic waste should not only be treated for energy recovery, for instance by incineration, with the consequence of carbon being emitted as carbon dioxide. Instead, technologies should be further developed to recycle the carbon for use as material feed-stock (CCR – carbon capture and re-use). Keeping the carbon in a chemically reduced form will require energy which should then be delivered from renewable sources. In the longer term, solar and wind energy may not only be used to drive carbon (and other materials´) recycling, but also to capture carbon dioxide from ambient air, which would allow to reverse climate change to a certain degree and provide a full carbon cycle as a basis for a variety of structural and auxilliary non-food materials.

When developing the physical basis of society and economy towards sustainability, not only carbon flows need to be considered but the whole socio-industrial metabolism, ie the extraction, use, recycling and final disposal of all material resources. Fig. 4 shows the metabolism of the EU with flows measured as tonnes per capita for the reference year 2000 (water use is excluded, which would be an order of magnitude bigger and needs to be dealt with separately). In 2000, the abiotic resources dominate the metabolism, and a significant share of resources is used in other regions for the supply of the imports of the EU (which are used for domestic consumption and production of exports).

In order to outline how that metabolism may develop in future under sustainability conditions, the following aspects should be considered (details are given in Bringezu 2009):

- ✔ The net addition to stock (NAS), measuring the amount of buildings and infrastructures added each year to the existing ones, must become zero. Otherwise, the EU would become totally covered by buildings, roads etc., which would compromise the supply from agriculture and forestry. Zero NAS means that there will be a dynamic equilibrium between the construction of new houses and roads and the deconstruction of old ones.
- ✔ Domestic biomass harvest from agriculture and forestry may probably be kept constant or increased by up to 25% under conditions of sustainable cultivation, in particular by mobilising unused potentials from forestry. Imported biomass should be reduced with regard to a balanced global land use (see below).
- ✔ The use of abiotic resources (naturally non-renewable) should be significantly reduced in order to mitigate the domestic and foreign environmental pressure of resource extraction and waste disposal, and to contribute to a more equitable pattern of global resource consumption. The indicative target of 80% reduction had been derived

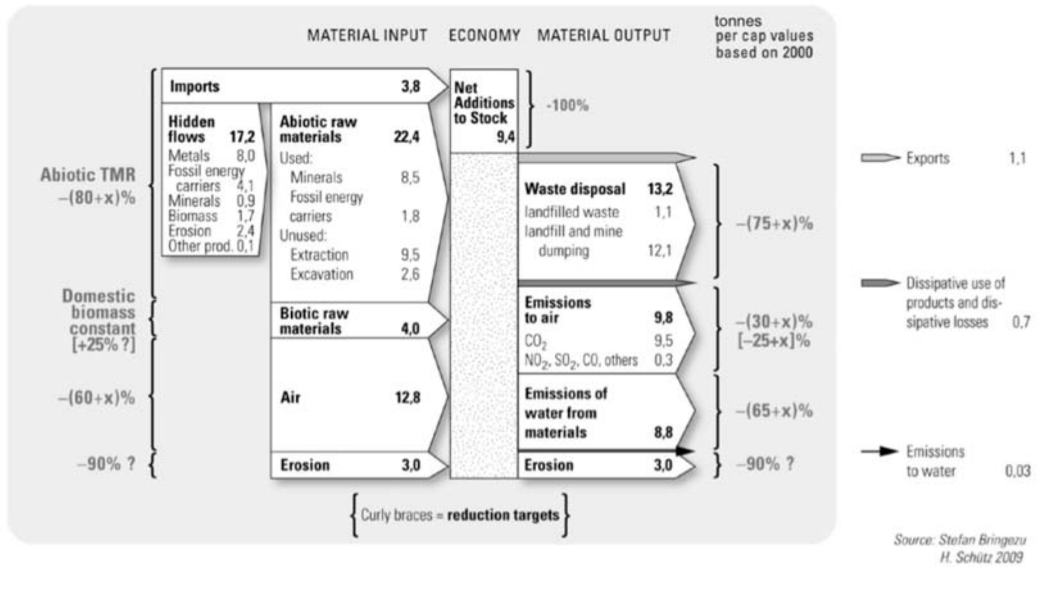

Figure 4: The socio-industrial metabolism of the EU in 2000 and target values for long-term development (Bringezu 2009).

from the assumption that global abiotic resource extraction should be halved and equally used by 9 billion people in 2050, and that the TMR would be developed in constant relation to TMC (political targets for absolute resource consumption should be based on TMC rather than TMR which should be used in relation to GDP, see below). Recent data, however, indicate that since 2000 global extraction has grown further, and moreover, also less developed countries which still need to develop their infrastructures are already above 6 t/cap TMC_{abiot}. Therefore, it seems more realistic to pursue a global target of returning to global abiotic resource extraction as of year 2000 and use this for 9 billion persons (see below).

- ✔ Erosion on agriculture fields within the EU should be reduced by a factor of 10 in order to approach the level of soil regeneration, although the data indicate large variation between member states and crops, and data availability also needs improvement.
- ✔ Fossil fuel use for combustion needs to be phased out. In Fig 4 a 90% reduction has been included in the target values implying the same reduction of fossil based carbon dioxide emissions. Total carbon dioxide emissions, however, will be reduced only by one quarter to one third, as the remaining input from carbon from biomass will be oxidised and emitted from respiration, fermentation or incineration under conditions of a dynamic flow equilibrium.

Policy challenges

There are some cross-resources strategies on the one hand, and some theme and resource specific challenges on the other hand, both of which requiring cross-sectoral action between different policy departments.

Cross-resources policy tasks

Monitoring and control of the Big Three global environmental pressures is key to progress on sustainable resource management on the national and European level. Indicators should measure national and EU consumption of global resources (Figure 5).

Consumption based accounting refers to domestic production plus imports minus exports of products and services, according to conventions of economic statistics. The environmental pressures linked to these product flows, either emission or resource or land use oriented can be quantified.

The measurement of global warming potential is meanwhile rather well established at the national scale. Both territorial accounting is practised as well as consumption orientated accounting (3), as trade and transport extend the carbon dioxide responsibility of countries (Peters et al. 2009).

Total Material Consumption (TMC) is the most comprehensive indicator measuring the use of primary material extraction for domestic final consumption. It comprises domestic extraction and harvest plus imports including their indirect resource requirements and minus exports and their indirect resource requirements. In other words TMC results from TMRdomestic plus TMRimports minus TMRexports (see Fig. 1).

Like TMR, TMC includes fossil fuel, metal, other mineral and biomass resources and accounts for both used and unused extraction (Fig. 2). It is part of the MFA

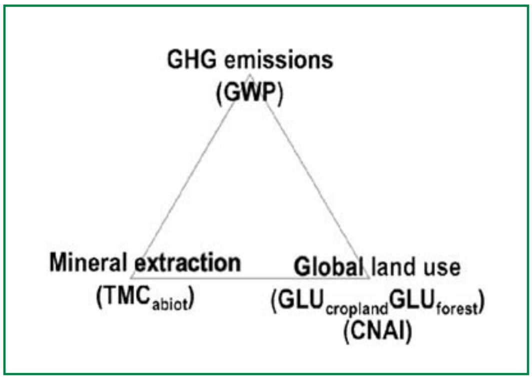

Figure 5: The «Big Three» global environmental pressures and related indicators.

methodology described by Eurostat (2001) and OECD (2008), and has been addressed as «best needed» indicator for material resource consumption (Eurostat 2007, ETC/SCP 2010). The interpretation in terms of environmental pressure is similar to primary energy requirements in a sense that it relates to the impact potential associated with the mass turnover of primary materials, ie. the magnitude of flows between nature and the human sphere (Bringezu et al. 2003).

TMC comprises biotic and abiotic resources and may be used as such. In case, separate headline indicators and targets are available also for global land use related to biomass harvest, it may be advisable to concentrate on the abiotic part of TMC, ie TMC_{abiot}.

Besides $GLU_{cropland}$ also $GLU_{agriculture}$ and $GLU_{forestry}$ should be monitored. When it comes to target setting, a focus may be lead on $GLU_{cropland}$ for considering the key agricultural land use issue. With regard to the use of global forest land one has to consider the varying productivity of forests in the different world regions. For instance, whereas Switzerland consumes forest based products which require less than per capita world average of forest land, the picture changes when the consumption of forest growth is measured. The consumption of the net annual increment (CNAI) seems an appropriate indicator for global comparison. Available data indicate that in 2006 Switzerland consumed more NAI per capita than was regrowing worldwide (Zah et al. 2010). As business-as-usual will lead to growing demand of forest based products and growing imports, the disparity will probably increase. The situation of Switzerland may be regarded as quite similar to large forest rich EU member states like Germany.

Policies for economy-wide sustainable resource management should develop long-term targets for the consumption of global key resources. For that purpose, (1) a global target needs to be determined, which is then (2) attributed to countries and regions. Regarding global green house gas emissions, in line with the UN International Panel on Climate Change (IPCC), the European Council has agreed to the objective to reduce GHG emissions of industrialised countries by 80-95% in 2050 compared to 1990, and global emissions will need to be reduced by at least 50% compared to 1990 (4). The EU and its member states have been working towards this end, and formulated interim targets in the «20-20-20 climate and energy package» for 2020 (5).

Policy targets for global land use and mineral resource extraction still need to be developed.

For developing a target for global sustainable resource use, either biomass and land or minerals, the concept of safe operating space as formulated by Rockström et al. (2009) can be further elaborated. They have suggested a global target for expansion of cropland; however, as Rockström et al. obviously did not consider the expansion of built-up land, those figures should be revisited. Instead, the target suggested by van Vuuren and Faber (2009), to halt the loss of biodiversity through the expansion of agricultural land after 2020 should be considered as reference, and the expansion of cropland should be limited accordingly. Based on available data, a long-term target could be around 0.2 ha/cap global cropland use.

With regard to the extraction of mineral resources, it is more difficult to determine a global target of sustainable use. Those resources cannot be regenerated by and within the speed of natural processes. While mining and refining tend to extract these non-regrowing resources with increasing efficiency, near surface deposits become more and more depleted, ore concentrations decline or deeper depths need to be explored, which tends to lead towards higher energy, water and waste intensity (Norgate 2010, McLean et al. 2010). The impacts are local to regional, albeit ubiquitous, and there will probably be no tipping point of global extraction which can be determined to lead to forecastable consequences. Instead, these flows contribute to a continuous, and currently growing rate of a changing environment. The extraction volume of minerals determines the scope of landscape change and, in addition, determines the overall generation of waste disposal along the production and consumption chain, from mining to final waste deposition. If a global target aims to return to extraction levels of the year 2000 globally, and use these resources equally amongst 9 billion people around 2050, then the reference level could be around 10 t/cap TMC_{abiot} (in 2000, the EU-15 consumed 33 t/cap TMC_{abiot}). (6)

Resource specific challenges

Biomass and land use

The key challenge here is to halt the loss of global biodiversity, and thus the expansion of global cropland as important driver of that loss. For that purpose, two complementary strategies need to be pursued:

- a) fostering the sustainable cultivation of each hectare through standards of good agricultural practise;

- b) controlling the demand for the number of hectares not to surpass levels which cannot be supplied sustainably.

For (a), agricultural policies need to be complemented by product policies; certification of biomass based products (food and non-food) can help to ensure that the reqired feed-stocks are derived from sustainable cultivation.

For (b), a comprehensive biomass strategy needs to be developed which considers the use for food, materials and energy, and the land altogether needed for the provision of feed-stocks for domestic consumption both in foreign countries and domestically. If GLUA reference indicators show an undue use of global cropland, then policies influencing demand for biomass based products need to be adjusted; in the case of the EU, that could mean to revisit the targets for biofuel quota again and to check biomaterials and timber product enhancement programmes not to widen the disparity between sustainable supply and growing demand.

Metals

The key challenge for metals is to foster recycling also beyond country borders and enhance a more efficent use along the production chain. Europe drains metals with export of new products and end-of-life products and waste like scrap cars, while the supply of metals is largely based on ores and concentrates imported from outside (for structure metals like steel and auxiliary metals like platinum group metals). Highlevel recycling needs to build up within Europe and beyond, and producer responsibility should be fostered to establish also collection and recovery systems abroad, in cooperation also with developing countries such as in Africa.

Construction minerals

Construction minerals are mainly sourced from within Europe. The key challenge here is to enhance efficient use in production and consumption which could be facilitated by a balanced combination of:

- ✔ increased pricing of raw material extractions, e.g. by an aggregated tax,
- ✔ education and training of engineers and architects as well as R&D on dematerialized construction,
- ✔ demonstration projects, eg. public buildings, to show how material and energy efficiency can be combined.

Certainly, there are other challenges as well, however, those roughly outlined here seem to be paramount when trying to moderate the magnitude of resource flows towards more sustainable levels.

Key strategies

There are four key strategies which may be deemed essential for implementing an economy-wide sustainable resource management (SRM) (7):

Resource efficient and recycling based industry

The search for a smart combination of dematerialization and rematerialization will drive innovation. Resource light product design is an essential prerequisite to reach factor 4 to 10 resource savings and to combine both resource and climate protection with cost savings in manufacturing. Product-service systems will help to orientate production towards consumers needs while offering functions rather than hardware. The multitude of anorganic elements used in the era of rare metals may on the long run be superseded by a limited number of structure building organic elements, in particular carbon as basis for chemicals and materials with multiple properties. Carbon recycling will then regenerate feed-stocks from organic waste, in the long-run by means of renewable energies. The stocks of materials in buildings and infrastructures as well as long-lived products will be the mines of the future («*urban mining*»).

The steady stocks society

The maturation of the socio-industrial metabolism will lead to a dynamic flow equilibrium between inflows and outflows of the materials stocked in buildings and infrastructures. Construction of new houses and roads will be associated with deconstruction of old ones, either at the same or other places. Recycling will be the dominant source of material input, in contast to the current phase of physical growth. In Western Europe, the leveling off of the increase in living space and road length per capita indicates that that stadium may not be so far ahead as it might be in Eastern Europe and the developing world. Investment patterns will have to shift from new additional buildings to maintenance, refurbishment and quality up-grade of existing ones.

Solarized infrastructures

The surface of buildings and infrastructures still remains a largely unused resource of energy supply. Roofs, facades, and windows, but also side walls of highways and traintracks, even the roads and tracks, may be equipped with either solar thermal or solar power generating functions. Integrating these functions will save land and improve energy security. In developing these technologies further it seems important to (a) avoid the use of hazardous substances (like Cd in photovoltaics) which may be dispersed later by improper waste disposal, in particular in developing countries; and (b) to minimize the resource requirements (TMR), and pressures such as GHG emissions per unit of energy supplied and per hectare.

Balanced bioeconomy and bioniconomy

The reduction of mineral resource use can lead to a relative increase of biomass input, which in itself should not increased significantly due to limited land resources. In devising policies for efficient use of biomass, priority should be given to food production, and the non-food use should prefer material purposes against energy which might better be recovered at the end of a casdade. Carbon recycling technologies should be further developed to use organic waste for the regeneration of material feed-stocks such as polymers. In the long run, the absorption and use of atmospheric carbon dioxide by means of renewable energies will provide the basis for a «bioniconomy» which uses bionic principles from nature. *Industrial photosynthesis*

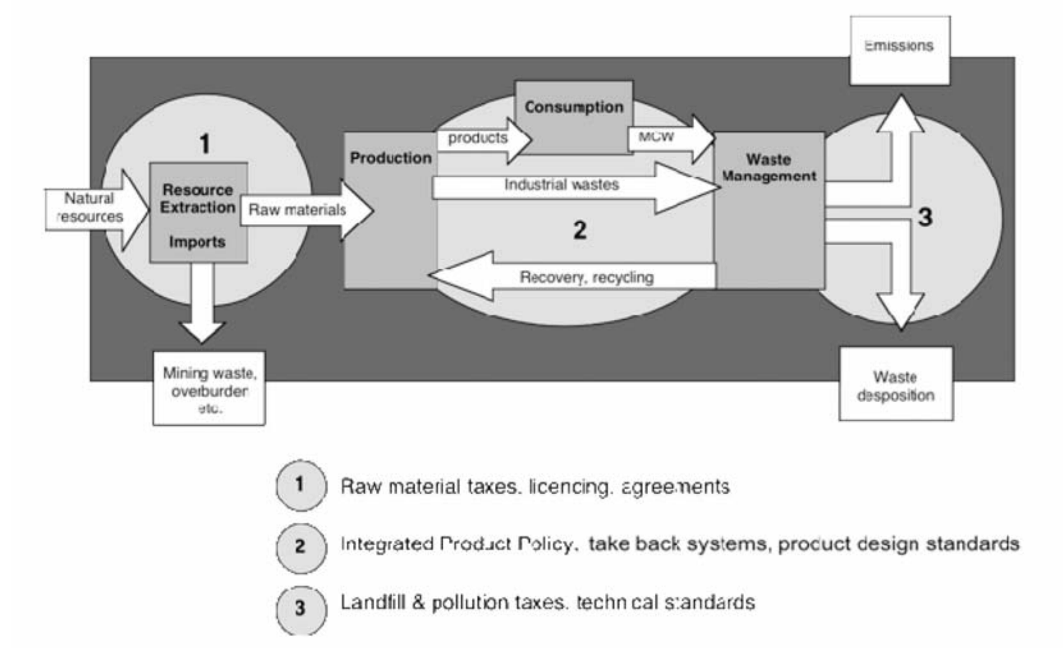

Figure 6: Target areas of material flow based policies for economy-wide sustainable resource management (Bringezu 2002).

will then allow to regenerate the material basis of the economy, largely based on carbon (hydrocarbons, carbohydrates, graphen etc.).

Policy development and outlook

When designing policies for sustaining the physical basis of economy, substance specific measures should be limited to the control of hazardous substances, as is already estabished by instruments such as REACH and the RoHS directive. Complementary to that, in order to develop the structure and volume of the socio-industrial metabolism towards sustainability, measures should be deployed to address *whole resource and product groups* and sectors (as outlined above under resource specific challenges). This will allow to:

- ✔ avoid problem shifting by too detailed regulation;
- ✔ provide long-term orientation and set incentive frame for engineers/consumers to find appropriate solutions;
- ✔ keep governance manageable;
- ✔ guide («edit») industry/households towards resource light demand;
- ✔ buffer the re-bound by controlling overall resource use;
- ✔ cap resource use (and thus related impacts) instead of final demand of products and services (and thus well-being).

Material flow based policies may target may various sections of the production-consumption chain in a balanced manner, in order to provide synergies and avoid leakages (Fig. 6). Traditionally, environmental policies started from the back end of that chain, ensuring safe waste disposal, then proceeded towards recycling and integrated product policy. More and more also the inflows of primary raw materials are gaining attention, as economic instruments using market mechanisms may foster incentives for a more efficient use of these resources, including recycling.

The transition towards an economy-wide sustainable resource management will depend on the successful establishment of institutions in order to engage and enable the actors in industry and society (8):

- ✔ discussion and agreement is needed on long-term goals, objectives and targets;
- ✔ indicator based information on current performance, business-as-usual outcomes and alternative scenarios is required at various levels of decision making;
- ✔ economic incentives should motivate the market actors to develop eco-innovations for resource efficient products and services;
- ✔ experiments and societal learning should be fostered, including the analysis of experiences from different countries by international comparison of sustainable resource management policies (Figure 6).

Various puzzle pieces within the framework of economy-wide sustainable resource management already exist. For instance, indicators are gradually enhanced, resource efficiency agencies effectively advise companies how to save materials, energy, water, waste, and costs. Some countries have even introduced taxes on mineral aggregates, others are considering reductions of subsidies for resource intensive industries, and to invest more into R&D, education and training for efficient and sustainable resource use, which is certainly an investment into the future.

Notes

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(1) The article is based on a presentation given to the European Environment Ministers´ meeting in Ghent, Belgium, 12 July 2010, and discussion with DG-Env staff 29 Sep 2010 in Brussels. More details and sources are given in Bringezu and Bleischwitz (2009).

(2) Based on www.materialflows.net – version 2008

(3) Note: in the policy debate on Post-Kyoto targets for GHG emissions it has been argued that people do not want to be made responsible for low-efficiency processes in production countries and therefore might not agree to consumption oriented indicators; however, the up-stream flows of GHG emissions liked to imports (and exports) can be calculated based on the assumption of domestic technologies, ie high process efficiencies, thus indicating the minimum emissions which would have occured if the consumed products were all produced within the own country. Similar calcaluations are possible for land use, and mineral extraction (although for the latter it seems more advisable to account for real extraction affecting the country of origin and reflecting the different mining and refining operations varying between metals and other minerals).

(4) Council of the European Union (2009): Presidency conclusions. Doc. 15265/09 as of 30 Oct 2009, Brussels

(5) This 'climate and energy package' was agreed by the European Parliament and Council in December 2008 and became law in June 2009. It foresees: A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels; 20% of EU energy consumption to come from renewable resources (CEC 2008; and Directive 2009/28/EC as of 23 April 2009); and a 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency (see http://ec.europa.eu/energy/efficiency/index_en.htm; accessed 6Oct2010)

(6) Without erosion

(7) More background and examples are given in Bringezu (2009)

(8) Policies for sustainable resource management are discussed and exemplified in Bleischwitz et al. (2009)

Bibiographie

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