Eco-Efficiency in Industry and Science 29

Michael Angrick
Andreas Burger
Harry Lehmann *Editors*

Factor X

Policy, Strategies and Instruments for a Sustainable Resource Use

Springer

Factor X

ECO-EFFICIENCY IN INDUSTRY AND SCIENCE

VOLUME 29

For further volumes:
http://www.springer.com/series/5887

Michael Angrick • Andreas Burger
Harry Lehmann
Editors

Factor X

Policy, Strategies and Instruments for a Sustainable Resource Use

Springer

factor X
beyond climate change

Editors
Michael Angrick
The Federal Environment Agency
Sustainable Production and Products,
Recycling Management
Dessau-Roßlau, Germany

Andreas Burger
The Federal Environment Agency
Economic and Social Environmental Issues,
Sustainable Consumption
Dessau-Roßlau, Germany

Harry Lehmann
The Federal Environment Agency
Environmental Planning
and Sustainability Strategies
Dessau-Roßlau, Germany

ISSN: 1389-6970
ISBN 978-94-007-5705-9 ISBN 978-94-007-5706-6 (eBook)
DOI 10.1007/978-94-007-5706-6
Springer Dordrecht Heidelberg New York London

Library of Congress Control Number: 2013953381

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword

The conservation of natural resources is, alongside climate change mitigation, the key environmental and economic challenge of this century.

From this insight arose the idea to launch a series of books devoted to the many and varied aspects of resource protection. As President of the German Federal Environment Agency, I am proud of the fact that numerous important authors have followed the publishers' call and set out their view of resource protection. For this I am particularly grateful, and I take the contributions to be also an expression of appreciation for the Agency and its staff.

Why is the protection of natural resources a key issue of current environmental protection policy?

Resource use has become more efficient in Germany over the past years. In 2008, we required 580 tonnes of raw materials per million Euro GDP, compared to 680 tonnes in the year 2000. In recent years we have approached the goal of doubling raw material productivity by 2020, compared to 1994, but unless additional measures are taken this goal set by the German Federal Government in 2002 in its National Sustainable Development Strategy will not be achieved. It is not enough to look solely at the trend in productivity to evaluate the sustainability of resource use. We also need to consider the absolute consumption of raw materials. As a long-term target, a reduction of consumption by a factor of about 10 should be achieved by 2050. Conserving resources is a global task. It is not ecologically worthwhile to increase raw material productivity in Germany merely by increasingly importing resource-intensive up-stream products. Therefore, it is important to develop indicators which also provide us with information on the 'backpacks of raw materials' that are hidden in these imports. The German Federal Statistical Office has analysed relevant data in a research project for the Federal Environment Agency. The analyses of the Federal Statistical Office show that when these backpacks are factored in, the productivity gains are significantly smaller than previously thought.

Economical use of raw materials not only reduces pressures on the environment but also opens up economic opportunities for individual companies and the economy as a whole, as shown by a modelling study carried out on behalf of the Federal Environment Agency.

From the perspective of environmental protection, efforts must focus on minimising the environmental impact of raw material extraction and use. To achieve this, raw material consumption must be further reduced in the long term. The short- to medium-term goals must be to harness saving potentials and increase efficiency.

To realise this, policy initiatives must provide incentives and set the appropriate framework.

The Federal Environment Agency takes ‘natural resources’ to mean renewable (biotic) and non-renewable (abiotic) raw materials, physical space (land) and the environmental media, water, soil, air. A narrow definition was chosen for the raw materials indicator in the German National Sustainable Development Strategy. Total economic use of (abiotic) raw materials, energy sources, ores, construction materials and industrial materials forms the reference basis for the key indicator ‘raw material productivity’. Raw material productivity is defined as the ratio of gross domestic product to the extraction and import, in tonnes, of abiotic raw materials and semi-finished and finished goods. The target of the German Federal Government is to double raw material productivity by 2020 compared to the year 1994.

The use of raw materials (such as energy sources, construction materials, e.g. minerals, metals) is the basis for any economic activity. Raw materials whose substitutability is limited are an important production factor. Global annual consumption of raw materials amounts to about 60 billion tonnes today. This is 50 % more than just 30 years ago and is set to continue to increase. The main drivers for the continued growth in raw material consumption are global population growth and the growth taking place in newly industrialised countries. In Europe today, daily per capita consumption of raw materials is 43 kg, compared with 88 kg in North America and 10 kg in Africa.

The rapidly growing demand for raw materials has already led to rising prices for raw materials in the past, and according to experts this trend will continue. For example, copper today costs about three times as much as in the 1990s. The growing consumption of raw materials is not, however, only an economic cost factor. Their extraction, transport and use puts pressure on the environment, for instance in the form of land consumption and emissions. The growing demand for raw materials diminishes their concentrations in deposits, which progressively increases the technical effort needed for their extraction as well as the associated costs and adverse environmental impacts.

The extent of resource consumption (currently 18 % of the global population consumes 80 % of the available resources) progressively reduces our planet’s capacity to regenerate the resources vital to human beings and animals. Therefore, a turnaround – away from current resource consumption patterns towards a sustainable economy – is needed worldwide. The urgency of the need to act locally according to sustainable principles is also evident from the rapid pace of resource consumption in so-called newly industrialised countries. If we adhered to current consumption patterns, global resource consumption would increase many times within the next 20 years and would then exceed the regeneration capacity of the environment at the expense of the basis of existence of present and future generations. Therefore, all countries should urgently make their economies sustainable by increasing resource efficiency, reducing resource consumption in absolute terms and abandoning resource-intensive consumption patterns in favour of resource-efficient lifestyles.

It is obvious that a switch in the use of natural resources will lead to a redistribution of these resources in coming decades. Attempts will have to be made to reach a common understanding on per capita consumption. Clearly, this also implies that rich industrialised countries will have to reduce their excessive consumption while other countries should be allowed to increase theirs. Mankind has to meet in a 'sustainability corridor'.

This book series seeks to explore the background of the resource issue, provide information and give relevant actors certainty as to the direction of developments in this field. I therefore hope that this series will attract a great deal of attention.

Dessau and Berlin Jochen Flasbarth

Prologue[1]

The projected global population growth will put significant pressure on the future environment. The majority of this population growth will take place in developing countries. The expansion in population will lead to an increased demand of more goods and services consequently increasing the pressure on global resource use.

Per capita economic growth in developing countries will further increase this pressure, as economic growth is generally associated with an increase in resource use. Even though there are trends to **decouple** resource use and economic growth in mature economies, this is not the case for developing countries. Countries such as China and India are currently experiencing rapid economic growth. Others will follow, claiming their equal right to material well-being. As these countries are likely to adapt their consumption patterns to those of industrialised countries, the pressure on global resource use will continue to increase.

However, globalised western lifestyle is not world-compatible, as even the current environmental burden is not sustainable.

Population in Europe is stagnating. The driving factor for resource use is primarily economic growth. Continuing economic growth means **that resource productivity** has to increase constantly even when only constant resource use levels are to be maintained. A 2 % growth rate per year, for example, needs a doubling of resource productivity every 35 years.

Even though some relative decoupling of growth and resource consumption is emerging, there is still an absolute increase of environmental pressure. With the growing trend towards a globalised economy, competition for resources is likely to increase progressively over time. This brings a consequential risk of geopolitical instability as competing interests seek to capitalise on key global resources. Through the development of a Resources Strategy, the EU has an opportunity to encourage a global approach to resource conservation and management.

[1] This text is an abridged version of EPA network, "Delivering the sustainable use of natural resources – A contribution from members of the Network of Heads of European Environment Protection Agencies on the Thematic Strategy on the Sustainable Use of Natural Resources", 2006, adapted by Harry Lehmann.

If we are to preserve the basis of existence for future generations, it is important to reduce the total resource use. Therefore we should establish quantitative targets at least for raw material consumption and land use. These areas are interconnected also with several other areas, e.g. energy use, so targets are not independent of each other but should still be set for each area. The targets should not be reached by exporting environmental pressure.

Raw material extraction and use is always associated with demands for material, energy and land and with the generation of waste and emission of pollutants. That means saving our ecosphere is correlated with a decisive reduction of man-induced material flows. Sufficient and equitable access to natural resources constitutes a basic human right, which calls for an acceleration of the shift towards sustainable consumption, and where appropriate, for a de-linking of economic growth and environmental degradation.

Further a fast decoupling of raw material consumption and economic activities is needed. On the long run, until 2050, a significant decrease of the consumption of resources, in the line with the idea of a factor 10 reduction target, has to be achieved. Therefore EU-wide and country-specific targets have to be set.

Considering the long-term sustainability of land use, one of the most critical issues is the change of use from 'natural' land-use categories, such as forests and wetlands, to semi-natural, such as croplands; or, even worse, from forests, wetlands and croplands to settlements and transportation infrastructures. In addition to the permanent and irreversible loss of fertile soils, such change leads to further environmental impacts, such as land fragmentation, interruption of the water economy, biodiversity reduction and micro-climate modification. Therefore net land use increase for non-biospheric activity should be reduced to zero, as space on earth is neither regenerable nor substitutable.

The following fundamental principles should underpin future Resources Strategies:

- The consumption of a resource should not exceed its regeneration and recycling rate or the rate at which all functions can be substituted.
- The long-term release of substances should not exceed the tolerance limit of environmental media and their assimilation capability.
- Hazards and unreasonable risks for humankind and the environment due to anthropogenic influences must be avoided.
- The time scale of anthropogenic interference with the environment must be in a balanced relation to the response time needed by the environment in order to stabilise itself.

The challenge of sustainable resource use concerns diverse fields of policies (e.g. economy, taxation, agriculture, fisheries, products, manufacturing, land use planning and research) and requires the co-ordinated use of different instruments. It is important to elaborate a "systems" view and approach to the Resource Strategy.

This Strategy must also reorient production and consumption patterns and make structural changes to the economy. The task is to reduce the consumption of natural resources by humans.

Some aspects of sustainable resource use are not well understood and additional research is also needed to optimise the approach. However, existing knowledge is sufficient to support a faster and stronger progress. This book hopefully will be of value on our transformation path towards a “Factor X” society.

Introduction

Worldwide resource consumption is far away from a sustainable level and threatens fundamentally the natural base of wealth for future generations. But by now there is only a limited comprehension both of the size of this challenge and the policies, strategies and instruments needed to reduce the resource use significantly in the next decades. The 17 contributions of this book try to fill some of these gaps. They are grouped into four parts.

The first part analyzes the limits of resource use by confronting the growing demand of fossil fuels, metals, minerals and agricultural products with the respective types of scarcities and limited availability.

F. Hinterberger and S. Giljum provide in Chap. 1 an overview of trends in worldwide material flows. In the light of overall growing resource use they highlight two main types of resource and their respective scarcities: non-renewable resources and limited biological capacities. Implications of growing resource use, reaching from increasing competition for natural resources to severe damages to the ecosystem, are also shown. The authors suggest to comprehensively measure and report global resource use on micro- and macroeconomic levels as well as implementing policy measures such as information campaigns, environmental tax reforms and global regulation.

In the second chapter J. Schindler explains scenarios for fossil fuels done by the Energy Watch Group and the Ludwig-Bölkow-Systemtechnik. According to these analyses the global supply of crude oil reached its peak already, supply of natural gas will peak soon and even coal production peak will be around 2030. This indicates clearly that the twenty-first century will see the transition to a post–fossil energy world.

The contributions of the second part depict potentials and derive possible goals for a sustainable resource use in different fields.

S. Bringezu outlines in Chap. 3 a rationale for the derivation of possible long-term resource use targets for total material consumption of abiotic materials and global land use for crops. He indicates targets that are expressed in tentative per capita values which may serve as a first orientation and basis for further debate and research.

Land take for settlement and transport in Germany is the topic of the contribution by G. Penn-Bressel. She elaborates the close interdependencies between protection of nature, efficient use of energy and materials and sustainable land use. She shows that the ongoing expansion of settlements and transport infrastructures as well as the continuous maintenance and running of these systems requires enormous inputs of materials and energy. Thus, one of the most demanding challenges in resource protection policy consists in slowing down urban sprawl and reducing the speed of consumption of new land (land take) for settlements and transport infrastructure.

Decarbonising the economy is an important part of any resource efficiency strategy. In Chap. 5 G. Knoche et al. explain how this aim can be reached taking Germany as an example. They demonstrate that main components of such a strategy are reduced energy consumption, a more efficient electricity production and the use of renewable energy. The described change focus on Germany but the contribution also concludes that a decarbonising of the economy on a European level could lead to significant synergy effects.

The following contribution by A. Tukker identifies and explores the potential of five strategies to realize a radical decoupling: (1) reducing emission factors of processes and products; (2) producing more products with similar or lower inputs; (3) intensifying use of products; (4) reducing the material or product intensity of consumer expenditure; and (5) enhancing quality of life at the same expenditure levels. The chapter concludes that none of these strategies is the silver bullet and that they have to be combined to realize the reduction factors needed.

In Chap. 7 B. Meyer discusses results of policy simulations with the economic environmental model Panta Rhei which shows that an improvement of material efficiency might allow at least a relative decoupling of economic activities and material use. A combination with a policy that concentrates on technical change in resource important sectors, which the chapter identifies, might enable even an absolute decoupling. The contribution shows that this can also be part of an engaged climate policy, since fossil fuels are one of the most important material inputs in the economy in quantitative terms.

In the third part, strategies and policies for a sustainable use of resources are developed. The authors highlight thereby different approaches.

F. Schmidt-Bleek and M. Wilenius give in Chap. 8 an overview on necessary policy changes. They emphasize in their contribution the necessity to change life-styles and to reduce by 2050 the world-wide average per capita consumption to a maximum of 8 tons of material per year. To achieve this goal they call for system policies instead of focusing on single problems.

In the next chapter A. Femia argues in favour of including a drastic increase of resource efficiency among the primary goals of society, with a higher priority level than that of increasing labour productivity. Resource efficiency is thought in this chapter as of a general ability to generate socially desirable results from natural resource use. As a drastic reduction of natural resource use is necessary for sustainability, dematerialisation should be an overarching goal of policy. This does a priori not imply a decrease nor an increase of GDP, but requires radical structural changes of the way society is organized to respond to individual and social needs.

A. Burger gives in Chap. 10 an overview of strategies and instruments that contribute to establish and strengthen markets for resource efficient products and services. It is based on an analysis of the obstacles on the micro- and macroeconomic level hindering the increase of resource efficiency and concludes that coherent, long-term and comprehensive strategies are necessary combining long-term efficiency targets as guardrails for investors and consumers with a reform of the general economic framework, institutional reforms and market specific instruments.

M. Halme et al. focus in their chapter on enterprises. They propose material efficiency services as one solution to improve resource efficiency. The chapter introduces a conceptual framework for analyzing business models of eco-efficient services and applies this framework to material efficiency services. Four business models are outlined and their feasibility is studied from an empirical vantage point, with special emphasis on the financial aspects.

Chapter 12 by J. Kanthak and M. Golde takes a view on international natural resource policy. As the world economy is very much integrated and raw materials and products are traded across borders, national oriented resource policy is not sufficient. An internationally coordinated policy will gain better results. The chapter identifies elements of international resource governance, discusses requirements and possible solutions for its implementation.

Chapter 13 by M. Jänicke reflects the necessity and the spectrum of possible modes of policy intervention for sustainable resource use. It focuses on material productivity and its environmental, economic and employment advantages. A variety of possible interventions along the supply chain is being discussed. Thereby a new phenomenon of policy acceleration is described using the experiment of climate policy in Germany as an example. It describes an ambitious policy, starting a process of innovation and diffusion that leads to market success of domestic innovators, which finally suggested even stricter policies. The author concludes that it is time for a more ambitious policy, even though, taking the complexity of material flow management into account, trial and error still may be inevitable.

The authors of the last part develop proposals for implementation of a policy that supports resource efficiency and a sustainable use of resources.

In Chap. 14 Ekins et al. suggest that existing climate policy, based on international targets and national policies to meet them, could be supplemented by a similar policy on resource use, involving: either a global level of taxation to meet resource use targets, with transfers to poorer countries to support their resource-efficient development; or a global resource permit trading scheme, with diminishing resource allowances over time. The latter could begin with a small group of larger, industrialized countries, which encourage others to join the group by imposing taxes on imports from non-members equivalent to their own self-imposed resource surcharges. Coupled to a regime of Sustainable Commodity Agreements, to promote environmentally sound resource extraction, such a system could lead over time to the globally sustainable development which has as yet quite eluded the global community.

B. de Leeuw et al. take a view from the World Resources Forum. It was launched in order to transcend the current political focus on climate change and to bring the broader issues of global resource consumption and resource productivity back onto the agenda. The contribution shows the results from the 2011 World Resources Forum which concluded with 14 recommendations.

The chapter by M. Koller and J. Günther describes in a first step the current resource policy landscape, then identifies challenges on the way to further progress and finally outlines next steps for addressing the challenges of the management of natural resources in the context of sustainable development. Important steps are seen in deeply rooting the principles of sufficiency, fairness and responsibility, consistency and resilience into the public and private sector, and in changing the institutional settings towards a more sustainable resource management. All this must base on a more systemic thinking, which addresses the nexus of the various resources, and on implementing sustainable resource use in the civil society as a practice of daily life.

The editors close with a view on the need of resource efficiency programs. They argue that it is urgently necessary that efforts at European level towards the conservation of natural resources be stepped up and that the European Union shows that it is prepared to play a role in the world and in global environmental protection that is appropriate to its political weight.

Contents

Part I
Limits to Resource Use

Chapter 1
The Limits of Resource Use and Their Economic and Policy Implications

Stefan Giljum and Friedrich Hinterberger

1.1 Why and How Natural Resources Are Limited

Due to growth of world population, continued high levels of consumption in the developed world combined with the rapid industrialisation of countries such as China and India, worldwide demand on natural resources and related pressures on the environment are steadily increasing. Renewable resources, and the ecological services they provide, are at great risk of degradation and collapse (see, for example, UNEP 2007; Millennium Ecosystem Assessment 2005; WWF et al. 2012). The depletion of these ecological assets is serious, as human society is embedded within the biosphere and depends on ecosystems for a steady supply of the basic requirements for life: food, water, energy, fibres, waste sinks, and other services. At the same time, extraction of many non-renewable resources is already reaching or near a peak; some authors even describe the situation in the near future as "peak everything" (Heinberg 2007).

Many of today's most pressing environmental problems are caused by the overall growth of production and consumption rather than by specific harmful substances (see, for example EEA 2010). The past 30 years saw a change in complexity and scope of environmental problems in Europe and other industrialised countries. Early environmental policy in the 1970s and 1980s was mainly concerned with the reduction of local or regional environmental degradation through pollution of certain environmentally harmful substances, such as air pollutants, sewage effluents, and hazardous wastes.

In this area, Europe has achieved significant improvements due to technological innovations and substitution of harmful substances and products. This has resulted

S. Giljum (✉)
Vienna University of Economics and Business, Welthandelsplatz 1/D4, 1020 Wien, Austria
e-mail: stefan.giljum@wu.ac.at

F. Hinterberger
Sustainable Europe Research Institute, Garnisongasse 7/17, A-1090 Vienna, Austria
e-mail: fritz.hinterberger@seri.at

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_1,

in better environmental quality of rivers and lakes, decreasing concentrations of pollutants in ground water, successful reduction of acid rain and improved air quality in many cities.

However, since the late 1980s, another type of environmental problem became increasingly important, associated with global changes in production, trade and consumption patterns. These problems are more difficult to address, as they are complex, international or even global in scope, and involve multi-dimensional cause-effect-impact relationships and time-lags. Issues such as climate change, loss of biodiversity, land cover conversion and high levels of energy and resource consumption are part of this type of environmental problems. These problems are more closely related to the overall volume (or scale) of economic activities than a result of the specific potential for environmental harm of single substances (Schmidt-Bleek 1992).

As evidence illustrates (EEA 2010), Europe has performed much worse in this regard: many species are threatened by extinction, fish stocks are depleted, water reserves are shrinking, overall waste volumes have been growing, urban sprawl transforms fertile land into sealed areas, valuable soil is lost through erosion, energy consumption grows, and Europe is far away from achieving a significant reduction in GHG emissions. Pollution prevention should continue playing an important role in EU policies, but these types of measures need to be complemented by additional strategies tackling the environmental problems related to the overall size of the production and consumption system.

At the same time, economic issues related to natural resource use increasingly gain in importance in international policy debates. Competition over natural resources is rising, as rich countries maintain high levels of per capita resource consumption, while industrializing nations rapidly increase their per capita material consumption, aiming at raising their material standard of living towards the levels of the Western world (Giljum et al. 2010; Dittrich et al. 2011). Europe is particularly vulnerable as large shares of the raw materials for production and consumption have to be imported from abroad. This is mostly visible for fossil fuels and metal ores: for iron ores, the import share is 83 %, for bauxite 80 % and for copper 74 % (European Commission 2008). Recent EU policy documents, such as the trade strategy "Global Europe" by the Directorate General Trade and the "Raw Materials Initiative" by the Directorate General Industry address the issue of resource security and maintaining access to raw materials in other world regions through an open international trade system. Increasing resource productivity is also regarded as a key strategy to foster innovation in Europe and to contribute to the realisation of "smart" and "green" growth (European Commission 2011).

Although the environmental and economic problems related to the current production and consumption system are already fully apparent, only around 20 % of world population with high purchasing power benefit from a system of global resource trade; 80 % of world population still live in material poverty with an income of below 10 US$ a day and will (legitimately) demand further growth and material consumption in the future. The generalisation of the resource-intensive economic model in Europe and other developed parts of the world to today's seven or even ten billion people in the future is therefore neither environmentally possible nor can it be economically and socially sustained. The issue of resource consumption and material welfare is therefore inseparably linked to global justice and a fair distribution of global natural resources between all inhabitants on our planet.

1.2 Current Trends in Global Resource Use: Some Basic Trends

Today, the world economy uses more material resources than ever before in human history. Global extraction of economically used materials grew by almost 80 % in the past 30 years. As indicated in Fig. 1.1 world-wide extraction of biomass (green), minerals (orange), fossil fuels (grey), and metal ores (blue) was around 38 billion tonnes in 1980, this number increased to more than 68 billion tonnes in 2008 (SERI 2011). Since 2003 growth rates were significantly higher than in any of the previous periods (+3.7 % annually compared to 1.7 % per year before 2003), in particular due to the rise of emerging economies, such as China, India or Brazil. Growth was observed in all major material categories, but most pronounced for industrial and construction minerals and metal ores. As a result, the share of renewable resources in global extraction decreased from 36 to 28 %. Scenarios illustrate that, in the absence of the before mentioned resource peaks, global levels of resource use could be around 80 billion tonnes in 2020 (Giljum et al. 2008) and more than 100 billion tonnes in 2030 (Lutz and Giljum 2009), if no policy measures are implemented aiming at an absolute reduction of resource use.

Subdividing these global material flows among continents reveals that Asia clearly dominates the extraction of all major resource groups. Except for metals it

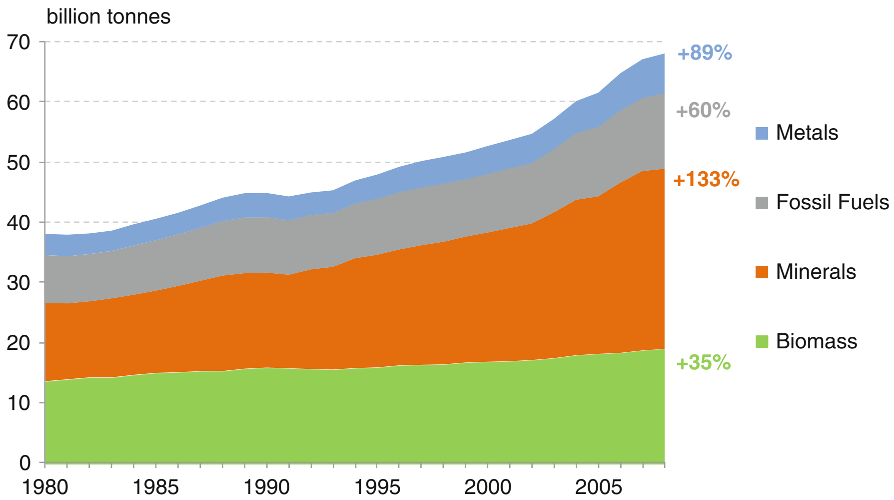


Fig. 1.1 Global material extraction by major material category, 1980–2008 (Source: SERI 2011)

extracts more than twice as much as any other continent. With regards to metals Latin America (especially Brazil, Chile and Peru) and Oceania (especially Australia) together supply 41 % of all metals globally. But Asia not only champions global extraction. The region is also responsible for about half of all global trade movements (imports and exports) and half of all resource consumption in physical terms. The Russian Federation alone provides 16 % of all materials worldwide and Saudi Arabia remains the leading global petroleum exporter (closely followed by Russia). However, Asia's average per capita consumption as well as its material productivity are still below the global average, despite an increase of the former by 46 % since the 1990s (Dittrich et al. 2012).

Huge differences can be observed between the per capita levels of material consumption in different countries around the world. In poor countries such as Bangladesh, Afghanistan or Malawi, Domestic Material Consumption (DMC) is as low as 2 tonnes per capita, which is barely enough for survival. On the other hand of the spectrum are the rich, oil-exporting countries (such as Qatar or the United Arabic Emirates), which have consumption numbers of more than 80 tonnes DMC per capita (Giljum et al. 2010). European countries typically have consumption levels between 15 and 20 tonnes of DMC (EUROSTAT 2010). If the so-called ecological rucksacks of European imports (and exports) are taken into account, those numbers increase by 50–200 % to 30 tonnes or beyond (Bruckner et al. 2012).

Encouraging is the fact that the share of the top 10 % of countries (in terms of per capita material consumption) reduced their share of global consumption from 33 to 27 %. However the lowest 10 % have apparently not benefited from this development, maintaining their part constant at only 2.5 %. Encouraging from an equity point of view is also the apparent change in power relations due to the fact that more and more developing countries process raw materials to semi- or finished goods, thereby competing on world markets. This of course is problematic for industrialized countries which have built an economic structure dependent on cheap raw material imports. In 1980, 55 countries net imported 3 % or more of their consumption, and 39 countries exported a significant amount of their extraction. By 2008 the ratio was 110 to 45 (Dittrich et al. 2012).

Absolute resource consumption also varies greatly among the different countries of the world. Compared to per capita consumption, which is relevant for equity issues, this indicator is particularly relevant from an environmental perspective. As shown in Fig. 1.2, countries which are populous, enjoy high incomes and/or are resource rich tend to consume more materials in absolute terms. China stands out as the top consumer with this respect, consuming almost 28 % of all materials extracted world-wide in 2008. China is followed by the United States with 12.5 % and India with 6.7 %.

From 1980 to 2008, the material intensity (calculated as material consumption per GDP) of the world economy decreased by about a third (see Fig. 1.3). This is reflected by an increase in material productivity (calculated as GDP per material consumption) by 40 %, as GDP (in constant purchasing power parities, PPP) grew much faster than material consumption (150 % vs. 82 %). So far, however, there are no signs of dematerialisation (absolute decoupling) at the global level. The achieved efficiency improvements have therefore been overcompensated by economic growth.

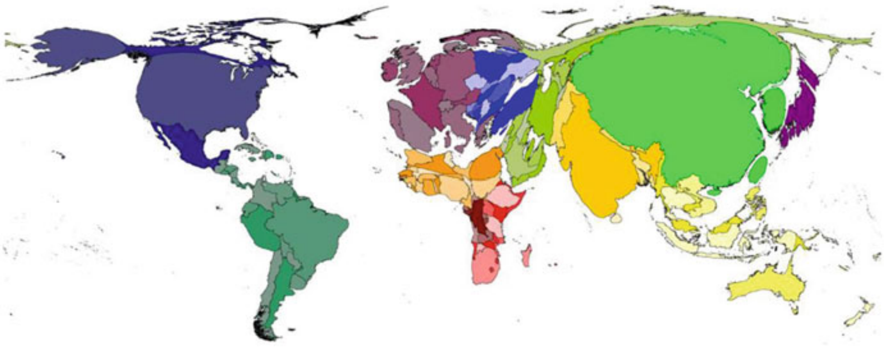


Fig. 1.2 Absolute resource consumption of high and low consuming countries, scaled according to their share in total global consumption (2008) (Source: Dittrich et al. 2012)

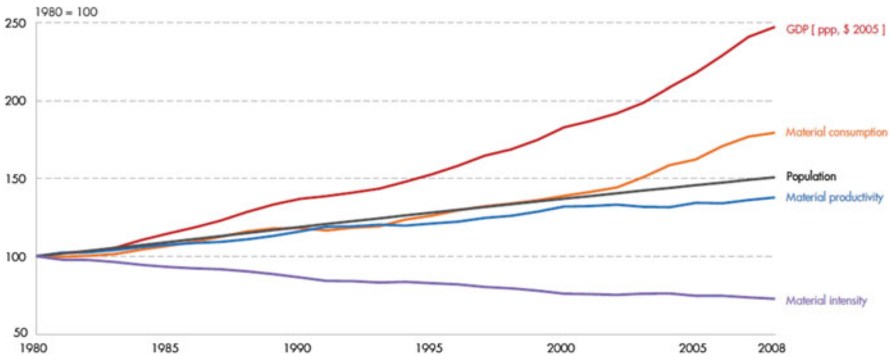


Fig. 1.3 Global trends in material consumption and productivity (Source: Dittrich et al. 2012)

In the light of these global trends of rapid increase in material consumption and the very dynamic scenarios on growing raw materials and energy use in the future, the question arises, whether further economic growth will be possible or whether the world economy will face ecological limits to growth. Maybe the current financial and economic crisis (observed since 2008) is rooted in the fact that resource extraction cannot further meet the demand by growing economies, partly explaining the sharp recent increase in commodity prices (See Pirgmaier and Hinterberger 2012; Kerschner and Arto-Oliazola 2011). Figure 1.4 below provides some evidence for this hypothesis, indicating that all oil price spikes in the U.S. tended to be accompanied by periods of recession. The dotted line indicates a tentative threshold above which the economy moves towards recession (Murphy and Balogh 2009).

Trends in resource consumption and resource prices are thus linked to development of economic growth. This was also emphasised by a recent article by Murray and King (2012) who concluded that the price of oil contributed significantly to the Euro crisis in Southern Europe.

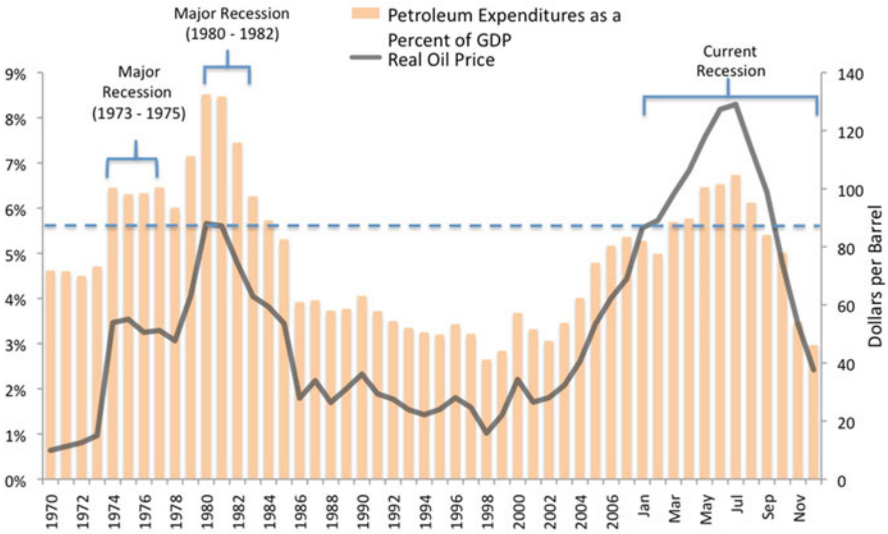


Fig. 1.4 Petroleum expenditures as a percentage of U.S. GDP and real oil prices (Source: Murphy and Balogh 2009)

1.3 Different Types of Resource Scarcities

Humans cannot use natural resource in ever increasing amounts as our planet is physically limited. The global so-called "Environmental Space" (Opschoor 1995; Spangenberg 2002) can be described as the limited capacity of the biosphere's environmental functions to support human economic activities. It is defined as the total amount of energy (emissions), non-renewable resources, agricultural land, forests etc. that everyone can use without causing irreversible damage to natural systems. The concept of Environmental Space also includes a social dimension, which is given by the principle of "global fair shares" or the "equity principle". This principle assigns to all currently living people a right to achieve a comparable level of resource use, and to future generations a right to an equivalent supply, thus reflecting inter- and intra-generational justice of distribution. This has particular relevance taking into account the huge inequalities in material consumption, which can be observed today (see above).

Derived from the concept of "Environmental Space", two types of limits to growth regarding material use and material availability can be distinguished: limited availability of non-renewable materials such as metals, as well as limited availability of ecological capacities of the global ecosystems. Additionally, resource scarcities can arise from geographic concentrations of resource reserves as well as scarcities caused by specific market constellations, such as monopolies in primary sectors.

Non-renewable resources, in particular fossil fuels and metal ores, are finite. As the "World Energy Outlook" of the International Energy Agency points out, an

Table 1.1 Predicted peak and depletion of different fuels and metals, and main area of usage

Commodity	Peak	Depletion	Main area of usage
Oil	2006–2026	2055–2100	Energy generation chemical industry and pharmaceuticals construction
Natural gas	2010–2025	2075	Energy generation
Coal	2100	2160–2210	Energy generation
Antimony	–	2020–2035	Metal alloys
Copper	–	2040–2070	Energy transport piping electronics
Gallium	May have passed	–	Electronics (mobile phones, solar cells)
Indium	–	2015–2020	Electronics (LCDs, solar cells)
Lead	Passed	2030	Automobile industry chemical industry
Platinum	–	2020	Electronics (printer, etc.) industry (plug, catalyser, glass production) medicine (pacemaker)
Silver	–	2020–2030	Electronics pharmaceuticals
Tantalum	–	2025–2035	Electronics (mobile phone, automobiles) pharmaceuticals chemical industry
Uranium	–	2035–2045	Energy generation
Zinc	–	2030	Anticorrosives energy storage (batteries)

Source: European Parliament (2009)
Note that out of the variety of different results, the authors derived the time spans most often mentioned in the respective studies. For some metals, no information about peak extraction could be found (marked with –)

energy revolution is necessary, in order to change human's use of energy towards environmental, economic and social sustainability. As the IEA points out the highly necessary shift of world-wide trends in energy use and related CO_2 emissions has not yet started (IEA 2011). Several scenarios exist for "peak-oil", i.e. the reaching of the level of maximum global oil extraction. All scenarios illustrate that peak oil will be reached between 2015 and 2050. If no affordable alternatives to oil can be developed in time, these developments will have severe negative economic impacts, for example in the construction and transport industries, as well as in the chemical or pharmaceutical sectors. Apart from oil, studies exist which suggest that peak extractions have already been reached or will be reached in the very near future for a number of metal ores such as zinc, silver, platinum or tantalum.

However, data on commodity reserves and depletion dates diverge significantly. On the one hand, this is due to different assumptions and estimation methodologies; on the other hand, political and economic strategies often influence the results of such predictions.

Table 1.1 above shows an overview of prognoses concerning the anticipated peak and a possible depletion of different fuels and metals, and their main area of use. One may note however that "peak" usually refers to oil production and the supplies of minerals need to take into account criteria such as co-production, recycling, and substitutability.

Natural gas cannot replace oil as main energy source, once the latter is depleted. By now, "peak oil" is widely accepted as reality. Nonetheless, the assumption that worldwide huge gas reserves will help to overcome this shortage is critical, as it ignores various important aspects: first, a considerable share in the gas exploited today is associated with oil production – ceasing oil production, hence, leads to a decrease in produced gas. Second, gas production is strongly limited by cost and time needed to build gas gathering, recovery, and transport infrastructures. Third but not least is, the dependency issue; apart from Russia – already at the edge of Peak Gas – the world's biggest remaining reserves of conventional gas are located in politically critical countries such as Iraq, Iran, UAE, Qatar, Turkmenistan, Nigeria and Venezuela. Generally, it is important to understand the interrelationship between oil, gas, and electricity; a change in the production of one will always affect the supply with the other (McKillop 2006).

Alternative sources of gas, such as shale gas, might however change the traditional picture considerably. For example, it is estimated that the United States might be independent from gas imports and become a net exporter by the year 2020 through the current rapid expansion of alternative gas production, furthermore almost self-sufficient in (energy) net terms by 2035. Technological development in hydraulic fracturing, initially applied for gas, boosts oil production in the United States. The global map of oil and gas flows is predicted to shift due to further extraction of unconventional gas (see IEA Press Release 2012). However, the environmental and health risks associated with those new forms of fossil fuel extraction may be considerable (AEA 2012).

Another type of resource scarcity is related to the geographic concentration of specific resources. For example, China dominates the current production of the so called rare earth elements (REE). It is believed that China is responsible for over 95 % of the worldwide production. Together with the United States, it holds half of the worlds reserves (GSoA 2012). REE are a crucial resource for the production of a large variety of commodities. For example, these metals are used as an input for catalysts, metallurgical applications and alloys, glass polishing and ceramics, permanent magnets, ceramics, computer monitors, lighting radar, televisions, and x-ray-intensifying film. Especially the elements scandium, yttrium and neodymium are potential inputs for the future technologies, such as information and communication technologies (ISI 2009). Furthermore REE are essential for the energy sector, especially for the upcoming green technologies producing energy from renewable sources (Achzet 2011).

A report of the European Commission (2010) describes a relative concept of criticality of raw materials and applies it to the analysis of 41 minerals and metals. A raw material is placed into a two-dimensional framework built up by different types of risks. The types "Economic Importance" and "Supply Risk" constitute the scope of the analysis. REE are seen as an economically important raw material and are underlying very high supply risks (including the concentration of production). In many cases such a production concentration goes a along with a low resource substitutability and low recycling rates.

This geographic concentration of REE can be understood as a resource scarcity that impacts the related material markets. The third type of resource scarcity is an outcome of the monopolistic supply-structure and the resulting Chinese export-restrictions of REE. The described production structure leads to an emergence of a trade structure without terminal markets. Concretely, trade takes place in a more or less opaque market which misses regulated exchanges (for example, for the REE germanium and rhodium). The market is controlled by companies at the end of the production process. Those companies pass on substantial price increases between the agreement at the time of order and the delivery; nevertheless it is widely accepted by the consumers.

An observed consequence is that Japan as one of the world's largest consumers tries to establish new and a more diverse supply sources by developing new mines in Vietnam, Australia and Mongolia to avoid supply interruptions (Achzet 2011). A challenge to overcome the Chinese dependency might be the long period to develop economically reasonable mines and therefore to increase the supply (GSoA 2012).

By relating the REE-issue to the context of the concept of Environmental Space it becomes obvious that minable deposits of REE are very limited (GSoA 2012). In consideration of the current amount and diversity of demand as well as the prospects and the growth rates (future- and green technologies as demand-driver) of REE, they will be finite in a foreseeable time span as a production resource.

Finally, a fourth type of resource scarcity relates to the limited biological capacities of ecosystems for providing renewable resources or for assimilating waste and emissions. Indicators on the human demand for ecological capacity, such as the "Ecological Footprint" indicate that already since the mid 1970s, humans appropriate more biocapacity than the global ecosystems can provide (WWF et al. 2012). Already today we are living in a situation of severe ecological "overshoot", using resources around 50 % beyond the carrying capacity of the planet. In such a situation, it is impossible to substitute larger shares of our consumption of non-renewable materials and energy by biomass-based energy and bio-materials. As the debate on biofuels in Europe has indicated, the substitution of only 10 % of fossil fuels through biofuels would have highly negative environmental impacts, as a large share of these biofuels would need to be produced outside Europe. Clearing of forests, rising water demand and increased pollution through pesticides would be the consequence (EEA 2008).

1.4 Some Consequences of Limited Resources

The above described trends in global resource use and the fact that an increasing number of abiotic and biotic raw materials become increasingly scarce will lead to a number of economic and social consequences. Humans are an integral part of ecosystems, which means that our well-being is highly dependent on our environment and the benefits we gain from nature. Well-being is a combination of several objective and subjective factors including resources (income, material, infrastructure) for a good life, health, security, good social relations, happiness and freedom of choice and action.

The benefits we obtain from ecosystems include a variety of services and functions of ecosystems, such as the provisioning of goods (e.g. food and freshwater), cultural benefits (e.g. aesthetic landscapes, recreational areas), regulating services (e.g. flood regulation, water purification) or processes, which other services are based upon (e.g. soil formation, nutrient cycling) (Millennium Ecosystem Assessment 2005).

Generally speaking, provisioning services are crucial to satisfy our needs for basic material for good life and health, for example by providing us with sufficient nutritious food. Regulating services link strongly to our health and security, e.g. by preventing floods and hereby securing us from disasters. Cultural services affect especially our subjective well-being, e.g. by offering space for recreational activities, which improve our life satisfaction and happiness. These services are strongly affected by excessive resource use.

For example, the way we produce our food has strong effects on the nutrients that pass through the soil into our groundwater. Intensive practices with high amounts of fertilizers might lead to contamination, which in turn affects the quality of the water we extract. Thus, it would need increasing efforts to purify the water if we want to prevent negative effects on our health.

The scarcity of 'critical metals' will affect the European economy in a subtle, but far-reaching way, as the European economy is an industrial and service-oriented economy, depending highly on different raw materials to produce high-end processed products. As the examples in Table 1.1 above show, an uncountable number of goods of daily use and applications contain small, but critical amounts of certain metals, the depletion of which could cause severe disruptions of a whole sector, and considerable interventions in accustomed life styles of European citizens. Apart from the main energy sources, such as coal and gas, the handling of these materials will become decisive in the future, as their increasing scarcity will lead to an even more accentuated augmentation of their prices, and consequently the costs for producing processed goods downstream (European Parliament 2009).

Thus, resource scarcities regarding some of the abiotic materials will lead to severe impacts on industries such as the electronic industries, which depend on these rare metals for producing for example LCD screens and other electronic devices. Also the development of environmental technologies can be influenced by resource scarcity. One example is the new generation of solar cells, which requires indium and gallium, also highly scarce, for producing semiconducting materials. Resource scarcity thus also limits the potentials of these new technologies to contribute to a cleaner energy system (Kleijn and Van der Voet 2010). It might therefore prove difficult to substitute a large share of current energy use by new technologies at the current level of energy consumption. If energy use would be reduced in absolute terms, however, a higher share of total energy consumption could be produced with these new technologies.

Precariously, the reserves of many non-renewable resources are located outside of Europe. This causes Europe to be critically dependant on other countries and regions and extends its responsibility for environmental and social impacts from the national to the global level.

In the discussion on the socio-economic impacts of resource scarcities, oil plays a crucial role for all economies, as all sectors depend on oil in its energetic use and many sectors use oil as a raw material for non-energetic uses (such as the chemical or pharmaceutical industry). “Peak oil” is expected within the next 10–30 years and the end of the broad use of oil for production and consumption activities will likely occur somewhere around the middle of this century. Further shortage of oil as the main energy source for many manufacturing sectors, the construction sector, and in particular also the transport sector, will cause negative economic impacts in the form of further rise of prices of final goods, if no alternatives are developed in time and transition towards a non-oil based economy can be governed in a structured way.

Finally, the future could see fierce conflicts over natural resources. Already today, conflicts and wars are increasingly being fought over obtaining or maintaining access to natural resources. Worldwide competition for natural resources will significantly increase in the near future due to increased demand, in particular from fast-growing emerging economies, potentially leading to further serious conflicts related to access to resources. Reducing pressures on the Earth’s limited resources is therefore a key strategy to avoid such conflicts. These conflicts affect the poorest parts of world population the most, even though they are currently not involved in the race for resources and therefore do not contribute to the overall problem. The war for tantalum mines in the Democratic Republic of Congo or the war for water in Darfur, were examples of this new kind of conflict in the past years.

1.5 Some Policy Implications

The analysis above illustrated that an absolute reduction (a de-growth) of natural resource use in Europe and other high-consuming countries is required as a basis for qualitative changes to cope with resource scarcities and to reduce the related environmental impacts. Realizing this requires much more than incremental improvements of the current system; what is needed is a radical change on how we use nature’s resources to produce goods and services and generate well-being. In order to allow developing countries to overcome poverty and increase the material welfare of their inhabitants in the future, countries with high levels of per-capita resource consumption are required to sharply decrease their share in global resource use in absolute terms.

A precondition for the necessary worldwide absolute reduction of resource use is to comprehensively measure and report global resource use on micro and macroeconomic levels, i.e. for products, companies, industries and countries. Only if levels and composition of resource consumption are known successful individual and policy measures can be designed, implemented and monitored.

The methodology of material flow accounting (MFA) has been established to measure in a comprehensive way resource use that faces the aforementioned limits (see OECD 2007). In general, four major types of resources are considered in MFA studies. All types of resources are accounted in terms of their mass flow (weight in tonnes) per year. This includes accounting for

- Biomass (from agriculture, forestry, fishery, and hunting) and biomass products (including textiles and wood products such as paper);
- Fossil energy carriers (coal, oil, gas, peat), used for energetic and non-energetic purposes (including chemicals based on fossil materials);
- Minerals (industrial and construction minerals) and mineral products (such as glass or natural fertilizers);
- Metal ores and metal products (including, for example, machinery or coins).

Additionally, use of water, land and carbon should be accounted and reported in a comprehensive system of resource use indicators (Giljum et al. 2011).

The next necessary step is to agree on targets for reduction of resource use. A Factor 10 improvement in resource productivity, i.e. the economic value produced per unit of natural resource has been suggested as an overall guiding target for Western countries (Schmidt-Bleek 2009). So far, there is no empirical evidence that technological improvements could remove the physical limits of the planet and allow sustaining ever-growing amounts of resource consumption for a growing world population. Therefore, qualitative strategies, such as an increased share of biofuels and biomaterials in total resource consumption, can only be implemented as part of such a quantitative reduction scenario, which avoids overusing the limited capacities of global ecosystems. EU policy documents acknowledged that European production and consumption patterns have environmental and social impacts, which reach far beyond the EU borders. In 2011, the European Commission adopted the "Roadmap for a Resource-Efficient Europe", where it is stated that a first set of policy targets for the resource categories of materials, water, land and carbon shall be presented by the end of 2013, along with a set of indicators to monitor progress towards these targets (European Commission 2011).

Ambitious targets are required, as empirical evidence disproves the possibility of an absolute reduction of resource use in a growing economy. In the past three decades, Europe achieved significant improvements regarding local or regional environmental degradation through pollution of certain environmentally harmful substances. This was achieved through technological innovations and substitution of harmful substances and products. But environmental problems related to the growing scale of the European production and consumption system, have worsen (see Chap. 1.1. above). Developing alternative forms of economic development, which are not dependent on economic growth (see Pirgmaier and Hinterberger 2012), is therefore not only a key objective from a social perspective. It is also crucial to ensure that the natural resource base, on which the quality-of-life of our societies builds on, is not being overexploited and collapsing.

While, on the one hand, Europe is one of the world regions with the highest per-capita resource consumption, on the other hand, the catching-up of other world regions and emerging economies, respectively, is leading to a rapidly growing demand on energy, biomass, metals and construction minerals. This is also important to face the critical dependency of Europe with regard to the most important resources located in other countries and regions.

So far, the world's economy has been strongly dependent on oil as main energy source and as important raw material for industrial sectors, such as the chemical and the pharmaceutical industry. Consequently, as peak oil is expected for the near future, a further shortage will cause negative economic impacts in the form of further rise of prices of final goods, if no alternatives are developed in time and transition towards a non-oil based economy can be governed in a structured way. Additionally, the expected decline in the availability of precious metals will strongly influence high-tech industries. It can be expected that worldwide competition for these resources will significantly increase in the near future, potentially leading to serious conflicts related to the access to resource reserves. Hence, in order to deal with this increased scarcity of natural resources, a significant reduction of the worldwide resource use will be necessary.

The global enforcement of stronger rules and regulations on social and environmental standards as well as the establishment of prices that reflect the true social and environmental costs are likely to lead to degrowth in resource extraction as well as in overall trade volumes and to an improvement of the social and environmental sustainability of trade. However, rising of social and environmental standards must not take place to the disadvantage of the poor, developing countries. Industrialised countries will need to provide substantial financial support to co-finance the costs of improving social and environmental conditions.

In international environmental policy negotiations it is often argued that trade could be more beneficial for the environment if the prices of resources would reflect the true social and environmental costs. For example, globally efficient patterns of production could be encouraged by reducing environmentally harmful subsidies. A global price on carbon could help in discouraging the use of fossil fuels and encourage alternative energy solutions with positive environmental benefits and climate impacts. In addition, prices of other resources need to rise in order to achieve substantial dematerialization.

However, policies aimed at "getting the prices right" (including the removal of subsidies and taxes on carbon) are not sufficient to ensure global dematerialisation and may risk increasing social inequalities and exclusion. Developing countries often caution against isolated and uncoordinated national action to reduce resource use in industrialised countries that may adversely affect developing countries, particularly if discriminatory trade policy measures are put in place. Agricultural exports from developing countries, for example, could face new and additional restrictions if developed countries implemented measures such as border tax adjustments, standards for material use and information measures such as labelling of products. Ecological rucksacks need to become a core criterion for evaluating any policy or management decision.

Therefore, broader policies are necessary, including environmental tax reforms, circular (recycling) economy promotion, stronger diversification of economies which are still dependent on export industries in the primary sectors, support for developing countries in meeting social and environmental standards (trade capacity building, co-financing schemes), technology transfers for resource and energy efficient production and other accompanying measures to limit the use of natural resources. One of the main preconditions to implement such policies is a reform of the current institutional regime of world trade to achieve greater involvement of developing countries in the work of institutions such as the WTO.

Given current patterns of trade and resource flows, it is likely that European environmental tax reform and other policy measures to reduce global resource use will not only have economic and environmental effects in Europe but also in the countries it trades with. Estimating these effects is important in order to analyse the effects of environmental policies aimed at reducing the overall resource use in industrialised countries on the opportunities for economic growth in developing countries. All these measures should be based on a proper judgement of the related resource use to ensure absolute dematerialization.

References

Achzet B (2011) Materials critical to the energy industry. An introduction. University of Augsburg, Augsburg

AEA (2012) Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe. Report for the European Commission, DG Environment

Bruckner M, Giljum S, Lutz C, Wiebe K (2012) Materials embodied in international trade – global material extraction and consumption between 1995 and 2005. Global Environ Change 22:568–576

Dittrich M, Giljum S, Bringezu S, Polzin C, Lutter S (2011) Resource use and resource productivity in emerging economies: trends over the past 20 years, vol 12. Sustainable Europe Research Institute (SERI), Vienna

Dittrich M, Giljum S, Lutter S, Polzin C (2012) Green economies around the world? The role of resource use for development and the environment. Sustainable Europe Research Institute (SERI), Vienna

EEA (2005) The European environment. State and outlook 2005. European Environment Agency, Copenhagen

EEA (2008) Time for action – towards sustainable consumption and production in Europe. 01/2008. European Environment Agency, Copenhagen

EEA (2010) The European environment. State and outlook 2010. European Environment Agency, Copenhagen

European Commission (2008) Commission staff working document accompanying the raw materials initiative. SEC (2008) 2741. European Commission, Brussels

European Commission (2010) Critical raw materials for the EU. European Commission, Brussels

European Commission (2011) Roadmap to a resource efficient Europe. COM(2011) 571 final. European Commission, Brussels

European Parliament (2009) Eco-innovation – putting the EU on the path to a resource and energy efficient economy. European Parliament's Committee on Industry, Research and Energy, Brussels

EUROSTAT (2010) Material flow accounts. Online database. Statistical Office of the European Communities, Luxembourg

Giljum S, Behrens A, Hinterberger F, Lutz C, Meyer B (2008) Modelling scenarios towards a sustainable use of natural resources in Europe. Environ Sci Policy 11(3):204–216

Giljum S, Burger E, Hinterberger F, Lutter S, Bruckner M (2011) A comprehensive set of resource use indicators from the micro to the macro level. Resour Conserv Recycl 55:300–308

Giljum S, Dittrich M, Bringezu S, Polzin C, Lutter S (2010) Resource use and resource productivity in Asia: trends over the past 25 years, vol 11. Sustainable Europe Research Institute, Vienna

GSoA (2012) Rare earth elements. Geological Society of America. http://geology.com/articles/rare-earth-elements. 01.03.2012

Heinberg R (2007) Peak everything: waking up to the century of declines. New Society Publishers, Gabriola Island

IEA (2011) World energy outlook 2011. International Energy Agency, Paris

IEA (2012) Press release 12. November 2012. North America leads shift in global energy balance, IEA says in latest World Energy Outlook. International Energy Agency, Paris

ISI (2009) Rohstoffe für zukunftstechnologien. Fraunhofer Institut für System-und Innovationsforschung, Karlsruhe

Kerschner C, Arto-Oliazola I (2011) "El zenit de l'economia mundial." La Directa, Quaderns d'Illacrua Directa 214 (Quaderns 47):1–4

Kleijn R, Van der Voet E (2010) Resource constraints in a hydrogen economy based on renewable energy sources: an exploration. Renew Sustain Energy Rev 14:2784–2795

Lutz C, Giljum S (2009) Global resource use in a business-as-usual world until 2030. Updated results from the GINFORS model. In: Bleischwitz R, Welfens PJJ, Zhang ZX (eds) Sustainable growth and resource productivity. Economic and global policy issues. Greenleaf Publishing, Sheffield, pp 30–41

McKillop A (2006) Peak oil to peak gas is a short ride. Energy Bulletin. Retrieved February 16, 2012, from www.energybulletin.net

Millennium Ecosystem Assessment (2005) Millennium ecosystem assessment synthesis report. Island Press, Washington, DC

Murphy DJ, Balogh S (2009) Further evidence of the influence of energy on the U.S. economy. In: Tverberg GE, Saunders K (eds) The oil drum. Denver (2010). www.theoildrum.com

Murray J, King D (2012) Climate policy: oil's tipping point has passed. Nature 481(7382):433–435

OECD (2007) Measuring material flows and resource productivity. The OECD guide ENV/EPOC/SE(2006) 1/REV3, Environment Directorate. Organisation for Economic Co-operation and Development, Paris

Opschoor JB (1995) Ecospace and the fall and rise of throughput intensity. Ecol Econ 15:137–141

Pirgmaier E, Hinterberger F (2012) What kind of growth is sustainable? A presentation of arguments. In: Hinterberger F et al (eds) Growth in transition. Earthscan, London/New York, pp 13–53

Schmidt-Bleek F (1992) MIPS – A universal ecological measure. Fresenius Environ Bull 2:407–412

Schmidt-Bleek F (2009) The earth: natural resources and human intervention. Haus Publishing Limited, London

SERI (2011) Global material flow database. 2011 Version. Sustainable Europe Research Institute, Vienna. Available at www.materialflows.net

Spangenberg J (2002) Environmental space and the prism of sustainability: frameworks for indicators measuring sustainable development. Ecol Indic 2:295–309

UNEP (2007) Global environmental outlook 4. United Nations Environment Programme, Nairobi

WWF, Zoological Society of London, and Global Footprint Network (2012) Living planet report 2012. WWF, Gland

Chapter 2
The Availability of Fossil Energy Resources

Jörg Schindler

2.1 Conventional Wisdom

The *International Energy Agency (IEA)* is the energy watch-dog of the OECD countries. Each year the IEA publishes its *World Energy Outlook (WEO)* report addressing global energy trends and projecting future energy demand and supply. These reports get prominent media coverage and frame the perception of governments, the media and the general public.

In its WEO 2008 report the IEA (2008) describes a reference scenario for global energy demand and supply for fossil, nuclear and renewable primary energy sources (Fig. 2.1).

The energy content of all energy sources is expressed in *million tons of oil equivalent (Mtoe*) to make them comparable. As can be seen, crude oil is the most important energy source, followed by coal and natural gas. The reference scenario up to 2030 sees no change in the ranking and assumes continued growth of all fossil energies. Nuclear and renewable energies will grow a little, but the dominance of fossil fuels remains practically unchanged. This scenario indicates that the future will be more or less like the past, just more of everything. Accordingly, the message is that *business as usual (BAU)* can continue for at least another two decades.

In the past, the IEA scenarios were driven by modelling future demographic and economic developments and – based on these projections – deriving the corresponding energy demand. It was taken for granted that the projected demand could be met by an ever growing energy supply. Until last year the supply side was never analyzed by the IEA itself, the possibility of growing oil supplies was treated as a matter of fact by referring to a study done by the USGS in 2000 (USGS 2000).

J. Schindler (✉)
Ludwig-Bölkow-Systemtechnik, Schopenhauerstr. 13, 85579 Neubiberg, Germany
e-mail: schindler@lbst.de

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_2,

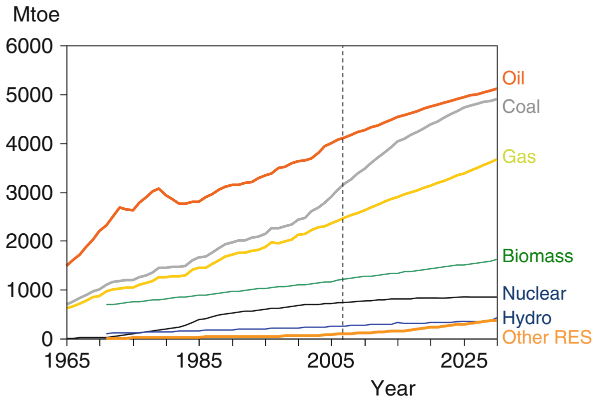


Fig. 2.1 World Energy Outlook by the IEA – reference scenario (Source: Historical data: BP, Statistical Review of World Energy, Projection: IEA (2008))

The 2008 edition of the WEO marks a change in this respect, probably as a reaction to the growing turmoil and price volatility in the oil markets. It analyses for the first time past and likely future production volumes in the major oil fields of the world. An effort is made to quantify the decline in the existing production base. Then possibilities for production from new sources are discussed and also the obstacles are addressed. Yet, this has no visible influence on the reference scenario. But the report also warns of an imminent oil crunch if a number of preconditions for a growing oil supply are not met. The finiteness of oil is not mentioned.

Quotations from the Executive Summary of the WEO 2008

The world's energy system is at crossroads. Current global trends in energy supply and consumption are patently unsustainable – environmentally, economically, socially. But that can – and must – be altered; there's still time to change the road we're on.

In fact, the immediate risk to supply is not one of lack of global resources, but rather a lack of investment where it is needed.

Preventing catastrophic and irreversible damage to the global climate ultimately requires a major decarbonisation of the world energy sources.

For all the uncertainties highlighted in this report, we can be certain that the energy world will look a lot different in 2030 than it does today.

The WEO 2008 thus is a document full of contradictions: on the one hand, with the reference scenario business as usual is declared as being possible, on the other hand, the energy world in 2030 is supposed to be completely different. Although it is more realistic than preceding issues in many respects, the 2008 report is still very poor guidance for the energy future.

2.2 Crude Oil

The purpose of this chapter is to project the future availability of crude oil up to 2030 based mainly on a study for the Energy Watch Group (EWG) in 2007 (Zittel and Schindler 2007b).

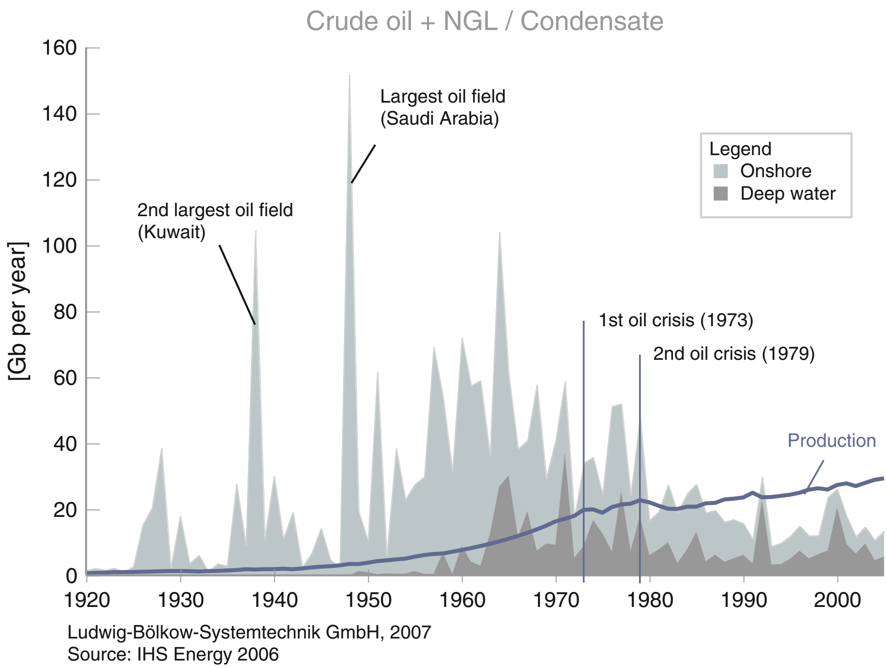


Fig. 2.2 History of oil discoveries and production (Source: IHS Energy 2006)

It is obvious that oil has to be found before it can be produced. Therefore, one has to know how much oil has been discovered and produced to date in order to assess possible future oil production. Figure 2.2 shows annual oil discoveries in terms of proved and probable reserves since 1920 and also annual production rates (IHS 2006). The units are gigabarrels (Gb) per year. Past discoveries are stated according to best current knowledge (and not as the reserve assessments at the time of discovery) – a method described as "backdating of reserves". Therefore, the graph shows what "really" was found at the time and not what people thought they had found at the time.

Discoveries peaked in the 1960s. In the period 1960–1970 the average size of new discoveries was 527 Mb per New Field Wildcat. This size declined to 20 Mb per New Field Wildcat in the period 2000–2005.

Since the 1980s yearly oil production exceeds the volume of new discoveries and the discrepancy is growing over time. Only when oil has been found can it be produced. Therefore, the peak of discoveries which took place a long time ago will someday have to be followed by a peak of production ("Peak Oil").

World oil reserves are estimated to amount to 1,255 Gb according to the industry database (IHS 2006). There are good reasons to modify these figures for some regions and key countries, leading to a corresponding EWG estimate of 854 Gb (Table 2.1). The greatest differences are the reserve numbers for the Middle East. According to IHS, the Middle East possesses 677 Gb of oil reserves, whereas the EWG estimate is 362 Gb.

Table 2.1 Oil reserves – EWG assessment vs. IHS energy data

	Remaining reserves		Production 2005		
Region	EWG [Gb]	IHS [Gb]	Onshore [Gb/year]	Offshore [Gb/year]	Consumption 2005 [Gb/year]
OECD North America	84	67.6	3.20	1.71	9.13
OECD Europe	25.5	23.5	0.1	1.94	5.72
OECD Pacific	2.5	5.1	0.025	0.18	3.18
Transition economies	154	190.6	4.1	0.18	2.02
China	27	25.5	1.1	0.22	2.55
South Asia	5.5	5.9	0.11	0.16	0.96
East Asia	16.5	24.1	0.3	0.65	1.75
Latin America	52.5	129	2.0	0.61	1.74
Middle East	362	678.5	6.97	1.97	2.09
Africa	125	104.9	2.03	1.53	1.01
World	854	1,255	19.94	9.15	30.3

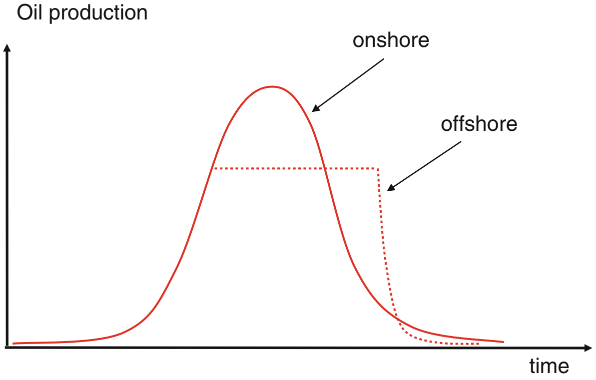


Fig. 2.3 Idealized oil production profile

Remaining reserves are only one parameter for projecting future oil production. Another approach is the analysis of production patterns, i.e. profiles of production rates over time of individual oil fields and production profiles of individual oil basins.

Figure 2.3 shows the idealized production profiles for onshore and offshore wells. It shows that every oil well eventually reaches a peak of production and afterwards the production rate will inevitably decline.

This is one important cause for the occurrence of typical production patterns also in oil provinces. As is schematically shown in Fig. 2.4, the biggest fields in a province will be developed first and only afterwards the smaller ones. As soon as the first big fields of a region have passed their production peak, an increasing number of new and generally smaller fields have to be developed in order to compensate the decline of the production base. From then on, it gets increasingly difficult to sustain the rate

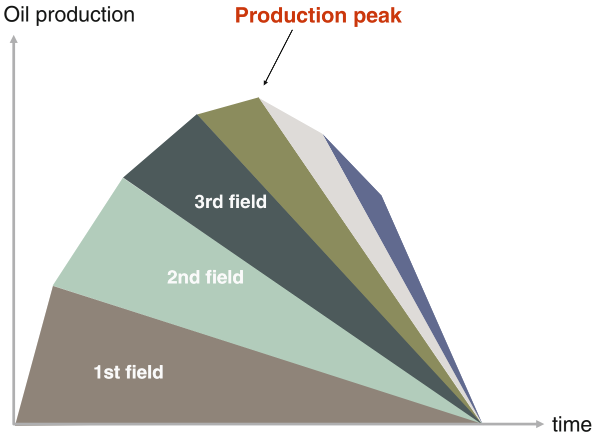


Fig. 2.4 Typical oil production pattern for a region

of the production growth. More and more large oil fields show declining production rates. The resulting gap has to be filled by bringing into production a larger number of smaller fields. But this is not possible anymore at a sufficient rate once the rate of discoveries has fallen. These smaller fields reach their peak much faster and eventually amplify the overall decline of the production rate of the region. The region's production profile will become more and more "skewed".

This pattern can be observed very well in many oil provinces. But in some regions this general pattern was not prevalent, either because the timely development of a "favourable" region was not possible for political reasons or because of the existence of huge surplus capacities so that production was held back for longer periods of time (this being the case in many OPEC countries). However, the more existing surplus capacities are reduced, the closer the production profile follows the described pattern.

Production in the United Kingdom (UK) is a good illustration of the production pattern described above (Fig. 2.5). The production decline in the late 1980s was due to necessary safety work on the platforms following the severe accident at the platform Piper-Alpha. Similar patterns can be shown for many regions in the world.

Oil production in regions which have passed their peak can be forecasted with some certainty for the next years. In these cases remaining reserves are no longer the decisive parameter for projecting future production rates.

Figure 2.6 shows past and projected future oil production in the USA. Forty years ago, the USA were the world's largest oil producer, contributing almost 50 % to the world's oil production. However, since the peak in 1970 the conventional production has been in decline. The development of Alaska (made possible by the higher oil prices resulting from the oil price shocks in the 1970s) could stop this decline for a few years, until this region also passed peak production. Offshore oil from the continental shelf has been produced since 1949, but turned into decline around 1995. Oil fields in the deep water areas of the Gulf of Mexico were only

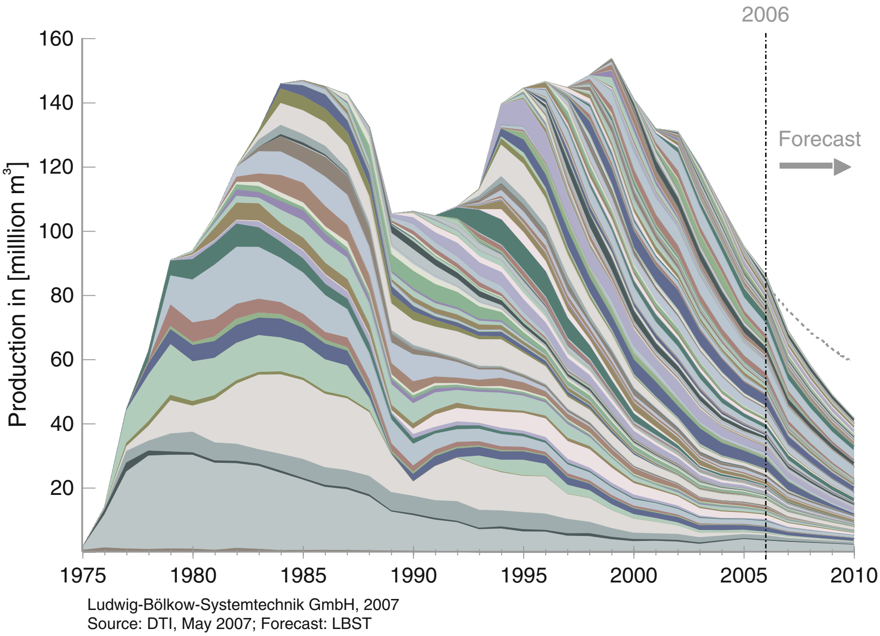


Fig. 2.5 UK – yearly oil production of individual oilfields. The unit m³ for oil production per year is used because the official production statistics for all oil fields published by the UK DTI (Department of Trade and Industry) in the early years only used this unit. 1 m³ oil = approx. 6.3 barrels oil (Source: DTI (2007). Forecast: Ludwig-Bölkow-Systemtechnik)

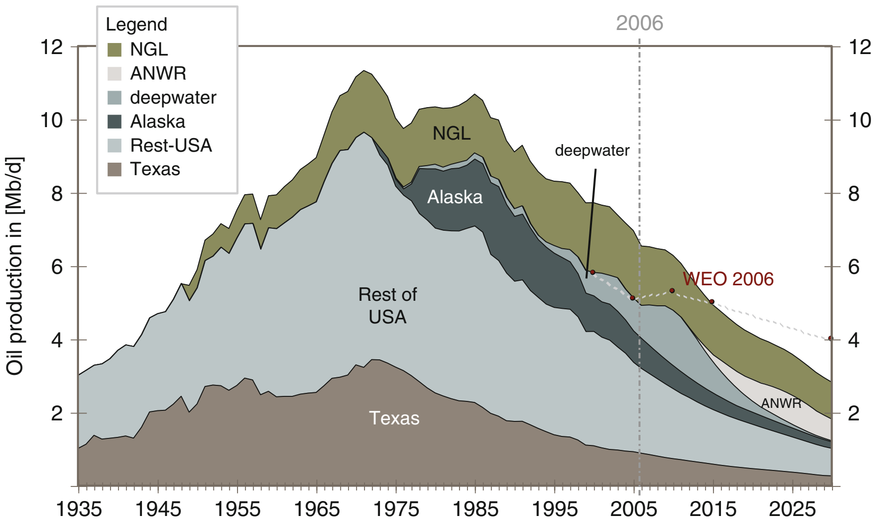


Fig. 2.6 Oil production in the USA

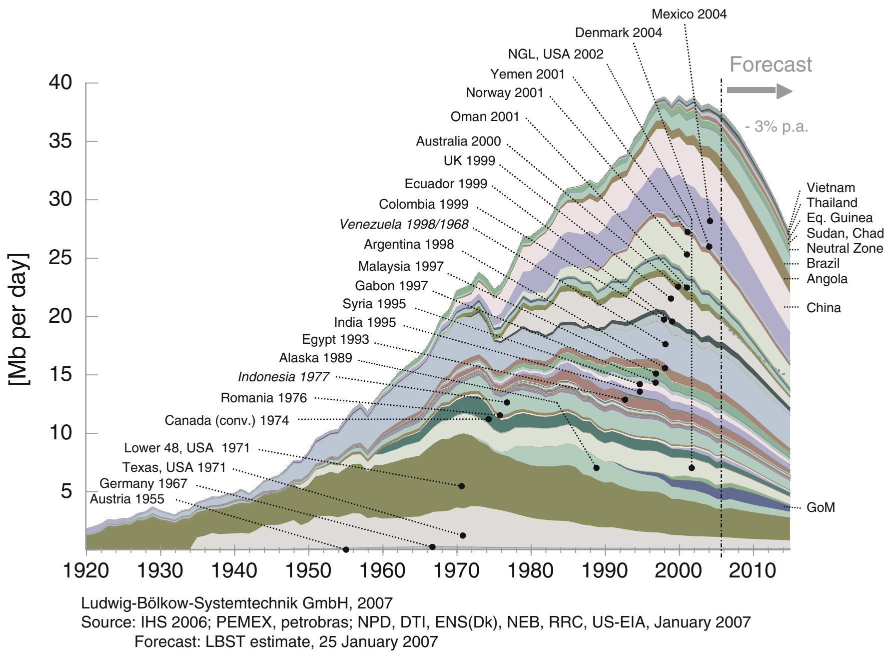


Fig. 2.7 Oil production of countries outside (core) OPEC and FSU (Source: IHS (2006), PEMEX, petrobas, NPD, DTI, ENS (Dk), NEB, RR, US-EIA (2007). Forecast: Ludwig-Bölkow-Systemtechnik 2007)

developed in the late 1990s and early 2000s. The large contribution of natural gas liquids (NGL) can also be seen. NGLs are liquid components of natural gas which are separated in the production process.

The example of the USA demonstrates that once peak oil is reached in a region the subsequent decline cannot be reversed, even when there are no limitations regarding access to capital or technologies.

Figure 2.7 lists the production profiles of all oil producing countries apart from the OPEC countries in the Middle East and countries belonging to the former Soviet Union (FSU). Countries with a year behind the name are countries past peak, the year indicates the year of peak production. These countries are ordered in the figure according to their peak dates. The other countries (without a year) on the right-hand side of the figure are countries whose production is regarded as being more or less on a plateau. Total production of these countries accounted for about 35–40 Mb/day in the beginning of 2007 – being already in decline it was projected to decline further.

One and a half years later, in mid 2008, the group of countries shown in Fig. 2.7 was joined by additional countries, most prominently by Russia where production peaked in 2007. But also Angola and Nigeria joined the club of countries past peak. These countries then accounted for a production of approx. 50 Mb/day which will in future also decline every year.

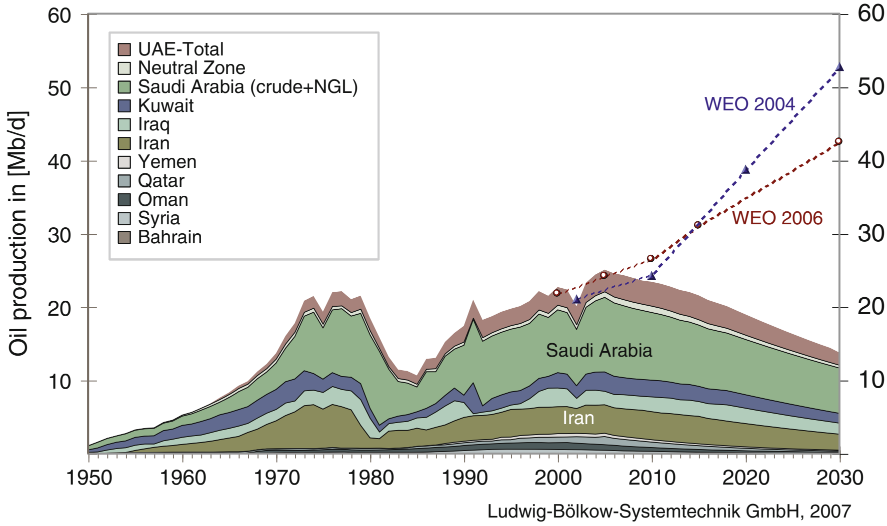


Fig. 2.8 Oil production in the Middle East (Source: Ludwig-Bölkow-Systemtechnik 2007)

If world oil production is to stay constant in the coming years or even is to grow, then only the oil producing countries in the Middle East (ME) remain to eventually increase their production in order to compensate for the decline in the rest of the world. That this will be possible is assumed by the IEA, for example. Figure 2.8 shows past production and future projections by the EWG for the ME countries, projecting a peak in the near future followed by a gradual decline. The main reasons are that EWG thinks that ME reserves are grossly overstated (cf. Table 2.1) and that the bulk of current production comes from very few very old oil fields which already have trouble maintaining production levels (Simmons 2005). This is in sharp contrast to the IEA which in its World Energy Outlooks (WEO) in 2004 and 2006 projected steep rises in the production of the region.

But there are also other reasons. Saudi Arabia, being the key country in the region, has announced that it is aiming at a long term production capacity of 12.5 Mb/day. This is far off the projections by the IEA and the hopes of major oil importing countries. Even if Saudi Arabia were able to increase production above this target (which is very doubtful), it is questionable whether this really would be in its national interest.

Based on the data and assessments outlined above, the EWG study describes a scenario of the possible future oil supply up to 2030 (Fig. 2.9). As in the previous figures, "*oil*" comprises *conventional crude oil* including *lease condensates, heavy oil* and *oil derived from Canadian tar sands*, and also LNG. Not included are refinery gains, gas-to-liquids, coal-to-liquids, ethanol as well as other biofuels (all of which are often counted in an aggregate termed "all liquids", but which certainly are not crude oil; LNG is only included because it is included in most statistics and available statistical data do not allow a differentiation for all countries).

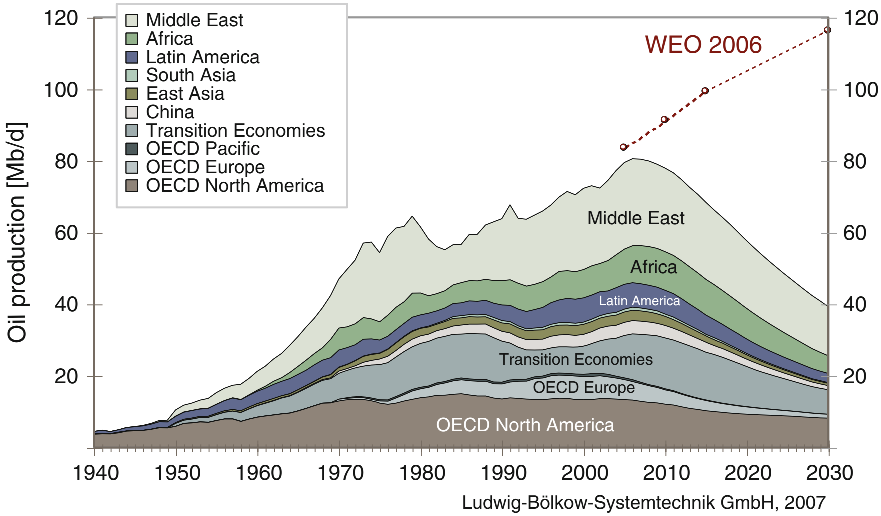


Fig. 2.9 The EWG scenario – Peak Oil is "now" (Source: Ludwig-Bölkow-Systemtechnik 2007)

These are the key findings of the EWG study:

- "Peak oil is now" (the scenario has 2006 as date of peak oil)
- The most important result of the study is the steep decline in oil production after peak.
- The projections for the global oil supply are:
  - 2006: 81 Mb/day (peak)
  - 2020: 58 Mb/day (IEA: 105 Mb/day)[1]
  - 2030: 39 Mb/day (IEA: 116 Mb/day)
- By 2020, all world regions except Africa will produce less than they did in 2005; by 2030 all regions will produce significantly less.

The difference to the projections of the IEA could hardly be more dramatic (IEA 2004, 2006, 2008).

The EWG study was based on data up to 2005. What was the actual development since then? The available production data compiled by the US Energy Information Administration (EIA) are shown in Fig. 2.10 (Energy Information Administration (EIA) 2006). World oil production plateaued in mid 2004 and remained at this level for 4 years (in a bandwidth between 72.5 and 74.5 Mb/day); since the onset of the financial crisis in the autumn of 2008 production is now declining. This plateau is all the more surprising (from the perspective of conventional wisdom) since oil prices surged from 2004 to mid 2008 to unprecedented levels. Obviously, supply could no longer keep up with the demand.

[1] Referring to IEA projections in the WEO 2006. IEA values for 2015 are interpolated.

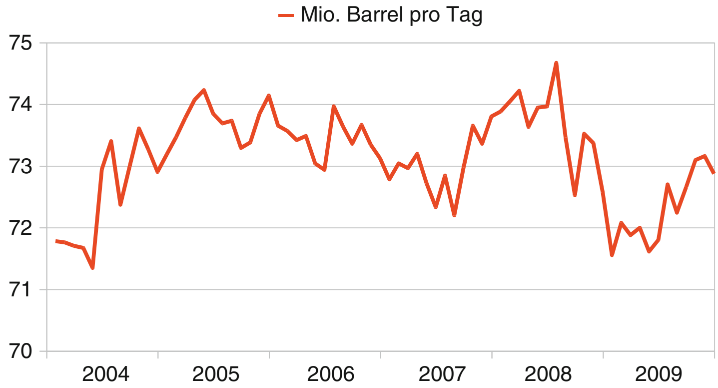


Fig. 2.10 Plateau of global crude oil production since mid 2004 (Source: US EIA Koppelaar (2009))

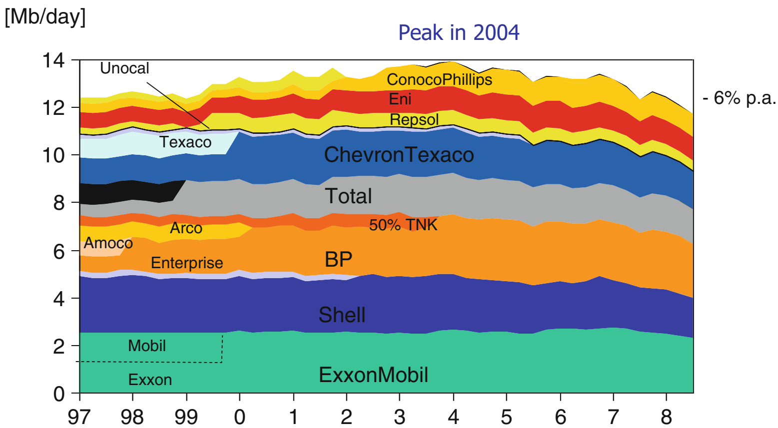


Fig. 2.11 Oil production of the eight largest international oil companies since 1997

Looking at the operations of major international oil companies over the last 10 years, two developments are striking (Fig. 2.11):

- the wave of mergers, and
- the inability of these companies to substantially raise their aggregate production.

The mergers were necessary to compensate for the declining production in individual companies. Rising expenditures, especially for production, just led to a peak in 2004 of aggregate production, but since then production has been declining at an increasing rate. The significant production increases repeatedly announced by the super majors since 2000 never materialised.[2] This is all the more remarkable in view

[2] Recently, the "lack of access" to more promising oil regions has been blamed by the international oil companies for their disappointing performance regarding production volumes.

of the dramatic rise in oil prices since 2004. This is another strong indication for "peak oil is now".

To sum up this chapter on oil: Oil supply has reached a plateau since mid 2004. The onset of the ultimate decline is imminent. This will signal the beginning of the end of the era of fossil fuels.

2.3 Natural Gas

The availability of natural gas can be investigated on a global and a regional level. Because of the infrastructure requirements for the transport of natural gas, there is no sizeable world market (different to crude oil). The shipping of natural gas between continents requires the liquefaction of the gas (LNG – liquefied natural gas) and the transport of the gas in special LNG carriers. Most natural gas is consumed in the wider region of origin. At present, there are three big regional markets: (1) North America (Canada, USA, Mexico), (2) Europe, Russia, Central Asia, North Africa, (3) East Asia.

A supply scenario for natural gas on a global level takes into account past production profiles and remaining reported reserves for the ten world regions (as defined by the IEA). According to a scenario by Ludwig-Bölkow-Systemtechnik shown in Fig. 2.12 future growth in supply is deemed possible mainly in the Transition Economies and the Middle East. Reserves in the Middle East are concentrated in Iran and Qatar. Fitting the production profiles with a logistic curve to match the reserves leads to a

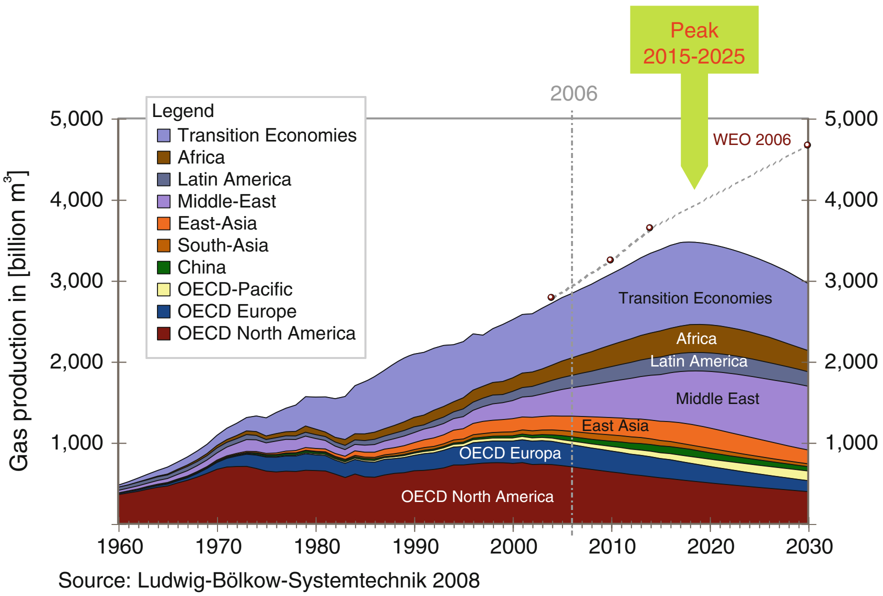


Fig. 2.12 Natural gas production – history and scenario (Source: Ludwig-Bölkow-Systemtechnik 2008)

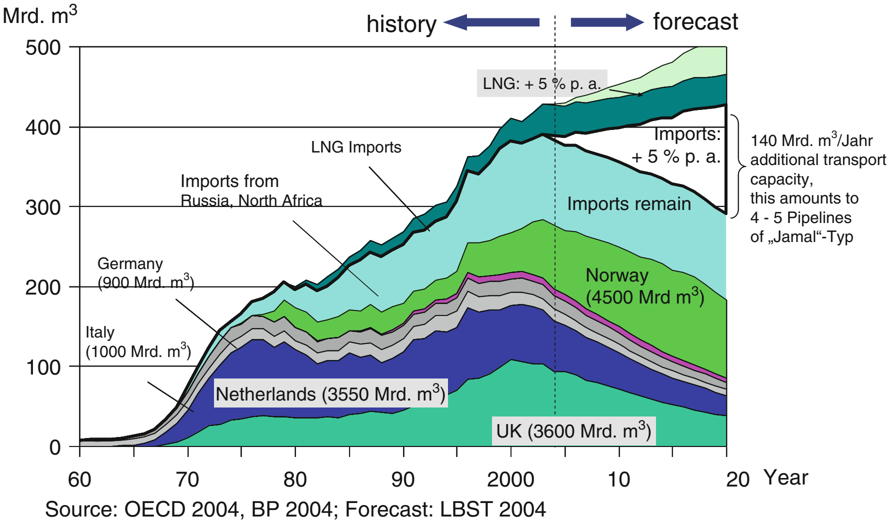


Fig. 2.13 Europe: natural gas production (Source: OECD (2004), BP (2004). Forecast: Zittel and Schindler (2004))

projected peak of global natural gas production between 2015 and 2025. This scenario shows what is possible, not what is likely. The scenario would require Qatar and Iran to expand their natural gas production dramatically in a very short time.

Also shown in Fig. 2.12 is the projection by the IEA in its WEO 2006 which has no peak up to 2030. We do not think that this increase in natural gas production will be possible if reported reserves are even remotely believable.

On a regional level the supply outlook can be very different from the global picture. Figure 2.13 shows natural gas production and consumption for Europe in Mrd. m^3 (= billion m^3).

Natural gas production is in decline in all European countries except Norway. The projected increase in Norwegian production cannot compensate this decline. Europe already relies heavily on imports from Russia and North Africa. If European gas consumption is to remain unchanged or increase in future, then imports will have to grow steadily.

It is a controversial issue whether Russia will be able to increase its natural gas exports at the required rate in the coming years. The big producing natural gas fields and their production profiles are shown in Fig. 2.14 (the unit Tcf/year stands for Tera cubic feet per year). Also shown are big known gas fields which are not yet developed and their required production. In 2009 it was already clear that some of the new fields will not be developed in time. Therefore, a decline in Russian gas output in the coming years is likely.

In theory, global natural gas production can grow for another 5–15 years by approx. 25 % until production peaks and the decline starts. Whether this projected growth will actually happen is an open question at the moment.

In any case, a switch from oil to natural gas to substitute the future decline in oil is not a very convincing short term option and certainly not a long term option – anyway

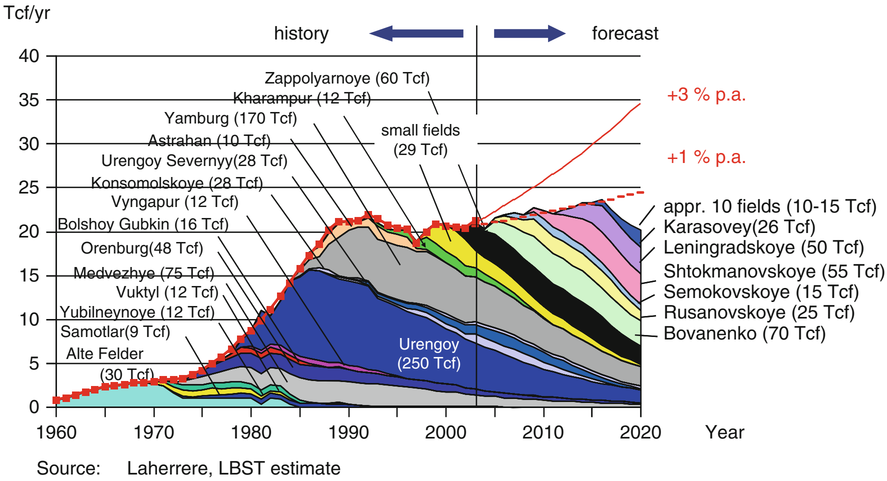


Fig. 2.14 Russia: natural gas production (Source: Laherrere and Campbell 1995)

not globally and not for Europe (there might be some regions in the world with ample natural gas resources where locally things look different). This is the reason why the European Commission has dropped its strategy to introduce natural gas as a fuel for transport.

2.4 Coal

When discussing the future availability of fossil energy resources, conventional wisdom has it that globally there is an abundance of coal which allows for increasing coal consumption far into the future. This is either regarded as being a good thing as coal can be a possible substitute for the declining crude oil and natural gas supplies or it is seen as a horror scenario leading to catastrophic consequences for the world's climate. But the discussion rarely focuses on the premise: how much coal is there really?

This chapter is based mainly on the EWG study on coal (Zittel and Schindler 2007a). One important finding of this study is that the quality of data on coal reserves and resources is poor, both on global and national levels. But there is no objective way to determine how reliable the available data actually are.

The timeline analyses of data elaborated in the study suggest that on a global level the statistics overestimate the reserves and the resources. In the global sum both reserves and resources have been downgraded over the past two decades, in some cases drastically.

Figure 2.15 shows the changing estimates of world coal resources[3] over time by the German *Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)*.

[3] Resources are defined as amounts of coal that are either discovered but cannot be produced economically, or are expected to be discovered in future based on geological indicators. Coal resources are "in-situ" amounts irrespective of production possibilities.

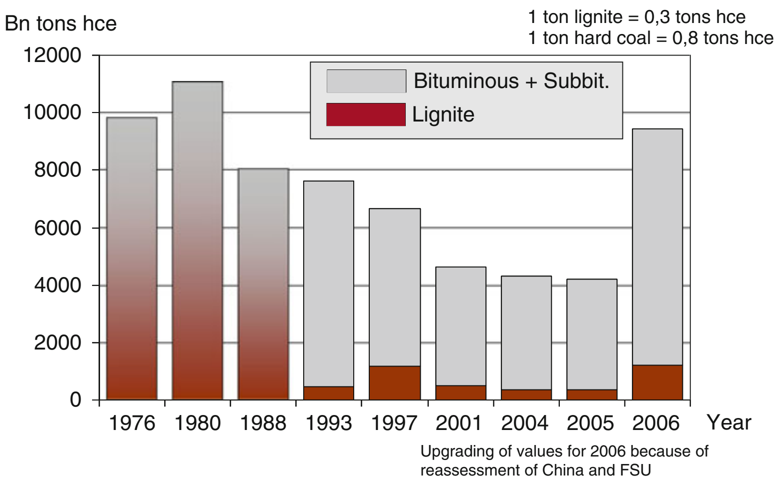


Fig. 2.15 World: Coal resources estimates by BGR (Source: BGR 1995, 1998, 2002, 2005, 2006, 2007). Analysis: LBST (2008))

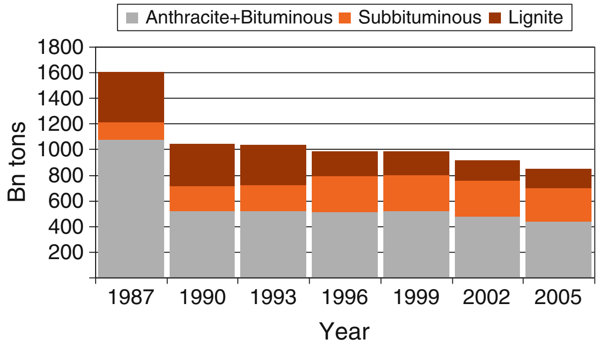


Fig. 2.16 World coal reserves (*Reserves* are defined as well explored amounts of coal that can be produced economically with current technologies. WEC differentiates between "Proved Reserves in Place" und "Proved Reserves" and has boundaries for maximum depth and minimum seam thickness) as reported by the WEC (2002, 2004, 2007)

Three categories are used for describing different coal qualities: bituminous and subbituminous being one group, lignite the other.

The unit *hce* stands for *hard coal equivalent* accounting for the different energy contents (heating values) of different coal qualities.

Figure 2.16 shows the development of world coal reserves as reported by the World Energy Council (WEC).

The logic of distinguishing between *reserves*, which are defined as being proved and recoverable, and *resources*, which include additional discovered and undiscovered inferred/assumed/speculative quantities, is that over time production and exploration activities allow some of the resources to be reclassified into reserves. It should be noted that resources are regarded as quantities in situ, of which 50 % at most can eventually be recovered. In practice, such a reclassification from resources to reserves has only occurred in two cases over the past two decades: in India and Australia. Therefore, there is a strong conjecture that coal resource data are not really relevant for the assessment of the future coal production potential.

On a global level, hard coal reserves have been downgraded over the years by 15 %. The same general picture of global downgrading is obtained when including all coal qualities from anthracite to lignite. Cumulative coal production over this period is small compared to the overall downgrading and is thus no explanation for it.

The most dramatic example of unexplained changes in the data is the downgrading of the proven German hard coal reserves by 99 % (!) from 23 billion tons to 0.183 billion tons in 2004. The World Energy Council briefly notes in its "2004 Survey of Energy Resources" (WEC 2004): "Earlier assessments of German coal reserves (e.g. end-1996 and end-1999) contained large amounts of speculative resources which are no longer taken into account". Thus, large reserves formerly seen as *proven* have been reassessed as being *speculative*.

German lignite reserves have also been downgraded drastically, which is remarkable as Germany is the largest lignite producer worldwide. Poland has downgraded its hard coal reserves by 50 % compared to 1997 and has downgraded its lignite and subbituminous coal reserves in two steps to zero since 1997.

For some countries such as Vietnam proven reserves have not been updated for up to 40 years. The data for China were last updated in 1992, in spite of the fact that about 20 % of their then stated reserves has been produced since then, and another 1–2 % has been consumed in uncontrolled coal seam fires.

World coal reserves and production are concentrated in a small number of countries. These countries are shown in Fig. 2.17 with their reported reserves and their production and are ordered by the size of their reserves. The bars show the reserves as indicated on the left axis (1,000 Mtoe = 1 billion tons of oil equivalent). The red line shows the yearly production in 2006 as indicated on the right axis, differentiated between hard coal and lignite (Mtoe/year). According to these data, the (theoretical) global production to reserve ratio (R/P) amounts to 155 years.

The concentration of the coal market on very few countries is further demonstrated in Table 2.2 based on data for the year 2007 (Btoe = billion tons of oil equivalent). This table also displays the exports of the major coal exporting countries. Only approx. 15 % of the coal produced worldwide reaches the world market, 85 % of the coal is used in the countries of origin.

As can be seen from Fig. 2.17 and Table 2.2, China is by far the world's largest coal producer and consumer, using nearly one third of the global total and twice as much as the USA on rank two.

Even though the quality of reserve data is poor, an analysis of possible future production profiles based on these data is still deemed meaningful.

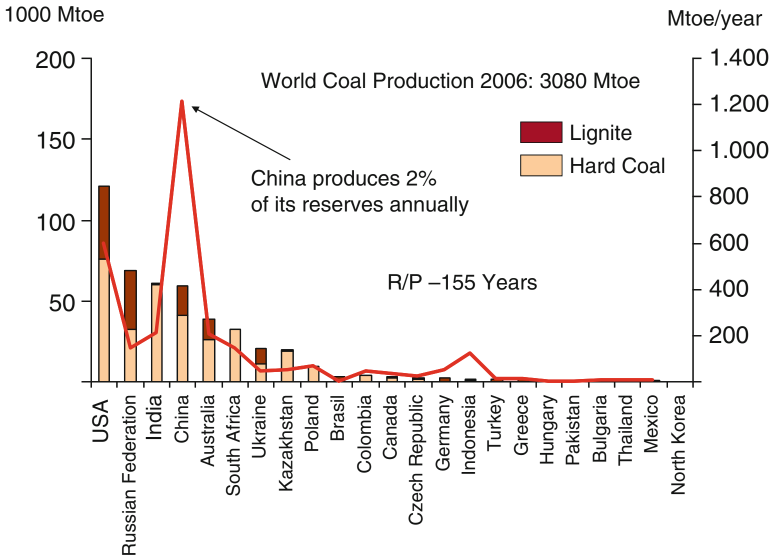


Fig. 2.17 Coal reserves and production by producing countries (Source: BP Statistical Review of World Energy (2007). Analysis: LBST (2007))

Table 2.2 World coal market 2007

	Largest	2nd largest	3rd largest	4th largest	Share of top 4
Reserves 2007	USA	Russia	China	India	67 %
	120 Btoe	69 Btoe	59 Btoe	36 Btoe	
Production 2007	China	USA	Australia	India	>70 %
	1.289 Mtoe/a	587 Mtoe/a	215 Mtoe/a	181 Mtoe/a	
Net exports 2007	Australia	Indonesia	South Africa	Russia	78 %
	162 Mtoe/a	80 Mtoe/a	54 Mtoe/a	54 Mtoe/a	

Source: BP Statistical Review of World Energy (2008). Analysis by LBST

According to past experience, it is very likely that the available statistics are biased on the high side and therefore projections based on these data will give an upper boundary of the possible future development. Accordingly, future production profiles have been developed using logistic fitting to past production.

Figure 2.18 below provides a summary of past and future world coal production in energy terms based on a detailed country-by-country analysis.

This analysis reveals that global coal production may still increase over the next 10–15 years by about 30 %, mainly driven by Australia, China, the Former Soviet Union countries (Russia, Ukraine, Kazakhstan) and South Africa. Production will then reach a plateau and will eventually decline thereafter.

The possible production growth until about 2020 according to this analysis is in line with the two demand scenarios of the IEA in the 2006 edition of the *World*

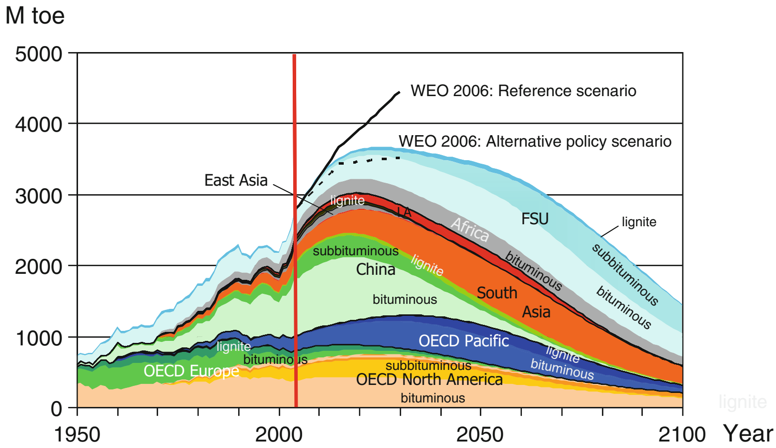


Fig. 2.18 EWG scenario of global coal production (2007) (Source: Zittel and Schindler 2007a)

Energy Outlook. However, the projected development beyond 2020 in the EWG scenario is only compatible with the *IEA alternative policy scenario* in which coal production is constrained by climate policy measures. Whereas the *IEA reference scenario* assumes further increasing coal consumption and production until at least 2030. According to the EWG analysis, this will not be possible due to limited reserves.

Since the completion of the EWG coal study in 2007 new data have become available leading to a slight reassessment of the EWG scenario. According to the most recent WEC report (WEC 2007), India has downgraded its reserves by about 40 %. In addition, India in recent years has imported coal at increasing rates (so why don't they use their own resources?). Also, current difficulties facing coal production in South Africa make it more likely (irrespective of how big the reserves really are) that coal production will be on a plateau for many years to come rather than being expanded significantly. The result of this reassessment is shown in Fig. 2.19. The timing and the level of peak coal is more or less the same as in the EWG scenario but the decline after peak is much steeper.

Again, it needs to be emphasized that these projections represent an upper limit of future coal production according to the authors' best estimate. Climate policy or other restrictions have not been taken into account.

This chapter can be summarized as follows:

- Global coal resource estimates seem to be of no practical relevance regarding future coal production and as a consequence future coal availability.
- Global coal reserve data are of poor quality, but seem to be biased towards the high side.
- Projections of production profiles suggest that global coal production will peak around 2025 at about 30 % above the current production rate – this being the upper boundary of the possible development.

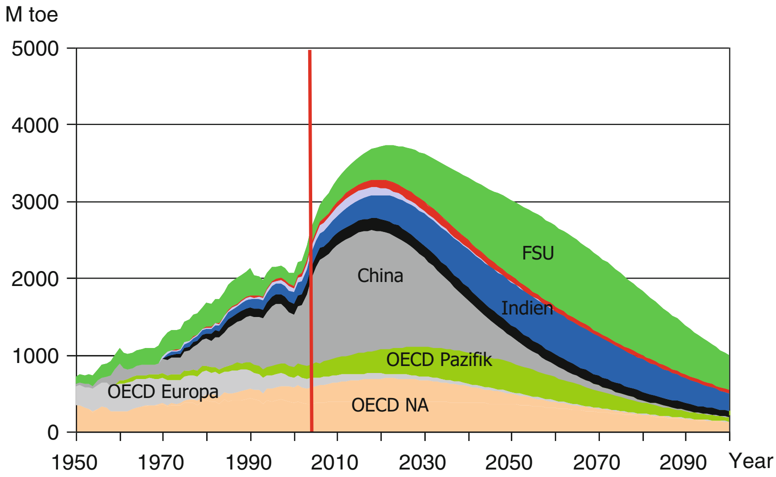


Fig. 2.19 Revised EWG scenario of global coal production (2008) (Source: LBST analysis 2008)

There should be a wide discussion on this subject leading to better data in order to provide a reliable and transparent basis for long term decisions regarding the future structure of our energy system.

The repercussions for the climate models on global warming are also an important issue.

2.5 The Fossil and Nuclear Supply Outlook

The above supply scenarios for crude oil, natural gas and coal can be integrated into a scenario of the future availability of all fossil and nuclear energy sources (Fig. 2.20).

The contribution of nuclear energy is also represented in the scenario, though nuclear energy is not dealt with in this paper. For the assessment of LBST and the Energy Watch Group see the study (Zittel and Schindler 2006). Regarding this point we generally agree with the IEA, which also does not foresee a significant increase in nuclear energy in the coming two decades (see Fig. 2.1). Nuclear energy's share was assumed to remain unchanged in this scenario. As can be seen, nuclear energy is not really relevant for the global picture.

The aggregate scenario shown in Fig. 2.20 is based on data as of 2006, so not all newer assessments are integrated. But in the context of this paper this is not really relevant, the scenario should be read as a qualitative statement with the numbers just indicating the likely magnitudes of possible contributions of individual fossil and nuclear energy sources at specific dates in the future. Though the exact numbers naturally are uncertain (and will remain so), this qualitative description of the future

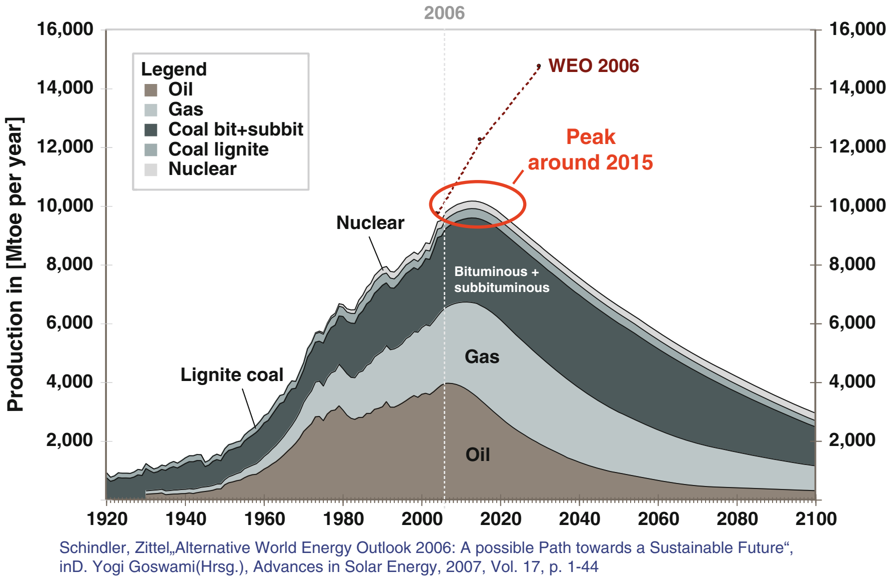


Fig. 2.20 Peak oil will be followed by the peak of all fossil and nuclear energies (Source: Schindler and Zittel 2007)

supply outlook has a very high likelihood of representing the possible availability of fossil and nuclear energy in the coming decades.

The message of this scenario is quite dramatic (and possibly surprising for many observers):

- The current advent of peak oil will lead to the subsequent peaking of all fossil (and nuclear) energy supplies in the very near future.

Even though natural gas and coal are expected to peak respectively one and two decades later than oil, the imminent decline in oil production will have as a consequence the peaking of all fossil and nuclear energy sources in about 5 years time – around 2015.

The twenty-first century will see the transition to a post fossil energy world.

References

BGR (1998) Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen 1998, Hannover
BGR (2002) Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen 2002, Hannover, 2003
BGR (2006) Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen 2005, Hannover
BP (n.d.) Statistical review of world energy, various editions
Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) (1995) Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen 1995, Hannover

Energy Information Administration (EIA) (2006) Annual coal reports, 1994–2006
IEA (2006) World energy outlook 2006. OECD/IEA, Paris
IEA (2008) World energy outlook 2008. OECD/IEA, Paris
IHS (2006) Energy, petroleum economics and policy solutions (PEPS). Geneva and London
International Energy Agency (IEA) (2004) World energy outlook 2004. OECD/IEA, Paris
Koppelaar R (2009) Oilwatch monthly, June 2009. ASPO Netherlands. www.peakoil.nl
Laherrere JH, Campbell CJ (1995) The world's oil supply 1930–2050. Petroconsultants, Geneva
Schindler J, Zittel W (2007) Alternative world energy outlook 2006: a possible path towards a sustainable future. In Yogi Goswami D (ed), Advances in solar energy, vol 17, Earthscan Publications, pp 1–44
Simmons MR (2005) Twilight in the desert – the coming Saudi oil shock and the world economy. Wiley, Hoboken
US Geological Survey (USGS) (2000) World petroleum assessment 2000. www.usgs.gov
WEC (ed) (2002) Survey of energy resources 2002. World Energy Council, London
WEC (ed) (2004) Survey of energy resources 2004. World Energy Council, London
WEC (ed) (2007) Survey of energy resources 2007. World Energy Council, London
World Energy Council (WEC) (ed) (1980) Survey of energy resources (Prepared by BGR-Federal Institute for Geosciences and Natural Resources Hannover for 11th World Energy Conference Munich)
Zittel W, Schindler J (2004) The countdown for the peak of oil production has begun – but what are the views of the most important International Energy Agencies, Ottobrunn. Published in the Internet, e.g. firts at EnergyBulletin.net. Now accessible at aspo-deutschland.blogspot.de/publikationen
Zittel W, Schindler J (2006) Uranium resources and nuclear energy. Energy Watch Group. www.energywatchgroup.org
Zittel W, Schindler J (2007a) Coal: resources and future production. Energy Watch Group. www.energywatchgroup.org
Zittel W, Schindler J (2007b) Crude oil – the supply outlook, 2007, revised edition 2008. Energy Watch Group. www.energywatchgroup.org

Part II
Goals and Potentials for a Sustainable Use of Resources

Chapter 3
Targets for Global Resource Consumption

Stefan Bringezu

3.1 Introduction

This chapter explores the question which meaningful targets could be set, internationally and by individual countries, with regard to their global resource consumption, in order to ensure a sustainable use of those resources.

On a global scale, only few targets for specific environmental "downstream impacts" of resource use have been agreed upon so far, such as in the Kyoto Protocol for greenhouse gas (GHG) emissions within the UN Framework Convention on Climate Change.[1] The Kyoto process, based on profound scientific analysis and comprehensive modelling by the IPCC, was the first international attempt to reduce the volume of a major outflow of the socio-industrial metabolism to the environment. Accordingly, operational targets have been set in many countries to reduce the use of fossil fuels which represent the corresponding resource input. For specific hazardous emissions, the Montreal Protocol successfully limited the emissions of major ozone depleting substances.[2] The global control of chemical substances is supported by the Stockholm Convention on persistent organic pollutants (POPs),[3] and the Rotterdam Convention[4] aimed to increase the safety of international trade of hazardous chemicals. The Basel Convention is dedicated to ensuring the safe management of internationally traded hazardous waste,[5] although with hardly any substantial effect on the generation and overall volume of

[1] See http://unfccc.int

[2] See http://ozone.unep.org

[3] See http://chm.pops.int and http://www.chem.unep.ch/pops

[4] See http://www.pic.int

[5] See http://www.basel.int

S. Bringezu (✉)
Wuppertal Institute for Climate, Environment and Energy,
Döppersberg 19, 42103 Wuppertal, Germany
e-mail: stefan.bringezu@wupperinst.org

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_3,

solid and liquid wastes. Those wastes are the consequences of resource extraction, manufacturing, product use and recycling. About two thirds of the socio-industrial metabolism are resource flows for non-energy purposes, mainly minerals and biomass (Bringezu et al. 2009a).

In a more general way, on the level of goals, the international Convention for Biodiversity[6] calls for appropriate actions to manage global land use at local and regional level. The greatest threat to biodiversity has been land use change, mainly the expansion of agriculture at the expense of natural ecosystems (MEA 2005). However, there is still no monitoring, let alone controlling, of the global land use change induced by consumption activities of countries, similar to that in place for GHG emissions.[7] Only such monitoring would allow countries to define appropriate targets for adjusting their production and consumption activities to sustainable levels of resource use.

Thus, there is currently no mechanism on the global scale to ensure that overall resource use, or at least major parts of it, is being kept at sustainable levels, with impacts in an acceptable range of uncertainty. Sustainable resource use, and thus consumption, requires, however, more than the control of negative environmental implications. It must also serve certain socio-economic functions. Therefore, this article will first look at the more general goal of sustainable resource consumption. It will then focus on major global environmental pressures and outline relevant megatrends. The "Big Three" indicators will be described which can be used to address those major pressures. As GHG emissions are already an established issue in international debates, the focus will be on mineral resource extraction and global cropland. In a rather tentative way, possible rationales will be discussed for setting global targets and how to relate them to single countries.

3.2 The Goal of Sustainable Resource Consumption

In 1992, the United Nations Conference in Rio defined the Agenda 21,[8] which in Chap. 4 states that "special attention should be paid to the demand for natural resources generated by unsustainable consumption and to the efficient use of those resources consistent with the goal of minimizing depletion and reducing pollution". At the same time, poverty and environmental degradation were seen in conjunction, and it was acknowledged that the unequal use of resources must be taken into account when solving environmental problems. In 2002, the Johannesburg Plan for Implementation was defined,[9] and the so-called Marrakesh process which aims to

[6] See http://www.cbd.int

[7] The net effect of consumption can generally be calculated by adding domestic emissions and emissions associated with imports minus exports. Indirect GHG emissions of imports to and exports out of Germany, for instance, have been accounted for by Schoer et al. (2007).

[8] See http://www.un.org/esa/dsd/agenda21

[9] See http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pdf

promote more sustainable production and consumption patterns worldwide by concrete actions in various countries.[10] Still the process is rather open with regard to indicators, priorities and targets. Climate change is the dominating environmental issue, the need to increase resource productivity is increasingly being acknowledged (see e.g. OECD 2004, 2008); however, a global reference for absolute resource consumption is still widely lacking.

In Europe, the European Union in its 6th Environmental Action Programme aimed at "better resource efficiency and improved resource and waste management, to help bring about more sustainable patterns of production and consumption".[11] The programme called, among other things, for the establishment of a thematic strategy for the sustainable use of natural resources, which for the purpose of implementing the objectives should inter alia include the "establishment of goals and targets for resource efficiency and the diminished use of resources, decoupling the link between economic growth and negative environmental impacts".[12] The Thematic Strategy on resources (European Commission 2005) introduced the idea of a double decoupling: first, between resource use and economic growth (i.e. resource productivity increase), and second, between resource use and environmental impacts. Whereas it is undisputed that on the level of single products and materials it is possible to choose alternatives with less specific environmental impacts (as far as they can be quantified), there is still an ongoing debate over whether such a decoupling can realistically be assumed at the macro level, considering substitution, rebound effects, problem shifting and limited knowledge about impacts (see e.g. Bringezu 2006; Bringezu et al. 2009b).

Considering that the use of resources fulfils important societal functions and at the same time is linked not only to environmental but also socio-economic impacts, Bringezu and Bleischwitz (2009) formulated seven principles of sustainable resource management:

1. Secure adequate supply and efficient use of materials, energy and land resources as reliable biophysical basis for creation of wealth and well-being in societies and for future generations;
2. Maintain life-supporting functions and services of ecosystems;
3. Provide for the basic institutions of societies and their co-existence with nature;
4. Minimize risks for security and economic turmoil due to dependence on resources;
5. Contribute to a globally fair distribution of resource use and an adequate burden sharing;
6. Minimize problem shifting between environmental media, types of resources, economic sectors, regions, and generations;
7. Drive resource productivity (total material productivity) at a rate higher than GDP growth.

[10] See http://www.scp-centre.org

[11] Decision 1600/2002/EC, O.J. L 242/1 of 19.9.2002.

[12] §8 (i) (c) of the 6 EAP.

Consequently, the operationalization of targets for sustainable resource consumption will have to deliver more than the adequate control of environmental impacts. Nevertheless, the following section will start with a focus on the major environmental pressures which need to be mitigated on a global scale.

3.3 Major Environmental Problems of Global Resource Consumption

3.3.1 A Systems Perspective

The human sphere and the environment are interrelated by complex interactions. Human activities influence the state of soils, water bodies, the atmosphere, natural eco-systems and their biodiversity while the various compartments and natural system components are also interconnected by physico-chemical and biological functions and feedbacks. As a consequence, it is not easy to model earth and socio-economic systems comprehensively, and an enormous effort is already involved in climate related modelling.

Major negative impacts on the environment are related to massive material flows exchanged with the socio-economic system and the associated land use. In analytical terms, the input and output of the socio-industrial metabolism exert a certain pressure on the environment, consisting in fact of a whole range of specific pressures, depending on the quantity and quality of the flows, and possible land use changes, which are related to extraction and use of resources, including the recycling and final disposal of wastes, and emissions to air and water (for a discussion of quality vs. quantity aspects see Bringezu et al. 2009b; Bringezu 2006).

There are three major pressures with global impacts: GHG emissions, mineral resource extraction, and land use. GHG emissions are key to climate change. Mineral resource extraction is the starting point of all abiotic material flows and determines the pressures which are related to the mass turnover from mining, through manufacturing, final production, use, recycling to final disposal. Land use, in particular land use change, is most relevant for the use of biomass for food and non-food purposes and the pressures on biodiversity and ecosystem change and resilience.

Of course, there are many other impacts as well. Water abstraction may change vast landscapes, eutrophication and acidification change the quality of water and soils and affect biodiversity, persistent organic chemicals pose long-term health hazards, etc. All of these flows are related to the performance of the socio-industrial metabolism, and important to consider.

However, when seeking to analyse and assess that metabolism and to further develop it in a sustainable manner, it seems adequate to distinguish between the dynamics and adjustment of its *volume and structure* on the one hand (incl. "dematerialization" and recycling), also addressed as "conditioning" (Bringezu 2006), and the fine tuning and "detoxification" on the other hand (incl. substitution). The former focuses on the megatonne flows which may exceed certain natural capacities (e.g. for GHG absorption) or societal tolerances (e.g. for landscape changes by deforestation).

The latter pinpoints the nanogram fluxes of hazardous compounds with potential toxic effects. The control of POPs and other chemicals requires detailed analytical information. The institutional framework to apply this information has already been established to a large extent (e.g. REACH in the EU, and the international conventions mentioned in the introduction). What seem largely lacking are instruments and institutions to monitor and control consumption of megatonne flows and related upstream and downstream system related impacts. Past policies have focussed on downstream impacts and consequently followed a reactive type of action. In a complementary manner, upstream flows can be used to derive "input oriented" indicators to account for a generic environmental pressure and allow implementing a more precautionary type of environmental policy (Bringezu et al. 2003, 2009b).

The various pressures also differ in scale. For instance, water consumption is of particular relevance in water scarce regions. Overuse in some areas may have repercussions on other regions, there are conflicts and refugees, and because water scarce regions are numerous one may also regard water consumption as a global problem. However, water is mainly consumed locally and the implications usually also impact the regions where the consumption takes place, although "virtual water" or "water rucksacks" and the consumption of water via import of products is increasing with international trade in agricultural commodities. Should targets for sustainable water consumption be defined they would need to be related to water availability at the local and regional scale (and regions could develop water balances including import and export of virtual water).

There are also other pressures, such as eutrophication and acidification, which usually exert their impact on a local to regional scale. The former is largely connected to agriculture and municipal sewage, the latter to combustion processes. Both are related to the mass throughput of mineral resources (and would thus also be mitigated by a dematerialization strategy, assuming a constant composition of flows), but should be monitored and controlled using a production-specific approach in the regional context on the one hand and a product-specific life-cycle-wide approach on the other hand.

This leaves the "Big Three" environmental pressures with global impacts: GHG emissions, mineral resource use, and land use change. As activities are already underway to establish monitoring, targets and control measures for climate change, this contribution will focus on mineral resource use and land use, in particular agricultural land use change.

3.3.2 Growing Resource Use

Global used and unused extraction of fossil fuel, metal, mineral and biomass resources in 2000 was estimated to amount 80 billion tonnes.[13] Estimates of global soil erosion from agricultural land ranged between 25 and 50 billion

[13] MOSUS data base established by S. Giljum and colleagues: http://www.materialflows.net (accessed February 17, 2009).

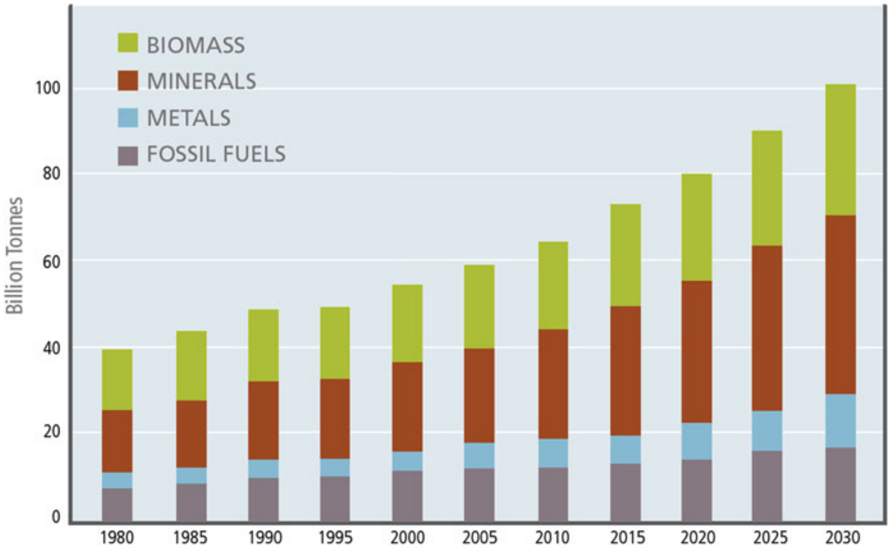


Fig. 3.1 Baseline development of global used resource extraction (Source: Aachen Foundation (2011) based on SERI, Global 2000, FoEE (2009))

tonnes[14] per year (Brown 1985; Pimentel 1993). A first preliminary estimate of global excavation of soil and earth for infrastructure building (landscape modelling) ranges between 40 and 50 billion tonnes (Bringezu et al. 2009a). Altogether, between 145 and 180 billion tonnes may have been extracted from the global environment in 2000.

Focussing on the used extraction and harvest of raw materials, baseline modelling predicted a doubling between 2000 and 2030 (Fig. 3.1). In absolute terms, unused extraction – not shown in the figure – would add about a double to triple amount.

If by 2050 global total material consumption (TMC) per capita matched the EU's TMC per capita at the beginning of the century, this would mean an increase in global resource consumption by a factor of 2–3. In 2000, the EU with its 15 member states had a TMC of 44 t/cap, which was rather close to the median value of 43 t/cap for the industrialised countries known until then (Bringezu et al. 2009a). Assuming that a world population of nine billion people would adopt the current EU technology and consumption pattern this would result in a global resource extraction of about 400 billion tonnes in 2050. If the TMC of the USA in 1991 were to serve as a global model, this would result in about 666 billion tonnes, corresponding to an increase of global resource extraction by a factor of 4–5 between 2000 and 2050.

[14] The order of magnitude might not have decreased since those values have been estimated. 2–5 Mha of global arable land are lost every year to soil erosion (den Biggelaar et al. 2004). According to Lavelle et al. (2005) persistently high rates of erosion affect more than 1.1 billion hectares of land worldwide.

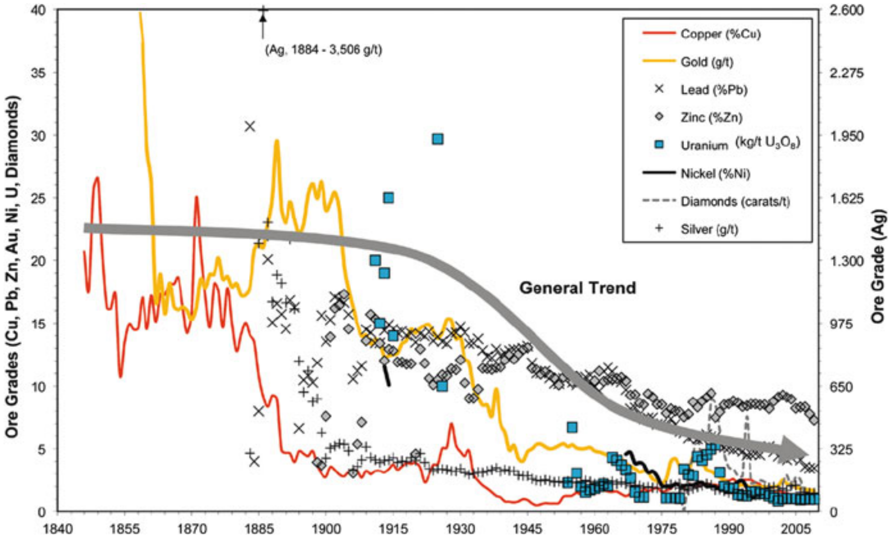


Fig. 3.2 Declining ore grades – the example of Australia (Source: With friendly permission from Gavin Mudd, up-date 2010 based on Mudd (2009))

Altogether, worldwide adoption of current industrial technologies could increase global resource extraction by a factor 2–5 by the middle of the century.

So far, there is no scientifically sound model which can predict the consequences of growing global resource extraction, use and disposal for local, regional and continental ecosystems. One may expect, however, that natural inventories, especially biodiversity will become more depleted, the capacities for regeneration and resilience will decrease, and society will become more vulnerable to natural change while having less scope for reaction and adaptation.

3.3.3 Increasing Impacts of Mineral Extraction

Mineral resource extraction will most probably excavate growing amounts of unusable material. This is mainly due to the downward trend in minable ore grades (Fig. 3.2). In addition, the relation of waste rock to ore is growing with open pit technology (see e.g. Mudd 2009). As a consequence, the amount of mining waste per tonne of base material will grow, and so will the impacts associated with landscape change, water abstraction, habitat destruction, acid mine drainage and other pollution.

Thus, the environmental impacts of mineral use could grow to a higher extent than the use itself.

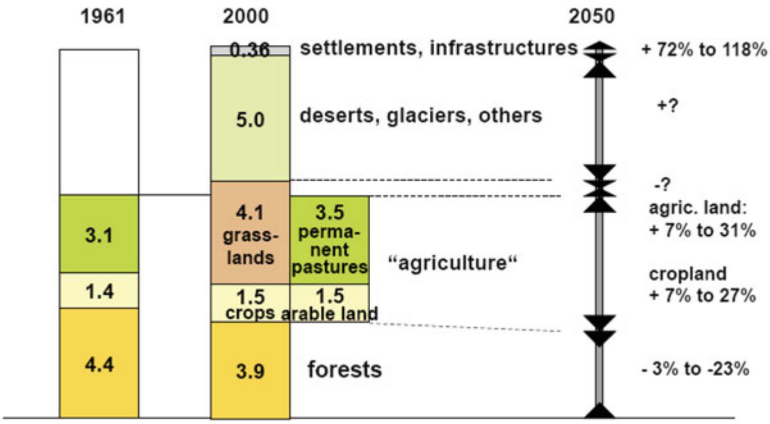


Fig. 3.3 Global land use and major trends (Source: Bringezu et al. (2009a) based on Kemp-Benedict et al. (2002), MEA (2005), GEO 4, OECD (2008))

3.3.4 Increasing Impacts of Land Use Change

Global land use in the past has changed mainly through the expansion of agriculture into natural ecosystems. Without effective control this trend will probably continue, also due to increasing demand for food and non-food biomass. In 2000, agricultural land (cropland and permanent pastures) comprised about 5 billion ha. Projections and scenarios for the expansion of agricultural land range from 7 to –31 % by 2050 (MEA 2005; UNEP 2007). Intensively cultivated cropland stretched over 1.5 billion ha in 2000, and could expand by 7–27 % (MEA 2005). It is in particular the expansion of cropland which exerts high pressure on the conversion of land cover, impacts on biodiversity, carbon stocks and soils (MEA 2005; Lambin and Geist 2006).

In addition, urban sprawl and the expansion of the global road system is expected to about double the global area for settlement and infrastructure by 2050 (Fig. 3.3). As this often happens on most fertile soils it drives agriculture further into natural ecosystems. The absolute growth in settlement and infrastructure area may be of the same order of magnitude as the (additional) enlargement of cropland. Whilst built-up land often encroaches upon cropland, which has already a relatively low biodiversity and low carbon stocks, cropland expands into grasslands, savannahs or forests and thus exerts higher pressure on biodiversity and GHG emissions. Within settlement areas, due to gardens and a patchwork of green spaces, species diversity is often higher than in areas of intensively cultivated cropland which sometimes resembles a "green desert". Therefore one may argue that it is the expansion of cropland area in particular which is associated with a depletion of biodiversity.

Global cropland will most probably expand in the coming decades. In the past, agricultural yields grew faster than the world population (Bringezu et al. 2009c). More food could be produced on existing cropland. In the future, the trends might become less favourable, as average crop yields may compensate for population

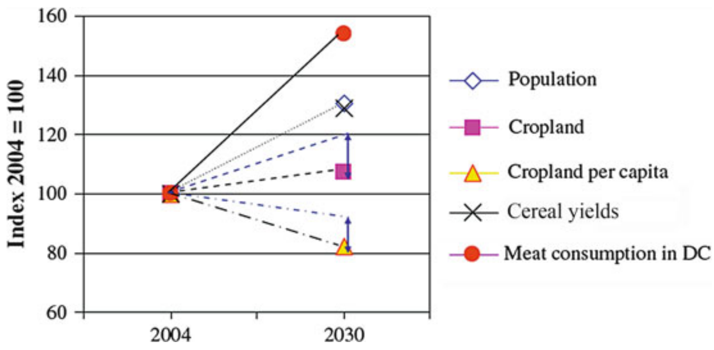


Fig. 3.4 Expected trends in global population, average cereal yields, and cropland and meat consumption. *DC* developing countries (Source: Bringezu et al. 2009d)

growth but not for an increasing demand for animal based food. Between 2000 and 2030 the global population is expected to grow by 36 % (medium projection by UN/FAO). This would be about the same rate that average crop yields are expected to increase. At the same time, however, food demand is changing towards a higher share of animal based diets, particularly in developing countries. The FAO expects meat consumption of the world population to increase by ca. 22 % per capita from 2000 to 2030, milk and dairy consumption by 11 % and that of vegetable oils by 45 %. Commodities with lower land requirements like cereals, roots and tubers, and pulses will increase at lower rates per capita.

As yield increases will probably not compensate for the growing and changing food demand, cropland will have to be expanded just to feed the world population (Fig. 3.4). So far no explicit projection of global land use change induced by changing food demand seems to be available. From the Gallagher report (RFA, Gallagher 2008; Bringezu et al. 2009c) an estimated additional requirement of 144–334 Mha of global cropland for food in 2020 was derived.

Any further requirements for non-food crops, for instance biofuels and biomaterials, will add on top of this.

World ethanol production for transport fuel tripled between 2000 and 2007, and biodiesel expanded 11-fold, resulting in a total share of biofuels of 1.8 %.[15] In 2008, feedstock for biofuels was grown on about 2 % of global cropland (Bringezu et al. 2009c). Although the area seems relatively small there has been a steep increase in biofuel production in recent years which may be expected to continue, as the industry has invested heavily in production capacities triggered by policy targets in many countries.

[15] A recent estimate for 2008 by OECD/FAO (2008) arrives at 64.5 billion litres ethanol and 11.8 billion litres biodiesel, up 22 % from 2007 (by energy content). From 2005 to 2007 (average) to 2008, the share of ethanol in global gasoline type fuel use has increased from 3.78 to 5.46 %, the share of biodiesel in global diesel type fuel use rose from 0.93 to 1.5 % (OECD/FAO 2008).

Various projections and estimates of potentials outline the additional cropland requirements for biofuels (Bringezu et al. 2009c). For instance, with some robust scenarios based on first generation biofuels, Ravindranath et al. (2009) calculated that 118–508 Mha of cropland for feedstock would be required to provide a 10 % biofuel share in transport in 2030.

The expansion of cropland will lead to conversion of grasslands, savannahs and forests, in particular in tropical countries. A special concern is land use change induced by the growing demand for biofuels and the subsequent GHG emissions, and consequences for biodiversity.

Clearing the natural vegetation mobilizes the stocked carbon and may lead to a carbon debt, which could render the overall GHG mitigation effect of biofuels questionable for subsequent decades. The total CO_2 emissions from 10 % of the global diesel and gasoline consumption during 2030 was estimated at 0.84 Gt CO_2, of which biofuels could substitute 0.17–0.76 Gt CO_2 (20–90 %), whereas the annual CO_2 emissions from direct land conversion alone are estimated to be in the range of 0.75–1.83 Gt CO_2 (Ravindranath et al. 2009). Even higher emissions would result in the case of biodiesel originating from palm oil plantations established on drained peatland.

Increased biofuel production is expected to have large impacts on biological diversity in the coming decades, mostly as a result of habitat loss, increased invasive species and nutrient pollution (Bringezu et al. 2009c). Habitat loss will mainly result from cropland expansion. Species and genotypes of grasses suggested as future feedstock of biofuels may become critical as invaders. Nutrient emissions to water and air resulting from intensive fuel cropping will impact species composition in aquatic and terrestrial systems. Modelling of the future biodiversity balance for different crops on different land types has shown that GHG reductions from biofuel production would often not be enough to compensate for the biodiversity losses from increased land use conversion, not even within a time frame of several decades (Eickhout et al. 2008). Beneficial effects for biodiversity have only been noted under certain conditions, when abandoned, formerly intensively used agricultural land or moderately degraded land is used.

Current biofuel policies aim to implement production standards which require minimum GHG savings and assure that production land does not consist of recently converted natural forests, or other land with high value for carbon storage or biodiversity. However, for net consuming regions like the EU and countries like Germany, models have shown that an increased use of biofuels would lead to an overall increase in absolute global cropland requirements (Eickhout et al. 2008; Bringezu et al. 2009d). This implies that if biofuels are produced on existing cropland, other production – in particular to meet that share of the growing food demand which cannot be met by increasing yields – will be displaced to other areas ("indirect land use"). As long as the global cropland required for agriculture based consumption grows, it will not be possible to prevent displacement effects, land conversion and related direct and indirect impacts through selected production standards for biofuels.

Overall, one may expect that production standards and product certificates will not be sufficient to limit the expansion of global cropland. To achieve this, the protection of natural ecosystems against conversion would need to be enforced (e.g. by economic instruments) and the demand of consuming countries would have to be adjusted to levels which can sustainably be supplied in the global context. It is the latter strategy which requires appropriate indicators and targets considering global land use of countries and regions.

3.4 Indicators Describing the "Big Three" Environmental Pressures

The "Big Three" environmental pressures are GHG emissions, total mineral extraction, and (change of) global cropland. These headline indicators each represent the tip of an indicator pyramid (Fig. 3.5).

GHG emissions are usually coupled with other emissions related to the combustion of fossil fuels or agriculture (incl. cattle breeding) – the most relevant processes for climate change – such as emissions of acidifying and eutrophying substances, particulate matter and ozone-depleting substances (e.g. N_2O). Certainly, there are also other, more specific processes which generate GHG emissions from other sources (e.g. cement production from carbonate oxidization), and specific substance flows to generate air borne impacts such as ozone depletion (e.g. by CFCs). Any prioritization between the different specific impacts represents a subjective or policy oriented decision. For the time being it seems widely accepted that climate change and GHG emissions attract top attention. At the same time, when GHG emissions are chosen as key indicator, the mitigation measures will to a large extent also reduce other associated pressures.

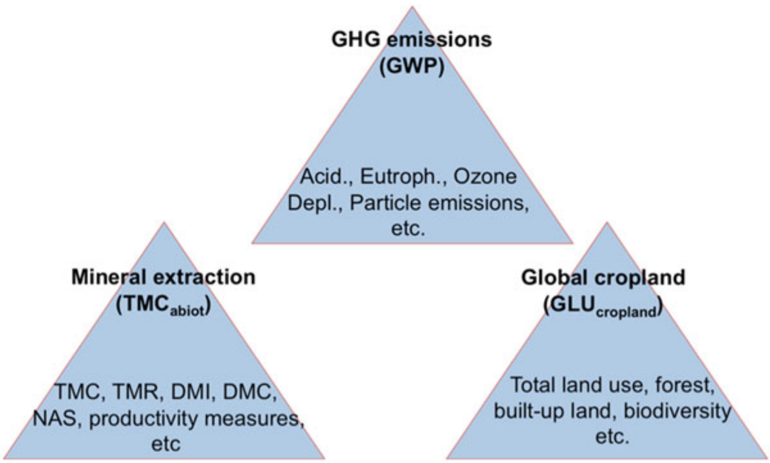


Fig. 3.5 Headline indicators of the "Big Three" environmental pressures and related indicator pyramids (Source: Own compilation)

Mineral extraction, measured as TMC_{abiot} (total abiotic material consumption),[16] belongs to a set of economy-wide material flow indicators (Eurostat 2001; OECD 2008; Bringezu et al. 2009b). These indicators measure the performance of the physical economy, its volume and structure, and relate to input, output, balance, consumption and productivity of resource use. Selecting TMC_{abiot} as target indicator considers the key role of abiotic resource flows for systemic environmental pressure.

Biomass use and related pressures may be best reflected by indicators related to land use, in particular land use change. Expansion of global cropland may be regarded as key issue, and related, more specific, indicators, for instance of biodiversity changes, may be associated with land use accounts and indicators. Of course, the dynamics of other land use categories such as settlement area and related impacts would also need to be considered, although attention should focus first on the expansion of global cropland for the coming decades.

In the following the two headline indicators needed other than GHG emissions are characterised.

3.4.1 Primary Minerals Consumption

Minerals extraction represents the starting point of major anthropogenic material flows from mining and quarrying, through manufacturing, production, use, to recycling and final waste disposal. Currently, mineral flows outweigh biomass flows by far. They comprise used extraction of fossil fuels, metal ores, construction and industrial minerals, and the unused extraction of the interlinked overburden, interburden, etc. and similar translocations of soil and earth from undisturbed settings[17] such as excavations for infrastructure development.[18]

Abiotic minerals extraction can be measured on a global level and attributed to national consumption by the indicator TMC_{abiot}.

For the interpretation of the indicator in terms of environmental impacts, the following aspects seem relevant:

- TMC focuses on primary materials extraction; the systems perspective is crucial as the indicator accounts only for material flows between the environment and the socio-industrial system; as such it determines a certain mass flow per time

[16] TMC = Total Material Consumption, comprises both abiotic and biotic resources.

[17] For operationalization see Schmidt-Bleek et al. (1998), Ritthoff et al. (2003).

[18] From a systems perspective, erosion may be regarded as flow along the system boundary between socio-industrial metabolism and environment; as a consequence, it may be (1) included when environmental pressure through mass translocation also by agriculture shall be accounted for, analogous to translocations in mining (Schmidt-Bleek et al. 1998); or it may be (2) regarded as impact of human activities and excluded from material flow accounts when concentrating on the throughput of industries and directly linked flows like unused extraction (e.g. Eurostat (2001) regards erosion as memory item).

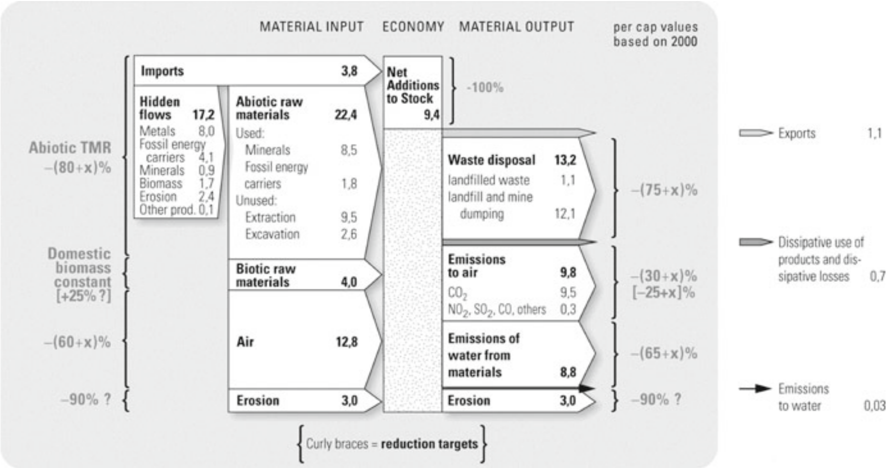


Fig. 3.6 Overview scheme of the EU's socio-industrial metabolism with targets for long-term development (Source: Bringezu 2009)

(not a static weight of certain materials), and thus the order of magnitude of environmental pressures determined by this flow;

- TMC refers to primary materials, in analogy to indicators of primary energy requirements which do not distinguish between different types of energy; differences in material composition are considered only in broad resource categories (abiotic vs. biotic, used vs. unused; types of resources such as fossil fuels, metals, minerals);
- TMC represents a consumption indicator which is based on the input indicator TMR (total material requirement) by attributing the primary material use to the final demand of an economy (excluding exports and their resource requirements);
- Input indicators such as TMR (and thus TMC) can be interpreted as generic pressure indicators (Bringezu et al. 2003) which are complementary to indicators of specific environmental pressure (e.g. eutrophication, acidification); generic pressure indicators like primary energy requirement, primary materials requirement, water consumption measure the system turnover of major flows which determines the subsequent impacts according to the dimensions of the system (in general, the globe);
- Generic pressure indicators like TMR and TMC indicate environmental pressures which are in the first place not dependent on the chemical properties of the materials extracted; for instance, within the same environment, the extent of landscape change caused by the extraction of a tonne of sand may be similar to that of a tonne of iron ore;
- The indicators TMR and TMC comprise all material flows without water and air which are induced by human activity; therefore, they are robust against substitution of specific materials and can capture related problem shifting;

- The input indicators TMR and TMC automatically account for the amount of future waste; based on yearly accounts, the indicators are related to net addition to stock (NAS) and domestic material output (DMO); in the current phase of growth of the socio-industrial metabolism a decrease of the input indicators TMR and TMC would most probably also require a reduced NAS; as a consequence, the associated specific pressures such as expansion of built-up land and the generation of construction and demolition waste would probably also be mitigated; the connection between TMR and NAS is visualized in Fig. 3.6.

3.4.2 Global Land Use for Agricultural Consumption

Statistics on global land use for agriculture have been compiled (FAO 2006) and improved by remote sensing (Ramankutty 2008). In order to attribute global land use to the consumption of specific countries, the method of global land use accounting (GLUA) was developed, in analogy to the TMC approach. As agricultural land use dominates overall land use, in a first step GLUA was used to quantify the land use associated with the consumption of agricultural good, $GLU_{agriculture}$ (Bringezu and Schütz 1995; BUND and Misereor 1996; Schütz 2003; Schütz et al. 2003; Steger 2004; Bringezu and Steger 2005; Bringezu et al. 2012, 2009b).

GLUA combines the resource flows and associated land use of a national economy, region or product chain, and thus provides a measure of the mass flow related land use. It aims to provide a measure of the actual land use. In that respect, it differs from other sustainability indicators such as the Ecological Footprint (EF), which calculates virtual land area in order to translate carbon dioxide emissions into global hectares of marine or forest area (Wackernagel et al. 2005). Thus, GLUA is much more focussed and depends on fewer assumptions.

The GLUA method allows (1) the global "gross production area" needed for the production of certain domestically consumed goods (e.g. biodiesel produced from soya) to be calculated (Bringezu et al. 2012). Allocating (2) the use of biomass to several purposes (e.g. soy bean oil for diesel or food, and soy cake for feed), the "net consumption area" for all agricultural goods consumed in a country or region can be calculated. GLUA differentiates according to where in the world the land linked to the domestic consumption of goods is used: domestically or abroad. At the domestic level, the land used for the production of goods exported to other parts of the world is also considered.

With regard to its interpretation it seems important to consider:

- the absolute extent of global cropland has less meaning than its change; land use change (LUC), in particular the expansion of cropland, is responsible for losses of natural habitats and associated losses of biodiversity (MEA 2005);
- $GLU_{cropland}$ integrates all types of intensively cultivated land for food and non-food consumption, and is thus robust against substitution of crops, conversion technologies and types of use; it thus captures problem shifting associated with

direct and indirect LUC (e.g. shifts of land use to other countries due to increased domestic consumption of biofuels).

The concept has also been used to consider consumption of biomass from forestry (Zah et al. 2010). This enables decision makers to also detect LUC and related problem shifting associated with the further development of advanced biofuels based on ligno-cellulosis.

3.5 Which Targets Can Be Suggested?

3.5.1 Global Targets of Resource Use Versus National Consumption of Global Resources

In a first step, a rationale for targets will be outlined which, in a second step, will be related to the national consumption of those resources by specific countries. While abiotic resource extraction and cropland use are relatively easy to measure at the global level, it is not straightforward to account for the "consumption" of those resources by national or regional activities. As economies are increasingly interwoven by trade and use resources of foreign countries, it will not be sufficient to consider only the direct use within a certain country; rather, the resource use in other regions which is related to the domestic activities must also be taken into account.

Accounting for the national consumption of global resources should consider the following aspects:

- The attribution of resource use should be based on the consumption of products and services; for that purpose it can be derived from the economic definition of final consumption; this excludes resource use for the production of exports (which is attributed to the receiving countries, and subsequently to their final consumption); it seems important to distinguish between total *resource use* of an economy (incl. resources used for the production of exported goods), and *"resource consumption";*
- The indicators applied should account for the resource requirements of the consumed products and services throughout their lifecycle; indicators which fulfil this requirement are, for instance, TMC and $GLU_{cropland}$ (when considering net consumption land); they also capture shifting of resource supply and related environmental pressure between regions;
- The comparison of resource consumption of countries and in relation to global resource use and target parameters should be based on per capita values according to the equity criterion of sustainable development.

By relating global resource use to its ultimate purpose, i.e. final consumption, these criteria allow resource consumption by countries and regions – which varies with natural resource endowments and geographical and political boundaries – to be measured and benchmarked in a comparable manner.

3.5.2 *Towards a Rationale for a Target of Global Mineral Extraction*

When approaching a more sustainable and mature[19] performance, one may expect that the socio-industrial metabolism of the world economy will be characterised by a significant decline of combustive fossil fuel use and a reduction of net physical growth (Bringezu 2002, 2009). Both trends will be associated with a decrease in the extraction of primary minerals, fossil fuels and construction minerals, including their hidden flows.

In addition, one may argue that due to their inherent properties and implications in terms of mining and quarrying, a business-as-usual consumption of other minerals will be incompatible either with a continuous supply or with acceptable levels of accumulated resource extraction and related impacts in various regions. As mentioned above, the reduction of primary material input would reduce the generic environmental pressure associated with the throughput of the socio-industrial metabolism. The gradual change in the global environment caused by steady extraction of mineral resources could thus be mitigated. This would also contribute to an internationally more balanced resource use and burden sharing, as environmental impacts in foreign countries induced by consumption activities in rich countries, in particular, would be reduced as well.

Schmidt-Bleek (1992) suggested that global resource consumption should be halved by the middle of the twenty-first century and an equal per capita use should be aimed at. When applying this to the global extraction of abiotic resources, which amounted to about 100–110 billion tonnes (without erosion) in 2000 (or 16–18 t/cap), that amount would have to be reduced by half and the remainder shared equally by nine billion people in the future; the acceptable level would then be around 5.6–6.1 t/cap $TMC^*_{abiot.}$[20] In 2000, EU per-capita consumption was 33.4 tonnes TMC^*_{abiot}. It would therefore have to be reduced by at least 80 %, or a factor of 5. This is consistent with suggested reductions by a factor of 10 over about 50 years (Schmidt-Bleek 1992, 1994) and a factor of 4 over 30 years (Weizsäcker et al. 1995), which were defined for all industrialised countries, although both factors originally were not specified for certain components of the socio-industrial metabolism, and were formulated before the actual resource consumption of countries could be measured.

Assuming that the physical relations of foreign trade and domestic consumption will remain more or less constant, that reduction may also be applied to TMR^*_{abiot} (as illustrated in Fig. 3.6). For the EU, this would imply that goods exported by the

[19] The development from a phase of physical growth towards a phase of steady stocks may be regarded as essential characteristic of maturation.

[20] Note that TMC^*_{abiot} does not include biomass nor erosion.

EU and the resources imported for their production would undergo a resource productivity increase similar to that of products consumed within the EU.[21]

For a first international comparison, TMC**[22] has been estimated for all countries which provide sufficient data on their international trade (Dittrich 2010). TMC_{abiot}** comprises all domestic and foreign used and unused extraction for minerals, including fossil fuels, metal ores, construction and industrial minerals, but excluding excavation for infrastructure and erosion. Applying the same rationale as for TMC_{abiot}* this would provide a target of 4.4 t/cap for a world population of nine billion people.

The actual situation indicates that many countries, including developing countries and transition countries, already exceed this value (Fig. 3.7). Preliminary estimates of TMC_{abiot}** in 2005 are 15 t/cap and 13 t/cap for China and India, resp., 11 t/cap for Brazil and 20 t/cap for Russia; in contrast, rich economies exhibit significantly higher resource consumption, such as USA 55 t/cap and EU 32 t/cap. It should be noted that the data base for construction mineral extraction is uncertain for many countries, in particular for developing and transition countries. In an attempt to correct for implausibly low values in the materialflows.net data base, Dittrich (2010) assumed a minimum of 4 t/cap of construction minerals extraction for developing countries. As a consequence, only few countries with abiotic resource consumption below 4.4 t/cap are reported (Fig. 3.7).[23]

On the one hand, this reveals the need for more research into, and accounting of, resource extraction in developing and transition countries. On the other hand, assuming that 2–4 t/cap construction mineral use and 4 t/cap TMC_{abiot}** may represent the current bottom line of abiotic resource use in developing countries, this leads to the question of whether a 4.4 t/cap target is appropriate. For any target there is the need to consider whether it is feasible and whether it leaves room for development in poor countries where the stock of buildings and infrastructure has yet to be built up. When defining policy targets, it seems necessary to consider not only the need, but also the opportunities and obstacles for technological and institutional improvements towards dematerialisation and increased resource productivity. Research will have to clarify how much abiotic resource consumption will be required for decent living conditions in the various world regions.

From today's perspective it will already be a tough challenge to reduce the overshoot of abiotic resource extraction worldwide beyond the level of 2000, and to aim for a more equal distribution of consumption between countries. If the aim is to

---

[21] In case the EU would increase its exports (in relation to domestic consumption) in order to supply other regions to a growing extent, the decline of the TMR would be lower than that of the TMC. Any policy target aiming to reduce absolute resource consumption should be oriented towards TMC, whereas targets for resource productivity should be based on TMR (as explained below).

[22] Note that TMC** includes all primary materials without excavation and erosion.

[23] The data for 2005 resulted in a global average TMC_{abiot}** of 18 t/cap (Dittrich, personal communication, September 2009) which is about 25 % higher than the data provided by www.materialflows.net

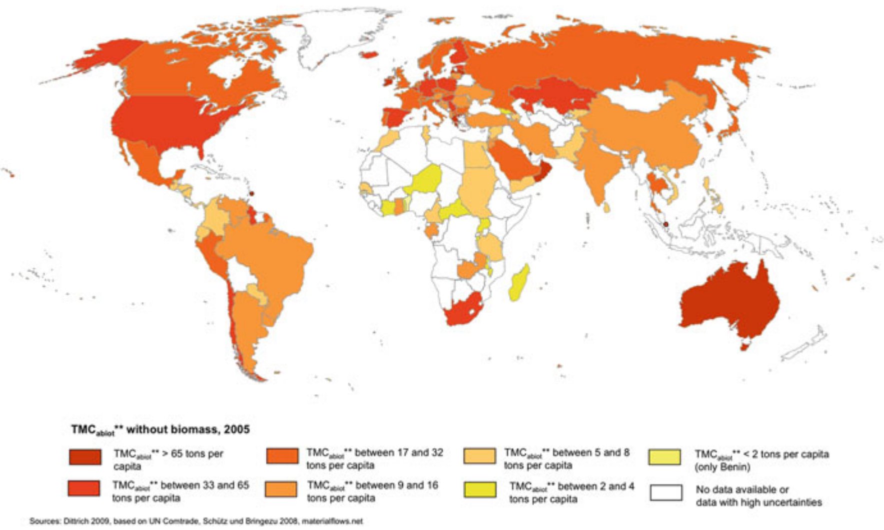


Fig. 3.7 Global distribution of total material consumption of abiotic raw materials, used and unused extraction (TMCabiot**) per capita; excluding excavation for infrastructure and erosion; preliminary values (Source: Provided by M. Dittrich, September 2009, based on Dittrich (2010), UNComtrade, Schütz and Bringezu (2008))

stabilise global abiotic resource consumption and return to the level at the beginning of the century, this will be reflected by doubling the target values mentioned above.

Besides used and unused extraction, excavation for infrastructure will also have to be accounted for, and should be included in future targets, as the quality of the environmental impacts does not seem to differ significantly from that of the other types of primary abiotic resource extraction.

Against this background, Bringezu (2011) suggested 10 t/cap TMC$_{abiot}$* as policy target for 2050.

3.5.3 Preliminary Target for Global Cropland

In 2000, global cropland (arable land and permanent cultures) covered 1.5 billion ha or 0.25 ha/cap. By 2050 it will probably expand by about 20 % (300 million ha) mainly to feed the global population.[24] If the consumption of biomass based goods should be equally distributed among nine billion people in terms of the required land for production, reflecting equal access to that resource, a preliminary target

[24] Based on FAO (2006). The FAO expects an expansion of 200 million ha by 2030; further expansion was estimated to follow the growth of the world population until 2050.

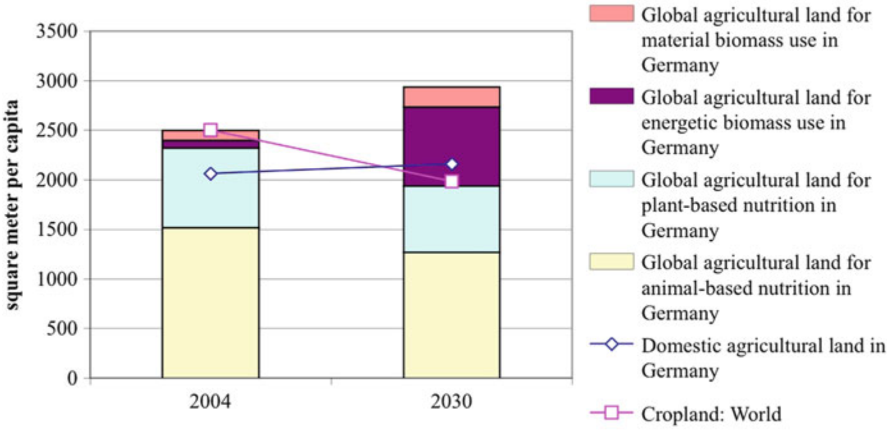


Fig. 3.8 Global net consumption land of Germany in 2000 and according to BAU II in 2030 (Source: Bringezu et al. 2009d)

value of about 0.20 ha/cap could be derived. Although in the end, the value can provide some preliminary orientation, various aspects need to be considered in the detailed derivation and interpretation of a target.

The example of Germany shows that business-as-usual will lead to an expansion of $GLU_{agriculture}$ (Fig. 3.8). If current policy targets for biofuel quota in 2020 are implemented and trends continue until 2030, the consumption of agricultural goods will lead to an expansion of domestic cropland and increasing imports, and altogether require between 2.5 and 3.4 million ha more cropland than in 2000 (Bringezu et al. 2009d). This indicates that German consumption will contribute to the global expansion of cropland and the further intensification of agricultural land, e.g. through conversion of pastures to cropland. The expansion of cropland will lead to indirect land use changes for biofuel feedstock production, and in particular for biodiesel cause additional GHG emissions.

A comparison of German agricultural land use with global categories of cropland and permanent pastures is not straightforward. Permanent pastures as accounted for by FAO consist to a large extent of more or less natural grasslands, pampas and savannahs, often with a relatively low livestock density. This can hardly be compared to meadows in Western Europe which are cut several times a year to provide feed and receive significant amounts of manure and fertilizer. Therefore, pastures within Germany compare more to cropland with regard to intensity of use and environmental pressure.[25]

[25] For further discussion see also Bringezu and Steger (2005) who state the importance to account for "intensively cultivated land".

Further research and more detailed assessment are needed to provide reference data for intensively cultivated pasture land worldwide.

Due to the lack of such data, and for a more conservative assessment of intensively cultivated land, Bringezu et al. (2009d) compared the German net consumption land for agricultural goods with the per capita available cropland worldwide. In 2000 consumption of all agricultural goods required 0.25 ha/cap, which was still within the range of average global land use. However, due to a growing world population and its changing demand on the one hand, and rising consumption of biofuels, business-as-usual would mean exceeding the global cropland reference value in 2030.

Further development of a global target value for cropland, or intensively cultivated agricultural land, will need to consider operational criteria for proper delineation of "cropland and land of similar intensity of use". And one will have to discuss whether the global target value should be based on the extension of current basic trends, or aim at a certain decrease in future land use change.

Focussing on cropland and the need to halt its global extension, Bringezu (2011) suggested 0.20 ha/cap $GLU_{cropland}$ as preliminary policy target. A more elaborate derivation and specification of that target value for 2030, considering explicitly the safe operating space concept described by Rockström et al. (2009) while criticizing their target value, is given in Bringezu et al. (2012).

3.6 Targets for Resource Consumption Versus Productivity

Targets for resource consumption exclude resources used for exports, thus indicating "responsibility" of domestic final use. As discussed above, TMC_{abiot} and $GLU_{cropland}$ (net consumption land) are available indicators which can measure global resource consumption of national/regional economies.

These indicators – and the derived targets – should be distinguished from indicators of resource productivity. The purpose of the latter is to measure the extent to which an economy is making the most value added – or contribution to GDP – from least use (!) of resources (not necessarily from consumption of resources). Accordingly, measures of resource productivity should

– also cover resources used for the production of exported goods, and
– consider both abiotic and biotic resources,

in order to foster systems-wide resource efficiency of total resource use. It seems important to increase resource productivity not only in the production of products for domestic consumption but also in the production of exports. Biomass use must also be as efficient as possible on a life-cycle-wide basis.

As a consequence, GDP/TMR seems to be the most appropriate headline indicator to measure total resource productivity. If that indicator is applied it does not seem necessary to also introduce land-use-related productivity indicators and targets. As possible target for the EU, a doubling of total resource productivity between 2010 and 2030 has been suggested (Bringezu 2011).

3.7 Conclusion and Outlook

The findings and discussion of this chapter may be summarised as follows:

- A globally sustainable resource management will depend on the control of the "Big Three" pressures: GHG emissions, mineral extraction (and subsequent flows), and land use for biomass harvest, esp. cropland.
- Considering only domestic resource use and related pressure would not be sufficient, as growing economies tend to increase the share of foreign resource supply. Targets should therefore be oriented towards the direct and indirect consumption of both domestic and foreign resources.
- Methods exist for monitoring global resource use and the "Big Three" pressures induced by national consumption activities. The data base needs to be improved in particular for developing countries.
- A distinction should be made between indicators and targets on resource consumption on the one hand, and resource productivity on the other hand. The best candidates for consumption indicators are the combination of TMC_{abiot}[26] and $GLU_{cropland}$, for total resource productivity it is GDP/TMR.
- When setting policy targets, feasibility needs to be taken into account and whether poorer countries have a chance to catch up. More research is necessary to define what minimum levels of resource consumption are required for "decent living conditions" in the various world regions.

Acknowledgments The author would like to thank Helmut Schütz for data checking and Monika Dittrich for the provision of the TMC_{abiot}** world map.

References

Aachen Foundation (ed) (2011) Factsheet measuring resource extraction. Aachen

Bringezu S (2002) Towards sustainable resource management in the European Union. Wuppertal Pap 121:6–46

Bringezu S (2006) Materializing policies for sustainable resource use and economy-wide management of resources: biophysical perspectives, socio-economic options and a dual approach for the European Union. Wuppertal Pap 160:7–33

Bringezu S (2009) Visions of a sustainable resource use. In: Bringezu S, Bleischwitz R (eds) Sustainable resource management. Global trends, visions and policies. Greenleaf Publishing, Sheffield, pp 155–215

Bringezu S (2011) Key elements of economy-wide sustainable resource management. Annales de Mines, Section Responsabilité & Environnement 61:78–87

[26] Using only TMC_{abiot}, without a complementary indicator of biomass-related land use, would be misleading; as long as GLUA data is not available, targets should be based on TMC (including both abiotic and biotic resources), in order to avoid problem shifting towards (enhanced) overuse of biomass.

Bringezu S, Schütz H (1995) Wie misst man die ökologische Zukunftsfähigkeit einer Volkswirtschaft? Ein Beitrag der Stoffstrombilanzierung am Beispiel der Bundesrepublik Deutschland. In: Bringezu S (ed) Neue Ansätze der Umweltstatistik. Ein Wuppertaler Werkstattgespräch. Birkhäuser Verlag, Berlin, pp 26–54

Bringezu S, Bleischwitz R (2009) Sustainable resource management. Global trends, visions and policies. Greenleaf Publishing, Sheffield

Bringezu S, Schütz H, Moll S (2003) Rationale for and interpretation of economy-wide materials flow analysis and derived indicators. J Ind Ecol 7(2):43–67

Bringezu S, Schütz H, Saurat M, Moll S, Acosta Fernandez J, Steger S (2009a) The implications of Europe's resource use: basic trends, global and sectoral patterns, environmental and socio-economic impacts. In: Bringezu S, Bleischwitz R (eds) Sustainable resource management. Global trends, visions and policies. Greenleaf Publishing, Sheffield, pp 52–154

Bringezu S, van de Sand I, Schütz H, Bleischwitz R, Moll S (2009b) Analyzing global resource use of the national and regional economies across various levels. In: Bringezu S, Bleischwitz R (eds) Sustainable resource management. Global trends, visions and policies. Greenleaf Publishing, Sheffield, pp 10–51

Bringezu S, Schütz H, O'Brien M, Kauppi L, Howarth RW, McNeely J (2009c) Towards sustainable production and use of resources: assessing biofuels. Report of the International Panel for Sustainable Resource Management, UNEP-DTIE, Paris

Bringezu S, Schütz H, Arnold K, Merten F, Kabasci S, Borelbach P, Michels C, Reinhardt G, Rettenmaier N (2009d) Global implications of biomass and biofuel use in Germany: recent trends and future scenarios for domestic and foreign agricultural land use and resulting GHG emissions. J Clean Prod 17:57–68

Bringezu S, Steger S (2005) Biofuels and competition for global land use', Global issue papers of Heinrich–Böll Foundation, Proceedings of the workshop "Bio in den Tank: Chancen – Risiken – Nebenwirkungen (Bio into the tank: Chances – Risks – Side Effects)", Fachtagung der Heinrich–Böll–Stiftung und des European Climate Forum, 15 Apr 2005, Berlin

Bringezu S, O'Brien M, Schütz H (2012) Beyond biofuels: assessing global land use for domestic consumption of biomass. A conceptual and empirical contribution to sustainable management of global resources. Land Use Policy 29:224–232

Brown L (1985) The pressures keep growing. The state of the world in 1985. In: context: strategies for cultural change, vol 9. Context Institute, Langley, USA, p 12.

BUND (Bund für Umwelt- und Naturschutz Deutschland) & MISEREOR (ed) (1996) Zukunftsfähiges Deutschland, ein Beitrag zu einer global nachhaltigen Entwicklung. Birkhäuser Verlag, Basel/Bonn/Berlin

den Biggelaar C, Lal R, Wiebe K, Breneman V (2004) The global impact of soil erosion on productivity I: absolute and relative erosion-induced yield losses. Adv Agron 81:1–48

Dittrich M (2010) Physische Handelsbilanzen. Verlagert der Norden Umweltbelastungen in den Süden? Dissertation. Kölner Geographische Arbeiten, University of Cologne, Cologne

Eickhout B, van den Born GJ, Notenboom J, van Oorschot M, Ros JPM, van Vuuren DP, Westhoek HJ (2008) Local and global consequences of the EU renewable directive of biofuels: testing the sustainable criteria (MNP report 500143001/2008). Netherlands Environmental Assessment Agency, Bilthoven

European Commission (2005) Thematic strategy on the sustainable use of natural resources. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. COM(2005) 670 final {SEC(2005) 1683} {SEC(2005) 1684}

Eurostat (2001) Economy-wide material flow accounts and derived indicators: a methodological guide. Office for Official Publications of the European Communities, Luxembourg

Food and Agriculture Organization (FAO) (2006) World agriculture: towards 2030/2050. Interim report, Rome

SERI Global 2000, Friends of the Earth Europe (2009) Overconsumption? Our use of the world's resources

Kemp-Benedict E, Heaps C, Raskin P (2002) Global scenario group futures. Technical notes. Stockholm Environment Institute, Stockholm
Lambin EF, Geist H (eds) (2006) Land-use and land-cover change: local processes and global impacts. Springer, Berlin/Heidelberg
Lavelle P, Dugdale R, Scholes R, Berthe AA, Carpenter E, Codispoti L, Izac AM, Lemoalle J, Luizao F, Scholes M, Tréguer P, Ward B (2005) Ecosystems and human well-being: current state and trends. Nutrient cycling. In: Millenium ecosystem assessment ecosystems and human well-being. Synthesis. Island Press, Washington, DC, pp 331–353
Millenium Ecosystem Assessment (MEA) (2005) Ecosystems and human well-being: synthesis. Island Press, Washington, DC
Mudd G (2009) The sustainability of mining in Australia. Key production trends and their environmental implications for the future. Research report no. RR5, Department of Civil Engineering, Monash University and Mineral Policy Institute, Revised – April 2009
OECD (2004) Recommendation of the council on material flows and resource productivity. Adopted by the OECD Council April 21, 2004
OECD (2008) Recommendation of the council on resource productivity. Adopted by the OECD Council on March 28, 2008
Pimentel D (ed) (1993) World soil erosion and conservation. Cambridge University Press, Cambridge
Ramankutty N, Evan AT, Monfreda C, Foley JA (2008) Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000. Global Biogeochem Cycles 22(1):1–19, American Geophysical Union
Ravindranath NH, Sathaye J, Woods J, Fargione J, Watson H, Faaji A, Makundi W, Canadell P (2009) GHG implications of land use and land conversion to biofuel crops. In: Howarth RW, Bringezu S (eds) Biofuels: environmental consequences and interactions with changing land use. Report of the international SCOPE biofuels project. Cornell University, Ithaca. http://cip.cornell.edu/biofuels/
RFA, Gallagher E (2008) The Gallagher review of the indirect effects of biofuels productions. Renewable Fuels Agency, East Sussex
Ritthoff M, Rohn H, Liedtke C (2003) Calculating MIPS. Resource productivity of products and services. Wuppertal Spezial 27e:8–35
Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin EF, Lenton TM, Scheffer M, Folke C, Schellnhuber HJ, Nykvist B, de Wit CA, Hughes T, van der Leeuw S, Rodhe H, Sörlin S, Snyder PK, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell RW, Fabry VJ, Hansen J, Walker B, Liverman D, Richardson K, Crutzen P, Foley JA (2009) A safe operating space for humanity. Nature 461:472–475
Schmidt-Bleek F (1992) Will Germany remain a good place for industry? The ecological side of the Coin' Fres. Environ Bull 1:417–422
Schmidt-Bleek F (1994) Wieviel Umwelt braucht der Mensch? MIPS Das Mass für ökologisches Wirtschaften. Birkhäuser Verlag, Basel/Berlin/Bosten
Schmidt-Bleek F, Bringezu S, Hinterberger F, Liedtke C, Spangenberg J, Stiller H, Welfens MJ (1998) MAIA. Einführung in die Material-Intensitätsanalyse nach dem MIPS-Konzept. Birkhäuser Verlag, Basel/Berlin/Bosten
Schoer K, Buyny S, Flachmann C, Klink S, Mayer H (2007) Environmental-economic accounting (EEA): environmental pressures from German imports and exports. Results of EEA on embodied energy, carbon dioxide and transport of goods. Paper presented at the 93rd DGINS conference, 19–21 September 2007, Budapest/Hungary
Schütz H (2003) Economy-wide material flow accounts, land use accounts and derived indicators for Germany: MFA Germany. Final report to the Commission of the European Communities; DG Eurostat/B1, contract ref No. 200141200028, Eurostat B1, Wuppertal
Schütz H, Bringezu S (2008) Resource consumption of Germany – indicators and definitions. TEXTE, 08/08. Umweltbundesamt, Dessau-Roßlau
Schütz H, Moll S, Bringezu S (2003) Globalisation and the shifting of environmental burden: material trade flows of the European Union. Wuppertal Pap 134e:5–59

Steger S (2004) Der “Flächenrucksack” des europäischen Außenhandels mit Agrargütern. In Welche Globalisierung ist zukunftsfähig? Wuppertal Institut zur Globalisierung

United Nations Environment Programme (UNEP) (2007) Global environment outlook, vol 4. UNEP, Nairobi

von Weizsäcker EU, Lovins AB, Lovins LH (1995) Factor four – doubling wealth, halving resource use. Droemer Knaur, Munich

Wackernagel M, Monfreda C, Moran D, Wermer P, Goldfinger S, Deumling D, Murray M (2005) National footprint and biocapacity accounts 2005: the underlying calculation method. Global Footprint Network, Oakland. http://www.footprintnetwork.org/download.php?id=5. Accessed 14 Mar 2009

Zah R, Binder C, Bringezu S, Reinhard J, Schmid A, Schütz H (2010) Future perspectives of 2nd generation biofuels. Vdf Hochschulverlag AG an der ETH Zürich, Zürich

Chapter 4
Sustainable Land Use – Example: Land Take for Settlement and Transport in Germany

Gertrude Penn-Bressel

4.1 Introduction – The German National 30-hectares Goal for the Year 2020

Amongst the environmental targets set by the German Government in the framework of the national sustainable development strategy (BReg. 2002, p. 99–100), the main target for sustainable land use – reducing *L*and *T*ake for *S*ettlements[1] and *T*ransport Infrastructure (LTST) to 30 (hectares) a day by 2020 – has caused a great deal of discussion, criticism and even excitement. The 30 (hectares) goal was first proposed in 1998 by then minister of environment Angela Merkel and was subsequently adopted by the Federal Government in 2002.

Compared to the baseline situation with an average LTST of 120 ha per day during the period from 1993 to 1996 (Destatis 2010), the target for the year 2020 signifies a reduction of the speed of LTST by a factor of 4 (Fig. 4.1).

In discussion papers, the German Council for Sustainable Development (RNE) as well as the German Advisory Council on the Environment (SRU) added the vision that by 2050, LTST should be reduced to zero (see RNE 2001, p. 2 and SRU 2005, p. 113).

In order to further stimulate the discussion and to encourage early action, the Federal Environment Agency (UBA) proposed an additional intermediate target for

[1] In this publication, the term "settlement" means housing areas, industrial zones, commercial areas and other built up sites like hospitals. It includes sites for non transport infrastructures, e.g. electrical plants, plants for waste water treatment or facilities for leisure activities such as public greens, parks, children's playgrounds, campgrounds, tennis courts and other kinds of sports fields. Also included are areas for photovoltaic parks on greenfields as well as on brownfields.

Not included are sites for wind power plants erected on fields and meadows which remain in agricultural use.

G. Penn-Bressel (✉)
Federal Environment Agency (Germany), Wörlitzer Platz 1, 06844 Dessau-Roßlau, Germany
e-mail: gertrude.penn-bressel@uba.de

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_4,

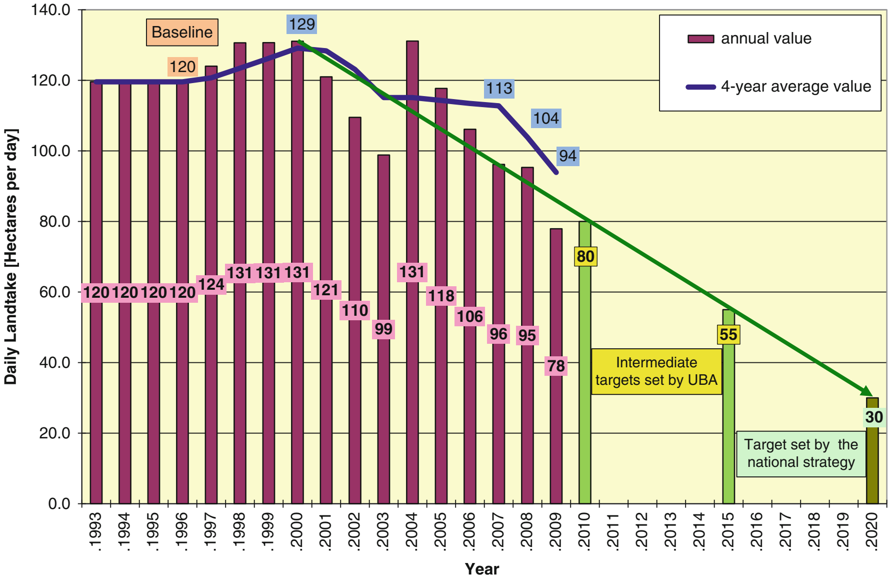


Fig. 4.1 Daily land take for settlements and transport infrastructure (LTST), 1993–2009, and targets set for the years 2010, 2015 and 2020 (Data source: Destatis 2010)

the year 2010 of 80 ha a day in a strategy paper (UBA 2003). If land take were further reduced linearly from 2010 to 2020, this would result in an additional intermediate target of 55 ha per day by 2015.

The impact of LTST on sustainable development, driving forces and the actions to be taken in order to slow down LTST will be discussed in the following chapters.

4.2 Why Is It Crucial for Sustainable Development to Reduce the Speed of Land Take?

Some people argue in what they think is a quite sophisticated way that LTST is no problem at all because the land does not vanish by changing land use. In their views, land remains available to us for future use, no matter how it has been used in the past. But this way of thinking is quite short-sighted.

For the land use change linked to urban sprawl and expanding infrastructures is one basic element of our present lifestyle and economic patterns, which have severe environmental impacts and depend on enormous inputs of energy and raw materials. Given the fact that – in a global perspective – mankind is still growing in number whilst the stock of natural resources is not, the excessive per capita consumption of resources by the population of developed countries is far from sustainable.

Therefore, settlements and transport systems should be transformed in a way that not only increases resource efficiency in relation to Gross Domestic Product (GDP) but that also requires substantially lower total resource inputs.

Unfortunately, efforts to move towards higher resource efficiency are further hampered by the fact that in a growing number of German regions the population is shrinking – due to regional economic decay and demographic change – and the specific resource consumption (i.e. the necessary resource input per capita of the population) to keep the system running will grow steadily, even if LTST could soon be slowed down.

Finally, we should not forget that land take by settlements and transport infrastructures is an irreversible process which progressively diminishes the quality of fertile soils and degrades or destroys natural habitats or potentials for biodiversity in landscapes and which may lead in the end to an irreversible destruction of natural resources through extinction of populations and loss of genetic information.

4.2.1 Environmental Impact and Energy Consumption Induced by Land Take

Urban sprawl and the expanding network of transport infrastructure are consistent parts of rapidly spinning vicious circles, fuelled for many decades by abundant quantities of fossil energies offered at low prices. Motorised vehicles enabled people to move into newly constructed, more comfortable dwellings far from town centres, and – as land is cheaper in the outskirts – many of them not only offering more room inside the house but also large private gardens. The reduced density of land use increases the distances to all relevant destinations – including access to public transport – and increases the probability that finally private cars will become the only acceptable mode of transport.

Cheap motorised transport also favours the spatial concentration of many kinds of private companies, allowing for extra profits by "economies of scale".[2] This spatial concentration of single functions may induce transportation on a regional, interregional or even global scale.

By these mechanisms, motorised traffic and the number of traffic jams increase, demanding more transport infrastructure. The expansion of transport infrastructure

[2] The term "economies of scale" means e.g. that in large plants, with the aid of automation or efficient organisation, fewer workers can get more work done in less time, which reduces labour costs considerably. This is true not only for many types of production units, but also – on local or regional level – for retailers. For instance, large shopping centres are the result of the desire to minimise the costs for buying merchandise, for labour and for the final distribution of the merchandise. The latter costs have been shifted to the consumers, who readily make use of their own private cars to go shopping – creating significantly more traffic on a regional scale. Furthermore, large retailers can make use of or even abuse their market power by purchasing from producers at low prices.

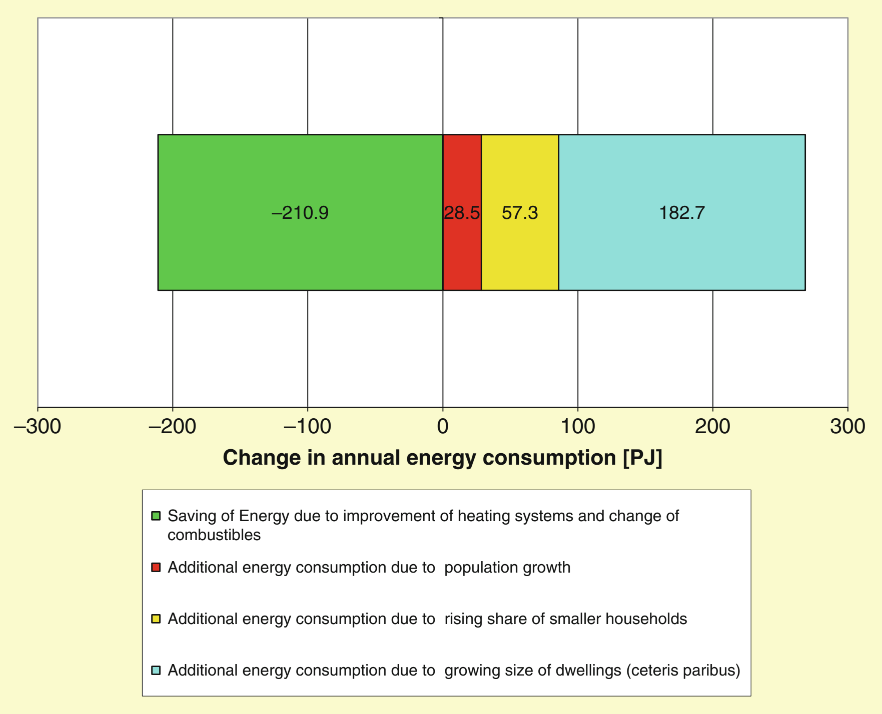


Fig. 4.2 Change in annual energy consumption for the heating of private dwellings, 1995–2004, and reasons for changes in energy consumption (Data source and presentation: UGR* 2006)

*UGR: Umweltökonomische Gesamtrechungen (Environmental Economic Accounting), is periodically published by Destatis; UGR presents special data on the environmental impacts of the economic framework and the activities of households and industries in Germany; https://www.destatis.de/DE/Publikationen/Thematisch/UmweltoekonomischeGesamtrechnungen/ThemaUGR.html; https://www.destatis.de/EN/Publications/Specialized/EnvironmentalEconomicAccounting/EnvironmentalEconomicAccounting.html

in combination with low fuel prices further encourages urban sprawl and the concentration of economic structures, which in turn again increases the need for transport. The impacts of this vicious circle on the environment are obvious, e.g. emissions of greenhouse gases, pollutants or noise, the fragmentation of landscapes or the sealing of soil and its impacts on water resources or on the risk of flooding.

Furthermore, additional buildings and infrastructures require huge inputs of materials and energy – not only during construction but also throughout their entire lifecycle, e.g. for maintenance and repair, for renovation and regular cleaning, for heating in winter, cooling in summer and illumination at night. In Germany, the rise in the number of households and in living space inside dwellings which took place during the decade from 1995 to 2004 caused annual energy consumption by private households for room heating to increase by 268.5 PJ (UGR 2006, p.23).

This is an increase by 13.1 %, whilst the population during that time period grew only by 1.3 % (Fig. 4.2).

During the same decade, large amounts of public subsidies and private money were invested in order to increase the efficiency of heating systems in old buildings by modernisation and to further reduce the emissions of carbon dioxide by a change of combustibles, replacing coal by natural gas. These activities resulted in annual energy savings of 210.9 PJ (−10.3 %). As a result of the growth in floor space, annual energy consumption for space heating increased in total by 57.6 PJ (+2.8 %)[3] despite all the investments in energy efficiency improvement. Energy consumption per capita grew by 1.5 %.

Thus, the excessive activities to expand the building stock and infrastructures in order to accommodate the population which in Germany at that period of time was still growing (mainly by immigration), led to an increase in total energy consumption as well as to an increase in specific energy consumption on individual level.

Given that per-capita energy consumption in Germany as compared to the global level of energy consumption is far from sustainable, every action which further increases the individual need for energy consumption is clearly a step in the wrong direction. Of course, it is recognised that housing is one of the irrefutable human needs that has to be supplied. But it is time to discuss which level of supply is really necessary and appropriate and how to improve the resource efficiency of the appropriate supply.

4.2.2 *Input of Materials – Especially Mineral Construction Materials and Products*

Data from the Federal Statistical Office shows that, in Germany, the stock of material resources bound inside the "technosphere[4]" has been steadily rising during the last decades (UGR 2010). Though the speed of growth in the material stock has slowed down lately by 25 % from about 850 million tons p.a. in 1995[5] to 634 million tons p.a. in 2008, the speed of accumulation of materials inside the technosphere still remains high.

Figure 4.3 shows that the increase of the material stock in the technosphere is due in large part to the input[6] of mineral construction materials and products (="*minerals*"). In 1995, the fresh input of *minerals* of 779 million tons caused about 92 % of the

[3] Energy consumption by private households for the heating of private dwellings 1995: 2057 PJ; 2004: 2115 PJ.

[4] "Technosphere": The realm of human habitat created by modern civilisation.

[5] As the Federal Statistical Office (StBA) changed in 2004 some details of the methods dealing with recycled mineral waste from derelict sites, the author has stratified the data on increase of material stock for the time before 2004.

[6] In this chapter, input of *minerals* into the technosphere is defined as the result of domestic extractions of mineral raw materials plus imports of construction materials and products minus exports.

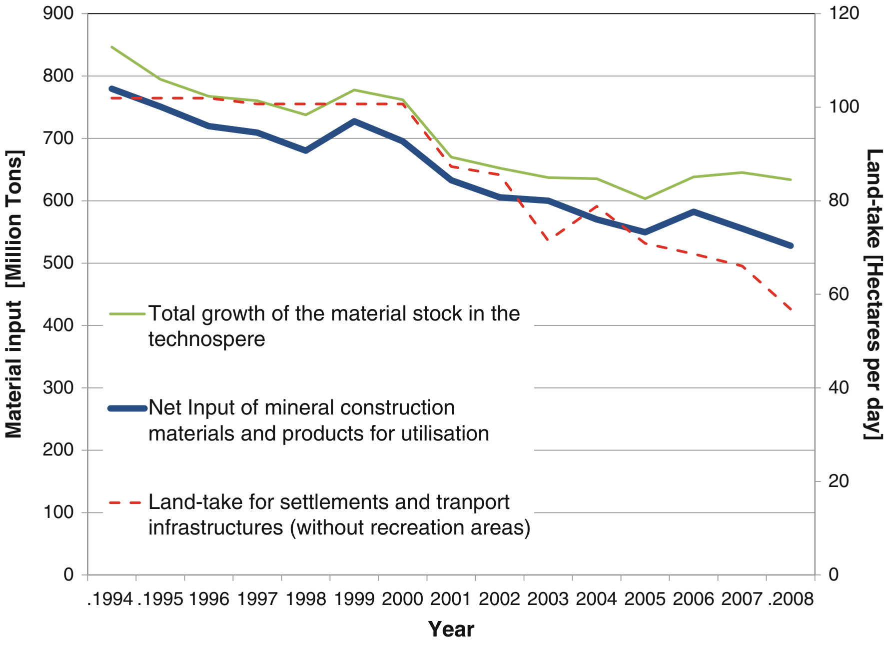


Fig. 4.3 Contribution of the net input of mineral construction materials and products to the total growth of the domestic material stock in the technosphere and comparison with the speed of land take for settlements and transport (Data sources: UGR 2010; BGR 2009)

total increase in the material stock. As construction activities have slowed down somewhat since then, the share of *minerals* in the increase of the total material stock fell slightly, to 528 million tons (83.3 %) in 2008. The figure also shows that material input declined at roughly the same rate as the relevant parts of LTST.[7]

Most *minerals* utilised in Germany are extracted from domestic sites. This exerts considerable impacts on landscapes. 552 million tons of mineral construction materials were extracted in Germany in 2008, disfiguring landscapes in an area of 1,420 ha p.a. or 3.9 ha a day.[8] The area affected by the extraction of *minerals* even exceeds the areas affected by the extraction of lignite (760 ha p.a./2.1 ha a day) and peat (400 ha p.a./1.1 ha a day) taken together.

As mentioned above, the net input of *minerals* in Germany due to construction, enlargement or repair of buildings or infrastructures amounted to 528 million tons in 2008. It is an interesting question what exactly this material might have been used for.

In a first step, in a *top-down approach* the author correlated the total annual net input of minerals with parameters linked to the construction of buildings or

[7] Except recreational areas which mostly consist of non built up areals.

[8] Author's own calculations are based on data from the Federal Institute for Geosciences and Natural Resources BGR (2009, p. 86), from which the data on mineral extraction for the industrial production of glasses and ceramics ("Quarzsande", "Tone (Feuerfest und Keramik)", "Rohkaolin") was omitted.

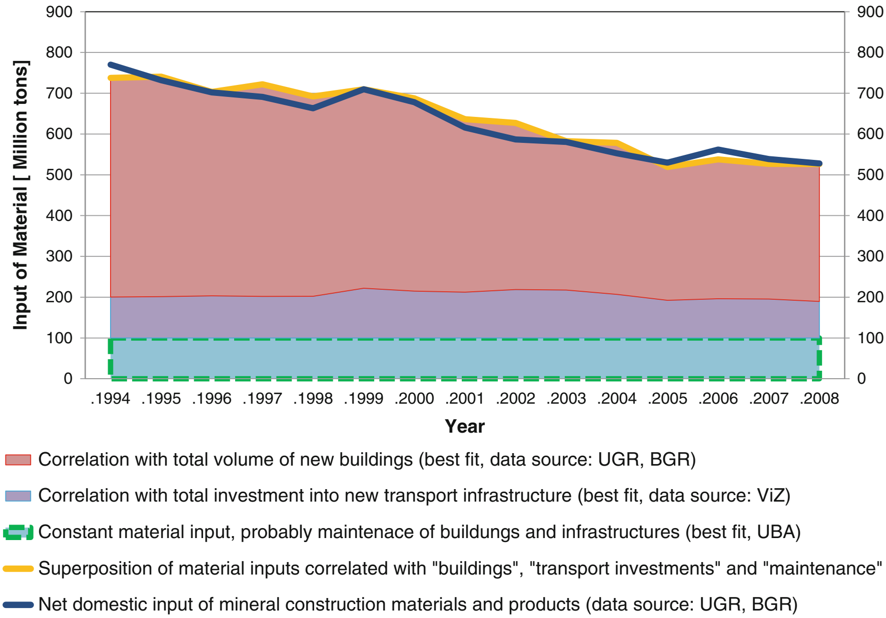


Fig. 4.4 Correlation of annual net domestic input of mineral construction materials and products [t] with the superposition of total annual volume of new buildings [m^3], annual investments into transport infrastructures [€] and an additional constant material input for maintenance [t] (Data sources: UGR 2010; BGR 2009; ViZ 2009; IÖR 2010; WI 2011)

infrastructures, such as number of buildings, number of apartments, volume or floor space of buildings, land take for settlements, land take for transport infrastructure or the budget of public investments into transport infrastructures etc. (Data sources: Destatis 2010; ViZ 2009).

As mentioned before, the downward trend in net mineral input into the technosphere during the last decade roughly corresponds with the decrease in LTST. But still better correlations with material input were found by using a linear combination of the following three items (Fig. 4.4): *the volume of new buildings*, the *budget of public investments into transport infrastructure* and a parameter remaining *invariable over time*, which should roughly represent the rather steady annual material input for *maintenance activities*.

In a second step, in a *bottom-up approach* the results of two different research projects (IÖR 2010; WI 2011) on material input into the different types of buildings and several types of infrastructures were consistently compiled by UBA.

1. For the most relevant types of buildings, IÖR had calculated the material inputs into the shell of a typical building of that kind (including the basement). The data for these types of buildings given by IÖR was multiplied by UBA with the number of buildings of this type that have been erected every year since 1994, in order to get the total annual material input into the construction of new buildings.

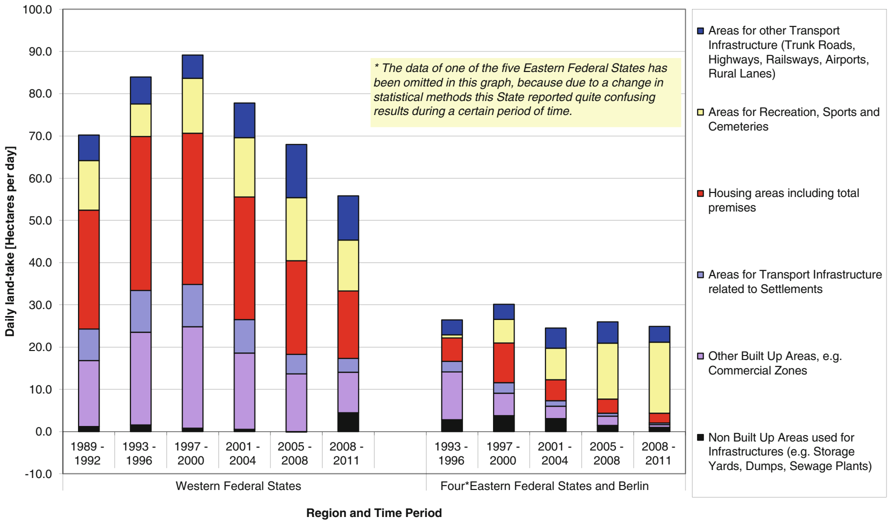


Fig. 4.5 Total domestic net input of mineral construction materials and products und known and unknown purposes of their utilisation (Data sources: UGR 2010; BGR 2009; ViZ 2009; IÖR 2010; WI 2011)

2. Based on data for the year 2004, WI had compiled the annual material input into a choice of most important infrastructures. In order to expand these results to the whole time period from 1994 to 2008, UBA varied the annual material inputs into the different types of transport infrastructures according to the annual investments into the construction of every type of transport infrastructure. As for infrastructures, closely related to settlements, UBA varied the material input according to the expansion of LTST for built up areas.

The following Fig. 4.5 shows the combination of the results of the top-down approach with the bottom-up approach described earlier.

The results of IÖR and WI have been supplemented by the author with an assessment for two additional items (red-rimmed areas):

- material input for construction of the surface of regional and local trunk roads *WI only considers the surfaces of federal highways, railways and federal waterways*
- material input for construction of the surface of new parking lanes, bicycle lanes and pavements on roads to accompany the enlargement of settlements by new building sites
  WI only considers the surfaces of new lanes for motorised traffic and new public infrastructure like water or gas pipes or power supply lines inside the streets (including their imbedding into stratums of sand) and the construction of centralised infrastructures like waste water treatment plants

The findings of these two bottom-up projects show that the most important purposes of utilisation of minerals identified so far are material inputs into

- *the construction of new buildings*, though it declined with the slowdown of construction activities from 139 million tons in 1994 to 52 million tons in 2008 (three intense green stripes in the centre of the graph),[9]
- *the construction of new infrastructures for new settlements* (electricity, water etc.) including their imbedding into stratums of sand, which declined with the slowdown of settlement activities from 52 million tons in 1994 to 32 million tons in 2008 (grey stripe beneath the green ones),
- *the maintenance of all infrastructures inside and outside settlements*, which probably remained quite stationary at a level of 80 million tons per year (dark brown stripe at the bottom).

Other purposes like the construction or the enlargement of the *surfaces* of new roads, railways and waterways or the construction of the *surfaces* of roads in new settlements only give small contributions to the total input of minerals into technosphere. As a result, the combination of both methods, top-down and bottom-up, indicate that

- roughly estimated by the top-down method, 100 million tons of mineral construction materials might be utilised every year for maintenance work of all kinds on existing buildings and infrastructures, of which 81 % can be explained by the WI bottom-up method while 19 % remains unexplained (narrow yellow stripe right above the brown stripe at the bottom of the graph).
- deduced by the top-down method, in the year 2008, 90 million tons of mineral construction material might have been used for the construction or expansion of trunk roads and other important linear transport infrastructure outside settlements, of which only 15 % (14 million tons) can be explained by the WI bottom up method for the surfaces of federal roads, rails and channels and another 20 % (18 million tons) by the supplemental assessments of the author (UBA) for the surfaces of regional roads outside settlements, whilst 65 % (58 million tons) of this material input remains unexplained (second yellow stripe from the bottom of the graph).
- Finally, there remains another *mineral* input in 2008 of 338 million tons. As has been deduced by the top-down approach, this material input might be connected with the construction of new buildings and the corresponding new settlement infrastructures such as roads, gas pipes, water pipes including their bedding into stratums of sand. Alas, the findings of the bottom-up approaches by WI und IÖR[10] explain only 109 million tons (32 %) of this material input, with equal shares for the building shells and the accompanying public infrastructure, whilst an input of 229 million tons (68 %) remains unexplained (light green and yellow stripes at the top of the graph).

[9] The reasons for the decline of building construction consisted in the breakdown of the market of apartment houses (−48 million tons), the reduction of construction of family homes for demographic reasons (−31 million tons) and the slowdown of commercial projects (−7 million tons).

[10] Supplemented by the author with some minor inputs for parking lanes, bicycle lanes and pavements.

Just in order to try to get an explanation for a part of the latter unexplained material flow, the author did an assessment of how much material might have been extracted from the sites in order to make room for the basements of the buildings (light green stripe). This resulted in 38 million tons to be transported off the sites, which might perhaps have entered the statistics.[11] *If it did enter the statistic, this would only explain where a small part of the unexplained material extraction came from but it does not yet explain where all this material ended up and for which purposes it might have been used.*

Thus, the two topmost stripes in Fig. 4.5 (yellow and light green) distinguish another important part of the material input into the technosphere for which there is still no explanation at all. Some of the unexplained material inputs might be accounted for the infrastructures on the premises of settlements such as driving lanes, parking lots, footpaths, terraces, pools, pipes and their beddings or for the substructures of trunk roads, highways and railways. And there are still a lot of soil movement activities which have not yet been considered at all such as arise in the construction of dams alongside rivers and coasts.

In total, there are still large gaps in our knowledge of material streams which call for additional research.

4.2.3 Decline of Resource Efficiency and Economic Efficiency Through Demographic Change

Though there are still prosperous regions or communities in Germany, where the population is growing by migration (Fig. 4.6), the population in Germany as a whole stopped growing and began to shrink in 2003. Since, every further enlargement of the stock of buildings or related infrastructures will tend to further diminish the resource efficiency of the real estate sector. This holds true even if the national level of resource productivity in relation to gross domestic product (GDP) may be improving. In view of the fact that an increasing number of German regions face demographic change which has already resulted in a considerable depopulation of some regions during the last 20 years, the continuing urban sprawl even in shrinking regions will lead not only to ecological but also to severe economic and social problems.

In an increasing number of regions, the number of empty derelict buildings and also of rather neglected built up areas is growing steadily (Destatis 2011). Additionally, there are many residential and commercial buildings which are still partly occupied but are seeing a considerable decrease in occupancy, leaving empty locations between the occupied ones. Most probably, many of them will never be filled up again properly with new dwellers or commercial users.

[11] With this item, it is not quite clear, if or if not it did enter into the statistics of extraction of mineral materials at all. But if it did not enter, this means that additional amounts of material extracted are in want for the explanation what they were used for.

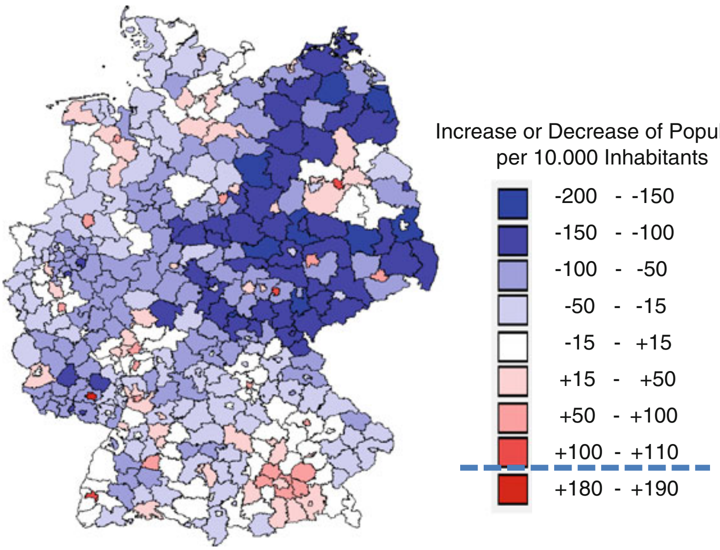


Fig. 4.6 Annual increase or decrease of population in German regions and towns, 2009 (Data source: Destatis 2011)

But while the number of users is decreasing, the running costs for maintenance of the existing infrastructures and the buildings still in use remain nearly constant. As a result, in shrinking regions, the costs per capita for maintaining buildings, infrastructures and public or private greens tend to be much higher than in regions where the population is still growing, where buildings are densely occupied and where infrastructure provision is sufficient but not overabundant. Thus, low efficiency in land use – eventually even aggravated by further LTST – endangers the competitiveness of shrinking regions in relation to growing regions.

As average incomes in shrinking regions in general are lower than in prosperous, growing regions, the social impact of high per-capita costs – on the individual subjects who have to pay as well as on the public budgets having to support those who can't – is substantial. As these costs are not affordable in the long run, the ultimate remaining option is to rededicate derelict settlements and infrastructures to agriculture or forestry purposes or to leave them to a process euphemistically called "natural succession".

4.2.4 Preserving Fertile Soils and Biodiversity as Natural Resources

It has to be recognized here that "returning soils to nature" does not in any way mean a return to their initial state, as if nothing at all has happened to them.

This is because the former natural qualities and functions of soils at sites which have been released from utilisation for settlements or transport infrastructure cannot be restored quickly or only at high costs. Especially the natural fertility of soils, once it has deteriorated by sealing or compression, by pollutants or other impacts of human activities, may only recover after long periods of time, maybe thousands of years. So even if soils are "given back to nature", they often will return in a rather downgraded state. This means not only that their productivity might be diminished, but due to pollution they might not be suitable at all for the production of food and feed. Slowing LTST decelerates the degradation of soils and helps to preserve them also for the benefit of future generations with all the options they may offer for the production of food and feed, renewable energies or renewable materials. The importance of fertile soils is further increased by the fact that the stock of fossil energies is declining and the need for biomass as a substitute is increasing. In view of global population growth and the limited stock of fertile soils suitable for the production of biomass, fertile soils are becoming a very scarce and valuable resource. Thus, it is not only ecologically sensible but also economically wise to preserve fertile soils.

Additionally, we have to save green spaces outside settlements which are dedicated to biodiversity. Preserving all the aspects of biodiversity including genetic variability also means to preserve existing and potential information about complex chemical substances, efficient energetic processes, sophisticated physical constructions or smart behaviours which nature has optimised over millions of years to improve the chances of survival of creatures under various circumstances. In the post-fossil era that lies ahead, it might be crucial to be able to resort to this treasure of natural wisdom in order to find paths to sustainable production of raw materials and energy. Not only useful substances but also good ideas for the solution of technical challenges or social conflicts may be gained from biodiversity. That's why we should take utmost interest in preserving biodiversity as completely as possible.

4.3 Interaction Between the 30-ha Goal and Economic and Social Issues

LTST is the result of strong driving forces and the activities of many different stakeholders. To be successful, all strategies and measures aimed at slowing down LTST have to take into account the economic or social background of all the driving forces or actors. One important step will be to develop visions of successful and attractive future economic and social development minimising additional land take and other environmental impacts.

4.3.1 Driving Forces and Decision-Makers Pushing Land Take in Germany

Despite the targets set in 1998, the speed of land take even accelerated and peaked at 130 ha per day during the 4 year period from 1997 to 2000. As Fig. 4.7 shows,

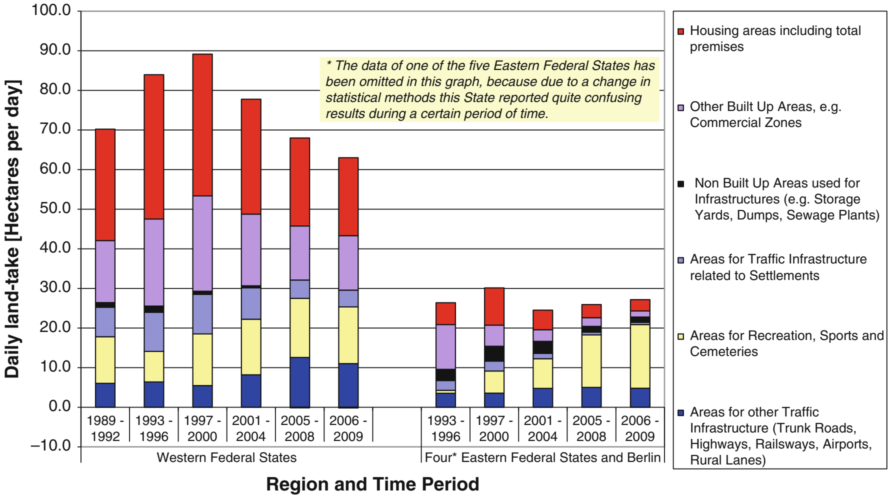


Fig. 4.7 Daily land take for different categories of settlements and transport infrastructures in western and eastern federal states, 1989–2008 (Data source: Destatis 2010)

the dynamics of this development and the different types of land use changes differed considerably between eastern and western federal states.

The driving forces for this boom, which started in 1990 and faded out after 2004, can be traced back to the coincidence of four factors:

1. *Economic boom in western Germany and large flows of migration* from the East, increasing the need for commercial zones and housing. The starting point was the unification of the two parts of Germany and the opening of the frontiers to Eastern Europe which resulted in a breakdown of eastern economies entailing high rates of unemployment.
2. *Domestic generation of baby boomers establishing their own households and, a few years later, buying homes*, which accelerated land take. This process was kindled by new subsidies for the purchase of family homes favouring the construction of new buildings – without any regional differentiation. This system of subsidies was started in 1996, cut somewhat in 2004 and abolished in 2006. In the final phase, the annual public expense exceeded ten billion Euros.
3. *Enormous federal subsidies for the development of new commercial zones and transport infrastructures in eastern Germany* as a political response to economic decay and unemployment. Except in the case of retail centres and logistic facilities, the construction of commercial zones was not fuelled by demand from enterprises. Most of these developments were driven solely by desperate hope for new jobs.
4. *Additional federal subsidies for real estate investments in eastern Germany*, e.g. for the construction of new apartment and office buildings.

As a result, additionally to brownfields from old industries, eastern Germany today offers a rich choice of freshly developed but only partly occupied commercial facilities and housing areas, which some people ironically call "illuminated pastures". Further, in older settlements, the number of deserted apartments and family homes is increasing, for due to persistent out-migration and low birth rates, the population in eastern Germany is decreasing rapidly.

In western Germany, with the start of the new millennium, economic development slowed down a bit and immigration decelerated, too. The low rate of immigration now coincides with a young domestic population whose ranks have been depleted by a birth rate that has remained constantly low in western Germany for the last 40 years. Consequently, demand for housing and commercial zones started to fall significantly and in some regions an increasing number of empty dwellings and commercial sites can be seen. But LTST still continued on quite a high level, driven by:

5. *Globalisation of economies* leads to displacement of production sites and logistic facilities to the vicinity of long distance transport infrastructures such as highways, harbours and airports, occupying a lot of new greenfield sites. Accordingly, transport infrastructures have been enlarged to meet the new demand.
6. *Economy of scale, especially in the retail sector*. Large shopping centres and factory outlets offering large parking lots were set up on greenfields at the edge of towns.
7. *Common lifestyle and consumer preferences*, relying on private cars in general and propagating dwelling in single family houses.
8. *Developers and construction companies specialising* in the exploitation of greenfields and the construction of new buildings. These stakeholders form a powerful lobby in favour of subsidies and other policies spurring LTST.
9. *Gains in land prices* from the transformation of greenfields into housing areas or commercial zones. Landowners, who in many cases are not the active farmers, get nice profits from LTST and naturally try to influence planning activities to their own advantage.
10. *Competition between municipalities*, trying to attract new inhabitants or private companies from neighbouring municipalities, hoping for additional tax revenue and deliberately neglecting all future costs for necessary supplemental infrastructure.
11. *General non-transparency* of the costs and benefits of public investments in new infrastructures. Often the system of taxes and fees makes newcomers assume only part of the costs of the new infrastructures whilst the general public has to shoulder the rest.
12. *Weak application of the existing instruments of spatial planning* by the authorities of some federal states and regions. As a result, large differences exist between federal states not only in the prevailing density of settlements, which might have many historical reasons, but also (ceteris paribus) in fresh LTST per capita.
13. *Prevailing philosophy of investment in Germany.* Governments and administrations still take pride in the creation of new buildings and infrastructures. Over time, the investments into additional stock led to a huge stock of old public buildings and infrastructures needing maintenance. This philosophy also led to the neglect of all non-materialistic investments, especially in manpower for education and scientific research.

Today, 10 years and two global economic crises after the start of the millennium, immigration from foreign countries has slowed down further everywhere in Germany. Consequently, in 2007, the 4-year average of daily LTST finally sunk to below 100 ha. But it still remained above UBA's intermediate target of 80 ha per day for 2010.

4.3.2 Is It Possible to Achieve the 30 ha Goal Without Negative Impacts on the Economy?

Though it is very unlikely under current economic and demographic circumstances that LTST in Germany will accelerate considerably again, the present rate remains still at quite a high level, both in absolute terms and compared to some other European countries. This can be demonstrated by the following example: (von Haaren and Nadin 2003, p. 345–356; SRU 2004, p. 166)

Average land take in Germany during the 1990s was about 120 ha per day, which is equivalent to an annual land take of 52 ha per 100,000 inhabitants. The 30 ha goal would mean reducing LTST to an annual 13 ha per 100,000 habitants.

In England, where green belts and open spaces are under stronger protection, where the revitalisation of brownfields has some political priority and where the relevant planning authorities are to be found more at national or regional level than at local level, annual LTST at that time was about 14 ha per 100,000 inhabitants. This means that England had in fact almost achieved the German "30 ha goal" by the end of the 1990s.

It has to be noted that during this time period, the British economy was booming, which demonstrates that booming economies may become largely independent of LTST. This was certainly true of the type of highly developed economy of that period, which strongly relied on a powerful, but largely virtual financial sector. Alas, it has become quite obvious today that this kind of economy – though it did not need much material input or LTST – is not sustainable all the same.

But, do we have to conclude from this experience that economic systems in no need of additional land take and based on services rather than on production of goods can never be sustainable? The answer – hopefully – is no, as the following vision might suggest:

Independence of land take and low input of material and energy might also come true for highly innovative economic and social systems which – besides meeting basic needs such as food, clothing, shelter and security – are based on health care, wellbeing, social and political involvement, cultural performances needing but few resources (e.g. painting of miniatures), rising awareness of resource efficiency, education, training of skills, development of sciences and unending efforts towards technical innovation.

Technical innovation is the crucial point for the efficient production of renewable energies and materials on the one hand and on the other hand for minimising the need of the whole system for resource input by energy saving and efficient use and recycling of materials, land and soils. One of the most important tasks in this context is to further develop and improve resource efficient technologies which allow safe storage and reliable global access to information of all kinds. Knowledge, culture and social interaction becoming virtual should not imply new manifestations of illiteracy but on the contrary, more people than ever should have easy access to virtual libraries available on command to every interested reader.

Efficiency in the use of physical resources means relying more than ever on the only resource which so far has proven to be nearly inexhaustible: Human commitment, human creativity and human intelligence. This kind of economy might even approach a development which could be called sustainable.

4.4 Consistent Strategies to Meet the 30 ha Goal

As sustainable land use comprises more topics than only quantities of land use change and as land use policy has the tendency to affect every area of life and economic activity, only systematic and consistent strategies directed at all relevant driving forces and stakeholders exerting influence on land use will be able to lead the way to sustainable land use. Some elements of such a strategy will be discussed in the following sections.

4.4.1 Intermediate, Regional or Sectoral Targets to Meet the 30 ha Goal

As already mentioned, UBA proposed an intermediate national target of 80 ha a day by 2010 and assumed a linear reduction of land take in subsequent years until the 30 ha target would then be reached in the year 2020. But setting national targets doesn't solve the problem of how to get there and how each region and each local government should contribute to the national goals. The National Strategy of Biological Diversity (BMU 2007) states that, by the year 2015, all German regions should declare which targets they have set for themselves.

As a mere starting point for the discussion, the KBU (Commission of Soil Protection at the UBA) has proposed a set of targets for each of the federal states (Table 4.1) (KBU 2009). Taken together these targets meet the national 30 ha goal. The targets have been calculated based on a mix of the following three criteria:

- the actual population (2007)
- the anticipated future population (2020)
- the rate of land take at the beginning of the millennium (2001–2004)

The third criterion takes into account the different historical developments and the different "planning cultures" of the individual federal states.

Table 4.1 Proposal for a set of targets at federal state level for the period 2007–2020 (Hectares per day), KBU (2009)

Federal state	Land take for settlements and transport		Intermediate targets		Targets to meet the national goal of 30 ha a day
Time period	2001–2004	2004–2007	2007–2010	2012–2015	2017–2020
Berlin	0.29	0.28	0.50	0.68	0.85
Free Hanseatic city of Hamburg	0.79	0.77	0.68	0.59	0.51
Free Hanseatic city of Bremen	0.17	0.20	0.17	0.18	0.18
North Rhine-Westphalia	15.2	15.4	11.6	8.7	5.7
Saarland	0.72	0.75	0.57	0.44	0.31
Baden-Wuerttemberg	10.4	9.3	7.8	5.7	3.6
Hesse	3.9	3.9	3.1	2.5	1.8
Saxony	5.2	5.4	3.8	2.6	1.5
Rhineland-Palatinate	5.8	6.6	4.2	2.8	1.5
Schleswig-Holstein	8.4	6.7	5.8	3.6	1.4
Bavaria	18.0	16.9	12.9	8.8	4.7
Lower Saxony	14.4	13.5	10.2	6.7	3.2
Free state of Thuringia	2.2	1.6	1.6	1.2	0.73
Saxony-Anhalt[a]	12.8	16.1	5.6	3.5	1.4
Brandenburg	8.2	8.3	5.6	3.5	1.3
Mecklenburg-Hither Pomerania	8.7	7.2	5.9	3.5	1.2
Germany	115.1	112.8	80.0	55.0	30.0

[a]Due to some artefacts in the statistical data, the rate of LTST in Saxony-Anhalt seems – in relation to population and economic development – exorbitantly high. Therefore, goals for the individual federal states were calculated making some reasonable corrections to the initial data

Additionally, it might be useful to define sectoral targets in order to identify the contribution of different thematic policies, e.g. the Federal Transport Infrastructure Plan (BVwP). In the context of a study to prepare a concept for the integration of Strategic Environmental Impact Assessment in the next BVwP, it has been proposed to reduce the speed of enlargement of the federal road network by 75 %. By the end of the last millennium, federal roads still grew by 2.5–3.0 ha a day. Until 2020, this rate should be reduced to about 0.75 ha a day (B&P 2010).

4.5 First Practical Steps to Reduce the Speed of Land Take

The UBA (amongst other institutions) has also proposed a consistent set of actions to be taken and new instruments to be applied (UBA 2003; TAB 2007). The UBA takes an active part in the public discussion on why it is crucial for sustainable development to stop urban sprawl and degradation of soils – not only in Germany but also on a global scale. During the years following the UBA report, discussions continued in the framework of the National Strategy of Sustainable Development and some first actions were taken to slow down urban sprawl and at the same time restore public finances. The most important moves were

- in 2004 and 2006, respectively, reduction and abolishment of direct subsidies for construction or purchase of dwellings inhabited by their owners
- in 2007, the attempt to reduce the commuter allowance; this action was very brave but not successful, for it was overturned by a judgement, of the Federal Constitutional Court (BVerfG 2008).[12]

A second attempt to reduce the commuter allowance has not yet been undertaken. In 2008, a new subsidy for construction or purchase of dwellings inhabited by their owners was established in the guise of supplementary pension schemes (Wohn-Riester). These experiences illustrate the difficulty of changing the system against strong interest groups.

On the other hand, in several federal states, regional development support is now focused on or even limited to the development of brownfields and other derelict urban sites, whilst subsidies for the development of greenfields have been cut or even abolished.

Furthermore, in 2004 a research programme known by the acronym REFINA was launched by the Federal Ministry of Education and Research. Other ministries were also involved in this programme, namely the Federal ministries of Environment, of Transport, Urban Development and Spatial Planning, of Agriculture, of Finance, and several ministries of the federal states. REFINA was dedicated to developing a rich choice of instruments and actions aimed at slowing down LTST and furthering development inside settlements and to putting them into practice by model projects in regions, towns and villages. The results were spread widely and intensified the public discussion of this issue.

4.5.1 New Measures and Instruments to Slow Down Future Land Take

A lot of research has been conducted and practical experience gained during the last years. The following gives a short overview of the current state of play in these areas.

[12] It is interesting to note that the Court didn't criticise the fact that this allowance had been cut. Instead, the Court picked at the fact that the cut was not logically consistent in all aspects. According to the judgement a total abolishment founded solely on environmental reasons might have been tolerated, whilst the actual reduction for fiscal reasons in combination with exceptions for social reasons in favour of long-distance commuters was not.

4.5.1.1 Communication, Education and Information Tools

In order to head for the 30 ha goal, public views on a lot of topics have to be changed thoroughly to obtain support for the rigorous and today quite unpopular instruments and measures which have to be applied. One of the most crucial topics in this context is demographic change and its impacts on real estate markets. But also resource and energy consumption by buildings and infrastructures might become important issues in the near future.

Communication with the Public and with Decision-Makers

First of all, we have to recognise that every communication strategy has limits in what it can achieve. For instance, you can't convince the owners of greenfields in economically booming regions who are willing to sell. For, even if the price for arable land is actually rising and will continue to rise in future, it is not likely that it will ever reach the price level of building plots. And you can't convince young families to move into the inner parts of towns and villages if the environmental quality there is deficient. So, often, communication has to be combined with instruments and measures designed to bring about the desired changes. On the other side, measures without communication might be futile, too, for unfavourable opinions on living near city centres, partly based on bad experiences and partly on prejudices, are difficult to overcome without communication.

In REFINA and other model projects, a large variety of good arguments and communication instruments were developed and tried out together with actions in order to really improve the quality of old houses in the inner parts of villages and towns. An excellent example of this kind of policy presents the case of the United Villages of Wallmerod initiative in the federal state Rhineland-Palatinate, which some years ago started a successful communication and investment programme "Life inside the Village – Life in the Middle of the Middle".[13]

Additionally, publicly accessible information tools were developed for use for town marketing, e.g. on the properties and characteristics of different parts of towns and the infrastructures and public services they offer along with information on the housing market. This should provide better information for newcomers and might even attract more middleclass households into the inner parts of towns.

Improvement of Professional Training

But even if public opinion turns in favour of the redevelopment of old sites and buildings, you need professional planners, architects, project developers and craftsmen, who have the knowledge and the skills to deal with the task. It is also

[13] www.lebenimdorf.de

indispensible to change professional training in these fields. This may also open up new opportunities for construction companies having specialised until now in the development of greenfield sites.

Monitoring and Assessment of Future Land Use

Several research activities have been devoted to the development and implementation of tools for identifying and assessing the potentials which could be developed within existing settlement areas for managing the wealth of information on contaminated and non contaminated sites and for making this information readily accessible to relevant stakeholders or the public. First tools have already been developed by the environment ministries of the federal states of Bavaria[14] and Baden-Wuerttemberg,[15] who invested great efforts to raise local governments' awareness of the opportunities presented by developing the inner parts of their villages or towns. In some villages and small towns, up to 30 % of all sites were found to be unoccupied.[16]

In the framework of REFINA these kinds of tool have been further elaborated and combined with tools e.g. for forecasting population development and infrastructure capacities and maintenance needs, and in some cases these tools were also combined with quite sophisticated scenario tools for predicting the future development of settlements or whole communities.[17] Also, models and calculation tools were developed which enable local governments to assess future costs and benefits of public investments (including revenue from taxes and fees but also the costs for maintaining public infrastructures) for many years in advance. These calculations when done properly might temper a bit the hopes for the extra income that can be gained by attracting new tax payers.[18]

4.5.1.2 Support and Enforcement Instruments

The legal system in Germany allows, in principle, restrictions to be imposed in planning at federal-state and regional level which could achieve any quantitative goal. But in reality, the driving forces mentioned in Sect. 4.3.1 have an enormous influence on planning decisions. Therefore it is crucial to weaken or redirect some of the driving forces by a consistent set of instruments.

---

[14] www.lfu.bayern.de/umweltwissen/doc/uw_96_flaechensparen.pdf

[15] www.melap-bw.de/infos/;www.leader-hohenlohe-tauber.de/dorfkomm/pdf/leitfaden.pdf; www.pfif.info/

[16] REFINA project: HAI - Handlungshilfen für eine aktive Innenentwicklung; www.refina-info.de/projekte/anzeige.phtml?id=3124

[17] www.lean2.de

[18] www.folgekostenrechner.was-kostet-mein-baugebiet.de

But even if restrictive planning instruments will not be implemented in the near future, instruments addressing some of the driving forces – though not sufficient by themselves to reach the 30 ha goal – will at least guide development some steps further into the right direction. In Germany, a rich choice of such instruments has been discussed during the last decade.[19] In the following, only those instruments are presented which might have some relevant quantitative effect, whose legal basis has already been investigated and which are supported at least to some degree by relevant parts of the scientific or even political community.

Adjusting the Economical Framework

Restrictive planning instruments have to struggle with market forces strongly pulling in the opposite direction. Therefore it is crucial to adjust the economic framework so as to weaken driving forces which pull developments out of towns onto greenfields and draw development into existing settlements. Of course, it is impossible to change the global economic framework by national policies, but some economic drivers can be influenced to some degree on national, regional and local level, particularly through subsidies, taxes or public investment decisions on infrastructures and buildings.

First, all existing subsidies and tax incentives for housing and economic, rural and regional development should be directed towards the renewal or improvement of existing sites. Likewise, all subsidies flowing into the building sector should be concentrated on the modernisation of existing buildings, with the emphasis on energy efficiency and adaptation to climate change or demographic change. With a view to sustainability, it would be worthwhile launching a general discussion on the distribution of public funds between the construction sector and other important public tasks, e.g. education or child care.

Second, the German system of property taxes and property transfer taxes could be very much improved by changing it so as to encourage the efficient use of areas inside settlements.

Third, existing public transport infrastructures should be repaired, modernised or optimised instead of constructing additional ones. All subsidies encouraging additional traffic should be cut and the system of HGV tolls should be extended to include additional types of roads and types of vehicles.

Last but not least, the system of financing municipalities should be thoroughly changed. In order to minimise destructive competition between different local governments leading to excessive greenfield development in the hope of attracting additional taxpayers, the collection of taxes should be shifted to the regional level, and the tax revenue should be allocated according to the needs resulting from the functions, burdens and tasks assigned to the individual municipalities in the regional context.

---

[19] UBA (2003, p. 108ff), TAB (2007), REFINA Projects, e.g. DoRiF (DoRiF 2009).

Further Improvement of the Planning System

Besides quantitative restrictions on the development of new settlements, additional qualitative planning requirements should be adopted.

In order to make sure that all spatial planning will be focused on development inside settlements instead of on greenfields, sustainability checks (e.g. demographic projections to assess the necessity of developments, investigation of development potentials inside settlements, long-term cost-benefit analyses and – of course – environmental impact assessments) should be obligatory for every planning process. This should be true especially for plans and projects supported by subsidies.

Especially for less prosperous regions, it will be of utmost importance to reverse ancient plans for the enlargement of settlements which have not yet been put into practice and to annul building permissions for unbuilt or derelict sites where there is no hope of future development. The removal of superfluous buildings und building permissions might even stabilise to some extent the value of the remaining real estate.

New Instruments Increasing the Price of Land Take

Some authors (UBA 2003; Krumm 2004) have proposed new instruments, i.e. taxes or fees, designed to increase the costs for transforming greenfields into new construction sites.

The effects of tax increases depend on the amount of the tax in relation to other costs for buying and developing land. The tax rate for land take or soil sealing proposed by UBA – on condition that at the same time the property transfer taxes will be abolished and the total tax revenues remain unchanged – should amount to 18.6 € per square meter of land transformed from greenfields to construction sites. Economic model calculations show that this level of taxation will reduce land take for settlements and accompanying transport infrastructure by roughly 20 % (Frohn et al. 2003). Although this would not be sufficient to attain the 30 ha goal or to stop land take completely, it would be a step in the right direction.

At present, we cannot properly predict the level of a tax necessary to reach the 30 ha goal. For such a radical change in the tax level the effects cannot be tackled by models working in the range of prices and taxes that have been observed over the last decades. Besides, we strongly believe that a sound mix of economic and planning instruments will work better than radically increasing the price of land only. After all, an adequate level of taxation in combination with planning instruments to reach the 30 ha goal could only be found in the real economic system by trial and error.

Though some scientists have sympathy with these taxation tools, not many supporters are currently to be found at the political level.

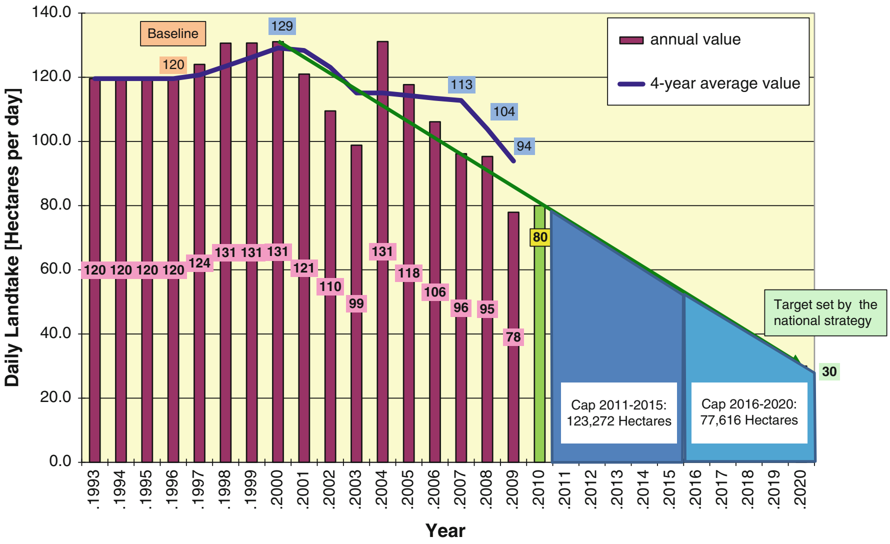


Fig. 4.8 Proposed caps on future land take for settlements and transport infrastructure until 2020

4.5.1.3 An Innovative Instrument to Guarantee the 30 ha Goal

Last but not least, it is time to mention the proposals to introduce trading in land take allowances – in analogy to greenhouse gas emission trading. The scientific discussion on this instrument started as early as the 1990s. The UBA and the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) tried to explore the legal and practical conditions under which such trading could take place and how it could be harmonised with the normal planning system (ISI 2009; BBSR 2006).

From the ecological point of view, there is no doubt that, apart from strict spatial planning by the federal states and regional governments, this is the only appropriate instrument to effectively achieve the 30 ha goal. More controversial is the discussion on the economic and social impacts of a strict limitation of land take all over Germany and on the distributional effects of any kind of allocation of the remaining allowances to regions and municipalities.

Figure 4.8 shows that the 30 ha goal of the national strategy of sustainable in combination with the intermediate goals for LTST proposed by UBA[20] imply a total cap of 201,000 ha for the decade from 2011 to 2020. Following a linear path LTST would be capped to 123,272 ha and 77,616 ha, respectively, during the 5 year periods 2011–2015 and 2016–2020.

[20] see Sect. 4.1.

Model calculations show that a cap of 201,000 ha until 2020 should be sufficient to cover all needs[21] for housing, commercial development and transport even under conditions of a new wave of immigration, if these land use changes were allocated exactly where they are needed (UBA 2003, p. 121).

Therefore, there is no real argument against a cap on land take from the social and economic points of view. In contrast to a strict and invariable allocation of allowances to local and regional governments, trading has the advantage that it might easily adapt to unforeseen events, e.g. local or regional deviations in demographic or economic development. If allowances are traded under market conditions between different municipalities, land take will happen at sites where it yields the greatest economic or noneconomic[22] benefits and the money will flow to places where it might do the most good.

In the framework of REFINA (see DoRiF 2009) and other research programmes (see e.g. ISI 2010), some simulations involving one or two dozens of municipalities were carried out to study the behaviour of professional planners in trading allowances, in calculating costs and benefits of different types of development, in (fictive) activities to develop greenfield and brownfield sites and in buying and selling allowances as well as the reactions of the "market" like the trading volume and the development of "prices" for allowances.

As a result, it could be demonstrated that cost-benefit analysis led – from the economic point of view – to better decisions by professional planners on whether "to develop or not to develop" greenfields. On the other hand, compared to other kinds of players (i.e. students of non-planning disciplines), professional planners tended to take the social impact of their decisions more strongly into account even under market conditions. This resulted in planning decisions which – from a purely economic point of view – were found to be some distance away from the economic optimum, but which were justified by social arguments.

As to the discussion with the most relevant stakeholders, local governments in general refuse to get tied into a system which might restrict their planning power by impeding their future decision making. This is true not only of municipalities in growing regions which might be obliged to buy additional allowances but also for municipalities in shrinking regions.

Nevertheless, federal politics opened a door to trading in land take allowances. In 2009, the former federal government constituted itself by signing a coalition agreement. Under the subheading "*Climate protection, energy and environment*", this agreement contains – among other agreed actions to encourage development within existing settlements – the following provision: "*Voluntary interregional*

[21] This would be sufficient for 5.0 ha of additional commercial zones plus 1.75 ha of additional recreation zones plus 5.0 ha of additional housing areas to be developed in each and every of the existing 12,000 municipalities (towns and villages) in Germany. These additional housing areas developed on 60,000 ha of greenfield sites could accommodate one million additional single family houses (including traffic infrastructures).

[22] Non economic benefits might "pay off" on polling day.

trade of land use allowances between municipalities shall be tested in the framework of a model project".

Based on bilateral discussions between the Federal Ministry for Environment and the Federal Ministry for Transport, Building and Urban Development and in consultation with the authorities of the federal states and the syndicates of regions and municipalities, two well-matched, complementary model projects are in preparation.

One, guided by the UBA, will try to establish a model project on trading in land use allowances as announced by Federal Government. A scientific report with recommendations on the setting of this model project with 50–100 municipalities has recently been published (see FORUM 2012). UBA has by now started the practical part of the model project[23] which involves a first set of 15 brave municipalities.

The other model project, guided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), will try to devise non-monetary arrangements between municipalities for sharing the advantages and disadvantages of new developments and redevelopments.

In regard to sustainable land use, the years ahead might be quite interesting from the scientific point of view and hopefully, from the practical point of view as well.

4.6 Conclusions

Land take for settlements and transport infrastructure and at the cost of greenfields and fertile soils is an important issue, not only for the environment, climate protection and the efficient use of resources but also from the economic and social point of view, given the enormous global and regional challenges presented by global economic growth and increasing competition, globally growing and regionally shrinking populations and the unequal distributions of food and other resources between different regions.

The problem was recognised by Federal Government a decade ago, an action target was formulated on federal level, i.e. the goal to reduce daily land take to 30 ha by the year 2020, which ceteris paribus means an increase in the resource efficiency of land use by a *factor of 4*.

Furthermore, the UBA has proposed an intermediate goal for the year 2010 of 80 ha a day. Assuming a linear reduction until the year 2020, this implies a cap on total additional land take of 201,000 ha over the next 10 years.

A lot of measures to slow down land take a bit have already been launched at federal level as well as at Federal State, regional and municipal levels. Especially some subsidies have been cut or directed from development of greenfields to redevelopment of brownfields, and a lot of research, model projects and contests have been started on the development and utilisation of effective and efficient instruments to enforce sustainable land use and in order to demonstrate best practice.

[23] www.flaechenhandel.de.

As there are strong driving forces boosting land take, effective action should consist of a coordinated package of measures to adjust the economic framework and to implement at the same time strict spatial planning policies, based on the analysis of actual needs on one hand and on the development of existing potentials inside already built up areas, on the other.

But it has been quite clear from the start that effective measures are quite unpopular among stakeholders as well as the general public. The first and most important task is therefore to raise awareness of the impacts of urban sprawl and of the advantages of reducing land take not only for ecological systems, but also for economic efficiency, social systems and for urban and rural development. In order to highlight the importance of the issue and to explain the urgency of actions, messages on these topics have to be transported and highlighted by the very leaders of national, federal, regional and local governments, respectively.

Whilst stringent spatial planning could be implemented in Germany within the existing legal system, innovative instruments, in particular trading in land use allowances (analogous to trading in greenhouse gas emission allowances) and other ways of redistributing the costs and benefits of urban and rural development between municipalities, are still under discussion within the scientific community. The Federal Government has initiated two coordinated model projects to try out instruments which might lead to sustainable land use in a way which is both ecologically effective and economically efficient.

References

B&P (2010) FE-Vorhaben 96.0904/2007: Erarbeitung eines Konzepts zur “Integration einer Strategischen Umweltprüfung in die Bundesverkehrswegeplanung” Endbericht; July 2010; Bosch und Partner, TUB et al.; Annex C, p 50

BBSR (2006) ExWoSt-Forschungsfeld “Fläche im Kreis”. ExWoSt-Informationen 25/4, October 2006

BGR (2009) Rohstoffwirtschaftliche Länderstudien, Heft XXXVIII, Bundesrepublik Deutschland: Rohstoffsituation 2008, Hanover, October 2009

BMU (2007) National strategy on biological diversity, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, October 2007

BReg. (2002) Federal government: perspectives for Germany – our strategy for sustainable development, Berlin

BVerfG (2008) Urteil des Bundesverfassungsgerichts v. 9. Dezember 2008 zu § 9 Abs. 2 EStG i. d. F. d. Steueränderungsgesetzes 2007 v. 19. Juli 2006 (BGBl I S. 1652)

Destatis (2010) If no other sources are mentioned, all data in this chapter on population, land take, construction activities and material input has been provided in the framework of running public statistics or in the framework of UGR by the Federal Statistical Office (alias Statistisches Bundesamt, StBA, destatis)

Destatis (2011) Regionalatlas/Bevölkerung/Bevölkerungsveränderung/2009/Tabelle. http://www.destatis.de/regionalatlas. Accessed 2012

DoRiF (2009) Bizer, Henger, Köller und Stephenson; Handelbare Flächenausweisungsrechte – Zielsetzung und Ausgestaltung des Flächenhandels; Erläuterungen zum Forschungsvorhaben Designoptionen und Implementation von Raumordnungsinstrumenten zur Flächenverbrauchsreduktion (DoRiF), March

FORUM (2012) Bizer, Bovet, Henger et a.; Handel mit Flächenzertifikaten – Fachliche Vorbereitung eines überregionalen Modellversuchs; Umweltbundesamt (Hrsg.), UBA-Texte 60/2012; ISSN 1862–4804, July

Frohn Joachim et al (2003) "Wirkungen umweltpolitischer Maßnahmen – Abschätzungen mit zwei ökonometrischen Modellen"; Frohn, Joachim; Hillebrand, Bernhard; Meyer, Bernd et al.; Wirtschaftswissenschaftliche Fakultät der Universität Bielefeld, Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI), Köln, u. EWS-GmbH, Osnabrück; published in the Series „Umwelt und Ökonomie", vol 35, Physica-Verlag, Heidelberg

IÖR (2010) IÖR 2010: Ermittlung von Ressourcenschonungspotenzialen bei der Verwertung von Bauabfällen und Erarbeitung von Empfehlungen zu deren Nutzung. UBA-Texte 56/10. Schiller, Georg et al

ISI (2009) UBA-Texte 23/2009: Dr. Rainer Walz, Dominik Toussaint, Dr. Christian Küpfer, Dr. Joachim Sanden, Gestaltung eines Modells handelbarer Flächenausweisungskontingente unter Berücksichtigung ökologischer, ökonomischer, rechtlicher und sozialer Aspekte; UFO-Plan-FKZ 203 16 123/03

ISI (2010) Ostertag K, Schleich J, Ehrhart K-M, Goebes L, Müller J, Seifert Stefan und Küpfer C: Neue Instrumente für weniger Flächenverbrauch. Der Handel mit Flächenausweisungszertifikaten im Experiment. Stuttgart: Fraunhofer Verlag

KBU (2009) Flächenverbrauch einschränken – jetzt handeln; Empfehlungen der Kommission Bodenschutz beim Umweltbundesamt; Dezember 2009

Krumm R (2004) Nachhaltigkeitskonforme Flächennutzungspolitik – Ökonomische Steuerungsinstrumente und deren gesellschaftliche Akzeptanz (unter Mitarbeit von Heinbach W.D.). Forschungsbericht FZKA-BWPLUS, Tübingen

RNE (2001) Ziele zur Nachhaltigen Entwicklung in Deutschland – Schwerpunktthemen, Dialogpapier des Nachhaltigkeitsrates; Rat für Nachhaltige Entwicklung, Berlin

SRU (2004) Sachverständigenrat für Umweltfragen: Umweltgutachten 2004 – Umweltpolitische Handlungsfähigkeit sichern, Langfassung

SRU (2005) Sachverständigenrat für Umweltfragen; Sondergutachten Umwelt und Straßenverkehr: Hohe Mobilität – Umweltverträglicher Verkehr; Juli 2005

TAB (2007) Jörissen J, Coenen R, Sparsame und schonende Flächennutzung – Entwicklung und Steuerbarkeit des Flächenverbrauchs; Berlin, 2007; Studien des Büros für Technikfolgenabschätzung beim Deutschen Bundestag – 20

UBA (2003) UBA-Texte 90/03: Reduzierung der Flächeninanspruchnahme durch Siedlungen und Verkehr, Berlin, Dezember 2003, ISSN 0722-186X

UGR (2006) Statistisches Bundesamt (StBA, destatis): Umweltökonomische Gesamtrechnungen

UGR (2010) Statistisches Bundesamt (StBA, destatis): Umweltökonomische Gesamtrechnungen

von Haaren C, Nadin V (2003) Vergleich der Flächeninanspruchnahme in Deutschland und England. Raumforschung und Raumordnung H. 5, S. 345–356, quoted by SRU (2004), p. 166

WI (2011) Materialbestand und Materialflüsse in Infrastrukturen; MaRess AS 2.3: UFO-Plan-FKZ 3707 93 300; Steger, Sören et al.

Chapter 5
The Need for Decarbonising Our Economy

Guido Knoche, Kai Kuhnhenn, Carla Vollmer, and Kathrin Werner

5.1 Limiting Climate Change

Climate change is not something in the distant future. It is already happening – worldwide, in Europe and also in Germany. Any doubts of mankind's responsibility for the largest proportion of global warming since the middle of the twentieth century must not be taken seriously anymore (IPCC 2007). Modern civilization's energy-intensive lifestyles in particular together with extensive deforestation, farming and animal husbandry are the main causes of the rise in atmospheric greenhouse gas concentrations since 1750 – the so called pre-industrial era.

Significant changes on the global, continental and regional level have been observed in recent years. Researchers have also observed a number of physical and biological systems already being substantially affected by warming over the past three decades. The inertia of the global climate system implies that the full impact of the global greenhouse gas emissions will only become apparent in future decades. In this regard high attention has been given to Nicolas Stern's estimations of the global cost of 'business-as-usual' climate change, which is to be in the magnitude of between 5 and 20 % of the projected Gross Domestic Product (GDP) in the twenty-first century (Stern 2007).

By the end of the twenty-first Century, the scientific community currently estimates a warming of at least 2–4 °C compared to the end of the twentieth century, at which point in time (since the beginning of industrialization) the global mean temperature had already risen by about 0.5 °C. Recent findings also indicate an acceleration and intensification of some processes related to climate change, including a sea level rise by more than a meter by the end of the twenty-first century, which is almost twice the increase stated in the 2007 report of the IPCC (Richardson

G. Knoche (✉) • K. Kuhnhenn • C. Vollmer • K. Werner
Federal Environment Agency (Germany), Wörlitzer Platz 1, 06844 Dessau-Roßlau, Germany
e-mail: guido.knoche@uba.de; kai.kuhnhenn@uba.de; carla.vollmer@uba.de; kathrin.werner@uba.de

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_5,

et al. 2009). In addition to gradual global warming, it is also possible that above certain magnitudes of warming, the climate could change abruptly, with irreversible, long-term consequences on a global scale. These could include the melting of sea ice and the reduction of the albedo in the Arctic, resulting in a considerable increase in global warming. Such processes should not be underestimated, because abrupt, drastic changes in climate have the potential to seriously affect human societies, possibly exceeding their capacity to adapt.

All in all: by continuing our carbon and resource intense lifestyle we seem to be biting the hand that feeds us. Yet in regards to climate change, and even with a decision about the continuation of the Kyoto-Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) in a 2nd commitment period on the UN climate summit in Doha/Qatar in December 2012, parties to the UNFCCC will at the earliest have a new legal comprehensive instrument for reducing global greenhouse gas emissions being effective only from 2020 onwards.[1] Since the UN climate summit in Copenhagen, Denmark, in December 2009 left the global community in perplexity, the Cancun and Durban climate summits in December 2010 respectively December 2011 helped to dissolve many open issues. With the Cancun Agreements 2010 the global community has recently established clear objectives for reducing greenhouse gas emissions to keep the global average temperature rise below two degrees.[2] This reference determines the red line for international efforts on mitigating climate change policies in the mid- to long term horizon.

5.2 Keeping Track of the 2 Degree Path: Cutting Emissions to 95 % Below 1990 Levels in Industrialized Countries by 2050

Regarding the 2 degree threshold, not only the long term perspective is relevant to limit global warming below 2 °C. Recent findings also indicate that the window of opportunities, in which the international community could still limit global warming to a maximum of 2 °C, is closing rapidly (Parry et al. 2008). A further delay in implementing necessary mitigation policies would make it more likely that global climate change will exceed our adaptive capacity. Therefore, a remarkable trend reversal of global greenhouse gases emissions must already be achieved in the current decade. According to the IPCC, this requires short-term investments in infrastructure and rapid de-carbonisation of the energy system, as a result of which greenhouse gas emissions would be reduced between 2015 and 2020. In this regard, IPCC has defined an indicative reduction corridor for industrialized countries in the order of 25–40 % below the 1990 level. Additionally, limiting global warming to a

[1] UNFCCC and the Kyoto Protocol were set into force in 1994 and 2005 respectively.

[2] Document FCCC/CP/2010/7/Add.1 under www.unfccc.int (dec. 1/CP.16), as of 21.03.2011.

maximum of 2 °C in comparison with pre-industrial levels is now only considered to be in reach if developing countries also participate in the worldwide efforts to reduce emissions. Following the IPCC, developing countries need to make strenuous efforts to reduce their greenhouse gas emissions approximately 15–30 % below the current expected emissions trend by 2020. This means, developing countries clearly need to decouple economic growth more strongly from greenhouse gas emissions.

In the long term (2050) and according to the IPCC, annual global greenhouse gas emissions must be reduced by at least 50 % compared to 1990 in order to stay on the 2 degree path. Therefore, by 2050, global greenhouse gas emissions must fall from about 40 gigatonnes of carbon dioxide equivalents per year in 1990 to less than 20 gigatonnes of carbon dioxide equivalents per year.

Due to their historical responsibility for climate change and their moral commitment to enable developing countries a sustainable development, by 2050 the industrialized countries must reduce their greenhouse gas emissions by at least 80–95 % below the 1990 values.

Germany has so far influenced the international climate policy process to a decisive extent and is, within the scope of the EU burden-sharing agreement on the Kyoto Protocol (KP), well on its way to fulfilling the commitment to reduce its greenhouse gas emissions by 21 % in comparison to 1990 during the first commitment period from 2008 to 2012. It is one of the leading national economies throughout the world and holds a remarkable reputation in the international community, not only due to its domestic commitments to environmental and sustainable development issues. With its current government pushing to reduce greenhouse gas emissions by 2020 to 40 % below 1990 levels, Germany has an ambitious midterm goal. For the year 2050, under a legally binding framework in which global greenhouse gas emissions are to be at least halved, an emission reduction of 95 % would be appropriate for Germany. As recent studies already indicate, Germany has a high potential to reduce its greenhouse gas emissions, in particular based on a power supply made up of renewable energy resources (Prognos and Öko-Institut 2009). In doing so Germany could do justice both to its own ambition to play a leading role in combating climate change and to its historical responsibility.

To play this leading role, it is important to achieve the target of 95 % emission reductions without relying on the possibility to offset emissions, i.e. paying for emissions to be reduced elsewhere instead of reducing German emissions.

5.3 The Role of the Energy Sector

A 95 % decrease in emissions by 2050 is a challenging task that must be achieved in an environmentally safe as well as economically and socially acceptable way. The cost of GHG-reductions varies between different sectors and different mitigation options. Emissions in the energy sector – responsible for over 80 % of the total

German emissions in 2008[3] – for example, can be fully avoided by employing already available technologies. In contrast, emissions from industrial processes and the agricultural sector, together amounting to about 18 % of total emissions, are much harder to reduce.

Due to its large share of total emissions and lack of mitigation options in some other sectors, a full decarbonisation of the energy sector is a precondition for meeting a 95 % reduction target in 2050. In this article, the focus will be on the production of electricity since it is responsible for almost half of the energy sector's emissions. How a sustainable decarbonisation of this subsector can be achieved through energy efficiency and the extensive use of renewable energies will be explored in the next sections.

It should be noted that we do not consider Carbon Captures and Storage (CCS) as an alternative to reduce emissions from the energy sector since – according to the precautionary principle – the potential storage capacity should be reserved for emissions that are more difficult to mitigate (e.g. emissions from industrial processes). Additionally, storage capacities should also be preserved for technologies to remove CO_2 from the atmosphere, which might be a necessary option in the future.

5.4 The German Vision: Power Supply by Renewable Energies

Germany can establish itself as a leading global player by converting to solely renewable sources of energy, setting an example for the sustainable development of the energy system. The benefits of such a target are manifold: Besides reducing greenhouse gas emissions, it would also enhance environmental and resource conservation, leaving options open for coming generations, while improving public health. It would showcase a low risk energy supply based on sources available worldwide. In the long term there is no alternative to such a reorganisation of the energy system.

A precondition for an energy supply fully based on renewable energies is highly efficient energy use. Energy demand has to be reduced at various levels.

- Firstly, our standard of living should be uncoupled from energy consumption. We must use less energy (power, heating and mobility) to provide the necessary energy services, such as warm and bright living spaces, goods manufacturing and transport of goods and people.
- Secondly our resources have to be conserved by efficient transformation and end use technologies. With other words energy must be transformed, transported and used as efficiently as possible.
- The remaining energy demand can then be met with energy from renewable sources.

[3] National Trend Tables for the German Atmospheric Emission Reporting 1990–2008 (Version: EU-Submission 15.01.2010).

5.4.1 Precondition: Efficient Power Supply and Consumption

Today's power supply and consumption in Germany is not efficient enough.

New applications of electricity such as the growing use of heat pumps or – in the future – electromobility may even increase electricity demand, adding to the need to efficiently supply and use electricity as outlined above.

Numerous studies show that there are economically feasible ways to reduce power consumption in Germany (Wuppertal Institut für Klima, Umwelt, Energie 2006; McKinsey & Company 2007; Prognos AG 2007). Cost-cutting power savings sum up to about 110 terawatt-hours (TWh) per annum. This represents about a fifth of current power consumption in Germany or the output of some 20 new 800 MW base load coal-fired power stations (UBA 2009a).

Starting today, making use of these efficiency opportunities this potential could be exploited in about 10 years time, savings nearly EUR ten billion per year.

The challenge is now to overcome the various restraints, obstacles and barriers to the reduction of power consumption through a set of instruments, some of them based on the EU-level.

- The EU Electricity-using products Directive (2005/32/EC) is such an instrument principally suitable for decreasing energy consumption. A precondition is that ambitious, dynamic efficiency standards (top-runner principle) for electric equipment are integrated in the Directive. The efficiency standards should be re-examined regularly according to a product-specific schedule and upgraded where appropriate. Additionally, effective implementation is needed in the form of market surveillance, which has to be improved in Germany by institutional support.
- A dynamic, coherent and consumer-friendly energy consumption labelling has to be established. The most important feature of such an energy labelling is a regular updating so that the most energy efficient appliances are in the best efficiency class. This labelling should be extended to further products relevant for power consumption such as heat pumps, televisions sets, vacuum cleaners and heating systems.
- Obligatory energy management systems should be introduced for all manufacturing companies. If companies only identify and implement those measures which offer direct economic benefits, a 10 % reduction of the greenhouse gas emissions could be reached.
- The efficiency of the power supply has to be improved, too. The most effective measure is to increase the share of combined heat and power (CHP) in electricity production – Germanys target for the CHP-power share is 25 % in 2020. The efficiency imperative applies to renewable energies as well as to any other energy source, therefore – where possible – renewable energies power plants should also use CHP.

5.4.2 The Possibility of a 100 % Renewable Electricity Supply

In recent years, renewable energies have gained considerable significance in the electricity market in Germany. While the share of renewable energies was 6.8 % of the gross electricity consumption in 2000, it surged to 20.3 % until 2011. Within this period, renewable energies have become an essential backbone of the energy industry.

The most important renewable energy sources in the electricity market are wind- and bioenergy, making for 8.1 and 6.1 % of the total electricity consumption in the year 2011 (BMU 2012) respectively. In light of this vigorous development, an electricity supply entirely based on renewable energies seems possible in Germany by 2050.

This perspective is also outlined by the German surveys "Energieziel 2050: 100 % Strom aus erneuerbaren Quellen" (UBA 2010) "Langfristszenarien 2011" (DLR, Fraunhofer IWES, IfnE 2012) and "Klimaschutz: Plan B 2050" (Greenpeace 2009). In scenario A of the survey Langfristszenarien 2011 (DLR, Fraunhofer IWES, IfnE 2012) renewable energies provide about 85 % of the gross electricity generation, by 2050. The survey "Klimaschutz: Plan B 2050" even holds out the prospect of 100 % by 2050. Nevertheless, both surveys outline the significance of electricity demand reduction (through efficiency improvements) and electricity imports for achieving the mentioned shares of renewable energy in the electricity sector. While Langfristszenarien 2011 (DLR, Fraunhofer IWES, IfnE 2012) considers electricity imports of 61.9 TWh/a (mainly solar energy coming from North African deserts) necessary, the survey "Klimaschutz: Plan B 2050" takes higher exploitation of German geothermal and solar potentials into account.

5.4.3 Preconditions for Increasing the Share of Renewable Energies to 100 %

There are many challenges on the way to an electricity supply system based totally on renewable energies. Initiating such a development, important decisions concerning the future energy supply system have to be made and specific basic conditions are required. In the following paragraphs, some important conditions and decisive points are briefly described.

A very important precondition is a *strong political commitment as well as* long-term and binding renewable energy targets. The German Federal Government has committed itself to the target of at least a 35 % share of renewable energies in the gross electricity consumption by 2020, rising to 50 % by 2030 and to at least 80 % by 2050. These targets are laid down in the German Renewable Energy Sources Act (EEG) 2012.

To achieve the aimed "100 % renewable energy electricity supply", political targets have to be defined stepwise (e.g. every 10 years) and regularly updated to ensure the feasibility of the scenario. Also, the phase out of the fossil-nuclear energy system must not be further delayed. In 2011 the Federal government decided the phase-out of nuclear power by 2022 and systematic expansion of renewable energies. Also, there is no need for new coal-fired power plants up to 2020 (UBA 2009b). Instead, old and inefficient coal-fired power plants should be replaced by gas-fired CHP-plants which better complement fluctuating renewable energy plants.

The above mentioned political will must also encompass the further development of the EEG. In current amendments power plants based on renewable energies can opt for a bonus system based on average monthly stock exchange electricity price to foster feed-in of renewable electricity according to actual demand. This policy instrument should be further improved. Wind energy plants are subsidised for supplying grid support services. In order to further increase the dependability of the grid, similar regulation should be developed for all types of renewable energy systems. Despite of all attempts for market integration, both priority purchase and distribution of electricity from renewable energy sources continue to be of highest importance.

In Germany, the future *electricity system* will mainly be based on fluctuant renewable energies like wind and solar energy which are exploited in a widely distributed electricity plant system. In order to integrate large amounts of such renewable energy sources into Germany's electricity supply, our future electricity system must be designed to meet these new requirements as efficiently and cost-effectively as possible.

To this end, renewable energies as well as the *demand side must be more involved in generation/load balancing and in load-frequency control*, for example by using virtual power plants. In addition, a stock of highly flexible and low-emission fossil-fuel-fired power plants will be necessary – for a transitional period – to complement renewable energies (UBA 2009b).

Such a renewable energy electricity supply system imposes high requirements on the *grid*. Within the next years, the grid has to be optimized, amplified and extended for the transport of electricity from production areas, mainly in the Northern part of Germany, to areas with high electricity demand in the Western and Southern parts. Since the amendment to the Energy Industry Act (Energiewirtschaftsgesetz) the first mandatory and coordinated grid expansion plan for the main electricity transmission grids and long-distance gas lines (10-year grid development plans) was set up. This plan was made to clarify the necessary level of grid expansion and facilitate its achievement. Furthermore, it could help to gain public acceptance for the construction works if accompanied by comprehensive consultations with stakeholders. The aim is to establish binding grid expansion requirements through a demand planning legislation (Bedarfsplangesetz) in 2013. The Grid Expansion Acceleration Act (Netzausbaubeschleunigungsgesetz, NABEG) aims at swifter expansion of electricity transmission grids in particular. For the first time, the Federal Network Agency has published a federal grid map, which identifies the corridors for important electricity transmission lines. Additionally, there is need for sufficient storage options such as pump or cavern storages. To achieve this, technological research, identification of suitable sites and respective spatial planning are essential.

In recent years, renewable energies have become an important economic factor. In 2011,around 381,600 people were employed in this field, with an positive trend (BMU 2012). This indicates an increasing need for craftsmen, installers, engineers and scientists. Therefore, another important precondition is *education* in this industrial sector.

Although renewable energies are in general environmentally advantageous, they can also have undesirable effects on the environment. E.g.

- methane and other gas emissions like ammonia escape during the electricity generation of biogas plants and
- the sound emissions during the piling process for foundations for towers of off-shore wind energy plants can have devastating negative effects on sea animals.

If energy supply is to be based completely on renewable energies, environmental impacts have to be as small as possible. Already today there is an urgent need to improve *environmental standards for power plants*. The production and the disposal of renewable energy plants have to be environmentally friendly as well. Some steps have already been taken, such as the *Biomass-electricity-sustainability ordinance*, which sets the parameters for the cultivation and the use of biofuels and bioliquids with regards to its origin and its greenhouse gases emissions.

Another important precondition is the *public acceptance* of renewable energy power plant installations. In the present energy supply system large power plants are located at few sites. As mentioned above, a renewable energy supply has a decentralised structure. Under the renewable energies, solar energy, wind energy and biomass especially impact the landscape. With the ambitious targets set by the German government, more and more renewable energy plants will be installed, affecting more regions and hence more landscapes. Research shows that renewable energies are generally seen positive by the German society. But public opinion can change. Furthermore, the required extension of the grid can also require construction of overhead power lines which already face resistance of concerned residents. There is need for information and public relations, but also for a public discussion process, regarding a sustainable energy system.

5.5 A Vision for Europe

Principally this approach also works on the European and even global level. The worldwide potential for renewable energies, after making conservative assumptions for technological, structural and environmental constraints, is about six times the current global energy consumption. Even if, as expected, global demand for energy rises considerably, demand could still be met completely and reliably with energy from renewable sources (BMU 2009).

As far as the electricity sector is concerned, balancing energy at a European level bears great benefits, as balancing on a larger scale facilitates the balancing of fluctuating energy sources. A study has shown that the share of secured wind capacity to total wind capacity is about twice as high at the European level compared to Germany territory (EWEA 2009).[4]

[4] Due to the fact that wind power is not always available, the power output which – statistically – is available reliably is much lower than the maximum power output. The difference between the two is reduced by increasing the total power output of the connected wind power fleet.

Of course, the necessity of grid optimisation, fortification and expansion is even more crucial on a European scale.

Most of the other preconditions described above also apply for Europe, for example the political will with long-term and binding development targets. The Renewables Directive has established a binding EU-wide target to source 20 % of their energy needs from renewables, including biomass, hydro, wind and solar power, by 2020. To achieve a European wide fully renewable energy supply in 2050, such political targets have to be rigorously monitored and ambitiously advanced further into the future.

References

BMU (2012) Erneuerbare Energien in Zahlen. Nationale und internationale Entwicklung. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Berlin

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) (2009) *Erneuerbare Energien – Innovationen für eine nachhaltige Energiezukunft.* Berlin: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

DLR, Fraunhofer IWES, IfnE (2012) Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global

European Wind Energy Association (EWEA) (2009) Integrating wind: developing Europe's power market for the large scale integration of wind power

Greenpeace (ed) (2009) Klimaschutz: plan B. Energiekonzept für Deutschland

Intergovernmental Panel on Climate Change (IPCC) (2007) Fourth assessment report. Intergovernmental Panel on Climate Change, Geneva

McKinsey & Company (2007) Kosten und Potenziale der Vermeidung von Treibhausgasemissionen in Deutschland. Study commissioned by BDI

Parry M, Palutikof J, Hanson C, Lowe J (2008) Squaring up to reality. Nat Rep Climat Chang 2:68–69

Prognos AG (2007) Potenziale für Energieeinsparung und Energieeffizienz im Lichte aktueller Preisentwicklungen. Study commissioned by the Federal Economics Ministry

Prognos AG, Öko-Institut e.V. (2009) Modell Deutschland. Klimaschutz bis 2050: Vom Ziel her denken. Study commissioned by WWF Deutschland

Richardson K, Steffen W, Schellnhuber H-J, Alcamo J, Barker T, Kammen D, Leemans R, Liverman D, Munasinghe M, Osman-Elasha B, Stern N, Waever O (2009) Climate change. Global risks, challenges & decisions. Syntheses report. Climate Change Congress Copenhagen, University of Copenhagen, Copenhagen

Stern N (2007) The economics of climate change – the stern review. Cambridge University Press, Cambridge, UK/New York

Umweltbundesamt (2009a) Concept for a future climate policy – plotting a new course in 2009. Climate Change 15/2009

Umweltbundesamt (UBA) (2009b) Climate change mitigation with a secure energy system. Developing a sustainable power supply. Executive Summary

Umweltbundesamt (2010) Energieziel 2050: 100% Strom aus erneuerbaren Quellen. Dessau-Roßlau

Wuppertal Institut für Klima, Umwelt, Energie (2006) Optionen und Potenziale für Endenergieeffizienz und Energiedienstleistungen. Study commissioned by E.ON AG

Chapter 6
Strategies for Enhancing Resource Efficiency

Arnold Tukker

6.1 Introduction: 'An Economy Crashing Against the Earth'

Since the Industrial Revolution, humans have realised an economic growth unprecedented in human history. This growth was made possible by technical progress, but also by an unprecedented rise in the use of finite, non-renewable resources, transformation of ecosystems into cultivated land, and the use of nature as a sink for residuals of production and consumption.

We now live in a world of 6.7 billion people, where 1 billion live wealthy lives, 1–2 billion live in fast developing economies, and 3–4 billion people get by on just a few dollars a day. But a new and rapidly expanding middle class in fast developing economies like China and India is quickly closing the wealth gap with the West (Myers and Kent 2004). This happens in a world where already at present the economy seems to 'crash against the Earth' (see Box 6.1) – a process still mainly driven by consumption in Western, industrialised economies.[1] We also know that if fast developing countries copy current Western consumption and production patterns, we will need around five planets to provide the resources for these lifestyles (see Box 6.2). Since we do not have those five planets, environmental crises and

[1] Western and non-Western economies now almost cause the same environmental pressures, but Western economies are large importers of goods manufactured in other economies. Hence, taken pollution embodied in trade into account, consumption in Western economies still is mainly responsible for global impacts.

A. Tukker (✉)
The Netherlands Organisation for Applied Scientific Research TNO, P.O. Box 49, 2600 AA Delft, The Netherlands

Industrial Ecology Program/Department of Product Design Gloshaugen, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway

Institute of Environmental Sciences (CML), Leiden University, P.O. Box 9518, 2300 RA Leiden, Netherlands
e-mail: tukker@cml.leidenuniv.nl; arnold.tukker@tno.nl

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_6, © Springer Science+Business Media Dordrecht 2014

Box 6.1: The Great Collision – A Global Economy Crashing Against the Earth

James Gustave Speth (2008), former United Nations Development Programme administrator, starts his book 'The Bridge at the Edge of the World' with a sobering summary of findings in recent authoritative environmental and ecological assessments: "Half the world's tropical and temperate forests are now gone… About half the wetlands and a third of the mangroves are gone… An estimated 90 % of the larger predator fish are gone, and 75 % of the marine fisheries are now overfished or fished to capacity… Species are disappearing at rates about a thousand times faster than normal… Over half of the agricultural land in drier regions suffers from some degree of deterioration and desertification. Persistent toxic chemicals can now be found by the dozens in essentially each and every one of us"

Box 6.2: Our Ecological Footprint: Ending Overshoot

The Ecological Footprint, developed in the 1990s by Matthis Wackernagel and William Rees, is a measure expressing how much bioproductive land is needed for meeting human consumption. It consists of various factors: land use for infrastructure, land use for agricultural activities and fishing, and (potential) land use for compensating CO_2 emissions from non-renewable energy resources.

In 2005, the Earth's biocapacity is estimated on 1.8 global hectares per person (at a global population of just over 6 billion). Yet, the resource extraction and emissions caused by the consumption of an average European caused a use of around 4.6 gha bioproductive land. Population growth to 9 billion people in 2050 would make shrink the available biocapacity to around 1.2 Gha/person. This implies that even in the absence of economic growth, in a world where each citizen can claim equal rights to bioproductive land, the average European should reduce its ecological footprint with a factor of 4–25 % of their current footprint. For US citizens, now using 9.6 gha/per person, this would mean a reduction of a Factor of 10–10 % of their current footprint (WWF 2006).

conflicts about access to natural resources will not be avoided, unless we find ways to use resources more efficiently, as well as more equally (EEB 2009).

There is considerable debate about fundamental questions and the strategies to follow, discussed in Sect. 6.2. Section 6.3 introduces the key leverage points for change, and discusses the decoupling potential per leverage points. A Sect. 6.4 with implications for policy and monitoring and a concluding section complete this chapter.

6.2 Fundamental Strategic Questions – Towards a 200 Trillion Dollar Economy?

6.2.1 Introduction

In principle, the goal of economic development is to contribute to quality of life. Our primary interest is hence to see how final 'quality of life' can be de-linked from environmental impact. The basic formula to describe relation between production, wealth and environmental impact was first proposed by the famous $I = P \times A \times T$ equation of Ehrlich and Holdren (1971), with:

I = Environmental Impact
P = Population (in capita)
A = Affluence per capita
T = (Technical)eco-efficiency of production.

Some fundamental and persistent debates have arisen about the key characteristics of the sustainability strategy to follow. Can we bet on technical breakthroughs (i.e. improving T) alone or should we set limits to (economic) growth (i.e. capping A; see e.g. Meadows et al. 1972; Daly 1991; Jackson 2009)? And in relation, should we question the concept of a consumerist society altogether (e.g. Schumacher 1973; Ehrenfeld 2008)? Should we manage resource input into the economy or focus on environmental impacts of our ways of production and consumption (e.g. EC 2003)? The following sections analyse these questions to set the scene for the further analysis of resource efficiency policies in Sect. 6.3.

6.2.2 Growth Versus De-growth

Probably the most fundamental debate about sustainability is the question if economic growth, a goal taken for granted by most if not all governments on the globe, should not be limited. In 1972, this point was raised by first report of the Club of Rome, 'Limits to Growth' (Meadows et al. 1972), and authors such as Daly (1991), who coined the term 'steady state economy'. These authors hold it for not conceivable that technical progress alone will provide so much efficiency improvements, that limitless economic growth on a finite planet will become possible. Loosely following the argument of Jackson (2009): it seems now widely shared that carbon emissions need to be reduced by a factor of 5 by 2050 compared to 1990 (cf. Stern 2006; IPCC 2007). This may just be feasible if all technical options available will be used. But if we also want to repeat the phenomenal factor 20 global economic growth between 1900 and 2000 in the twenty-first century, we look at carbon intensity reductions of a factor 50 or more, which seem illusive.

Yet, these are the growth rates to which policy, business and consumers in the West have got used to and now see as 'normal'. 'De-growth' even seems at odds with how our economic system currently works. As amongst others argued by Jespersen (2004) and Jackson (2009), in most western economies labour efficiency improves with 2–3 % a year. Without economic growth, the result is more jobless people, hence less consumer expenditure, less tax revenues, and in turn less government expenditure or higher government debt – in sum, an economy in crisis. Recently, Peter Victor (2008) showed for Canada that a no-growth economy only can be stable if the number of working hours is decreased without lowering salaries proportionally.

This debate is further complicated by the fact that a large part of the global population is not yet able to live decent lives with the income they have. As will be shown later, it may be doubtful if income growth beyond certain thresholds still will improve quality of life. Yet, it is also clear that below a specific income threshold, people are confined to low-quality or even miserable lives. They die early. They don't have access to education or other basic facilities. They live in slums. Obviously, income is not the sole determinant for this, but a very important one. Various studies have plotted income of people or countries versus the Human Development Index, life expectancy, or simply experienced quality of life (e.g. Worldwatch Institute 2008; Jackson 2009, UNDP undated). All such studies showed that such indicators improve until an income of 10–15,000 $ per capita, and then level off. This strongly suggests that for providing 'decent lives' to their citizens countries need an income per capita in this order of magnitude.

This simple piece of information now allows making some ballpark estimates of how a twenty-first century global economy could look like. With probably nine billion people on earth by 2050 (cf. Lutz 2004), all just on this minimum acceptable income level, the global economy would need to have a size of around 100 trillion $. This scenario however implies a significant income reduction in Western economies, and a full stop of growth in the fast developing BRICS countries, which seems not realistic. In 2005, the 1.1 billion people in OECD countries had an average income of about 35,000 US$.[2] Even a radical reduction of yearly growth targets to below 1 % per year will bring this to 50,000 US$ in 2050. It further can be expected that a sizable part of the 2.5 billion people living in the BRICS[3] countries will catch up with Western wealth levels (cf. Myers and Kent 2004). Under the simple assumption that by 2050 about 2 billion people almost inevitably will earn around 35–50,000$/year, and that the remaining 7 billion people would need to reach a minimum acceptable average income of 10–15,000$, the global economy would end up having a size of around 200 trillion $ in 2050. Even this modest 'limits to growth' scenario implies still a Factor 4 economic growth compared to global GDP, which was about 50 trillion $ around 2,000.

[2] Based on population and GDP/person data from OECD (2008).

[3] Brazil, Russia, India, China, South Africa.

6.2.3 Resource Input Versus Impact Limitations

The need for radical 'Factor X' objectives seems to be accepted by many as a kind of general vision (e.g. Factor 10 Club 1997). But translating this notion to goals for specific sectors or impact categories generates much more discussion. Various authors – particularly from what can be called the 'Wuppertal school' – argue that ultimately material use drives all impacts caused by our economic system. Hence, each sector and activity has to contribute a radical reduction of material use per final consumption unit (e.g. von Weizsacker et al. 1997; Factor 10 Club 1997; Hinterberger et al. 1997). But others frame the problem differently. The EU rejects in its Communication on a Strategy for Natural Resources the idea that the sheer input of resources into the economic system form invariably a problem. The real problems are the emissions related to resource use – such as CO_2 from fossil fuels (EU COM 2003). For many resources a direct link between resource use and emissions is absent (e.g. Nielsen et al. 2004). A similar position was taken by the Dutch Ministry of Environment Advisory Council. They see certain emissions (particularly of greenhouse gases), the use of certain biotic resources and biodiversity loss as problematic, but not the use of non-renewable resources in itself (VROM Raad 2002).

In practice the difference between these positions may not be as large as it seems. For instance, it is unlikely that an emission problem such as global warming will be solved without radical changes in our energy provision system that is now still largely based on fossil energy resources. Indeed, the simple math from the former section imply that with a Factor 4 economic growth and the need for a Factor 5 reduction in carbon emissions, the required reduction in carbon intensity of the economy is a Factor 20. Hence, at least for some types of impact, and for some resources, the need for absolute decoupling exists.

6.2.4 Implications: Radical Resource Efficiency Improvements Required for Food, Mobility and Housing

The implications for a resource efficiency agenda of this analysis are rather clear. A 'limits to growth' strategy that keeps global GDP at current levels seems morally not acceptable and politically illusive. It would not provide the vast majority of global citizens with an income that lets them live decent lives. It would expect rich countries to accept a sharp reduction of their existing income, and deny the new middle class in the BRICS to catch up. The most radical 'limits to growth' agenda that still truly allows for worldwide poverty eradication and avoids drastic income cuts in rich countries, is aiming at a 200 trillion $ economy somewhere in the twenty first century.

This implies a Factor 4 economic growth compared to the situation of around 2,000. With in several areas, such as climate change, absolute impact reductions of a Factor 5 required, radical reductions of impact intensities of a Factor 20 in such areas seem inevitable.

6.3 Intervention Options for Decoupling and Potential Per Decoupling Strategy

6.3.1 Introduction

The so-called IPAT formula presented earlier directly points at the three main drivers for environmental impact: population, affluence and technical efficiency. Yet, for the analysis of how to reach decoupling the formula is less useful. The product of P and A equals economic expenditure. This leaves T as the (only) factor that can lead to decoupling. The reduction of neither population nor wealth is a viable strategy for reducing impact. First, population growth is currently not the key determinant for environmental impact, and difficult to influence anyway.[4] And second, as discussed in Sect. 6.2, reduction of affluence is not realistic, particularly for the world's poorer majority. Note as well that the whole concept of sustainable development is making development possible within the carrying capacity of the Earth (WCED 1987). Various authors hence have proposed formulas in which the 'T' factor is further decomposed (see e.g. de Bruyn 1998, 1999; Cleveland and Ruth 1999; Chertow 2000; VROM Raad 2002; Azar et al. 2002; Tukker and Tischner 2006). We propose here the following decomposition and related decoupling strategies (see Box 6.3):

Box 6.3: Relation Between Quality of Life and Environmental Impact

The relation between impact and consumer expenditure (CE, which is the product of P and A) can be written as follows. What we after de Bruyn (1998) call 'product composition of expenditure' (PCE) determines which fraction of the consumer expenditure CE is spent on the use of material products or immaterial value. The intensity of the use of products (IUP) determines how many products have to be produced. The (product) efficiency of production (PEP) determines how much production activity is needed to produce these products. The impact efficiency of technology (IET; the emission factors and resource intensity of production processes at a given output) determines how much impact per unit production occurs. Multiplication of consumer expenditure with these factors gives the total environmental impact (formula a-c). In environmental input–output analysis, life cycle impacts are calculated by multiplying a consumption vector, a technology matrix and an int ervention matrix, which fits well with the structure proposed here. The product of CE and PCE is actually the consumption vector, which distributes the income in a region over different

(continued)

[4] As discussed, most forecasts now predict a world population of 9–10 billion people in 2050 (Lutz et al. 2004). Furthermore, about 70–80 % of the current sustainability problems are driven by consumer expenditures of 1–2 billion people from developed economies and the (growing) middle class in emerging economies (compare Myers and Kent 2004).

Box 6.3: (continued)

expenditure categories. The intervention matrix reflects emissions and resource use per unit process and equals IET. The technology matrix covers the two remaining factors (see e.g. Heijungs 1997; Weidema et al. 2005; Tukker et al. 2006)

(a) Impact =	$\frac{\text{Impact}}{\text{Production activity}}$	× $\frac{\text{Production activity}}{\text{Product output}}$	× $\frac{\text{Product output}}{\text{Product use}}$	× $\frac{\text{Product use}}{\text{Euro spent}}$	× Consumer expenditure
(b) Impact =	Impact efficiency of technology	× Product efficiency of production	× 1/Intensity of use of products	× Product composition of expenditure	× Consumer expenditure
(c) I =	IET	× PIP	× IUP^{-1}	× PCE	× CE
(d) Impact =	Intervention matrix	× Technology matrix		× Consumption vector	

The relation with quality of life (QoL) and consumer expenditure (CE) can now be written as follows. First, many consumer expenditures merely are 'obligations' (Segal 1999): without doing them, one cannot function normally in society (for instance, the need for driving a car to shopping centre since there is no local village shop (anymore), or buying expensive suits since that is the dress code in the job one has). We call them expenditures on obliged needs, CE_ON, which must be subtracted from CE. Second, much of people's Quality of life is not directly market-related (e.g. friendship, a feeling of control over one's destiny, safety of the neighbourhood). Such Quality of life from Non-market sources (QoL-NM) must be added to CE. These two corrections lead to a true Quality of life (formula e-f) and allow for calculating the benefit of enlarging the consumer expenditure CE. If extra CE has no influence on the non-market Quality of Life (QoL_NM), nor the about of 'obliged expenditure' (CE_ON), all expenditure contributes to an improved quality of life. However, if the extra consumer expenditure goes at the expense of non-market sources of Quality of Life, or enlarges the expenditure on 'obliged' consumption, the net effect on Quality of life is less than proportional (formula g-h).

(e) Quality of life	= Consumer expenditure	+ Quality from non-market sources	− Consumer expenditure on 'obligatory needs'
(f) QoL	= CE	+ QoL_NM	− CE_ON
(g) $\frac{\delta QoL}{\delta CE}$	= $\frac{\delta CE}{\delta CE}$	+ $\frac{\delta QoL\_NM}{\delta CE}$	− $\frac{\delta CE\_ON}{\delta CE}$
(h) % change in quality of life per % rise of consumer expenditure	= 1	+ Change in quality of non-market sources by rise of consumer expenditure	− Change in expenditure on obliged needs by rise of consumer expenditure

Source: Tukker and Tischner (2006), Chapter 4.

1. the impact efficiency of technology (i.e. the emissions generated and resources used in a given technical production structure);
2. the product function efficiency of production (i.e. the output of a given production system);
3. the intensity of use of product functions;
4. the product function composition of expenditure (i.e. to what extent income is spent on material artefacts);
5. the ratio of Quality of Life and expenditure.

It is of course interesting to know which production-consumption chains are most relevant when doing attempts to decouple environmental impact from quality of life. This question has been answered unambiguously by a large number of studies (see e.g. Nijdam and Wilting 2003; Hertwich 2005; Weidema et al. 2005; Tukker 2006): consumption expenditure on food and drink, mobility, housing and energy using products drive 80 % of the impact of final consumption in Western economies.

6.3.2 'Reducing Emission Factors'

The first decoupling strategy can be called 'enhancing the impact efficiency of production', or shortly: 'reducing emissions factors'. This 'emission control' strategy was probably the first to be applied in environmental polices of many countries and probably still is the most applied. It hence often is referred to as the first or second generation of environmental policy (e.g. Simons et al. 2001). It essentially concerns reducing resource input and emissions of the system without fundamentally changing the technology of production and products produced:

1. Implementing end-of pipe measures (e.g. catalysts on cars)
2. Implementing cleaner technology (e.g. a more efficient paint spraying technology in paint shops).

This decoupling strategy has been applied with a lot of success in certain cases indeed. Particularly for small mass flows (toxic emissions, SOx) this strategy has brought major emission reductions (e.g. MNP 2005). An example are the projected emissions from car traffic in the EU15 between 1990 and 2020. Despite a considerable rise in amount of car kilometres, emissions of some substances will diminish with a factor 4–7 due to implementation of stringent emission standards by the EU (see Table 6.1). The table also shows this works well for 'by products' such as NOx, VOC and CO, but not for the main mass flows (in this case CO_2). This is a clear illustration of the limits of this 'end of pipe' decoupling strategy (compare also de Bruyn 1998).

Table 6.1 Emission estimates for automotive traffic in the EU15 between 1990 and 2020

Substance	Emission EU15 (1990)	Emission EU15 (2000)	Emission EU15 (2020)
Km	2.150 Bio	2.700 Bio	3.400 Bio
CO_2	570 Mio T	710 Mio T	900 Mio T
NOx	5.5 Mio T	3.8 Mio T	1.1 Mio T
CO	19 Mio T	17.5 Mio T	5 Mio T
VOC	3.5 Mio T	2 Mio T	0.5 Mio T

Adapted from: Ntziachristos et al. (2002)

6.3.3 The Same Output with Less Production Effort

The second decoupling strategy can be called 'enhancing the (product) efficiency of production', or shortly: creating the same output with less production effort. Here, the same product functionalities are produced as output with less production (and use phase) activities. This can take place in two forms:

1. A (usually marginal) improvement of the production efficiency of the existing system An example would be producing the same amount of goods in shorter production runs;
2. A radical innovation of the system that delivers the product functionality, e.g.:
   - An energy supply based on the use of 'solar income' (solar, wind, and water energy)
   - Radically improved production processes in sectors such as chemistry, agriculture, etc. by application of e.g. nano- and biotechnology.

In the latter case, the (technology) structure in society undergoes radical changes. Usually, 'Factor X' advocates point at this form of innovation (in part in conjunction with the following one) as the way forward to reduce emissions and material use per functionality drastically (see for example Weaver et al. 2000).

6.3.4 Intensifying the Use of Products

The third decoupling strategy can be called: Enhancing the intensity of use of products, or in short: stimulating multiple use.

This strategy seeks to enhance the intensity of use of product functions (in the form of material artefacts), once they are produced. Approaches that one can think of:

1. Designing products with multiple functionalities;
2. Developing systems of renting, sharing and pooling the same product;

The work of Meijkamp (2000) and Mont (2004) shows that such measures typically can lead to a factor 2 improvement of environmental impact.

6.3.5 Reducing the Material Intensity of Expenditure

The fourth strategy can be called Reducing the product composition of expenditure, or in short: spending with less impact. It requires consumers to shift their expenditure from material to immaterial value components:

1. Shifting expenses to the purchase of immaterial or intangible value. Such immaterial value is created when customers attribute an extra wealth and hence start to pay for value elements such as:
   - Experiences, atmosphere, etc.
   - Brand names, image, etc.
   - Intellectual property rights, such as copyrights and patents (compare e.g. legally downloaded music files and software, for which the price is mainly determined by copyrights and (almost free) illegal ones).
2. Shifting expenses to or realising economic growth by products and services with a relatively low life cycle impact (which is, in fact, a variant of the former point).

There seems to be a wide optimism about this strategy that bets on growth in terms of 'quality' and expenditure of services like culture, media and amusement (e.g. RMNO 1999; VROM Raad 2002). The question however is if this optimism is justified.[5] This can be illustrated with Fig. 6.1. It lists the life cycle impacts per Euro for the total final consumption expenditure in the EU25, split up in 280 expenditure categories (Tukker et al. 2006; Huppes et al. 2006).[6] The surface of the figure is the total environmental impacts caused by European final consumption expenditure. In theory, shifting expenditure from the high impact per Euro categories to the low impact per Euro categories would reduce the total impact. Yet, the flexibility to make this shift is limited. The top 5 % consists of foodstuff, and one cannot expect humanity to stop eating.[7] The bottom 5 % consists of services such as insurances, but these are in fact often bought in relation to other, high impact expenditure categories (e.g. car driving and housing). Neglecting these top and bottom 5 %, the difference in impact per Euro between the 'dirtiest' and 'cleanest' category is at most a Factor 4. Even if massive expenditure shifts from the 'dirtier' to 'cleaner' categories would be possible, this will hence at best give a Factor 2 net improvement in environmental impact. The conclusion seems clear: expenditure shift alone, without any technical improvement, will not lead to drastic reductions in impact of final consumption expenditure.

---

[5] For instance, much 'amusement' consists of TV-watching – and TV's with a plasma screen, which compete with fridges as a major electricity user in the home, are now penetrating fast in the Western world.

[6] The environmental impacts in the figure are an aggregation of well known Life cycle impact assessment categories such as global warming potential, acidification, eutrophication, etc. We refer to Tukker et al. (2006) for further methodological discussion.

[7] Meat scores of course higher than most other foodstuff, and a shift to diets with less expenditure on meat is of course not an impossible option. Yet, it is not easy to stimulate radical diet shifts (e.g. Tukker et al. 2009, 2011).

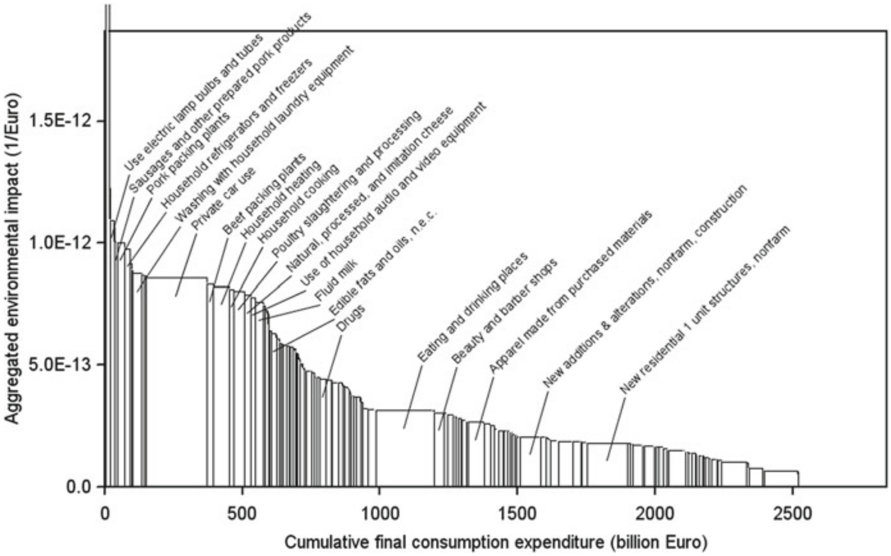


Fig. 6.1 Impact per Euro versus total expenditure for 280 expenditure categories, EU-25 (Source: Tukker et al. (2006); this figure kindly provided by Arjan de Koning of CML, Leiden University)

6.3.6 Enhancing Quality of Life Per Euro Spent

The fifth and last strategy is aiming at getting more ‘bang for the buck’: *Enhancing Quality of Life per Euro spent*. This strategy focuses on the two elements that can be identified as

1. Reducing ‘obligatory needs’ by creating ‘no need’ contexts: living conditions where one simply needs less material artefacts to reach the same result (e.g. a spatial policy planning that succeeds in reducing the need for commuting). Or, as a negative example: a society not to careful about worker conditions may see a relatively high expenditure on health care. Safety in the neighbourhood, in most European countries something that could be taken for granted 40 years ago, now needs continuous watch via camera systems, more intensive patrols, and instalment of burglar proof windows and doors.
2. Enhancing non-market related quality of life factors. Sometimes, ‘economic growth’ is little more than attaching a price tag to a ‘service’ that used to be for free. Taking care of toddlers, formerly done at home by a parent that was not involved in the formal economy, is now outsourced to a Kindergarten.[8] And in the safety example above, despite all measures the ‘quality’ experience still may be reduced.

[8] In their – otherwise very inspiring – book ‘The Experience Economy’, Pine and Gilmore (1999:97) give in this respect a rather depressing quote: ‘The history of economic progress consists of asking money for something that once was free’.

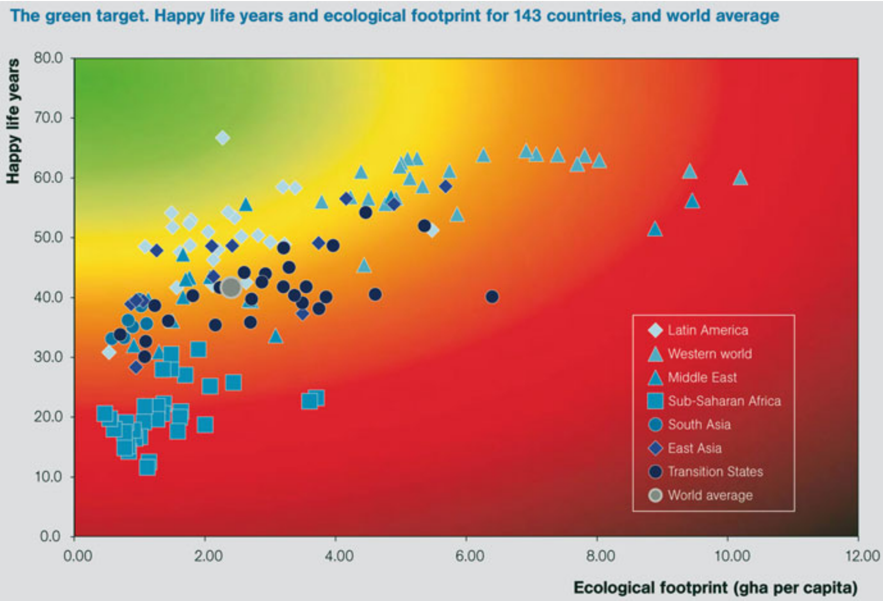


Fig. 6.2 Happy life years versus the ecological footprint for 143 countries (Source: Abdallah et al. 2009)

Various studies have plotted happiness of people (assessed via surveys) against income (e.g. between different countries or as change over time). These studies showed a rather surprising result: once a certain threshold in income is surpassed, additional income has no influence on happiness (Veenhoven undated). There is also a considerable body of literature that suggests that fulfilment of basic needs in modern society now is only possible by using many material artefacts (Segal 1999). So, though the Japanese national income grew with a factor 5 between 1959 and 1991, the increase in happiness was close to zero (cf. Hofstetter and Ozawa 2004). This suggests – at least – that the efficiency of income to create quality of life may show considerable room for improvement (Jackson et al. 2004; Jackson 2004). An illustrative example is given in the 'Happy Planet Index' report of the new economics foundation. According to the authors (Abdallah et al. 2009) '[i]t measures the ecological efficiency with which, country by country, people achieve long and happy lives. In doing so, it strips our view of the economy back to its absolute basics: what goes in (natural resources – measured as the ecological footprint of consumption – AT), and what comes out (human lives of different length and happiness).' Figure 6.2 suggests strongly that high footprints (related to high consumption per capita and high GDPs) are no precondition for a high quality of life. One could even go that far that having a very high GDP (and hence footprint) per capita is no sign of progress, but rather a sign of inefficiency in providing what truly matters: countries with equal quality of life and life years may differ up to a factor 4 in footprint.

6.4 Implications for Policy and Monitoring

6.4.1 Policy

Table 6.2 summarises the analysis from the former chapter. Where each decoupling strategy on its own has difficulty in realising a Factor 10 or more decoupling, all strategies in combination may deliver such reductions.

Where this seems promising news, the existing realities in sustainability policy should lead to a more prudent conclusion. The decoupling strategies discussed deal either with a (radical or incremental) change in the technical production system, and a (radical or incremental) change in the way how consumers interact with the system. Figure 6.3 gives a simple matrix with change in production on the x-axis, and change in consumption on the y-axis, creating four quadrants by differentiating between incremental and radical change. The decoupling strategies discussed were placed in this matrix. It is clear that if the change is radical, and affects both consumption and production, the higher the potential is for radical sustainability gains.

It seems safe to say that most existing sustainability policies focus on reducing emission factors or relatively marginal adaptations of existing production systems: the 'marginal' quadrant in Fig. 6.3. From such policies one cannot expect radical 'Factor X' decoupling. It is essential that the potential of the other decoupling strategies is used. It is hence essential that important shifts in policies take place, focusing more on the other (often more consumption oriented) decoupling policies.

Where this already may be a significant policy challenge, one has to remember too that a Factor 10+ decoupling will only be sufficient under the 'modest growth' scenario provided in Sect. 6.2. Repeating the factor 20 economic growth of the Twentieth century in the twenty first century will imply most likely further environmental pressures which cannot be offset by the presented decoupling strategies. Learning

Table 6.2 Ballpark data on the potential contribution of intervention mechanisms to decoupling of impact and quality of life

Intervention mechanism	Potential reductions of impact per unit quality of life (excluding rebounds)
Enhancing impact efficiency of production	Small mass flows: several factors by end of pipe or cleaner technology
	Large mass flows: limited
Enhancing product function efficiency output of production	Limited to intermediate, in case of incremental improvements and re-design
	Factor X in case of system innovation
Enhancing the intensity of use of product functions	Factor 2 or more, depending on the sharing, pooling or function combination system
Reducing the product composition of expenditure	Factor 2 (if limited to changes within existing product and service categories)
Enhancing the ratio quality of life and consumer expenditure	Several factors?

Source: Tukker and Tischner (2006)

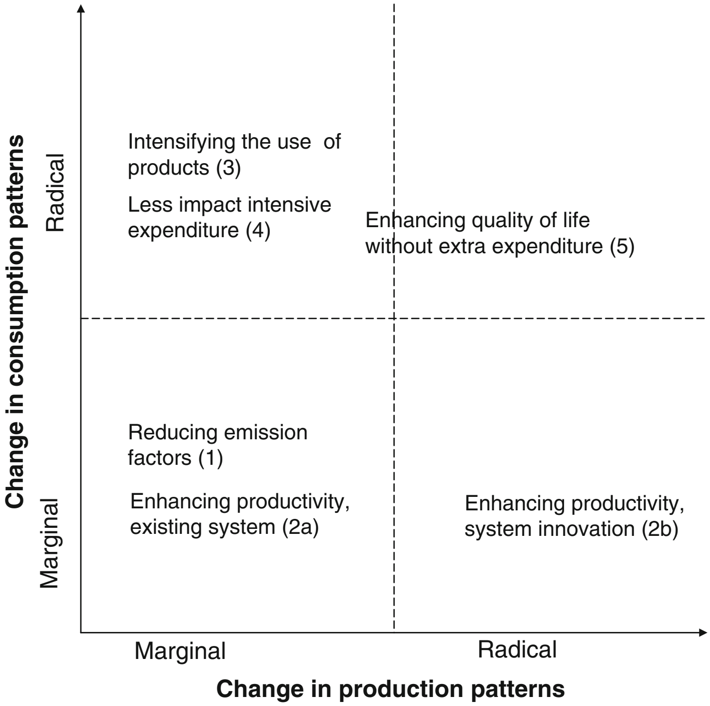


Fig. 6.3 Change of production and consumption patterns in relation to different decoupling strategies (Source: Tukker and Tischner 2006)

how to create an economic system that is stable under the conditions of limited growth seems hence another challenging and probably controversial point on the sustainability policy agenda (cf. Jackson 2009; Victor 2008).

6.4.2 Monitoring and Indicators

The conclusions above also have implications for monitoring. Currently, there is much interest in monitoring if economic growth is decouple from natural resource use or generation of emissions. Typically, on the basis of historical data one tries to analyse via 'decomposition analysis' which factor has contributed to decoupling: reduction of emission factors, changes in production (patterns), or changes in consumption expenditure patterns (including more intensive use of products). The best way of doing this is gathering economic and environmental pressure data in an environmentally extended input–output (EE I-O) framework. Such an EE I-O table works as follows. In the I-O part the value of the transactions between all sectors in the economy are mapped (hence input and output). The business to consumer sectors in this matrix deliver for final consumption, but of course these sectors have inputs from other sectors, and so on. By using a backward calculation procedure developed by Noble prize laureate Leontief, one can calculate how much added value was contributed by each sector to a product or service finally delivered to a consumer. Add to this the total final consumption expenditure for each product/service category, and a picture of the full economy in a country arises. When finally for each sector the environmental impacts per Euro turnover are gathered (the so-called environmental extensions), calculating the total life cycle impacts of consumption becomes a simple multiplication of consumption expenditure on a specific category, the contribution of each production sector to 1 Euro of such a final consumption product, and the impact per Euro in each sector. If now time series of consumption data, the I-O data and environmental extensions are available, via decomposition analysis one can see if a change in emission factors, production patterns of consumption patterns or total consumption expenditure was the reason for growth of environmental impacts. We refer to the standard literature on input–output analysis (e.g. Leontief and Ford 1970; Miller and Blair 2009; Ten Raa 2005).[9]

Yet, this obviously is not sufficient. Such monitoring focuses totally on the financial part of the economy, and misses the relation with quality of life (Sect. 6.3.6). Where the discussion there has relation with efforts to adjust GDP to have it reflected real wealth rise in a better way, it goes further. It strongly calls for measurement of 'happiness' or 'quality of life' as a parameter in its own right. Only then one is capable to analyse if more money indeed leads to more of what matters: quality of life (compare van den Bergh 2005).

6.5 Conclusions

In sum, this paper comes to the following conclusions. First, it is politically not realistic and morally not acceptable to limit economic growth and keep the global GDP at current levels. A minimum acceptable size of the global GDP in the twenty-first century seems 200 trillion $, 4 times the global GDP of around 2,000, in this scenario, OECD countries are not forced to reduce wealth, the growth in the BRICS does not need to be reduced to unrealistically low levels given existing trends, and the remaining World population has an income providing the minimal conditions for a decent life. This scenario has two policy implications:

- This Factor 4 economic growth in combination with the need for absolute reductions in impact (e.g. a Factor 5 for climate change) implies that significant, but with conscious efforts still achievable decoupling targets must be realised.
- A significant higher economic growth would imply much higher, maybe unachievable decoupling targets. It seems in any case that particularly Western countries cannot expect to experience the phenomenal Factor 10–20 economic growth realised in the Twentieth century in the twenty first century as well – which implies an adaptation to a new situation in itself.

[9] See for practical examples for instance: Weidema et al. (2005), Tukker et al. (2009).

As for the decoupling question, this paper shows (as have done many others) that there is probably a considerable potential for realising decoupling of environmental pressure and growth of quality of life. However, it is rather uncertain if the potential for decoupling will be realised almost automatically once countries become wealthier, as e.g. the theory of the 'environmental Kutznets curve' suggests. For sustainability problems where decoupling is seen as imperative, some kind of targeted intervention seems needed. Just addressing the production part of the production-consumption system is – relatively spoken – the easy option. One only has to address how companies produce, and to some extent, certain characteristics of the products they produce. Yet, this leaves an important potential for decoupling untapped, and, indeed, implies that one does not want to address the very fundamental question that apparently Western societies do not succeed in enhancing (perceived) quality of life at the current pace of economic (and related material use) growth. Addressing the markets and interaction between consumption and production hence also seems relevant. In the words of Scherhorn (2005): we should learn to use the market to foster competition supportive to sustainability, and we would like to add: to foster quality of life (Tukker and Tischner 2006).

This also has implications for monitoring and decoupling indicators. Where traditionally one would look at the impact per Euro of a production activity, a product, or a consumption activity, we now also have to include the relation between expenditure and quality of life. The type of work exemplified by the nef's 'Happy Planet Index' report should be structurally repeated. Measuring happiness, or qualify of life, is probably more relevant than the painstaking measurement of GDP, on which our statistical offices devote a large part of their resources. Only a minor shift of these resources to monitor this new parameter would provide over time an excellent insight in how consumption and production should be organised to create long, high quality lives for the many.

References

Abdallah S, Thompson S, Michaelson J, Marks N, Steuer N (2009) The (un)happy planet index 2.0. An index of human well-being and environmental impact. New Economics Foundation, London

Azar C, Holmberg J, Karlsson S, with contributions by Persson T, Ayres R, Sterner Th, Nasson J (2002) Decoupling – past trends and prospects for the future. Chalmers University of Technology and Gotenburg University for the Swedish Environmental Advisory Council, Ministry of Environment, Stockholm

Chertow MR (2000) The IPAT equation and its variants. Changing views on technology and environmental impact. J Ind Ecol 4(4):13–29

Cleveland CJ, Ruth M (1999) Indicators of dematerialisation and the materials intensity of use. J Ind Ecol 2(3):15–50

Daly H (1991) Elements of environmental macro-economics. In: Costanza R (ed) Ecological economics: the science and management of sustainability. Columbia University Press, New York, pp 32–46

De Bruyn S (1998) Dematerialisation and rematerialisation. In: Vellinga P, Berkhout F, Gupta J (eds) Managing a material world. Kluwer Academic Publishers, Dordrecht/London/Boston, pp 147–164

De Bruyn SM (1999) Economic growth and the environment. An empirical analysis. PhD thesis, Free University of Amsterdam. In Tinbergen Institute Research Serie, 216. Thela thesis, Amsterdam

Ehrenfeld JR (2008) Sustainability by design. A subversive strategy for transforming our common culture. Yale University Press, New Haven/London

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

European Commission (EC) (2003) Towards a thematic strategy on the sustainable use of natural resources. Communication from the Commission to the Council and the European Parliament. COM (2003) 572 final

European Environmental Bureau (2009) Blueprint on European sustainable consumption and production

Factor 10 Club (1997) Statement to government and business leaders. Factor 10 Institute, Carnoules

Heijungs R (1997) Economic drama and the environmental stage: formal derivation of algorithmic tools for environmental analysis and decision-support from a unified epistemological principle. PhD thesis, CML, Leiden University, Leiden

Hertwich E (2005) Life cycle approaches to sustainable consumption: a critical review. Environ Sci Technol 39(13):4673–4684

Hinterberger F, Luks F, Schmidt-Bleek F (1997) Material flows vs. 'natural capital': what makes an economy sustainable? Ecol Econ 23(1):1–14

Hofstetter P, Ozawa T (2004) Minimizing CO2-emissions per unit of happiness. In: Proceedings of the 3rd international workshop on sustainable consumption, 21 and 22 October 2004. Japan SNTT and AIST, Tsukuba

Huppes G, de Koning A, Suh S, Heijungs R, van Oers L, Nielsen P, Guinée JB (2006) Environmental impacts of consumption in the European Union using detailed input–output analysis. J Ind Ecol 10(3):129–146

International Panel on Climate Change (IPCC) (2007) Fourth assessment report. Summary for policy makers. Intergovernmental Panel on Climate Change, Geneva

Jackson T (2004) Chasing progress. Beyond measuring economic growth. New Economics Foundation, London

Jackson T (2009) Prosperity without growth. Earthscan, London/Sterling

Jackson T, Jager W, Stagl S (2004) Beyond insatiability – needs theory, consumption and sustainability. In: Reisch L, Røpke I (eds) The ecological economics of consumption. Edward Elgar, Cheltenham

Jespersen J (2004) Macroeconomic stability: sustainable development and full employment. In: Reisch L, Røpke I (eds) The ecological economics of consumption. Edward Elgar, Cheltenham, pp 233–250

Joseph PB II, Gilmore JH (1999) The experience economy. Harvard Business School Press, Boston

Leontief W, Ford D (1970) Environmental repercussions and the economic structure: an input–output approach. Rev Econ Stat 52(3):262–271

Lutz W, Sanderson WC, Scherbov S (eds) (2004) The end of world population growth in the 21st century. New challenges for human capital formation and sustainable development. Earthscan, London

Meadows DH, Meadows D, Randers J, Behrens WW III (1972) The limits to growth. Universe Books, New York

Meijkamp R (2000) Changing consumer behaviour through eco-efficient services – An empirical study on car sharing in the Netherlands. Thesis, TU Delft

Milieu– en Natuurplanbureau (MNP) (2005) Milieubalans 2005 (Environmental balance 2005). MNP/RIVM, Bilthoven

Miller RE, Blair PD (2009) Input–output analysis: foundations and extensions. Cambridge University Press, Cambridge, UK

Mont O (2004) Product-service systems: panacea or myth? PhD thesis, IIIEE, Lund University, Lund

Myers N, Kent J (2004) The new consumers. The influence of affluence on the environment. Island Press, Washington/Covelo/London
Nielsen PH, Tukker A, Weidema BP, Lauridsen EH, Notten P (2004) Environmental impact of natural resources. ESTO/EU DG JRC – IPTS, Sevilla
Nijdam DS, Wilting HC (2003) Milieudruk consumptie in beeld (A view on environmental pressure on consumption), RIVM report 771404004, RIVM, Bilthoven
Ntziachristos L, Tourlou PM, Samaras Z, Geivanidis S, Andrias A (2002) National and central estimates for air emissions from road transport. EEA, Copenhagen. ISBN 92-9167-416-8
OECD (2008) OECD Factbook 2008: economic, environmental and social statistics. OECD, Paris. Data available from: http://oberon.sourceoecd.org/vl=822201/cl=57/nw=1/rpsv/fact2008/. Accessed 14 Sept 2009
RMNO (1999) Kennis voor een duurzame economie (RMNO-nummer 141). RMNO, Rijswijk
Scherhorn G (2005) Sustainability, consumer sovereignty and the concept of the market. In: Grunert KG, Thøgersen J (eds) Consumers, policy and the environment. A tribute to Folke Ölander. Springer, New York
Schumacher EF (1973) Small is beautiful. Harper and Row, New York
Segal JM (1999) Graceful simplicity: towards a philosophy and politics of simple living. Holt, New York
Simons LPh, Slob A, Holswilder H, Tukker A (2001) The fourth generation. New strategies call for new eco-indicators, environmental quality management, winter 2001, p 51
Speth JG (2008) The bridge at the edge of the world. Yale University Press, Yale/London
Stern N (2006) The economics of climate change. The stern review. Cambridge University Press, Cambridge
Ten Raa T (2005) The economics of input–output analysis. Cambridge University Press, Cambridge
Tukker A (ed) (2006) Special issue on priorities for environmental product policy. J Ind Ecol 10(3):183–198
Tukker A, Tischner U (2006) New business for old Europe. Greenleaf Publishing, Sheffield
Tukker A, Huppes G, Suh S, Geerken T, Jansen B, Nielsen P (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
Tukker A, Poliakov E, Heijungs R, Hawkins T, Neuwahl F, Rueda-Cantuche JM, Giljum S, Moll S, Oosterhaven J, Bouwmeester M (2009) Towards a global multi-regional environmentally extended input output database. Ecol Econ 68(7):1928–1937
Tukker A, de Koning A, Wolf O, Bausch-Goldbohm S, Verheijden M, Kleijn R, Pérez-Domínguez I, Rueda-Cantuche JM (2011) Environmental impacts of changes to healthier diets in Europe. Ecol Econ 70:1776–1788
Van den Bergh J (2005) BNP? Weg ermee! [GDP? Throw it away!]. Economisch Statistische Berichten ESB nr. 4475 (18 November)
Veenhoven R (undated) World database on happiness. Accessed 24 May 2005. http://www2.eur.nl/fsw/research/happiness/
Victor P (2008) Managing without growth – slower by design not disaster. Edward Elgar, Cheltenham
von Weizsacker E, Lovins AB, Lovins LH (1997) Factor four: doubling wealth, halving resource use. Earthscan, London
VROM Raad (2002) Milieu en Economie: ontkoppeling door innovatie (Environment and Economy – decoupling via innovation). Ministry of Environment Advisory Council, The Hague
WCED (World Commission on Environment and Development; (1987) Our common future. Oxford University Press, Oxford/New York
Weaver P, Jansen L, van Grootveld G, van Spiegel E, Vergragt P (2000) Sustainable technology development. Greenleaf Publishers, Sheffield

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

Worldwatch Institute (2008) State of the world 2008. Worldwatch Institute, Washington, DC

WWF (2006) Living planet report 2006. Gland. http://www.panda.org/about_our_earth/all_publications/living_planet_report/

Chapter 7
Macroeconomic Impacts of Efficient Resource Use

Bernd Meyer

7.1 Introduction

Neo-classical environmental economics places the avoidance of emissions of residual materials and pollutants to the natural environment at the centre of its approach. Microeconomic partial analysis is the common research approach in this field. The emissions of residual materials and pollutants are identified as external effects.

The problem is that these emissions are a normal and unremarkable part of the economic process. Furthermore, the approach is questionable because the emissions arise at many different stages of the process and are not independent of each other. Therefore, it cannot be expected that the partial analytical results of environmental economics still endure from a total analytical perspective (Ayres and Knees 1969, p. 287). Moreover, one has to bear in mind that avoiding emissions does not necessarily reduce the exploitation of natural resources, whereby, at the same time, nature is damaged, as illustrated by the following examples: We can notice that the search for strategies for the prevention of CO_2 emissions generates behaviour that causes new problems whilst old problems are seen as less urgent. The growing acceptance of the use of nuclear energy belongs to the latter point; the extraction of fuels from plants to the first point. Biodiesel from oilseed rape and ethanol for diesel engines are increasingly being adopted as renewable energy sources. That is why there is less acreage available for cultivation of foodstuffs. The prices for foodstuffs are connected to prices for fossil fuels, which seriously affects even the poorest people in the developing world in case of increasing prices. Another example are hybrid vehicles which emit less CO_2 through temporary use of an electric motor. Nevertheless, these hybrid vehicles show a disastrous eco-balance, because the

B. Meyer (✉)
Gesellschaft für Wirtschaftliche Strukturforschung mbH,
Heinrichstr. 30, D-49080 Osnabrück, Germany
e-mail: meyer@gws-os.com

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_7,

electric motor and the battery have to be produced and later on disposed of, additionally. The development of the so called CCS technology (Carbon Capture and Storage) is at the centre of the logic of the CO_2-emissions avoidance strategy: in electricity generation in coal-fired power plants, CO_2 is isolated by additional energy input and diverted to subterranean, natural storage facilities where it will hopefully remain. The latter has not yet been proven. If this system comes into operation by 2020, this may reduce CO_2 emissions from electricity generation but the consumption of raw materials will be further accelerated.

For the creation of a global environment policy, an alternative approach is available within a systematic and comprehensive macroeconomic analysis that examines interdependencies between economic development and strains on the environment and that avoids the problems described. The principles of Ecological Economics that were formulated by Ayres and Knees (1969), Daly et al. (1968) describe the following relation: the economy is embedded in nature, extracts its resources and returns to it residual materials and harmful substances. These material flows start with the extraction of resources and go back to nature via all production levels and consumption. The amount of emissions (evaluated in tons) to nature differs from the amount of all extractions from nature only in those material inputs which are a part of the capital stock within the valuated period. In the dimension of the physical material flow, there is no final consumption of goods. The economically active human finally uses, in his production and consumption activities, the services of nature which he takes out of the material flow. The physical structure of material extracted from nature is changed, but the material is not consumed. The conversion of material flow happens by input of labour, capital and energy which again requires material flows.

Ecological Economics sees the economy as a part of a greater whole. Its domain is the network of interaction between the economy and ecological areas (Costanza et al. 1991, p. 3). Daly (1991, p. 32) characterizes it, in contrast to environmental microeconomics, as “Environmental Macroeconomics”; Boulding (1981) classifies it as being close to Evolutionary Economics.

This perspective makes it possible to focus environmental policy on material extraction instead of emissions. Emissions are avoided “automatically” if material extraction is successfully reduced, but the avoidance of certain emissions does not necessarily mean, that extractions are reduced. In this context, it is important to consider that residual materials and pollutants are emitted in many and varied ways and in many unclear stages of the economic process and that such emissions are driven by an enormous amount of agents. In contrast the input of raw materials is clearly arranged in their combination with the economic process: A limited and well known number of agents is organizing material extraction. A sub-aim of environmental policy must be to increase resource productivity at all levels of production (efficiency) and to reduce the use of resources in consumption activities (sufficiency).

Environmental resource inefficiency exists in the sense (inefficiency of type I) that the relation between our well-being and actual resource consumption is not acceptable. The extraction of materials is much too high, since we already face problems that are linked to climate change and many other challenges that result from environmental damage. Economic growth in terms of monetary units in constant prices may be possible in the future, but only if resource productivity – measured as GDP in constant prices per resource input in physical units – grows more than GDP. A decoupling of economic growth and resource extraction with an absolute reduction in extraction in physical terms is necessary. We need strong resource saving technical progress, which may be induced by higher resource prices generated by the use of economic instruments like taxes.

But the problem is even worse. Fischer et al. (2004) argue that there also exists economic inefficiency in the sense (inefficiency of type II) that firms do not choose cost-minimizing strategies in relation to actual prices. It is recognized that the input of material and energy is managed very inefficiently. Jochem (2004) reports, for example, about unnecessarily heavy constructions of vehicles and machines and about wastage of material in industries and households. Based on the experience of well-known consultancy companies Fischer (2004) estimates the dimension of this problem as follows: in the manufacturing, building and construction sectors and public administration in Germany, 20 % of material and energy costs could be saved if one is prepared to invest the savings of 1 year (material savings) or of 6 years (energy savings) in measures to increase efficiency. 1/3 of the input consists of consultancy costs, 2/3 are additional capital costs.

With respect to material input, one could ask why companies act uneconomically. Fischer et al. (2004) affirm that management systems in many companies are inefficient regarding material input: controlling instruments do not normally show material losses explicitly. They are developed for the evaluation of labour costs because this factor has increased steadily in the past, whereas prices of resources showed strong cyclical moves but rarely long-term trends. Moreover, decisions for the purchase of machines are dominated by the price, whereas maintenance costs have been given a lower priority. The exchange of information about material management is often insufficient because of institutional problems.

In short, markets are not able to guarantee an ideal material management. Therefore, the state could act as a medium for an information and communication programme aimed at improving resource productivity.

Meyer et al. (2007) evaluated the macroeconomic effects of an advisory programme on the basis of the knowledge of business consultants. The results, in this context, are interesting in general because the impact of dematerialization on the economy and the environment is similar for both types of inefficiency. There is of course a big difference in the instruments which are needed to induce technical progress or a more efficient use of existing technologies. An advisory program, which may be interpreted as the harvest of "low hanging fruits", is already able to decouple economic growth and resource consumption. But the rebound effect of higher growth rates is just as strong as the rise of resource productivity, so that in absolute terms resource consumption does not fall substantially.

This result means that there is a need for new resource saving technologies (efficiency of type I). A central question for the success of a policy that tries to induce resource saving technologies is – irrespective of what instrument is chosen – whether there are strategic technologies and products in relation to total resource consumption of the economy. Summarizing the results of Distelkamp et al. (2005) and adding some information about price elasticities of technologies, the present paper gives an answer to this question: There are such strategic products and technologies, and the technologies have rather high price elasticities. This finding may favour economic instruments.

7.2 Economic Effects of Dematerialization

Based on the experience of well-known consultancy companies Fischer et al. (2004) describe the inefficiencies in resource management as follows: In the manufacturing, building and construction sectors and public administration in Germany, 20 % of material and energy costs could be saved permanently, if the savings of 1 year (material savings) or of 6 years (energy savings) are invested in measures to increase efficiency. 1/3 of the input consists of consultancy costs, 2/3 are additional capital costs. What effects on resource consumption and macroeconomic development would a consulting and information programme have that would encourage firms to avoid these inefficiencies? Meyer et al. (2007) have given answers to this question based on the results of simulations with a deeply disaggregated economic-environmental model.

The instrument for this analysis is the PANTA RHEI (Heraclitus: "everything flows") model. The philosophy of the model assumes that all agents in incomplete markets take decisions under conditions of limited rationality. For the identification of the system structure and for the ascertainment of parameters of its behavioural equation, the use of econometric procedures is necessary. The empirical valuation of this model allows the calculation of reliable baselines as a reference and the valuation of effects of eco-political measures on the economy and environment.

The special efficiency of the PANTA RHEI model is based on the pursuit of the principles "bottom up" and "complete integration", which form the core of the INFORUM modelling philosophy (Almon 1991). The "bottom-up" principle implies that every industry is modelled in detail – PANTA RHEI has more than 600 variables for each of its 59 industries. Macroeconomic variables like GDP or the consumer price index are measured with industry variables by explicit aggregation. The principle "complete integration" means a complex modelling approach that covers inter-industry relations and income generation, distribution, redistribution and income use in a complex SNA system, which gives a complete representation of the budgets of the government, households and firms.

Deep sector structuring is necessary because the effects of economic development on the environment are very specific to the sector. The model contains an energy module explanation of the input of 30 energy sources, as well as a material module which includes the demand for natural raw materials in physical units within 7 categories. Furthermore, the system contains a module for the explanation of vehicle fleets and their use, as well as the housing supply module. A more detailed

Table 7.1 Average annual GDP growth in the baseline and in the Aachen Scenario in %

	2005–2010	2010–2015	2015–2020
Baseline	1.75	1.75	1.34
Aachen Scenario	3.05	2.58	1.55

Source: Meyer et al. (2007)

description of PANTA RHEI is given in Meyer et al. (2007). The model can be qualified as an integrated economic-environmental model with a very rich economic structure that allows identification of the drivers of resource consumption.

Starting with the year 2004, a baseline was calculated that predicts economic development and environmental use in Germany until the year 2020. In the alternative scenario, which is named "Aachen Scenario" after the client of the substantial study, Aachen Foundation Kathy Beys, it was assumed that in a period of 11 years all companies of manufacturing industries and of the building and construction industry can reduce their material costs by 20 % through consulting services. The additional costs for consulting and capital inputs equal the material savings of 1 year.

Dematerialization has two primary effects on the macroeconomic development: At first, it leads to lower costs in the beneficiary industries and to a lower turnover in industries that produce material and energy. Hence, there are winners and losers, but the winners are exclusively domestic companies, whereas material inputs are also imported in large quantities. It also has a distinct positive effect on GDP.

There are many indirect effects. The most important should be described briefly: The reduction of costs induces lower prices, although the decrease in prices is often lower than the cost reduction. As a result, profits increase for companies which use goods from manufacturing industries, but also for companies from the manufacturing industry. That signifies an increase in value added in these industries and in income for all households as well as a rise in tax revenue measured in real terms, which raises final demand and GDP. Table 7.1 shows average annual GDP growth rates in 5-year steps in the baseline and in the Aachen scenario. During the period of the information programme from 2005 to 2015 the average rate of GDP growth is about 1 % point above the baseline.

The reduction of material inputs raises value added and thus labour productivity. This variable and the price development are the most important determinants of the nominal wage rate – both with a positive elasticity on the nominal wage rate near to "1". Since prices fall and labour productivity rises, the nominal wage is relatively stable. This means – because prices fall – that the real wage rate rises.

Employment is correlated negatively with the real wage rate and positively with production. Since the latter effect is stronger than the real wage rate effect, employment rises. The product of the real wage rate and employment is the real labour income which will rise because both components do. Rising real labour income has a further positive impact on final demand, production and GDP.

Table 7.2 shows that employment will increase by about a million persons till the end of the programme in 2015. This development is marked by a considerable structural change: Employment in the manufacturing industry falls by almost 500,000, whereas

Table 7.2 The effects of the Aachen Scenario on employment. Variations on the baseline of 1,000 persons

Year	2005	2010	2015	2020
Total employment:	231	804	957	753
Negatively affected industries:				
Agriculture and forestry	−5	−28	−56	−63
Fishery				
Mining	0	−1	−1	−1
Manufacturing industry	−34	−223	−464	−530
Electricity generation	0	−1	−1	−1
Positively affected industries:				
Building and construction industry	17	150	236	219
Trade, repairs	31	166	256	263
Hotels and restaurants	0	6	5	4
Transport and communication	5	16	17	12
Financial service provider	1	9	13	12
Firm oriented services	125	304	428	392
Public and private services	92	405	524	447

Source: Meyer et al. (2007)

Table 7.3 Total material requirement in the baseline and in the Aachen Scenario in billions of tons

	2005	2010	2015	2020
Baseline	5.83	6.09	6.45	6.77
Aachen Scenario	5.77	5.69	5.66	5.85

Source: Meyer et al. (2007)

the service sector and the building and construction industries see growth in employment that clearly overcompensates for the decrease in the manufacturing industry.

In the baseline scenario, the use of raw materials will increase by an average of 0.6 % p.a. up to the year 2020 and average annual GDP growth will be 1.6 % during the same period. This results in an increase in resource productivity of 1 %. In the Aachen Scenario, work productivity increases by 2.9 % from 2005 to 2015. Material consumption can only be reduced to just under the level in 2005 by 2015, because economic growth increases as well. Table 7.3 compares the development of total material requirement in the two scenarios.

"Total Material Requirement" includes domestic extractions and the import of resources plus "unused domestic extraction" (excavation) and the indirect use of raw materials (rucksack) involved in the imported products. The measures are adequate to decouple the use of raw materials from the development of GDP. But because of the rebound effect resource use does not fall below its starting level in the year 2005. Only according to the baseline, a lowering of 13 % of the use of raw materials is reached.

So the question arises whether there are strategic industries, sectors and technologies in the sense that the material saving potential is much higher than in the average of manufacturing. If it is possible to identify such strategic technologies, sectors and products it might be possible to design a policy that maximizes dematerialization for a given rebound effect. The next chapter tries to give some answers.

7.3 Evaluation of the Potential of a Policy Aimed at Increasing Resource Productivity

How should the prospects of a policy be evaluated whose focus is to increase resource prices in combination with a resource-saving technical approach that leads to a structural modification of the economic process and dramatically reduces the use of resources? The answer to this question depends on whether the use of resources is concentrated on a clearly identifiable set of technologies and products or is spread across all economic areas. The second question is focused on the interdependencies of measures for saving resources within the CO_2-emissions target. Furthermore, it should be asked which effects could arise from an information programme that reduces the existing inefficiencies in the use of resources in companies.

In the following, the most important results of a study by Distelkamp et al. (2005) are summarized. Based on statistics on raw material use issued by the Wuppertal institute (Acosta et al. 2006), the study contains a basic static Input–output analysis for the year 2000. Data were compiled on domestic extractions, unused extractions (excavations etc.), imports of raw materials and indirect raw material imports (included in import goods – rucksack) and disaggregated in seven kinds/groups of raw materials.

First of all, it was asked which effect arises from a change in the technology, which is represented by the matrix of input coefficients. The input coefficient a_{ij} defines how many units of good i (from domestic production and imports) are needed to produce one unit of good j.

For the current question, the matrix of input coefficients is much more interesting than the immediate input of resources in the extracting industry or the imports of resources of the industrial sector. In this manner, a fixed relation is assumed between the gross production of the sector "stones and soils" and the extraction of gravel and sand which cannot be influenced by the described policy measures. The same applies to coal and ore mining. However, downstream production levels like the building and construction industry, steel industry and vehicle construction and all other industries and their direct and indirect demands on material inputs are important. This is determined by the matrix of input coefficients, which has 59 production sectors $59*59=3,481$ input coefficients.

With the following exercise the authors tried to measure the concentration of resource use: They reduced each individual input coefficient by 1 % separately, solved the enlarged Input–output model and compared for all 3,481 solutions the resulting macroeconomic changes of resource uses. The results for the 20 most important input coefficients, in respect to resource consumption are shown in

Table 7.4 The effect of a reduction of input coefficients by 1 % on Total Material Requirement (TMR) in Germany in the year 2000

Rank	Delivering sector	Receiving sector	Δ TMR in 1,000 tons	Of which, imported	Price elasticity
1	Coal	Energy	−13,829	−1,026	−1.0
2	Metals	Metals	−4,041	−3,856	Not defined
3	Stones and soils	Construction	−3,687	−62	−1.6
4	Agriculture	Food and luxury goods	−3,584	−799	−0.7
5	Stones and soils	Glass, ceramics	−3,542	−104	−1.2
6	Glass, ceramics	Construction	−2,838	−371	−2.4
7	Metals	Metal products	−1,691	−1,502	−0.8
8	Coal	Coal	−1,683	−131	Not defined
9	Vehicles	Vehicles	−1,449	−1,099	Not defined
10	Food and drink	Food and drink	−1,153	−639	Not defined
11	Coal	Coking plant, mineral oil products	−1,072	−79	−1.1
12	Metals	Vehicles and parts	−976	−799	−1.1
13	Construction	Real estate	−945	−139	−2.0
14	Coal	Glass, ceramics	−849	−63	−0.8
15	Crude oil, natural gas	Coking plant, mineral oil products	−800	−797	−0.4
16	Ores	Metals	−770	−770	−1.1
17	Chemicals	Chemicals	−747	−600	Not defined
18	Metal products	Metal products	−727	−592	Not defined
19	Financial services	Financial services	−694	−165	Not defined
20	Food and drink	Hotels and restaurants	−673	−333	−2.7

Source: Distelkamp et al. (2005)

Table 7.4. Column 1 gives the rank of the input coefficient, column 2 defines the delivering sector, column 3 the receiving sector. Column 4 gives the change in total material requirement measured in tons, column 5 shows the imports. In column 6 the price elasticity of the input coefficient that has been estimated by time series regressions over the period from 1995 to 2005 is given. It is the elasticity of the input coefficient in respect to the relation between the price of the delivering sector and the price of the receiving sector. If the delivering and receiving sectors in Table 7.4 are identical, then this is a delivery between firms inside the sector in question. In that case the price elasticity of the input coefficient is not defined.

Technologies from the areas energy, manufacturing, metal production, metal processing and food and drink seem to be involved. The 20 input coefficients listed in Table 7.4 account for 52 % of the raw material savings that could be achieved if all 3,481 input coefficients were reduced by 1 %. Furthermore, it can be seen that a policy which concentrates on the technological coefficients which are

Table 7.5 The effects of a reduction of all input coefficients of the regarded production area by 1 % on the macroeconomic use of resources

Rank	Production area	Δ TMR (in tons)	Proportion imported
1	Energy	–15,165	–1,597
2	Construction	–8,625	–1,676
3	Metals	–7,465	–5,916
4	Food and drink	–6,283	–1,967
5	Glass, ceramics	–5,743	–593

Source: Distelkamp et al. (2005)

Table 7.6 The effects of a reduction of private consumption in the listed applications by 1 billion € on the macroeconomic use of resources

Rank	Applications	Δ TMR	Thereof imported (in tons)
1	Solid fuels	–62,964	–4,865
2	Electricity	–28,109	–2,976
3	Garden products	–4,383	–842
4	Glass	–3,241	–879
5	Repair of flats	–3,215	–702
6	Food	–2,051	–965
7	Alcoholic drinks	–2,896	–967
8	Non- alcoholic drinks	–2,689	–973
9	Durable consumer goods	–2,403	–1,278
10	Transport services	–2,046	–839

Source: Distelkamp et al. (2005)

most important with respect to material consumption automatically affects the coefficients which are important also for CO_2 emissions.

It is also interesting that the price elasticities, which are all significant at the 95 % level, are relatively high. This means that those technologies that are most important for material consumption may be influenced by economic instruments.

The concentration of the problems in a few sectors becomes clear if one regards the input structures of the individual sectors. Table 7.5 lists the five industries with the highest material consumption. These sectors account for 50 % of the raw material savings which would be achieved if the input coefficients of all 59 industries were reduced by 1 %. Certainly, the industries already mentioned in Table 7.4 can be found here. Furthermore, it is remarkable that electricity generation is the most important sector.

A reduction in the use of resources can be achieved with existing production structures if the structure of demand is changed. We also have to consider the biggest component of demand – private consumption.

Table 7.6 shows the effects of a lowering of consumer spending by private households by 1 billion € in the 10 areas of consumption with the highest consumption of raw materials. The applications which are by far the most significant are solid fuels incl. heating and electricity.

The 10 most important expenditure categories of a total of 43 consumption purposes account for 76 % of the effect obtained if all 43 consumption purposes were reduced by 1 billion €.

7.4 Conclusions

The results of the study about the effects of an information programme for the harvesting of "low hanging fruits" and dematerialization show that a decoupling of growth and raw material consumption is possible. But the emerging rebound-effect, which is most noticeable with an increase of growth, destroys a part of the success. The necessary and drastic absolute reduction of material consumption will not be possible by such a policy alone. Additionally technical progress has to be induced. The solution to the problem might be a policy that focuses on – in respect to resource consumption – strategic sectors, products and technologies, which this paper identifies. This can be also part of an engaged climate policy, since the most important material input is that of coal in electricity production. Since the strategic input coefficients are significantly price elastic, it can be argued that there is hope that economic instruments can be successfully applied.

There seems to be large potential for an absolute reduction of resource consumption measured in physical units that is consistent with economic growth in monetary terms measured in constant prices. The extent to which economic growth may be depressed by a policy that succeeds in reducing resource consumption in absolute terms is a question that has to be analysed in future research.

References

Acosta J, Schütz H, Bleischwitz R, Bringezu S (2006) Ressourcennutzung nach wirtschaftsbereichen. In: Aachener Stiftung Kathy Beys (ed) Ressourcenproduktivität als chance. Books on Demand GmbH, Norderstedt, pp 187–189

Almon C (1991) The INFORUM approach to interindustry modeling. Econ Syst Res 3:1–7

Ayres RU, Knees AV (1969) Production, consumption, and externalities. Am Econ Rev 59(3):282–297

Boulding KE (1981) Evolutionary economics. Sage Publications, Beverly Hills

Costanza R, Daly HE, Bartholomew JA (1991) Goals, agenda, and policy recommendations for ecological economics. In: Costanza R (ed) Ecological economics: the science and management of sustainability. Columbia University Press, New York, pp 1–20

Daly HE (1968) On economics as a life science. J Polit Econ 76:392–406

Daly HE (1991) Elements of environmental macroeconomics. In: Costanza R (ed) Ecological economics: the science and management of sustainability. Columbia University Press, New York, pp 32–47

Distelkamp M, Meyer B, Wolter MI (2005) Der einfluss der endnachfrage und der technologie auf die ressourcenverbräuche in Deutschland. In: Aachener Stiftung Kathy Beys (ed) Ressourcenproduktivität als chance. Books on Demand GmbH, Norderstedt, pp 143–170

Fischer H, Lichtblau K, Meyer B, Scheelhase J (2004) Wachstums- und beschäftigungsimpulse rentabler materialeinsparungen. Wirtschaftsdienst 4:247–254
Jochem E (2004) Material use, efficiency, and substitution: impact on energy demand. Encycl Energy 3:835–844
Meyer B, Distelkamp M, Wolter MI (2007) Material efficiency and economic-environmental sustainability. Results of simulations for Germany with the model PANTA RHEI. Ecol Econ 63(1):192–200

Part III
Strategies and Policies for a Sustainable Use of Resources

Chapter 8
The Challenge of the Whole: Creating System Policies to Tackle Sustainability

Friedrich Schmidt-Bleek, Markku Wilenius, and Harry Lehmann

The dogmas of the quiet past are inadequate to the stormy present. The occasion is piled high with difficulty, and we must rise with the occasion. As our case is new, so we must think anew, and act anew. We must disenthrall ourselves, and then we shall save our country.

Lincoln's Second Annual Message to Congress, December 1, 1862

8.1 Key Concepts

1. The existing activities of the economic system de-stabilize the ecosystem services and functions that are crucial for the survival of humans on earth, and cannot be replaced by technology.
2. The physical root cause imperilling the eco-system services is the enormous consumption of natural resources (material, water, and land surface) for creating material welfare.
3. The economic root cause for the approaching disaster is the near zero price for using nature. This practice needs to be replaced by full value accounting standards for all environmental goods.

F. Schmidt-Bleek (✉)
Factor 10 Institute, Teplitzer Strasse 19, Am Roseneck, 14193 Berlin, Germany
e-mail: biovar@orange.fr

M. Wilenius
Finland Futures Research Centre, Korkeavuorenkatu 25 A, 00130 Helsinki, Finland
e-mail: markku.wilenius@woimasaatio.fi

H. Lehmann
The Federal Environment Agency, Wörlitzer Platz 1, 06844 Dessau-Roßlau, Germany
e-mail: harry.lehmann@uba.d

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_8,

4. Limited physical resources on earth, population growth and the need to protect eco-system services necessitate a substantial increase in resource productivity. Which means we need to use our resources in a much more intelligent way.
5. The human economy must be constrained to function within the limits of the environment and its resources and in such a way that it works with the grain of, rather than against, natural laws and processes (Ekins). We have to discover how we can make better use of energy that flows in the nature on a massive scale.
6. Decision makers must stop hunting for isolated solutions to isolated problems – such as climatic change or financial melt-downs – and integrate their duties into consistent system policies that are designed to prevent future disasters within the laws of nature in all areas of human activities.
7. First estimates indicate that capping the yearly consumption of natural material resources at close to 6 or 7 tons per capita seems unavoidable. This implies a tenfold dematerialization on average for the economy of traditionally industrialized countries.
8. This challenge to reduce resource consumption calls also for reconnection to peoples' value systems. Recent consumer studies show that people are indeed willing to lead a more sustainable and less consuming lifestyles provided these choices are made easy for them.
9. Cutting dramatically the consumption of natural material resources to the less than half of today's standard will happen only if there is a systemic effort in place from the public policy point of view: Laws, norms and taxation models, among other things, will need to be fully aligned.

8.2 Ecosystem Services

Human economies are subject to the laws of thermodynamics. On a finite planet, there clearly are limits to the amount of matter that can be mobilized by an economy. Energy is required for its mobilization, for its technical conversion into goods as well as their use and disposal. There are limits that can be accommodated by the biosphere before its eco-system functions and services are affected and begin to deteriorate.

Ecosystem services include the availability of liquid fresh water and unpolluted air; of a range of elements, minerals, and metals; of a high level of biodiversity; of edible plants and animals; of productive seeds, sperms, and soil; of a moderate temperature range on the surface of the earth; and of the protection against radiation from outer space. Without ecosystem services, humankind cannot survive.

Ecosystem services cannot be generated by technology on any noticeable scale. Services of nature are indivisible and cost-free available to all humans around the globe. The consequences of their deterioration will be borne by all people, irrespective who is responsible for their loss. If they could be traded on the market, ecosystem services would carry an infinitely high price. They are vulnerable to human economic activities.

Physical root causes for endangering eco-systemic services and functions are the excessive mobilization and use of natural resources (material, water, and land use). The *economic* root cause for the loss of ecosystem services is the near zero cost for using nature.

Root causes for ecological as well as *economic instabilities* include: Lack of responsible system considerations, wrong price architecture and wrong accounting standards for goods and services; low productivity of natural resources; perverse subsidies; short term planning, and excessive profit taking.

Already today, consequences of the excessive use of resources can be observed, e.g. massive soil erosion, water shortages, desertification, loss of species, and climatic changes, as well as increasing catastrophic events like hurricanes and floods. It is obvious that the ecological risk threshold has already been passed. James Hansen (NASA) has postulated that by passing 350 ppm (parts per million) CO_2 in the atmosphere "*a planet similar to the one on which civilization developed*" would no longer exist. Moreover, recent work on climate "tipping points" showed that as many as 14 large components of the earth system could undergo irreversible transition to new states, including dieback of Amazonian rainforest, and the loss of permafrost in Siberia. In 2009, an EU commissioned study headed by Pavan Sukhdev for the Deutsche Bank found that the global economy is losing more money from the disappearance of forests alone than through the banking crisis.

We have now reached 400 ppm. The growing concentration of CO_2 is largely due to the oxidation of carbonaceous material flows for generating energy. However, not all man-made CO_2 emissions stem from energy generation (e.g. some come from huge subterranean burning of coal seams), and CO_2 emissions generate environmental problems other than climate change. The flow of carbonaceous material through society is but one of the important material flows with various chemical compositions and environmental consequences.

This, of course, is no reason to relax the efforts for coming to grips with the climate issue. But it reminds us that the exclusive solution of one symptom of a systemic problem can delay, increase the costs of, and even prevent the solution of others.

Eliminating the emission of climate changing agents from the technosphere does not suffice to yield a sustainable economy.

The more humans interfere with the natural ecosphere at billions of different locations every day, the more intensive and frequently humans mobilize and extract natural materials and water from their natural location, the more natural surfaces are denatured or sealed, the more the customary functions and services of the eco-system will weaken, change, and disappear. The more material is mobilized and extracted for feeding the industrial metabolism, the larger will be the discharge of matter from the technosphere, each with its own additional impacts on the environment. Reducing emissions at the end of the end of economic activities, on the other hand, frequently leads to increasing material flows.

Important actions required:

- Minimize mobilization and use of natural resources – maximize their productivity
- Minimize the use and release of toxic substances
- Synthesize new materials that can replace increasingly scarce natural materials
- Synthesize marketable materials that fit into natural material cycles after use.

8.3 System-Policies

Traditional policies have not been able to prevent the life-threatening deterioration of the eco-system services. Neither have they been able to avoid the near collapse of the banking system. They are in principle not pre-cautionary because they are based on reacting to developments after they were recognized to be deleterious. Traditional policies tend to prevent, delay and increase the cost of solving problems that are not in the limelight of public attention. Traditional policies have thus given cause to enormous repair costs that can eventually far exceed the costs of changing course (Stern Report). Traditional policies are not capable of ascertaining sustainable conditions. Business as usual threatens the very survival of humans on earth. Nobody knows, how close we have already come to this. Recent studies show convincingly that cost of mitigation could be radically reduced if acted early on. If all countries would act now instead of 2020, cost can be reduced between 36 and 170 %. Preventive policies and acting on early warnings would certainly pay off.

System-Policies must become the norm because policies seeking to solve individual environmental, societal, economic, and institutional problems one at a time, without taking inter-dependencies among them into account, cannot protect the environment nor can it lead to a sustained human economy.

Future-oriented system-policies shall no longer focus preferentially – leave alone exclusively – on the solution of individual symptoms stemming from systemic problems. System policies are as essential for measures designed to protect the environment, as they are needed when attempting to seek improvements in pursuing social, economic and institutional improvements.

For instance, calling for "growth" without simultaneous dematerialization of goods and services, increases the environmental crisis. It is doubtful, whether taxing profits from financial transactions alone will prevent the financial sector from rocking the world economy again by frivolous behaviour of bank officials. Attempting to improve the employment situation by stimulating consumption has negative impacts on the stability of the ecosphere because of the commensurate increased consumption of natural resources and energy. Subsidizing the sale of millions of new cars with billions of euros under condition of forcing the destruction of millions of tons of natural resource investments in existing vehicles is not only ecologically counterproductive, it is as well likely the wrong measure for economic reasons, not to speak of the fact that it prevents urgently needed investments in educational facilities.

System Policies aim to improve happiness, welfare and wellbeing of people by optimizing the efficiency and precautionary nature of measures through eliminating root causes of harmful developments, rather than separately repairing their symptoms, which regularly provokes the risk of delaying, increasing the costs of, and even preventing the solution of others. System policies reduce the risks associated with taking actions.

Recent research shows that system policies can rely solidly on the emergence of increasingly postmaterial values. Representative surveys in four key industrialized countries (Germany, Italy, France and USA) showed that there are four key consumer trends: Search for more transparency, willingness to gain control over ones' life, downshifting the search for value for money while welcoming an "Age of Less", and willingness to consume more consciously. These consumer trends underline the realistic chances of moving toward system policies.

System policies take into account that dematerialization is not the only pre-requisite for approaching sustainability. Excessive use of water and land are others, as well as introducing eco-toxic substances into nature.

System policies focusing exclusively on ecologically harmful developments cannot lead to sustainability either, because happiness and wellbeing of people also depend on other factors. For instance, Denial of human rights can be the root cause for social instability. These rights include: Access to healthy food, water and other natural resources; dignity; justice; gainful employment; health care and education; liberty; security; freedom of speech; and fair distribution of wealth and income (not necessarily in this order).

Important actions required:

- Establish centrally placed "System Policy Units" in government, administration, and industry. Their principal task is to ascertain that each envisioned action is consistent with minimizing overall risks.
- Establish a publicly accessible institution that generates, collects, verifies, reviews, and analyzes data and information related to the mobilization and use of natural resources; an institution that supports training and education, eco-design, and the work of "System Policy" and other decision making units. It reports regularly on the resource intensity of GDP, and the performance of important sectors of the economy, employing the indicators mentioned below.

8.4 Decoupling Growth from Using Nature

The following inter-related areas will be considered here: targets, indicators, technology, and suitable economic conditions for change.

8.4.1 Targets[1]

As all technologies require the use of natural resources, the following question must be answered: How much dematerialization may be enough to reach steady co-evolution of the environment and the human economy?

There is no possibility known to us for rigorously identifying and quantifying the sum total of impacts of one non-linear complex parasitic system (the economy) upon another that is the host (the ecosphere). Therefore, the following path of reasoning was chosen to estimate a limit beyond which the loss of eco-system services may become critical.

Considering that the global resource use before the time when large-scale environmental insults were observed was about ½ of the that in the early 1990s of last century, considering further that some 20 % of the world population consumed about 80 % of the natural material at that time, and taking into account that equity demands equal access to natural resources by all people, and finally considering also that the world population still grows, Schmidt-Bleek suggested in 1992 a tenfold dematerialization target on average for western economies, a proposal which was endorsed by the highly acclaimed International Factor 10 Club in 1994.

This concept has since been met with considerable international recognition, both by business and industry, and on government level. The target entered the political agenda – with a first highlight at the Earth Summit +5 (New York, June 1997), where an EU initiative was agreed to on eco-efficiency in industrialized countries: "to consider setting a target of achieving a tenfold improvement in productivity in the long term with a possible four-fold increase in the next two or three decades." UNEP, which also recognizes the consumption of resources to be a key problem, addresses a tenfold reduction target in resource consumption in its report "Global Environment Outlook 2000": "A tenfold reduction in resource consumption in the industrialized countries is a necessary long-term target if adequate resources are to be released for the needs of developing countries."

Today, the yearly *global per capita* material mobilization amounts to over 15 tons (without considering water and plowed soil), suggesting that 6–8 *yearly tons per capita* may well be close to a sustainable consumption limit, including the use of energy carriers. Given the large-scale adjustments necessary, such a target may not be reachable before the middle of the twenty-first century.

It would seem obvious that the proposed target must be put to serious scientific scrutiny as regards the types of materials and the quantities to be reduced within which period of time, in order to optimize specific actions while minimizing disturbance of the economy. In addition, realistic targets for water consumption and for maximum land use must also be developed in a timely manner.

When looking at the actual speed of environmental deterioration, there is every reason to believe that increasing resource productivity as fast as possible is urgent, in particular for dematerialized energy generation.

---

[1] See also Wieviel Umwelt braucht der Mensch – mips, das ökologische Mass zum Wirtschaften, Birkhäuser, Basel, Boston, Berlin, 1993.

A tenfold overall dematerialization of the economy in the industrialized world will by itself yield a substantial reduction in energy demand, perhaps some 30 % or more. This estimate, too, deserves detailed studies, because a strategy of general dematerialization may be the most efficient and least costly route for keeping the global warming to within 2° C.

According to a study by A. D. Little and others, reducing the costs for resources by 20 % on average would not affect the output of SME's in Germany, amounting to potential savings of more than 150 Billion Euros per annum.

Potential added benefits of radically dematerializing the economy could be: Arresting climate change; reducing the loss of forests, species and soil; reducing dependence on resource-rich countries; avoid conflicts resulting from regional scarcity of water, land, and other resources; and lessen the probability of ecological surprises in the future.

Apart from ecological concerns related to the consequences of utilizing natural resources, *Globalizing the western way of life* is *not* possible because it would require the availability of more than two planets earth as resource basis.

Surprisingly, in spite of this there is little evidence that governments or the private sector are systematically preparing for overcoming pervasive resource scarcities. The reader may also recall that traditional ways of securing supplies of increasingly scarce raw materials is to apply bigger machinery and more energy for mobilizing materials and their extraction – not exactly what one would advice for approaching ecological sustainability.

Important actions required:

- Set targets for the medium and long-term per capita mobilization and use of natural resources (material, water, land use); e.g. a 6–8 ton limit of yearly material use per capita by 2050
- Promulgate a comprehensive law that regulates the mobilization and use of natural resources (material, water, and land use)
- Promulgate and harmonize world-wide key indicators for social, business, and economic decision-making that reflect the dependency of all human activities on stable eco-system functions
- Repeal legal requirements and privileges, standards and norms that demand or encourage resource consumption
- Eliminate perverse subsidies
- In public procurement, give preference to goods, infrastructures, and services with high resource productivity and longevity

8.4.2 Measuring the Decoupling Growth from the Use of Nature

Key-indicators must be available for approaching desirable social, economic and institutional goals within the guardrails of stable ecological conditions.

The metrics for relating the ecological basis to the human economy are kilograms (of matter) and square meters (of land) rather than euros or dollars. Much confusion has been generated in the past in discussions about whether or not there are limits to economic growth by the failure to distinguish clearly between these metrics and specify which is being considered. This adds to the general confusion about discussion of limits to growth, generated by early Club of Rome report. The report was a warning signal about reckless resource use, but it was taken as ultimatum to economic growth. So the whole discussion about those limits went astray, with the result that the actual message got lost. Only recently, particularly due to Peak Oil discussion, the notion of resource scarcity in the context of "limits to growth" have again gained public interest.

Indicators for measuring progress in decoupling the use of nature for generating welfare – and for comparing the performance of producers and consumers in this quest – relate the quantity of natural resources (materials, water, and land use) consumed from cradle to cradle in order to produce a unit of the desired solution (output in terms of service, value or utility).

Decoupling indicators should be based on characteristics that are common to *all* processes, goods and services. Their use must always yield directionally safe answers.

On the economic micro-level such units are "Rucksack" for the cradle to the point of sale, MIPS ("material footprint") for cradle to cradle Material Input [in kg] per unit Service (per unit value or utility) obtained; WIPS for the use of Water [in kg]; and FIPS for the use of land [measured in m^2] .

FIPS should be further detailed by considering the degree of de-naturalizing the land taken from nature. For instance, when land is plowed for crop production as opposed to being sealed for construction purposes.

On meso- and macro-levels of the economy, indicators such as yearly Total Material Consumption (TMC), or yearly Total Material Flow (TMF) are applied to economic units. These measures allow the observation of "*boomerang effects*", increases of overall resource use in spite of dematerializing on the level of goods and services.

Important actions required:

- Promulgate and require application of key indicators for social, business, and economic decision-making that reflect the dependency of all human activities on stable eco-system functions

8.4.3 Technology[2]

The efforts devoted by manufacturers and consumers to eco-innovation depend on the recompense they can expect on the market. Market attractiveness depends on two factors: what are the public policy constraints of the market and what is the demand of the consumers.

[2] See also Material Flows from a systematical point of view; H. Lehmann and F. Schmidt-Bleek, Fresenius Environmental Bulletin, August 1993.

Today, less than 5 % on average of the material resources taken from nature end up in products. The rest becomes waste on the way. Some 30 tons of nature is used to create one ton of car – without counting water consumption – and for many industrial goods the ratio is similar. Information and Communication Technology (ICT) is ten times more resource consuming on average. The costs to nature for one bank order per internet is equal to that of producing four aluminium cans for beer.

Decoupling economic growth from the use of nature is the central task of advanced technology. A new industrial revolution is due – the 6th "Kondratieff wave"– by creating a whole new high-tech world by dematerializing all processes, products, installations, structures and services to the highest degree possible.[3]

The EU definition of eco-innovation is as follows:

> Eco-innovation means the creation of novel and competitively priced goods, processes, systems, services, and procedures that can satisfy human needs and bring quality of life to all people with a life-cycle-wide minimal use of natural resources (material including energy carriers, water, and surface area) per unit output, and a minimal release of toxic substances.[4]

Practical experience in industry has shown that two- to fourfold dematerialization can often be achieved with state of the art technology and with investments that can be retired within a few years time. Dematerializing *existing* products and prolonging their useful lives are usually the first steps.

The biggest gains in saving resources are reachable through taking a systems' approach, focusing on meeting the needs of people rather than on improving existing technology. For instance, Stefan Wrage has re-invented the use of wind for propelling cargo ships over the oceans by means of "SkySails". Through the use of a (now available) special enzymes, washing temperatures for textiles can be lowered to room temperature, and developing self-cleaning surfaces (micro-technology, lotus effects) can eliminate some cleaning needs altogether, saving billions of tons of water, large quantities of detergents and energy worldwide. Hubert Rhomberg has designed a 25 floor wooden building, easy and fast to erect without waste, and with complete freedom to sub-divide and re-divide each floor according to needs (www.Rhombergbau.at).

Important actions required

- Focus on fulfilling human dreams and needs, rather than on "greening" existing technical solutions
- When designing advanced food stuff, goods, processes, services, and infrastructures, minimize their rucksacks, MIPS, WIPS, and FIPS – while maintaining/improving current western standards of living
- Dematerialize dramatically the generation of energy, its storage, transport, and its application
- Maximize continuous eco-innovation

[3] Markku Wilenius & Sofi Kurki: Surfing the Sixth Wave. Exploring the next 40 years of global change. FFRC eBook 10/2012.

[4] Reid, Alasdair, Miedzinski, Michal (2008), EUROPE INNOVA, Final Report for the EU Sectoral Innovation Watch Panel on Eco-Innovation, www.europe-innova.org

8.4.4 Achieving a Suitable Economic Framework

Whether or not economic growth in financial terms has a deleterious effect on the environment, depends on the extent to which it is accompanied by growth in energy use and material throughput. Historically, growth in material and energy use have tended to be correlated with economic growth in financial terms, but there is no imperative why this should be so, and it is possible for this link to be broken by technology, once encouraged by public policy.

The impacts of the human economy on the eco-system services can be understood as the externalities caused by the economy on the carrier system earth. This argues for a strong conception of sustainability, whereby the economy respects and adapts to ecological imperatives, rather than seeking to substitute manufactured for natural capital where the former fails to deliver the full range of functions and services of the latter.

Most importantly, the human economy must be constrained to function within the limits of the environment and its resources and in such a way that it works with the grain of, rather than against, natural laws and processes. This is the key challenge for the techno-economic development of the next decade because we have no more time to waste.

Emissions will fall as policies reduce extractions, but there is no guarantee that reducing emissions will reduce extractions, and the impacts associated with them, and may increase them. Policies to reduce extractions will seek to increase resource productivity through all stages of production, and to reduce resource use in consumption.

The key driver for economic decision-making is the market price of goods and services. Henceforth the "ecological truth" must be reflected in the price architecture of the market, rewarding the production and use of goods and services with the highest resource productivity.

Full cost prices of resources must be introduced, e.g. by cost-neutrally shifting taxes and levies from labour to natural resources, thus letting the market drive the competitive process of resource saving.

Not only would resources become worth saving, but discarding waste would also be discouraged through the market, and labour would become less expensive, inviting the creation of new jobs. Moving in this direction requires the introduction of system policies.

In addition to tax shifts, there is a host of additional policy options to support the saving of natural resources: e.g. favouring dematerialized goods and services in governmental purchasing; avoiding subsidies that lead to un-necessary investments in materials and land use; adjusting standards and norms; reviewing the freedom of moving and investing capital world-wide; restricting short term planning and profit taking; reviewing the environmental implications of personal property and property use rights.

Policies attempting to stabilize the relation between the economy and the ecosphere should be targeted on material mobilization and extractions, and not on emissions or residuals.

On the *international* level, a process is needed to define and harmonize time paths of targets for the consumption of natural resources, measured in tons per capita (similar to the greenhouse gas reduction commitments that are being sought under the UN Framework Convention on Climate Change), and the use of land, measured in square meters.

Perhaps the best international policy approach would be to introduce internationally marketable permits for use of natural resources, with the number set to decline by 2050 to the per capita limit mentioned above. The permits would be traded only between countries. Countries would be invited to join this system as soon as their resource use exceeded the average per person global allowance on the declining trajectory to 2050. The group of countries deciding in favour of participation in the system, will tax all import goods from non-participating countries to avoid distortions in international trade, provided that these countries have a use of raw materials per capita that is above the average of those countries in the system. The tax would also be applied to those countries that had failed to develop an adequate system for the measurement of resource use in their territory.

On the *national level*, countries would be free to choose their policy mix that is in line with the countries' economic constitutions, cultural and trading conditions. But a central part of the policy mix should be the use of economic instruments in the tradition of the "economic- environmental tax reform". What is needed now is that some countries would volunteer for pioneering to implement this new policy framework. Those countries, no doubt, could gain enormous benefit by building the future model of sustainable society, thus attracting enormous public attention.

Such a scheme would doubtlessly need much elaboration to cope with the complexities of the real world. It will also be necessary, in parallel with the broad scheme of resource taxation and the trading of resource use permits, to maintain the local regulation of specific substances according to their hazardous properties.

In this way the resource and environmental policy framework would both regulate and reduce the macro-material impacts which are currently so threatening the future of humanity, while continuing to control the local environmental hazards of pollution.

Important actions required

- Full-cost pricing of food, goods, energy, infrastructures, and services, e.g. by shifting taxes and levies from labour to natural resource, and curbing subsidies
- Make it profitable to produce, trade, install, maintain, repair, and consume eco-friendly goods, infrastructures, and services
- Encourage and support supply- and demand-side eco-innovation
- Enter into international negotiations with countries willing and capable to control the mobilization and use of natural resources with the aim to establish a contractual agreement within a sufficiently strong economic block that can entice other countries to join later for security and economic reasons. To the extent necessary, re-negotiate or repeal membership in international organizations with charters that fail to recognize that the economy must be constrained to function within the limits of the environment and its resources.

Chapter 9
Changing the Priorities: From Labour Productivity to the Efficiency in the Use of Resources

Aldo Femia

9.1 Introduction

This article discusses the need to put a drastic increase of the efficiency with which natural resources (NR) are used (i.e. resource use efficiency – RE) among the primary goals of society, and to assign to this goal a very high priority level, even higher than the one currently attached to the increase of labour productivity (LP). This need is a consequence of an indispensable change of the way we look at natural resources as well as at the final results of their use. This change in perspective impacts on the very definition of resource use efficiency as well as on the measurement of its terms. Therefore, we begin by defining RE as relationship between two ends, that of natural resource use and that of socially desirable outcomes of the socioeconomic process through which resources are transformed into residuals (Sect. 9.2). The economy-centric identification of RE with resource *productivity* (RP) is rejected as inadequate as a normative concept, also in the light of the recent steps forward done in the field of well-being's definition and measurement beyond GDP. We also briefly discuss the merits and limits, as environmentally (and normatively) relevant empirical correlates of the concept of overall NR use, of aggregate measures of NR use derived from economy-wide material flow accounts (EW-MFA). On this basis we then (Sect. 9.3) try and make a case for *dematerialisation* as a lighthouse for sustainability policy, and highlight some important characteristics – including limits – of the

A. Femia (✉)
Istat, National Accounting, Environmental and Satellite Accounts System,
Economy-wide Material Flow Accounts, Via A. Depretis 74/B 00184 Rome, Italy
e-mail: femia@istat.it

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_9,

dematerialisation concept. Subsequently (Sect. 9.4) we temporarily set aside the discussion on socially desirable outcomes and well-being in order to discuss, in a "traditional" economic reasoning context, the relationships between RP, economic growth and LP, with the aim of highlighting the importance of having the reduction of the overall labour input as a key element of a dematerialisation strategy. Our reasoning returns then (Sect. 9.5) to socially valuable outcomes. We try and highlight how the present institutional context is characterised by a contradictory and somewhat perverse dialectic between the pursuit of well-being and that of economic growth, since the latter imposes itself for very good reasons but beyond any ecological, and more and more also social, rationality. We subsequently (Sect. 9.6) suggest some objectives and tools for a RE-oriented policy, and finally (Sect. 9.7) wrap up the discussion.

9.2 Defining and Measuring Resource Use Efficiency in the Normative Perspective of Dematerialisation and Well-Being

9.2.1 Natural Resources (NR) and Socially Valuable Outcomes of the Socioeconomic Process

In very general terms, RE indicates how well NR are used in order to generate desired outcomes. It expresses a complex relation concerning the quality of this use as much as the quality and quantity of goods and services realised by using the resources. As a macro socioeconomic entity, it is usually identified with resources productivity,[1] and defined operationally as the ratio between Gross Domestic Product (GDP), considered a valid aggregate measure of the socially valuable outcomes of a country's activities, and one or more aggregate measures of the NR inputs necessary for carrying them out. The choice of the indicators for RP's numerator and denominator are clearly laden with value and technical judgements, among which the very idea that a single figure may represent the desired outcomes of resource use.

As for the numerator, the conception of social goals that is incorporated in standard economics common-sense and in using Gross Domestic Product (GDP) as aggregate measure of socially valuable outcomes is far from being granted. Our normative perspective imposes to question it and to argue in favour of going beyond economy-centric thinking in the definition of the socially valuable outcomes. RE would otherwise be limited to resource *productivity* and could be expressed by an indicator or a set of indicators all having monetary value at the numerator.

[1] See, e.g. OECD and UNEP work on "resource efficiency" (OECD, nd; UNEP, nd and 2012), as well as the European Flagship initiative on a "Resource efficient" European Commission (EC) (2008, nd).

The concept of "socially valuable outcomes", on the contrary, is an inherently multidimensional concept, to which we will also refer as to "well-being".[2]

As for the denominator, it is not obvious what should be understood as a resource[3]; nor is it obvious according to which metrics the different resources should be measured and aggregated to derive a single "total resource use" figure. Even restricting attention to the use of NR narrowly understood as the input of solid materials to the production process, there are several candidates, among which physical measures of total mass, monetary value measures, toxicity-weighted apparent consumption aggregates. Each of these has its strengths and limitations and choosing one is a matter of perspective and aims of the analysis.

9.2.2 GDP, Societal Goals and the Relation Between RE and RP

The conception of RE as an emergent property of the socioeconomic system, much broader than that expressed by RP, is strictly connected to acknowledging the complexity – and in many cases the ambiguity – of the relationship between GDP and the social value of the outcomes of the socioeconomic process. GDP represents only a specific aspect of real life phenomena, namely that of potential or effective market value, while the social value of the outcomes depends on many different aspects. It is widely recognised that well-being is an intrinsically multidimensional concept. This is a first key to understanding the complexity of RE defined as a relationship between the environmental and social ends of the materials' transformation chains. What makes up social (and often also individual) value is only marginally incorporated in the economic value of goods and services. A pair of shoes' price

[2] For an analysis to be normatively relevant and substantial it is necessary that the notions used have empirical content (see on this, among others, the works by K. W. Kapp, which provide a fundamental reference under many respects; e.g. Kapp 1963, 1970, 1974, 1976, 1977). In the present article we tried to respect this requisite, though the general nature of the argumentation might sometimes conceal this. For the definition and measurement of the socially valuable outcomes of the socioeconomic process, please allow us to refer generically to the ancient, recently revived, debate on well-being and its measurement, including sustainability as an essential dimension. Luckily enough, indeed, the use of GDP for representing all possible socially desirable goals has finally been put in question also in high level policy and official statistics circles (Stiglitz et al. 2009; EC 2009, OECD), so we need not feel uneasy in trying and go down the whole road beyond GDP by drawing the normative consequences of this "paper revolution".

[3] In principle, any of the ways in which socio-economic systems take advantage of the functions of nature may be thought as of the use of a natural resource. For instance, in the Thematic Strategy on the Sustainable use of natural resources and management of wastes (TS-SUR), natural resources are defined as "including raw materials such as minerals, biomass and biological resources; environmental media such as air, water and soil; flow resources such as wind, geothermal, tidal and solar energy; and space (land area)" (EC 2003, p. 8–9 and EC 2005, p. 3). This broad definition of resources makes the concept of scarcity applicable also to the functions of the natural environment. For an early conceptualization along these lines, see Hueting (1980).

does not *per se* tell much about the utility of the shoes to the one who pays for them (consumer surplus is not included) nor, most importantly, tells much about how and by whom they have been produced (in a safe working environment by a well-paid adult worker or by a slave child in an unhealthy basement), nor about how the money paid for the shoes will be shared and how much need of the income have those who perceive it (a tycoon who will buy a trip to the moon or a working poor). But that amount of money – whatever is behind and beyond the shoes – will enter GDP, once the costs of the intermediate inputs to the shoes' production process have been subtracted (in turn, the cost of the intermediate inputs may themselves represent sound and sustainable activities and the source of vital resources for a community, or be the result of expropriation, exploitation and impoverishment processes). A second key to understanding the complexity, which also reveals the ambiguity of the relationship, is that all these aspects are strictly interrelated. In the economic circuit one person's income always derives from another person's expenditure, and GDP, besides production, represents both sides of the coin, the one paying it and the one receiving it. It would therefore be pointless to try and define (even if clear and widely accepted ethical criteria were available) a set of "bad" products whose value should not be counted as production: the added value generated in their production may be income of literally vital importance for somebody, who spends it in valuable products such as food housing, etc… GDP is neither good nor bad in itself: the way it is produced, what is produced, how it is spent, and also where and when it is produced interact in a tight web of relationships that determine both the "good" and the "bad" sides of the well-being balance of society and individuals. Of course the characteristics of the economic circuit are not the only determinants of well-being; many social structures and institutional settings play a role and interact with it, partly determining its quality. However, in a world where economic activity pervades all aspects of human life and imposes its logics to human behaviour, where an anthropological transformation of humans from citizens into producers/consumers and eventually into products themselves is constantly ongoing, the characteristics of the economic circuit obviously prevail.

The conflict between employment and environment, that immediately sparkles when something like shutting down a polluting factory is proposed, is an almost trivial consequence of the internal coherence of the economic circuit, captured by the three-fold nature (production-income-expenditure) of GDP. This kind of conflict may sometimes be solved locally, making sure that an alternative employment, or an acceptable way to be unemployed, exists for the workers involved in the undesired production. However, ecological rationality applied globally would imply a generalisation of the conflict. The solutions which are possible locally are not applicable at a global scale, within the given economic framework: either enough new "ecologically sound" jobs are created to replace the many that are destroyed,[4] or somebody else should provide the subsistence means to idle masses of previously

[4] Advocates of the so-called "green economy" claim that it is only a matter of investments.

employed workers. The more the conflict is generalised, the more difficult it becomes to find somebody else that is able or willing to pay.

Increasing RP (unfortunately often called RE) is – not by chance – one of the buzzwords of the so-called green economy, which aims at keeping alive the growth paradigm – put in question by the ecological crisis – by opening up new spaces for business, insisting on *technology* as the main source of salvation, on *capital* as the essence of all that must be preserved and on *economic value* as the end and measure of everything.[5] But technology has always created new problems while trying to solve existing ones, and the benefits of RP gains brought about by technology are easily lost because of increases of material consumption if the RP gains are not "sterilised". Capital, by its very definition, is only justified by its ability to generate economic value (income), and in fact nowadays this definition subsumes all of what is able or necessary to generate income, including workforce (human capital) and Nature (environmental capital), which are – coherently – measured by their contributions to this ability.[6] Economic value and income are, however, as anticipated above and further discussed in Sect. 9.5, in an ambiguous and in a way perverse relationship with well-being and sustainability.

A policy for enhancing RE – where RE is thought of as the relation between resource use (RU) and well-being, rather than as the ratio between RU and GDP – would assume as a priority the "sterilisation" of RP gains' effects on material consumption, because it would aim at increasing well-being, disregarding altogether GDP as for the assessment of the latter.

Since RP's increase enables to provide goods and services of the same total economic value while using less NR, it *may* contribute to RE's enhancement to the extent that goods and services' value reflects their significance to those who need them. But whether RP's increase really contributes to RE *in general*, depends on whether

[5] The "green economy" literature provides, along with official policy documents, textbook examples of how potentially revolutionary concepts tend to be encapsulated and mixed up in mainstream thinking, where they are in the long run neutralized so that eventually business as usual, after some maquillage, may continue to prevail. To make an example from an otherwise very advanced work, according to UNEP (2012) a green economy is defined as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities". However, "major components of well-being and social equity in connection with green economy policy interventions may include: employment, the **growth of** the environmental goods and services **sector** (EGSS), **total wealth** including human **capital**, natural **capital** and produced **capital**, access to key **resources** such as clean energy, water and sanitation, and health. **Investing in** clean **technology**, for example, is expected to generate jobs and **income** from the growth of the EGSS. **Investing** in ecosystem restoration is expected to **enhance the value of natural capital**, while training in green skills will help **build human capital**, adding to the **total wealth of nations**". The terms and captions in bold (the emphasis has been added) point more to a shift in the conception of well-being from identification with short-run monetary income to permanent real income than to a radical change of perspective. This is a great progress, but not a sufficient one in our view.

Coming back in particular to resource efficiency, also in UNEP's quoted document it is represented by Energy productivity (Btu/USD), Material productivity (ton/USD), Water productivity (m^3/USD) and $CO2$ productivity (ton/USD).

[6] See e.g. the most popular approach to human capital measurement (Jorgenson-Fraumeni).

it is accompanied by the emergence of new *qualities* and characteristics of the economic circuit in which the goods and services are realised, used and possibly destroyed. RP, as well as LP, contributes to RE gains only if it is embedded in a context where people strive for, and are empowered to, live better not by producing/consuming more material goods but by having a better life (more leisure, a better job, a healthier and nicer natural and social environment…), where the economic system evolves structurally in coherence with changing life styles, and where institutional and cultural innovations actively enable and encourage this change.

9.2.3 The Economy-Wide Material Flow Approach to Measuring NR

In the last two decades significant consensus has been built around the idea that the drastic reduction of the total quantities of materials taken from the natural environment is an essential requirement for the global human system to move towards long-run ecological sustainability. According to this school of thought, the necessary dematerialisation can be achieved only if production and consumption are no longer considered as aims in themselves. This approach, as can be seen, entails interesting messages on both the ends of the RE relationship; nevertheless it is strongly characterised by its contributions on the resource flows. These contributions cover both the positive (measurement and analysis) and the prescriptive aspects regarding RN's end of the RE relationship. The two aspects are strictly connected. Normatively relevant choices of value are always present – often hidden – in the selection of the indicators. One key message of the dematerialisation school in this respect is the unsuitability, in a normative perspective, of "solutions" to the environmental crisis that entail shifting the problems[7] (the material flows) elsewhere (see Dryzek 1987).

In connection to the normative concept of dematerialisation, indicators of total used mass have been defined, that nowadays have citizenship in European official statistics as part of the economy-wide material flow accounts system (EW-MFA) and some of which are adopted in Sustainable Development Strategy for target-setting and monitoring. These aggregate measures – with which we will assume the reader is familiar – are by conception and construction not much influenced by "problem shifting".[8]

[7] Three types of problem shifting may be distinguished: in time (e.g. avoiding now air emissions by creating radioactive pollution for later), in space (e.g. changing the location of a polluting industry) and between resources (e.g. avoiding the use of one resource by using up another one).

[8] To be precise, EW-MF-based measures are not independent from problem shifting in time, since they refer to current flows only; however, within the limits of the underlying definition of "resources", Domestic Material Consumption (DMC) – which has been adopted by the EU (see EUROSTAT; nd) for the calculation of the resource productivity indicator used in the monitoring of the European sustainable development strategy – is in principle not influenced by shifting between

Special attention should be given to the case of problems shifting in space. Behind any socially valuable outcome there always are chains of production processes, which may stretch very far. What matters in environmental terms are their total effects, and not just the impact of the last visible steps. Individual or collective producers and consumers activate the material flows of the whole production chain from which the products they use stem and therefore they play a key role with respect to the waste and emissions that these products leave behind them: they may choose to ignore them, or to take action to avoid or reduce them. This *extended responsibility* idea has important normative implications that impinge on the measurement issue.[9] A measure of a nation's resource use should not be limited to the actual inputs into the nation's production and consumption processes for it to be valid in an ecological perspective; it should also account for the so-called hidden flows, including indirect flows connected to imports. When the latter are included, the measure is in principle not sensible to the displacement of production activities to other countries: it cannot be "fooled" by sweeping the unavoidable dirt under some foreign carpet.

Total NR use indicators – especially those including the so-called hidden flows have a far broader meaning, in environmental terms, than what is included in them immediately represents. For sure, they provide important – though clearly not exhaustive – information on the distance of the human system from ecological sustainability.

9.3 The Case for, and Some Remarks on, Dematerialisation

Often the normative (environmental) relevance of dematerialisation has been unnecessarily stretched and transposed on EW-MFA-based aggregate indicators as far as to state that the latter are good proxies for the overall stress (pressure) put on the natural environment. At the opposite end, the very significance, in environmental terms, of the mass-balance-based metrics for total resource use has often been questioned, emphasising the importance of the differences in quality of the materials and of the way these are handled and opposing to the dematerialisation idea the need to put under control the flows of specific materials or substances (See e.g. van der Voet et al. 2004). In order to avoid all ambiguity, while subscribing to the

resources (but for the unlikely case of substitution of solid materials with water or air), while the measures that consider indirect flows such as Total Material Requirement (TMR) or measures expressed in Raw Material Equivalents (e.g. DMC_{RME}) are independent also from shifts in space. Unfortunately, indicators of the latter kind are not as widely available as DMC: official statistics is not ready to provide the necessary data on the so-called "hidden flows", and the investments in developing the necessary tools are scanty.

[9] It should be noted that this is independent of whether and how different materials are aggregated.

EW-MF approach, we think it necessary to emphasise some points that are sometimes overlooked both by over-enthusiastic authors and by over-sceptic critics:

- sustainability of the human system is in principle not an attainable state but a fundamentally normative concept, an ideal target, calling for action based on looking forward not on a scale of decades but on a centuries and millennia scale;
- the holistic nature of the EW-MF approach makes it most relevant in this view of sustainability (which does not mean that action should be delayed any further);
- the "un-weighted" inclusion of all materials on the basis of their mass into EW-MF-based indicators is mostly appropriate when reasoning and defining targets in this time scales;
- this approach is complementary to other holistic and non-holistic approaches, especially when it comes to measuring environmental pressures, with respect to which EW-MF indicators only express the additional potential, generated in the reference period, of which only part unfolds immediately, while part will be released up to decades after;
- it responds radically to the precaution principle, acknowledging the great uncertainty and insufficiency of our knowledge on the functioning of the environmental system and on the way human artefacts interfere with it;
- dematerialisation is "only" a necessary condition for sustainability.[10]

Having pointed out this, let us underline a couple of conceptual strengths of the EW-MF approach that make dematerialisation a strategic normative concept for sustainability. One is that the EW-MF system view keeps the level of physical reality, which is the only one immediately relevant for the natural environment, well distinct from the realm of human values. Another is that it acknowledges the fundamental unity of material flows (socioeconomic transformations and use of materials and products), which are never looked at in isolation, neither separating vertically the different threads of different materials, which are deeply interwoven, nor cutting horizontally the steps of transformation, none of which has a meaning of its own. The intake of materials from Nature is indeed one end of a braid which is pulled at the other end and all materials taken will eventually come to this end. The way in which standard economics depicts the environmentally relevant aspects of the economic process lacks both strenghts.[11]

[10] It should be noted that maintaining dematerialisation as necessary only, and not also as sufficient, does not subtract from its importance as a normative concept.

[11] Standard economics maintains that the ultimate result of the use of resources is satisfaction of needs and that this is reflected in economic value; it then attaches to this some unwanted side-effects called negative externalities, by whose monetization it tries to close the self-referential mono-dimensional circle of its reasoning. Indeed, the concept of externality refers not to environmental degradation phenomena considered *per se*, but to unintended interferences of one economic agent's deeds in the utility functions of other economic agents. Environmental degradation phenomena, *per se*, may be much more or much less significant for the functioning of nature than for economic agents' utility, and are therefore ontologically not representable by monetary values.

As far as physical reality is concerned, the final results of the use of resources are not only useful material goods and services but also huge holes in the ground left from extraction, erosion and impoverishment of the agricultural topsoil, waste, and all kinds of polluting flows to nature. Some useful material goods are short-lived, and result very soon in output to the environment. The others, which consist in consumer durables and capital stocks as defined in national accounts, have a longer life. While waiting to become waste, as they eventually will, most of these goods occupy a surface, seal it, subtract space to nature, re-shape it, fragment landscape and habitats, and interfere with natural flows in environmentally harmful ways. In general, depletion and degradation of the natural environment are the consequences of material flows generated by the socioeconomic system and the creation of material stocks that would not exist otherwise in nature. Once the materials are introduced in the man-made circuit, they will sometimes and somehow show up as an environmental problem.

The normative implication of this view is that material flows should be cut at their very source, avoided altogether as much as possible. The way they are managed is certainly important, but in the long run it is the scale at which the processes go on that counts. In principle, the total use of each resource should be capped.

This ecological rationale is widely accepted under many respects. Taking EU policy documents as an example, the Sixth Community Environment Action Programme (6th EAP),[12] as well as the Thematic Strategy on the Sustainable use of natural resources and management of wastes (TS-SUR) often make explicit reference to the extended responsibility principle and life-cycle logic, which are typical of the dematerialisation approach.[13]

Despite these premises, however, the dematerialisation approach did not really break through in EU policy. Along with the EW-MF metrics, the idea of generalised dematerialisation as an overarching objective of (environmental) policy was rejected.[14] At the basis of this rejection there is an inappropriate and slightly contradictory use of the distinction between *scarcity* and *environmental impacts* of resource use, which are said to "require different policy responses". Indeed dematerialisation policy is deemed appropriate for – i.e. confined to – tackling scarcity, which however "is not the main issue" (with some exceptions); instead, a new concept of decoupling is coined: while the 6th EAP talks of decoupling economic growth from

[12] "aiming at ensuring that the consumption of resources and their associated impacts do not exceed the carrying capacity of the environment and breaking the linkages between economic growth and resource use" (European Parliament and Council 2002, p. 12).

[13] "Environment policy needs to move beyond emissions and waste control. It is necessary to develop means to identify the negative environmental impacts of the use of materials and energy throughout life cycles (often referred to as the cradle to grave approach).

It is also not sufficient to look at life cycles in geographic isolation. […] informed policy-making requires knowledge of how resources move through the global economy, what drives this and what the impacts are wherever the resources are extracted and used" (EC 2005, p. 5).

[14] As far as the metrics are concerned, reference was made to a simplistic interpretation: "it is clear that taking resource use as a proxy for environmental impacts is not the way to proceed" (EC 2003, p. 11).

environmental *pressures* and resource use, in the TS-SUR documents environmental *impacts* are the target.[15]

It must be noted that these documents acknowledged that resource use leads unavoidably to environmental degradation: policy can only strive to ensure it not to be "unacceptable". Indeed, in the very long run perspective of sustainability, hardly any technology can really be clean and any consumer product eco-friendly, because this would mean that they are *absolutely free of environmental impacts*; whatever technology may be used and products developed, they will always generate some waste, if anything else. Within this limit, it should also be acknowledged that technologies and products can be said to be cleaner and more eco-friendly only if their whole upstream and downstream transformation chains generate less emissions and unrecyclable waste, i.e. use less material resources (including fossil fuels) throughout the whole life-cycle. Therefore, controlling the environmental impacts of resource use – i.e. the harmful flows from production and products – is not sufficient, as it means focussing on some steps of the use chains of materials and can in practice be pursued only domestically. Only in a dematerialisation logic, which would consider the reduction of the upstream flows wherever they take place as a target, the environmental impacts can be tackled on a global scale.

In very general and almost philosophical terms, the point is that on the material flows level, the very distinction between cause and effect drawn in the passages cited above does not make much sense. We must always seek the cause in the realm of human values, and the consequence is in the whole stream of material flows put in motion or avoided. The dematerialisation idea emphasises the use side of resource flows because this comes first logically in a time perspective, but this is by no means different from aiming at a reduction of waste and emissions. It must be also noted that there is an implicit value choice concerning spatial problem-shifting in choosing to focus on the downstream flows and forget about the upstream flows that would be decreased by reducing resource use.

Incidentally, let us also note that even if scarcity in general is for the moment not the main issue at a global level, resources are also not freely available and there always are benefits to reap for resource-poor countries (such as most European ones) from saving them. Besides the obvious economic reasons for reducing resource use,

---

[15] Some passages are highly representative of a way of reasoning that is a-priori dismissive of dematerialisation policy: "At present the environmental impacts of using non-renewable resources like metals, minerals and fossil fuels are of greater concern than their possible scarcity. […] The Resources Strategy should therefore focus on reducing environmental impacts, thus enabling growing economies to use resources efficiently, from both an economic and an environmental point of view. This de-linking – commonly called decoupling – of impacts from growth is the overarching goal to which this strategy will contribute" (EC 2003, p. 4).

By the way, scarcity has meanwhile become a serious worry for the EU; this concerns at the moment some specific materials (e.g. rare earths), but it can be foreseen that it will soon expand.

"[…] if we focus on reducing the environmental impacts of resource use, the appropriate policy response would be to ensure that resource use does not lead to unacceptable environmental degradation. This response would include the promotion of clean technologies and more eco-friendly consumer products. Although in certain cases, e.g. through more recycling or more resource-efficient design, this could reduce the quantity of resources used, this would be a consequence rather than an explicit objective of the policy" (EC 2003, p. 10).

there are some very good political ones. The risk that the control of resources might be at the origin of armed conflicts is not explicitly mentioned under the "security of supplies" title in the TS-SUR, but lurks around it.

9.4 Resource Productivity, Economic Growth, Labour Productivity

Once the dematerialisation objective is adopted, a valid, and in principle *per se* sufficient, reason why society should strive for dramatic increases in RE immediately emerges: there is no other way to reconcile the quest for increasing socially valuable outcomes with that for ecological sustainability.

In the present paragraph, we will put aside all discussion on the relationship between GDP and socially valuable outcomes (we will come back to that in the next paragraph). Though keeping in mind what said above on the relationship between RP and RE, we will therefore refer to RE as defined in the currently dominant set-up of the problem (OECD, UNEP, EU…), i.e. to Resource *Productivity* (RP), as measured by an algebraic ratio between GDP and an aggregate measure of NR use. This part of the argument is functional to the more general reasoning: reference to GDP and RP will allow us to highlight some fundamental trade-offs and contradictions of the current economic framework and to start discussing about what would be necessary to weaken them and why it is so difficult to do it. In short, we will argue that in the short run economic growth is, *given the current constraints*, a necessary condition for the very survival of the socioeconomic system, even though it will eventually lead to the ecological catastrophe, since RP's increase will not be sufficient to achieve the necessary dematerialisation, but only to achieve relative decoupling.

9.4.1 Resource Use and Economic Growth

The trade-off between reducing NR use and increasing GDP can be illustrated by making reference to the tautology that the total use of resources (R) is identical to the resource use intensity of GDP ($IU \equiv R/GDP$) times GDP itself [$R \equiv IU * GDP$]. Unless the resource intensity declines fast enough – i.e. its reciprocal, RP, grows fast enough – a growth of GDP will cause a growth in the use of resources. On the contrary, if the IU decreases faster than GDP, resource use will decrease notwithstanding economic growth.

The so-called Environmental Kuznets Curve hypothesis, applied to resource use, claims that, beyond a certain income threshold, the IU actually decreases, as a natural consequence of the evolution of the structure of production, of technology and of the social and individual preference for environmental protection. This hypothesis is very popular in literature and is the object of numerous empirical investigations. For the apparent consumption of many individual industrial raw materials the inverse-U shape has actually since long been observed at the national economy level (see e.g. Malenbaum 1975; Jaenicke et al. 1992), and in some cases the decoupling at high GDP per capita levels is strong enough to result in diminished use in absolute terms (similarly to the case of some specific environmental pressures). However, the IU curves do not concern natural resources, but refined materials (the difference between the two is a lot of mining and refining waste); considered individually, they are influenced by “problem shifting” between resources, as is immediately clear when considering them jointly (there always is some material whose use is rising); and of course, not including upstream flows, they are individually and jointly much influenced by problem shifting abroad.

When the analysis is carried out adopting encompassing measures of resource use – such as those provided by EW-MFA – the reduction of the IU turns out not to be fast enough.

Already according to the TS-SUR (EC 2005):

> In the last 20 years, overall consumption per inhabitant has remained virtually unchanged in the EU at around 16 tonnes per year, and yet the economy has grown by 50% over that period. This means that Europe has significantly improved material efficiency. Despite these improvements, increased production volumes have often outpaced any overall environmental improvements or efficiency gains and current policies have not been sufficient to reverse fundamentally unsustainable trends either in Europe or globally. (p. 4)

A more recent and comprehensive study (Bleischwitz et al. 2009), confirms these findings:

> For EU25, Turkey, Japan and the USA data shows, that a majority of the countries could ameliorate their resource productivity. In most cases, however, resource productivity increased slower than GDP in the investigated country. Therefore, only a relative decoupling of resource use and economic growth can be witnessed in these countries. An absolute decoupling or “dematerialisation”, i.e. economic growth along with a decrease of resource use, occurred only in Germany regarding the DMC so far. Though, a few other countries could at least stabilise their resource use. The growth rates of resource productivity (2.5 %/a for EU-25 and 2.9 %/a for EU-15) fall behind the aims of the EU’s resource strategy. Thus, *the EU is not yet on track towards decoupling resource use from GDP*.[16] (p. 10; emphasis in the original)
>
> The data […] show *a clear link between economic growth and the use of resources* […] The data also show, that […] no absolute decoupling of resource use and economic growth has been achieved and thus a higher per capita income still corresponds to a higher consumption of resources. (p. 43; emphasis added)

It should be noted that the resource use measure adopted in these studies, DMC, is significant only for the potential environmental pressures generated by production and consumption that are directly carried out in the countries, while it suffers from

[16] The quoted study is aimed at responding to some questions that are at the core of the present article’s concerns: “Can companies spur their competitiveness and can the EU as a whole enhance its competitiveness through improving material efficiency and through developing new products and services that lower the overall resource intensity?”; “The policy-oriented aim of the current report thus is to align the economic interest in cutting material purchasing costs and innovation with the environmental issue of reducing environmental pressure. The focus on resource productivity can be seen as advantageous in that regard, since resources are used in all industries and productivity is a key concept for economic development”; “Our report seeks to test the hypothesis, that resource productivity leads to an enhancement of competitiveness through lowering material purchasing costs and through developing new products and services that lower the overall resource intensity” (p. 7).

the "problem shifting" shortcoming with regard to space, as it falls when the mix of a country's activities shifts towards the end of the production chains. Therefore, it is no wonder that resource-poor countries, some of which are big importers of material products for intermediate and final uses, tend to rank high in resource productivity in these studies.

It should be also noted that the importance of foreign trade – and consequently of indirect flows – is ever growing. As a consequence:

> Recent studies conducted for the EU and its Member States, the USA and Japan […] have shown that an increasing share of resource requirement and associated environmental burden is shifted abroad. The resource requirement of national economies is thus systematically and to an increasing extent underestimated. (Bleischwitz et al. 2009, p. 22)

The need for a quicker growth of RP, which may not be very evident looking at indicators sensible to "problem shifting" (the individual IUs of raw materials, and to some extent also DMC), emerges as soon as comprehensive resource use measures of a country are adopted, the more so the more comprehensive the measures.

If RP does not grow quickly enough, either active policies must be devised to boost it, or a way to make the economic system work with lower or no GDP growth must be found, or both.

9.4.2 Economic Growth and Labour Productivity

Let us now bring into play labour productivity (LP ≡ GDP/L, where L is ideally measured in time – e.g. man-hour – units). The continuous drive to increasing LP lies at the very heart of the success of so-called developed countries in terms of production of economically valued goods and services. Since the times of Adam Smith, the increase of LP is recognised as the most important long run determinant of economic growth. Indeed, unless the working efforts of the population are constantly intensified (which cannot be the case: eventually the bio-physical limits of population will be reached), sustained growth of per capita income is possible only in presence of a correspondingly sustained growth of labour productivity.[17] So, the quest for economic growth is basically a quest for increased labour productivity.

The tendency towards the increase of total labour productivity probably is in part a mere fact of nature: since human beings are intelligent, they always find ways to make new and better things, and to make things more easily. The capitalist economy

[17] Total labour productivity, i.e. the GDP generated per unit of labour input, is identical to per capita income times the working effort intensity of the population, with the latter defined as the ratio between the labour input to production and the total population: GDP/L ≡ (GDP/P)*(P/L). The latter ratio depends on the demographic structure, the employment rate and the daily working hours. Total labour productivity may grow because the quality of labour used in the production process increases, because capital is made available in greater quantity or better quality or is used more intensively, and because greater overall efficiency is attained in how these factors are combined in production, as to obtain a bigger or better output (multi-factor productivity). Changes in the composition of the economy by kind of activity imply changes of total labour productivity at the economy-wide level since different activities have different levels of labour productivity.

puts this kind of intelligence at work in a tremendously efficient way thanks to the powerful mechanism of competition between producers. Whether competition is completely free market or oligopolistic or state-supported, whether it results in selection or adaptation, one systemic long-run outcome of the continuous struggle between producers and nations is the growth of total labour productivity. In some case – notably where labour costs make up a large share of total costs – the cost of labour per product unit is a fundamental determinant of competitiveness, and reducing it by increasing labour productivity is an explicit target of the producers. But also where there is no such explicit goal, for the producers it is imperative, in order not to be pushed out of their markets, to accumulate and enhance the physical and human capital inputs as well as to better organise the factors of production by introducing product and process innovations. Several public policies directly contribute to help the producers meet these objectives, e.g. by promoting innovation and providing subventions for restructuring the production process or for keeping part of the work force temporarily out of production.

All these efforts necessarily result in the possibility of producing more with the same quantities of labour or of using less labour to obtain the same output. Historically, it is the "producing more" case that prevailed in the so-called developed countries. Producing the same output, given the rigidity of the working time, would have resulted in massive unemployment.

This prevalence of the "producing more" case deserves great attention in our normative perspective. Partly it prevails because the increase of LP corresponds to the creation of new possibilities, whose corresponding needs emerge spontaneously; partly because of the competition mechanism itself: besides that for increasing productivity, a constant and active quest goes on for expanding the market into non-market domains of the world and of life.[18] However, this would not suffice. As shown by post-keynesian and neo-ricardian economic analysis, in a dynamic system with technical progress and structural change, a situation of full employment will not automatically be maintained through time, because the aggregate demand for consumption and investment goods will not exhaust their actual production and/or the growth of demand will not match that of the production potential for all sectors: government intervention is needed.[19]

Indeed, governments' continuous efforts to keep production steady and growing, thus avoiding massive unemployment, is one major reason for the prevalence of the "producing more" case. To the extent that these efforts entail striving for international competitiveness by increasing the national system's productivity, government intervention at the same time tries to expand the national producers' markets. Government intervention often directly lowers the cost of labour so that it be used more than otherwise it would – e.g. by (de)regulating labour contracts and by liberalising the labour market or by collectivising the costs of labour market failures; this kind of intervention, however, may also have losses of LP as a side effect. Other

[18] This penetration ability is itself due to the production efficiency, which in turn increases also as a consequence of the expansion of the market.

[19] See for instance Pasinetti (1981).

regulatory and economic instruments positively contribute to keep employment high and the national economy going – e.g. production of services that the market would otherwise under-produce, deficit spending to sustain aggregate demand, expansive monetary policies, currency devaluations, special policies in times of crisis (e.g. saving banks from bankrupt), etc. Public policies therefore play important roles with regard both to increasing LP and to making sure that this increase be transformed into GDP growth and not into a reduction of L.[20]

In a dematerialisation perspective, economic growth as an objective of public policy must be radically put in question. Of course, it is of paramount importance to avoid that this result in having environment opposed to labour. Sustaining the demand side is in principle not a compulsory choice: a gradual reduction of working time and/or of the participation to the work-force would compensate the increase of labour productivity not only in its effects on resource use but also in those on employment.

> The choice between a larger quantity of commodities (or of its better quality) and free-time is not a simple possibility, but a *necessity* if we want to keep full employment. (Pasinetti 1981, p. 90; our translation from the Italian edition).

The benefits of labour and resource saving should be appropriately distributed, by sharing evenly workloads, income and leisure. The link between LP growth and GDP growth should be broken by transforming LP growth into a reduction in L that is welcome, i.e. into leisure and not into unemployment and poverty. To some extent this may be accomplished by de-linking the access to income (and in general to the resources necessary for a good life) from work (e.g. by introducing a universal basic income) somewhat more than the so-called welfare state already does.

The main difficulty for this change of attitude with respect to L and GDP lays in the "prisoner's dilemma" kind of situation in which individual producers and governments find themselves given the current institutional setting of the global market, which do not leave much room for solutions alternative to those that transform LP increase in GDP growth.

9.4.3 LP, RP and the Speed of Materials Throughput

The relationship between RP and LP deserves a central place in the whole discussion. With LP as driver for GDP, and GDP as driver for R, one may be tempted to establish a trade-off between LP's increase and R's decrease. However, such a conclusion would be misleading: as seen above, RP's growth may prevent R from growing when LP grows. Since $R \equiv (LP/RP)*L$, with L fixed, R increases only if LP's rate of growth exceeds RP's; if RP's rate of growth exceeds that of LP the use of resources will even decline.

---

[20] At present, especially in Europe, one of the policies mentioned (saving banks) has fired back. After these costly operations, deficit spending has been declared to be the worst of sins, and as a consequence the "produce more" case is not prevailing at the moment, which exacerbates all sorts of social problems.

As for the empirical evidence on these rates of growth, the study quoted above (Bleischwitz et al. 2009), shows that "in total, resource productivity improves at a slower rate than labour productivity". Nevertheless it also shows that is not true in general that LP has outweighed the increase in RP in recent years, as "in *several countries of the EU15 and Japan resource productivity has increased faster than labour productivity between 1980 and 2004/2000*" (p.42; emphasis in the original).[21] It is interesting to note that "under ceteris paribus conditions, DMC per capita would fall by 1.27% p.a., because of the autonomous technological progress" (p.12) and that "in general there is a *positive relation between competitiveness of economies and their resource productivity*. But the causality between both variables are not yet clear" (p. 58 emphasis in the original).

As for policy, EU documents acknowledge that active public intervention is needed to make RP grow fast enough:

> Reducing the use and improving the efficiency with which our economy and society uses resources will require actions at different levels of government and in the different sectors of the economy. (EC 2001, p.51)

And as for forecasts, the TS-SUR is optimistic regarding the expected impact of this intervention:

> In the period 1980–2000 the resource productivity (€/kg) of the EU-15 economy increased by 52%, which is 2.2% per year. On the basis of this trend, and assuming that proper implementation of this strategy will lead to at least a modest increase in resource productivity, it is reasonable to expect a rate of 3% resource productivity improvements per year for the period 2000–2030. This would represent a slight acceleration compared to the previous 20 years. (EC 2005, Annex 1)

But what are the conditions for RP's growth to be sufficiently large? To explore the mechanisms behind the empirical evidence, we may again refer to a tautology: by dividing both sides of GDP≡LP*L by R we obtain RP≡LP* (L/R). When formulated in terms of rates of change, this tautology points out that the difference between RP and LP growth is strictly connected to the change in the ratio between the quantities of labour and resources used as inputs. L/R expresses the quantity of labour applied on average to a unit of resources. The intimate meaning of this ratio, however, is revealed by thinking of L in terms of *time*. Thus thought, L/R is an inverse function of the time that materials spend in the socioeconomic system before becoming waste and emissions. It is important to note that this time is not a merely technological fact: structural economic change plays a very important role in determining it.

[21] The quoted report warns that two distortions may derive from the kind of data used to calculate RP and LP. Indeed, it is likely that the increase of RP be overestimated and that of LP underestimated, respectively because of "a shift of resource intense sectors or production processes abroad" and of "a trend towards more part-time employment" (p. 42, footnote). The latter distortion implies a "nominally lower labour productivity compared to a calculation based on man-hours" and an equivalent but contrary distortion (overestimation) of the labour input (L). This results in attributing to a growth in L a responsibility for the growth of GDP, and its consequent effects on R, which really belongs to LP. Indeed, despite RP increased faster than LP in several countries, as already seen only one country, among EU25, Turkey, Japan and the USA was able to reduce DMC in absolute terms.

Its overall average value in fact depends upon the *speeds* with which materials flow through the hands of labourers and with which products flow through the consumption system. While in industrial production the speed clearly is more strictly connected to technology, a major determinant at the whole economy level is its composition by activity, namely how much of the total working time is spent in non-material production. Of particular importance are some service sectors. The use of long-lasting goods as fixed capital in the production of services similar to those self-"produced" by households by using consumer durables is an interesting special case, as it has the characteristics of production from the value chain point of view, but is similar to consumption from the material flow point of view (the capital durable goods are not further transformed). Let us think as examples of taxis and launderettes. This area of production substantially contributes to the general increase of RP, as far as its growth at the expenses of non-economic activity implies a growth in GDP. This does not necessarily represent a socially desirable outcome. However there surely is a good side in the coin, and it is that if the machinery that households detain to "produce" similar services is not replaced anymore, this may result in a lower resource use. RP will grow more rapidly than LP, and R will possibly fall (assuming L does not grow too much), only if on average more work is applied to a given quantity of resources i.e. if the material throughput's speed in good's production is slowed down and/or goods useful life is lengthened. This points to the degree to which material goods remain in the economy as machinery or tools or objects of work before being replaced by new material goods, to the value generated and work done in the tertiary sector, as well as to the composition of demand, which in turn depends upon the characteristics of the use phase of products' lifecycle, upon consumers' and producers' preference for durability with respect to rapid wearing off, obsolescence etc. From the demand point of view, all factors that influence products' durability and actual permanence in activity are important, including individual and social attitude and institutional arrangements. The current situation from this point of view is not encouraging: when new products having the same functions of some existing good appear, they do not just replace the latter for the future buyer, but also push for the existing stock to be replaced (wasted) faster than it would. Process innovation is often directly aimed at allowing more things (whether new and more valuable or not) being produced in less (working) time: faster production chains, better logistics, better organisation in general, etc., and product innovation is often deliberately aimed at making obsolete things that are in perfect working conditions. The corresponding (induced) demand changes comprise preference for new items and for use-and-throw-away goods instead of maintenance, repair and durable goods, and are connected to phenomena such as fast (planned) obsolescence, rapidly changing fashion and the like. Think for example of all the electronic equipment waste brought about by digital technology's frantic innovation rhythm.

RP and LP are so strictly tied that they may be seen as the expression of two different faces of the same overall "productivity" properties of the system. Not just because "improving resource efficiency will increase economic efficiency more generally and thereby enhance competitiveness and foster innovation" (EC 2001, p. 51), but more fundamentally, because RP growth is the effect of exactly the same macroeconomic dynamics and technological innovation phenomena that are at the basis of LP's growth. It is the specific characteristics of these dynamics that determine their different speed. L/R should continuously fall if RP was not to grow too. An indefinite decrease of L/R could only be possible if the combined effect of structural change and of technical and organisational innovation was systematically distorted in favour of more resources and less labour use. Luckily, while this may be the case for technical change, it surely is not for structural change.

So, the empirical findings and the forecasts quoted above are not astonishing. Indeed, there is not as much need for a causal interpretation of the link between LP and RP (and maybe even no point in looking for it), as for an investigation of the structural, technological and organisational changes underlying productivity increases, and – in a normative perspective – of the conditions under which and how these changes may be made to be more resource-saving than labour-saving.

In a normative perspective, the whole question may therefore be reformulated as how to *deliberately steer* the socioeconomic system in order *to slow down the speed* of the resource throughput and *to lengthen products' and materials' useful lifetime*. While it seems difficult that technological progress be oriented towards reducing labour productivity as far as aspects such as the number of pieces that can be produced in a given time are concerned, a greater contribution may come from lifetime length.

In order to produce some things, some other things are strictly necessary. One way to reduce the resource intensity is to give up as much as possible material-intensive productions, and strive for substituting them with other, less material-intensive products and/or behaviours. As for substituting products, not only individual producers' but even whole production sectors in a country usually have only a quite limited range of possibilities among which they can choose *what* to produce. Once taken, these decisions cannot be changed easily, due to the high path-dependency of specialisation. In these cases saving resources necessarily implies, at least in the short run, saving labour too: society as a whole should take care of this problem.

Using labour to save resources, where this is possible, means solving two problems at the same time: in some cases goods and services may be produced differently, in a way that the same labour quantity is associated to the use of less resources, e.g. electricity may be generated from wind rather than burning gas or coal, waste collection and recycling may be pushed at the limit where it requires more natural resources than it saves, trains may in some cases substitute airplanes if those who travel do not have to hurry. Research, innovation and technical and organisational progress that makes the input of labour grow relatively to that of resources should be actively promoted.

9.5 Changing the Perspective on Socially Valuable Outcomes

The development of new shared visions and commonsense concerning the very objectives of societies is of paramount importance for the evolution towards a sustainable way of living. In particular, what should be measured and assumed as a target, in a normative formulation of the Resource Efficiency problem, is not the monetary value of the domestic product, but the quantity of services to which people have access. We will consider this more in detail in the next paragraph, along with some normative implications. Hereafter we will discuss the issue of societies' objectives in very general terms, connecting the discussion on economic growth, RP and LP of the previous paragraph to the ongoing debate on well-being and progress measurement, i.e. enlarging the perspective to the efficiency of natural resource use understood in more general – though less easily quantifiable – terms.

Two recent first-magnitude events apparently heralded the decline of the quite strict twentieth century idea of well-being and society's progress, according to which the steady increase of the volume of economic activity is the most important of all things: the Communication from the European Commission to the Council and the European Parliament entitled "GDP and Beyond – Measuring progress in a changing world" (EC 2009), and the so-called "Stiglitz report" (Stiglitz et al. 2009), issued by a commission of experts appointed by no less than the President of the French Republic, which gathered several top-level scientists, including five Nobel laureates.

These documents made clear once and for all that GDP per capita and its growth are far from sufficient to describe well-being levels and societies' progress and that the empirical contents of these concepts must be identified and defined *per se* and measured directly.[22] This is a strongly normative conclusion, since the step between "what to measure" and "what to pursue" is a very small one. Indeed, the idea that GDP is a measure for well-being and progress and the belief that economic growth is *per se* good are the two sides of a same coin, so that as soon as GDP as measure of wellbeing is questioned, the very rationality of pursuing its growth is immediately questioned too.[23]

The most notable fact about the current debate on the measurement of well-being and progress is that it succeeded in involving policy-makers and high-level government officials, making them seriously consider the idea that new answers must be given

---

[22] Research and debates on the topic are long standing. Just as an example, D. L. Meadows wrote in the preface to Hueting (1980), that "it has become customary to preface national economic policy recommendations with a brief disclaimer acknowledging that Gross National Product (GNP) does not provide an adequate index of social welfare and that GNP growth is neither inevitable nor necessarily always desirable" (also see, on GDP's meaning and problems, Fuà 1993; for an interesting, politically coherent, point of view, see Mujica 2012). However this debate was mostly relegated, until not long ago, to heterodox circles. The importance of the quoted documents lies not so much in their indubitably highly valuable contents as in the authoritativeness of their authors and promoters. In particular the Stieglitz report's main substantial contribution should not be looked for as much in the new elements it introduces in the debate as in the systematisation of the issue and of the quite numerous surrounding topics, as well as in some of its conclusions, such as those clarifying that social choices cannot be based on any single indicator.

[23] This is perfectly in line with the normative approach taken in the present article, which, as seen above, suggests that LP gains should be "sterilised" by transforming them into more leisure or unproductive work rather than into more production. Some radical theorists have gone as far as to adopt the "degrowth" slogan (see e.g. Martinez-Alier 2010). In our view, it may be misleading to consider economic growth *per se* as it is neither intrinsically good nor bad. The real problem is how to make possible that ecologically and socially rational choices prevail. GDP may grow or fall as a consequence, and *if a way to make the system work anyway is found* there is no need to be bothered by this too much.

to fundamental questions such as "which should be the ultimate goals of society?" and "are we basing our actions on a valid conception of progress?" and leading them to listen to the suggestions of social and environmental sciences on the topic. This notwithstanding, it is a matter of fact that GDP and its changes firmly remained at the heart of the worries, calls for action and choices of governments, workers' and entrepreneurs' organisations, politicians, opinion makers, journalists and – needless to say – mainstream economists. This is all the more true in the current crisis. Not by chance, in the present situation attention shifted away from the whole "beyond GDP" debate and Europeans search the skies for timid signs of recovery. The myth of economic growth is still so powerful that most of the people who are paying the crisis are easily misled into thinking that saving banks and paying unreasonable interest rates to speculators by cutting salaries and social services will lead to a supposedly not-so-far and economically and financially sustainable growth.

It is worth asking why, despite all sorts of a-priori theoretical reasoning and empirical evidence confirming that GDP per capita is not so important in terms of well-being and progress, the world still seems to need economic growth as badly as air. The point here is that the ideas that GDP is a measure for well-being and progress and that economic growth is *per se* "good" express something more than ill-founded but common prejudices. Partly these are inertial beliefs founded on historical reality: at least in some countries of the world, for a long while social progress and individual well-being have actually gone hand-in-hand with economic growth, though at present the relation is much weaker even in those same countries. But the most important fact is that *the perceived link persists in a perverse way, given by the "prisoners' dilemma" kind of situation described above*: GDP growth being for most people a precondition for their situation not to get worse and for some even for getting access to the very means of decent living, this link functions in negative but not in positive. The constant transformation of LP increases into potential unemployment is a fundamental gear in this transmission mechanism. It is as if society were running on a treadmill: even if it runs it does not advance; but if it stops, it goes back and eventually tumbles; those who are behind are the ones who get more hurt. So it is no wonder that even those who do not profit much from economic growth are bound to desire it and call for policies that sustain it, perhaps without enthusiasm but knowing that otherwise they would be in danger. The social consequences of the current crisis, that just began to be visible, are a sample of what happens when the menace is realised.

The paradoxical truth is therefore that economic growth is vital for the system, even though the link between GDP per capita and well-being (no longer) has a clearly positive sign. The economic system needs to grow just to be able to function and to keep employment and access to income at acceptable levels; it tends to generate poverty and unemployment as soon as it does not grow, whatever the income levels reached through past growth. In such a system the lack of growth is at the same time the symptom and the illness. *As long as the competition dilemma is not overcome, it will be possible to measure well-being and progress correctly, but not to pursue them.*

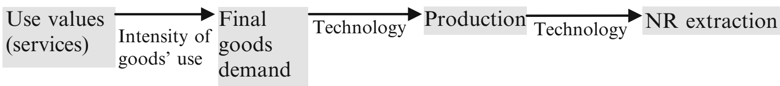
One necessary step is that to some extent the power of choosing what, how much and where to produce be subtracted from the domain of the restricted number of individuals that currently detain it (directly, through control of the means of production, or indirectly, through finance), and society be empowered instead. The loss of individual power of choice of some would be compensated by wider possibilities for many more others, as e.g. that of choosing between different ways to spend the time freed from paid work, and including in this choice the ways that require a safe natural environment. The conceptual revolution we are witnessing in the field of measurement of progress has, not by chance, important points in the inclusion of leisure and environmental quality in the set of socially valuable outcomes towards which well-being and progress must be measured. If society chooses to increase leisure rather than simply avoid unemployment, i.e. to redistribute work as jobs are destroyed by the giving up of unsustainable productions, it will surely turn out that well-being may increase because of a reduction in employment (measured in time units) and not despite it. Also, as the "green economy" insists, some unemployment may be avoided by creating jobs in the rational resource management and in the protection of the environment, which contribute to slowing down the average pace of the resource throughput by using more labour on the same resources. Of course, only if these jobs are substitutive rather than complementary to resource intensive ones there are advantages at the system level.

Another point connected to this debate relates to the economics science, which provides the theoretical and ideological basis for the idea that GDP and well-being are strictly connected, through the utility concept and the general equilibrium model. The idea that prices reflect – even though imperfectly – the utility of goods and services is the result of a purely formal and axiomatic analysis whose final result is basically anti-normative. On the contrary, within a normative approach, the implications in terms of well-being of the bundles of goods and services purchased by the consumers need to be evaluated in a substantial and epistemologically open way, i.e. by making reference to their material characteristics, to the actual width of the range within which individual consumption choices are made, to the conditions of fruition of the purchased goods and services, to the role of cultural norms and to the psychological dimension (see e.g. the Easterlin paradox). The economic advantages of an increase in RE are evident if the meaning of "economic" is widened as to include the actual fruition of use values: as long as the analysis is limited to consumption meant as purchase of goods and services and seen as an aim in itself, it may only provide the ideological justification of consumerism. This would entail a discourse on the use of time. Such a discourse should also not forget production, which is not an abstract realm detached from reality, but the activity in which people spend on average a sixth of their lifetimes and which provides a good deal of existential meaning and identity to many.

The importance of a change in the dominant perspective on societies' objectives can hardly be overemphasised, but it should be acknowledged that there are powerful mechanisms that limit the possibility that an ideal change may exert a real influence on the material reality. Are the current constraints to individual and government choices going to allow these choices to change in the necessary direction? The ongoing debate may beg this question as it deals with what to *measure* in relation to well-being and progress. But, no matter how successful this “new” view, society must still deal with the question of what to *do* in terms of institutional arrangements in order to empower itself to pursue well-being and genuine progress instead of economic growth. We leave this question open, and go on to introduce some possibilities that society may start considering – though it may not be able to implement them – while looking for the way to slow down the treadmill at manageable speed.

9.6 Objectives and Tools of a RE-Oriented Policy

Once the idea of controlling harmful flows to the environment at the end of the pipe is rejected and NR extraction is targeted as the necessary precursor of all environmental disruption, a policy seriously aiming at increasing RE must be devised. Such a policy should tackle all the links and articulations of the causal chains determining NR extraction, which in the last analysis is “activated” by the fruition of use values:



The links represented by the second and third arrows express a standard concept: given the technology, NR extraction is univocally determined by the corresponding total production of goods needed to meet the level and composition of final demand. Reference here is to the Leontievian model, limited to goods and ideally not stopping at the boundaries of the national system, in accordance with the *extended responsibility* principle.

However, the demand for goods must not be considered an exogenous determinant of total production and consequently of resource use, but an endogenous variable and a target for policy, just as goods’ production technologies. This leads us to the link represented by the first arrow, which is less obvious than the others and deserves some explanation. It depicts the relationship between the satisfaction of needs and the use of goods, something we may call *socioeconomic technique of transformation of goods into services*. This transformation is a socioeconomic phenomenon because, as hinted above, it may be carried out both inside the production system, in tertiary activities – in which case it implies that the consumers directly purchase some services, and not the goods necessary to produce them – or/and outside the production system, in the consumption sphere – in which case the necessary goods are purchased by the consumers.

Goods may be more or less intensively “transformed” into services i.e. may provide their services in a varying number of occasions and to a varying number of users. This is particularly evident for consumer durables, which usually produce an amount of services per time unit much lower than their potential.[24] For any given quantity and composition of the final services enjoyed, the higher the intensity of goods' use the less resources will be demanded to nature.

This intensity is clearly connected to technical features of the goods such as their durability and reusability, which should be made the explicit target of very incisive *ad hoc* policies.

It is almost common-sense that economic instruments may play a primary role in orienting technology, design and demand as to favour goods that have lower unitary material inputs, that are made of materials with lower indirect flows, that consume less energy, that can be easily upgraded, disassembled and recycled, etc. (on Resource productivity and environmental tax reform, see e.g. Ekins 2009). With respect to this, the dematerialisation approach suggests that *all* NR extraction should be taxed – directly when possible, otherwise indirectly as in the case of imports. This would give, through the transfer of the taxes to the intermediate and final users, the right incentives to rationalise direct and indirect NR uses. The *per ton* rate of the tax should be modulated on the different resources according to scientific evidence on their likely impacts; in all cases, however, the size of NR taxes should be large enough as to influence economic agents' behaviour (small price changes are not effective). It should also be large enough to allow reduction of taxes on labour as to provide incentive to its use. According to the extended responsibility principle the imported products should be taxed at their entrance in the national system in proportion to their total – direct plus indirect – NR content (this of course presents many practical difficulties, none of which is insurmountable). Of course subsidies that encourage the over use of resources should coherently be removed. The consequent change in the relative prices of NR and labour would make L/R, and therefore the RP-LP relationship change in the desired direction, and through this, also RE would improve.

Where economic instruments are not effective, it should also be no taboo to limit the freedom of producing or importing things that are likely to become very quickly and easily waste, just as it is limited the freedom of producing toxic toys and of importing counterfeited T-shirts.

The intensity with which goods are used also greatly depends upon social and institutional factors such as the degree to which the market has replaced typical households' own account service production; the attitude of people towards sharing things; the existence of appropriately organised common spaces and facilities; the prevailing structure of goods' property rights and the like.

We already hinted that rising RE may require simply giving up as much as possible some material intensive productions. The "transformation of goods into services" concept points to the possibility of achieving this, to a certain extent, without giving up a proportional quantity of final services. The answer given so far by the market and by policy to the need of a comfortable life has been to fill our houses with as many consumer durables as possible, most of which stay idle most of the times in order to be always available so that their owners may use them

[24] Indeed, when the same or similar goods are part of the capital stock they are likely to be used much more intensively.

whenever they might want them. But this is not a fact of nature. Many goods that are used and owned individually may in principle be shared: it is a matter of social organisation whether the corresponding needs are dealt with as collective or not. For instance for some home appliances houses and neighbourhoods may be organised as to grant access to their services without the need that everybody has one at home. Keeping durables idle amounts, when not technically unavoidable, to wasting not only the space they occupy but also the services they could provide, i.e. to having a lower well-being than it would be possible. The same is the case for the infinite lines of cars parked next to the sidewalks. If this kind of goods and their services were made the objective of active policies the transformation technique could evolve to a greater extent than we may now imagine. These policies, besides the usual economic and regulatory instruments, would extensively use pedagogical instruments, innovation in property rights, promotion of original institutional and organisational solutions, eco-labelling and environmental reporting to make available to the public information on individual goods' NR intensities, as to rise consumers' awareness (in the same way as e.g. nutritional contents of prepared food is made available) and the like. Coherently, for the public sector as a buyer of goods, green procurement policies taking into account NR inputs, durability etc. should be put in place.

This all is in general not at odds with market, competition and profit, although it may be so in many particular cases: on the contrary, in a framework of changing ideology on well-being and progress and of relative prices of resources dramatically rising, the fantasy of entrepreneurs and consumers would be a natural allied of sustainability policy. Many things are already shared through the market, as in the case of rental services, public transportation etc.; this kind of economic activities could be much more widespread than they are now. The costs and the NR necessary for the maintenance of the individual durables would of course be higher when they are used more intensively, but in total they would probably turn out to be lower, as also idleness deteriorates things; to the extent that more people would be employed in reparation services higher maintenance costs are even desirable in a situation where many former industrial workers would otherwise be unemployed. More substantial employment benefits could emerge in the rental services and the like. A faster turnover of durables would allow reaping the benefits of technological progress without having to replace stocks that have not been fully exploited.[25]

What this is at odds with is the speed at which currently life runs in the so-called developed parts of the world. Having things always at hand, while in many cases makes it possible to fulfil needs immediately as they arise, often is not a choice but a sheer necessity. A soberer and at the same time happier lifestyle is possible in principle; making it possible in practice would be an essential part of a policy aimed at sustainable progress. One important point is again the overall reduction and

[25] Recycling alone would be a sufficient alternative if all materials could be recovered from prematurely obsolete goods and if the energy necessary to melt them down could be produced without causing environmental stress. Since unfortunately these possibilities are not real (even in pure theory, as they are dismissed by the second law of thermodynamics), recycling may and must be one part in a general framework of objectives.

redistribution of the workload, already advocated above, which would be necessary also to free the time necessary for people to be slower and enjoy things differently. The difficulty lies in the renounce to some individual freedoms; it is a huge difficulty, as these freedoms are currently perceived by many as freedom *tout court*. A policy, to be viable, should make people aware that there are other, more fundamental, freedoms to be gained in exchange.

Society must include, among the other choices, that between constantly having a huge quantity of idle durables that enable people to be always fast, and organising itself as to have a lower stock with higher use intensity. There is at least one exception to this choice, however. Among the material intensive "goods" that are – luckily – idle most of the times, though being continuously replaced by newer and "better" ones, our societies keep a lot of weapons. C*eteris paribus*, a peaceful society surely is a less material intensive society, besides being more likely to be a happy one. The only rational option here would be not having *at all* the production, but apparently rationality does not prevail, in this field at least (*pace* Coase's theorem).

9.7 Wrap Up

Resource Efficiency as a normative concept is best conceived as something much wider than sheer Resource Productivity. This wider concept puts at the centre of attention the efficiency with which natural resources are used, in an enlarged responsibility perspective, in order to generate socially valuable outcomes. The latter do not necessarily coincide with, and sometimes even contradict, the creation of economic value as measured by GDP. Therefore, having RP increase faster than LP, though of primary importance in public policy and individual action aiming at ecological sustainability, is only one of the many facets of the much needed overall switch of societies' goals from economic growth to more directly defined, and properly measured, well-being and progress. The measures and changes necessary to boost RE largely coincide and interact in a synergic way with those needed to put under control the drive to continuous LP increases. The latter is inherent to the current condition of fierce competition between producers and nations. Low quality and resource intensive economic growth is both a necessary outcome of this drive and a prerequisite for the mechanism to maintain socially sustainable employment levels and income distribution conditions.

The far-reaching changes necessary in our socioeconomic framework concern many closely interrelated aspects: the level and quality of awareness, since the need to change direction is more often mentioned than felt; the spatial frame of reference, since resource use is a precursor of environmental pressures no matter where it occurs; the time frame of reference, since sustainability is an issue going far beyond the horizon of our current worries; the dominant ideology, since well-being and freedom ideas compatible with sustainability are somewhat different from the currently prominent ones; the measurement of well-being, since new sustainability, equity and progress concepts must be made operational and reflected in the reference indicators; the objectives of economic policy, since GDP growth should not be the overarching one, distribution of work and income should be appropriately controlled to avoid that LP gains result in undesired unemployment and economic incentives and disincentives should foster labour use and discourage resource use; the use of command and control policies, since new environmental standards directly tackling resource use should be enforced, on the basis of the precaution principle; education policy, as cultural norms are the most important determinant of individual and collective behaviour; and, most delicate of all, the width of the domain where the mechanics of competition and the dictatorship of financial capital rule, since the choice of what, where and how much to produce, in a world where 47 thousand persons a day starve while others' overconsumption jeopardises the planet's future does evidently not respond to *socially and environmentally rational choice.*

References

Bleischwitz R, Bahn-Walkowiak B, Onischka M, Röder O, Steger S (2009) The links between the environment and competitiveness – Part B: The relation between resource productivity and competitiveness. Final report ENV.G.1/ETU/2007/0041. Wuppertal Institut für Klima, Umwelt u. Energie, Wuppertal

European Parliament and Council (2002) Decision N° 1600/2002/EC of 22 July 2002 laying down the Sixth Community Environment Action Programme. OJ L 242/1, Brussels

Dryzek J (1987) Rational ecology. Basil Blackwell, Oxford

Ekins P (2009) Resource productivity, environmental tax reform and sustainable growth in Europe. Anglo-German Foundation for the Study of Industrial Society, London

European Commission (EC) (2001) On the sixth environment action programme of the European Community – 'Environment 2010: Our future, Our choice'. Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions COM(2001) 31 final

European Commission (EC) (2003) Towards a thematic strategy on the sustainable use of natural resources. Communication from the Commission to the Council and European Parliament. COM(2003) 572 final

European Commission (EC) (2005) Thematic strategy on the sustainable use of natural resources. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. COM(2005) 670 final {SEC(2005) 1683} {SEC(2005) 1684}

European Commission (EC) (2008) The raw materials initiative – meeting our critical needs for growth and jobs in Europe. Communication from the Commission to the European Parliament and the Council. COM(2008) 699 {SEC(2008) 2741}

European Commission (EC) (2009) GDP and beyond: measuring progress in a changing world. Communication from the Commission to the Council and the European Parliament. COM(2009) 0433 final

European Commission (EC) (nd) Flagship initiative on a "Resource efficient" Europe. Retrieved 03 Jan 2013 http://ec.europa.eu/resource-efficient-europe/index_en.htm

EUROSTAT (nd) Sustainable development indicators, Retrieved 03 Jan 2013 http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/indicators

Fuà G (1993) Crescita economica: Le insidie delle cifre. Il Mulino, Bologna. English edition: Economic growth, a discussion on figures, Dipartimento di Economia, Università degli studi di Ancona, 1994

Hueting R (1980) New scarcity and economic growth: more welfare through less production? North Holland, Amsterdam

Jaenicke M, Mönch H, Binder M (1992) Umweltbelastung durch industriellen Strukturwandel? – Eine explorative Studie über 32 Industrieländer (1970 bis 1990). Edition Sigma, Berlin

Kapp KW (1963) Social costs and social benefits – a contribution to normative economics. In: Beckerath EV, Giersch E (eds) Probleme der normativen Ökonomik und der wirtschafts-politischen Beratung. Duncker & Humblot, Berlin, pp 183–210

Kapp KW (1970) Environmental disruption and social costs: a challenge to economics. Kyklos XXIII(4):833–848

Kapp KW (1974) Environmental indicators as indicators of social use value. In: Kapp KW (ed) Environmental policies and development planning in contemporary China and other essays. Mouton, Paris/The Hague, pp 127–138

Kapp KW (1976) Economics in the future: the open system character of the economy and its implication. In: Dopfer K (ed) Economics in the future: towards a new paradigm. Macmillan, London, pp 90–105

Kapp KW (1977) Environment and technology: new frontiers for the social and natural sciences. J Econ Issues 11(3):527–540

Malenbaum W (1975) Law of demand for minerals. In Proceedings: Council of Economics, AIME Annual Meeting, New York

Martinez AJ (2010) Beyond GDP lies economic degrowth. Retrieved 29 Mar 2010, from http://www.euroalter.com/2010/beyond-gdp-lies-economic-degrowth/

Mujica JP Discourse at the RIO+20 UN Conference on Sustainable development, 21 June 2012. Retrieved on 04 Jan 2013 from http://www.youtube.com/watch?feature=player_embedded&v=3SxkMKTn7aQ

OECD (nd) Better Life Initiative: Measuring Well-Being and Progress. Retrieved 03 Jan 2013. http://www.oecd.org/statistics/betterlifeinitiativemeasuringwell-beingandprogress.htm

OECD (nd) OECD Work on material flows and resource productivity. Retrieved 03 Jan 2013 http://www.oecd.org/environment/environmentalindicatorsmodellingandoutlooks/oecd-workonmaterialflowsandresourceproductivity.htm

OECD (nd) Resource efficiency. Retrieved 03 Jan 2013 http://www.oecd.org/environment/resourceefficiency

Pasinetti L (1981) Structural change and economic growth. Cambridge University Press, Cambridge

Stiglitz JE, Sen A, Fitoussi JP (2009) Report by the Commission on the Measurement of Economic Performance and Social Progress. Retrieved 26 Mar 2010, from http://www.stiglitz-sen-fitoussi.fr/documents/rapport_anglais.pdf

UNEP (2012) Measuring progress towards an inclusive green economy. http://www.unep.org/greeneconomy/Portals/88/documents/research_products/Measuring Progress report.pdf

UNEP (nd) UNEP's Resource Efficiency Programme. Retrieved 03 Jan 2013 http://www.unep.org/resourceefficiency/Home/UNEPsResourceEfficiencyProgramme/tabid/55552/Default.aspx

Van der Voet E, van Oers L, Nikolic I (2004) Dematerialization, not just a matter of weight. J Ind Ecol 8(4):121–137

Chapter 10
Establishing and Strengthening Markets for Resource Efficient Products and Services

Andreas Burger

10.1 Benefits of a Proactive Policy

Several trends indicate that the economic importance of resource efficiency will strongly increase in future, both from the perspective of consumers and enterprises as well as from a macroeconomic point of view. Socioeconomic megatrends such as the growth in world population and the economic catching-up of emerging and developing countries will be major drivers of this development that increases strongly the demand for resources.

If no substantial progress is made in improving resource efficiency, global use of raw materials will raise from around 60 billion tonnes in 2010 to probably over 100 billion tonnes in 2030, and about 140 billion tonnes in 2050 (UNEP 2011). The growing demand is met by a limited and sometimes shrinking supply of natural resources. If "current global rates of resource use persist, by 2050 we will need, on aggregate, the equivalent of more than two planets to sustain us. Already today, some non-renewable resources are close to their known limits while many renewable resources are being irreversibly degraded or used beyond their regenerative capacity" (COM 2012a). Therefore, it is very likely that resource prices will further increase in the long run and resource efficient products and services will become more attractive.

This trend is already evident in recent years. The markets for resource efficient products and services are growing strongly. According to estimates of Roland Berger Consultants the world markets for energy efficiency will almost double between 2011 and 2025, raising from 720 to 1,236 billion Euros. An even stronger growth can be expected in the world markets of material efficiency with an increase of 183 billion (2011) to € 513 billion € in 2025 (BMU 2012). This far exceeds the predictions in the studies of Roland Berger carried out in previous years. Resource

A. Burger (✉)
Federal Environment Agency (Germany), Wörlitzer Platz 1, 06844 Dessau-Roßlau, Germany
e-mail: andreas.burger@uba.de

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_10,

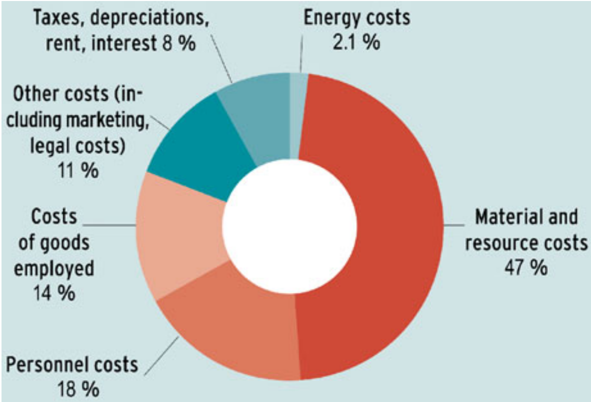


Fig. 10.1 Cost shares of gross production value in the manufacturing sector 2008 (Source: Federal Statistical Office 2010)

efficiency technologies will play a pivotal role on most markets in the twenty-first century. Also on the traditional markets – e.g. in the motor industry and mechanical engineering – the use of such technologies is becoming a major factor determining a company's competitive strength (UBA BMU 2011).

Resource efficiency is also a key factor to lower the production costs. In the German manufacturing sector the cost of energy and material already accounts for around half of the gross production value, whereas wage costs only account for around 18 % (see Fig. 10.1).[1] Therefore it pays off for companies to devote greater attention to material and energy costs. Taking into account raising resource prices in the coming decades the need for increasing resource efficiency will be even stronger. This is particular true for industries which are particularly dependent on raw material prices like e.g. the metal and food industry.

Accelerating resource efficiency by establishing and strengthening markets for resource efficient products and services is also beneficial from a macroeconomic perspective. It reduces the economy's vulnerability to sharp price rises and fluctuations on international raw materials markets.

The promotion of resource efficiency can also generate positive employment effects, as several studies indicate:

- Around 700,000 additional jobs could be created by 2030 if businesses in the German manufacturing sector implement the opportunities identified by consulting and thus cut their material costs by an average of 20 %. At the same time more than 9 % of raw materials consumption could be reduced (Distelkamp et al. 2010).
- The full implementation of EU waste legislation is estimated to generate 400,000 jobs by 2020 (Bio Intelligence Service 2011).
- Across the EU27 up to 322,000 jobs could be created directly by recycling 70 % of key materials the EU (as glass, paper, plastic, ferrous and non ferrous metals,

[1] These numbers reflect the share of material and resource costs from the perspective of the enterprises. It should be noted that the material costs themselves include labour costs in cases where the material takes the form of semi-finished and finished products used for production. Therefore, the share of material and resource costs is essentially lower from a macroeconomic point of view.

wood, textiles and bio-waste). The total potential – taking into account indirect employment effects, e.g. in the supply chain for recycling businesses – is more than 563,000 net new jobs (Friends of Earth 2010).
- A policy mix including an international agreement on recycling for metals, taxation on the use of metals in investment good industries and information and consulting programs could reduce the total material requirement in all EU Member States by 17.1–24.7 (compared to the baseline) and create up to 2.6 million jobs (GWS 2011).
- Improving energy efficiency in enterprises and buildings offer also great potentials for positive employment effects. Some 630,000 new jobs might be created in Germany, provided the federal government continues to pursue its goal of reducing national greenhouse gas emissions up until 2020 by some 40 percent over the 1990 index year. Measures to improve the energy efficiency in enterprises and buildings play a pivotal role in this context (Schade et al. 2009). In the EU the implementation of individual energy efficiency measures could lead to two million green jobs being created or retained by 2020 (COM 2011, 2012b; SEC 2011).[2]

The results of these studies indicate that resource efficiency offers a lot of economic win-win-options and that political intervention is needed to stimulate resource efficiency and to grasp the associated economic benefits.

10.2 Obstacles to Raise Resource Efficiency

Numerous barriers and market imperfections impede the development and diffusion of resource efficient products and services. Without tackling these obstacles the pace of improving resource efficiency will by far not be sufficient to achieve ambitious targets for absolute decoupling of resource consumption from growth needed for a sustainable development. It must also be taken into account that rebound effects hamper the process of an absolute decoupling.

10.2.1 Obstacles on the Macroeconomic Level

A major obstacle is the insufficient internalisation of external costs caused by resource extraction and consumption. Prices don't reflect the "ecological truth", resulting in distortions of competition at the expense of resource efficient products and production methods. In the case of R&D for resource efficient technologies and products even a double externality exists because of the spill over effects that can be observed for any R&D activities. Therefore an underinvestment in environmental innovations can be expected (Rennings 2000).

[2] These jobs "…are mainly for the renovation of the building stock, the uptake of products covered by eco-design and labeling measures (e.g. electric motors and drivers, refrigerators and freezers, circulators), and the improvement of energy efficiency in the manufacturing sector." (COM 2012a, b, p. 8).

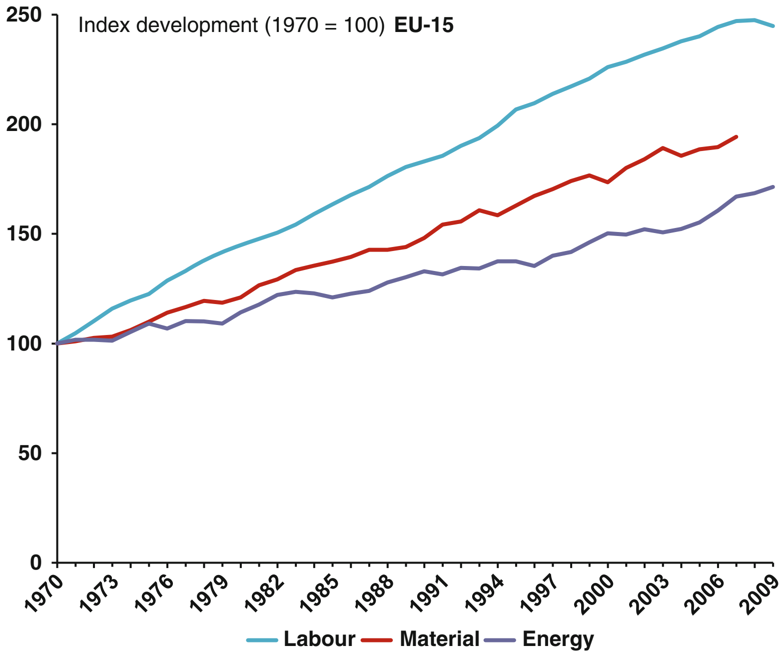


Fig. 10.2 Growth in the productivity of labour, energy and materials in the EU (EEA 2012)

Environmental harmful subsidies reinforce the problem of market distortions. In Germany subsidies totalling €48 billion have to be classified in 2008 as environmentally harmful, most of them with direct or indirect negative effects on resource efficiency (UBA 2010). On the global scale, for example, subsidies to fisheries which are estimated at around 27 billion US dollars annually are a key factor for overfishing (Sumaila et al. 2010). In 2008 fossil fuel consumption subsidies even accounted for an estimated 557 billion US dollars and production subsidies for an additional 100 billion US dollar, reducing significantly the profitability of energy efficiency measures and renewable energies (IEA 2011).

In addition, the tax burden on labour in many countries is very high, while the taxation of natural resources in the rule is still low. As a result economic incentives for labour-saving progress are much stronger than for resource-saving progress. In Germany, for example, labour productivity increased by three and a half times from 1960 to 2000, whereas materials productivity only doubled in the same period and energy productivity actually rose by only about 50 % (Fig. 10.2).

10.2.2 Obstacles on the Firm Level

Another important reason for the need of political intervention are different social and private discount rates. Empirical studies show that companies concentrate on investments with very short payback periods (Schmitt and Schneider 2010). Enterprises often do not accept a payback period of more than 2 or 3 years and therefore medium- and long-term cost reduction potentials by increasing resource efficiency are neglected in many cases.

Additionally, firms do not fully exploit the potential for economically beneficial resource-saving because they are confronted with informational, organizational and other problems like limited management capacities. Material flows in the production process are often complex and sometimes it is not easy to identify cost reduction potentials by assigning costs to individual process steps and products. Small and medium enterprises (SMEs) often lack the time and awareness to handle this challenge. Moreover the employees knowledge about the opportunities to increase resource efficiency in companies is usually not used sufficiently (UBA/BMU 2011).

10.2.3 Barriers Among Consumers

Informational barriers to exploit potentials for resources efficiency also exist among consumers. They often buy appliances which at first sight are inexpensive, but which prove to be inefficient and short-lived, involving high following costs for energy and disposal, and are soon replaced by a new appliance, because repairs and maintenance are more expensive than a new product. Consumers also suffer a lack of transparency and information concerning the resource consumption along the supply chain and the environmental consequences of the resource extraction.

10.3 Concepts, Strategies and Instruments

Given the complex factors that affect the development of markets for resource efficient products and services it is necessary to develop an integrated concept addressing the broad range of economic, social and institutional drivers and obstacles to resource efficiency. To tackle this challenge and to develop a coherent concept it is helpful to adopt national resource efficiency programs.[3] The additional benefit of a national program supplementing a market by market approach, which takes into account the characteristics of specific markets is manifold: it can serve as a platform to formulate overarching national targets, define the contribution of specific sectors to these targets, strengthen public consciousness about the need of raising resource efficiency and facilitate the necessary institution building. Moreover, it allows considering cross-effects between sector strategies, to coordinate the diverse measures and to use synergy effects between them.

[3] Therefore some countries (e.g. Austria and Germany) already adopted a national resource program and the European Commission developed a roadmap to raise significantly the resource efficiency up to 2020.

10.3.1 Long Term Targets as a Catalyst for Resource Efficiency

Long term targets for resource efficiency and reliable policy regimes increase both the efficiency and effectiveness of resource policies. Ambitious and long term oriented targets create incentives for private investors to develop resource efficient products and services. At the same time, stable framework conditions allow to reduce investment risks and financing costs. Long term targets should be underpinned by reliable policy regimes indicating clear signals to the market players about the medium and long term perspectives of resource policy. A monitoring process that regularly monitors the progress and evaluates the instruments is also essential for the credibility and the success.

10.3.2 Strategies

The markets for resource efficiency products and services are extremely heterogeneous. Therefore tailor-made concepts are often necessary to develop and strengthen the different markets. Moreover, the optimal design of the policy mix heavily depends on the market phase. Nevertheless it is possible to identify some core strategies and instruments which could be helpful to establish and strengthen markets for resource efficient products and services.

10.3.3 Getting the Prices Right

To change the fundamental dynamic of markets towards resource efficiency it is inevitable to create a level playing field between resource efficient and inefficient products by phasing out environmental harmful subsidies. Most of them are penalizing resource efficient solutions directly or indirectly. An important prerequisite is the establishment of a subsidy controlling system encompassing the screening, assessment and steering of all subsidies which are potentially environmentally harmful and hinder resource efficiency (UBA 2010).[4] It is estimated that the phasing out of fossil-fuel subsidies by 2020 would result in a reduction of the Global primary energy demand by nearly 5 % and a 5.8 % fall in CO2 emissions (IEA 2011).

Another way to eliminate market distortions are environmental taxes or other marked based instruments which either burden directly resources or indirectly by internalizing the environmental costs caused by resource extraction or consumption.

[4] (UBA 2010) Schrode, A., Burger A. et al: Environmental Harmful Subsidies in Germany – Update 2010, page 40f.

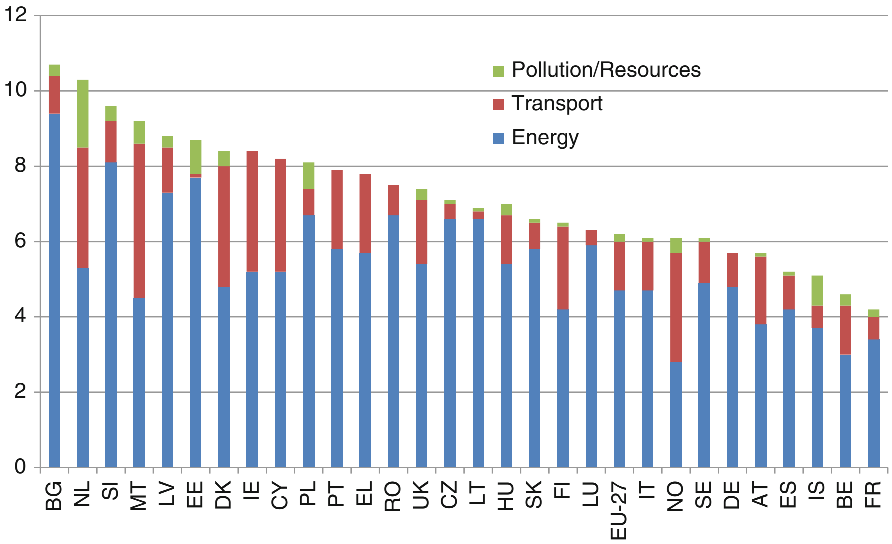


Fig. 10.3 Environmental taxes as % of total taxation (2010) (Based on ECORYS 2011)

A study for the EU Commission showed that there is a strong potential for a wider use of market based instruments for resource efficiency. Up to now market based instruments like taxes are relatively rarely applied to resources. In 2009 across the EU environmental taxes provided just over 6.3 % of the total tax revenue and outside the taxation of fossil fuels, resource taxes played a minor role (ECORYS 2011). Some countries, like Denmark and the Netherlands, had a much broader environmental tax base, resulting in an environmental tax share well above the EU average (Fig. 10.3).

10.3.4 Mobilizing Capital for Resource Efficiency Investments

The investment requirements in the field of resource efficiency are huge. UNEP estimate that the annual financing needs for making the world economy more resource efficient are between US$1.05 and 2.59 trillion, mainly from private sources (UNEP 2011). A reform of the financial market legislation is necessary to make long term investments more attractive than short term ones and to integrate sustainability criteria explicitly into the decision making process of institutional investors (WEF 2011; UNEP 2009). The development of resource-related Key Performance Indicators (R-KPIs) could also play an important role in this context by establishing resource efficiency as a key decision making factor in the financial sector. Financial authorities could use R-KPIs e.g. to define the legal and supervisory rules for risk management by financial providers more precisely and to introduce a mandatory reporting on R-KPIs in company management reports (Kristof and Hennicke 2010b).

Additionally, low-interest loans and loan guarantees of public funds should be provided to stimulate resource efficiency investments in the private sector, especially for small and medium businesses. Green Investment banks could play a pivotal role in this context, not only by providing capital but also in the area of risk hedging and capacity building (WGBU 2012).[5]

The use of new technologies, materials and products involves financial risks which SMEs in particular are often unable to take or for which it is difficult to get a bank loan. Resource efficiency innovation and market launch programs are needed which take into account the specific risks and hurdles connected with the development and market diffusion of innovative resource efficient technologies, products and services. In this context special attention should be given to bridge the so-called "valley of death" (COM 2009).[6]

Venture Capital Funds could also make a significant contribution to finance innovation processes. Investments for resource efficiency by Venture Capital Funds should therefore be promoted, e.g. by improving the legal framework for private venture capital funds or by partnerships between green investment banks and private funds. The UK Carbon Trust Venture Capital Fund and the CalCEF Clean Energy Angel Fund are examples for such public-private partnerships in the field of climate policy (WBGU 2012).

10.3.5 Smart Regulation and Labelling as a Driver for Resource Efficiency

Dynamic efficiency standards, based on a lifecycle analysis, should give permanent incentives for the development and market diffusion of resource efficient products and services and eliminate at the same time "the dirty end" of the market (Kristof and Hennicke 2010b). In line with the top-runner approach they should be geared to the most resource efficient products on the market on a specific date and combined with labelling. Additionally, this type of smart regulation could be embedded in a system of "encourage and challenge", by combining dynamic minimum standards with government assistance programs or tax concessions for those who go beyond the minimum standards voluntarily.[7]

---

[5] In Germany, for example, the KfW Bankengruppe has taken over the function of a green investment bank. In 2010 every third euro of KfW's promotional program flowed to climate and environmental protection – a total of EUR 25.3 billion. KfW invested EUR 8.8 billion for the energy rehabilitation of nearly 430,000 homes in 2010 alone. http://www.kfw.de/kfw/en/KfW_Group/About_KfW/thematic_dossier/Energy_turnaround_in_numbers.jsp

[6] The valley of death is a metaphor to describe a critical stage in the innovation process when on the one hand public funding for R&D ends and on the other hand companies are confronted with high financial risks if they decide to commercialise the innovation.

[7] Examples for the practical application of such a strategy are tax concessions on the motor vehicle tax for cars which exceed the mandatory European emission standards or low-interest loans for the

10.3.6 Enhancing Resource Efficient Closed Cycle Management

Closing material cycles is made more difficult by products that cannot be recycled, or only at considerable cost. Product developers and manufacturers often give insufficient thought to what will happen to their products when they reach the end of their life. There is therefore a need to stricter statutory requirements with regard to product responsibility.

Particularly in the case of valuable material flows, there is still a need to optimize waste collection infrastructures. For example, waste containing technology metals should in particular be collected and sent for high-grade recycling. Clear labelling and standardisation of materials can also help to increase recycling rates. Sharp fluctuations in prices of secondary raw materials are an obstacle to investment in a closed-cycle management system. Framework conditions that help to stabilise the markets, e.g. through specified minimum recycling rates, are therefore an important factor.

10.3.7 Public Procurement

Public Procurement offers a great potential to stimulate demand for resource efficient products and services and promote eco-innovations. In Germany, for example, the total volume of public procurement is around 260 billion Euros per year (UBA, BMU 2011). To exploit this potential resource efficiency should become a mandatory procurement criterion based on life cycle analysis.[8] Additional signal effects and an accelerated market diffusion of innovative products can be created by bundling public demand for particularly resource efficient products (Kristof and Hennicke 2010a).

Furthermore shadow prices which take into account external environmental costs caused by public procurement decisions could be used to promote resource efficiency. Energy inefficient products e.g. contribute strongly to climate change. If this would be accounted for by a shadow price for the induced CO_2-Emissions, public decisions would more often prefer energy efficient solutions. This is especially relevant for long-term public investments, e.g. for the planning of public buildings and decisions about infrastructure projects, e.g. in the transport sector (Maibach et al. 2007). This would underline the societal responsibility and the leadership of the public sector concerning an efficient resource use and environmental protection.

construction of new energy-efficient homes and the energy-efficient refurbishment of older residential buildings.

[8] The Netherlands e.g. already established the goal of 100 % Green Public Procurement for Federal Government and Government Agencies by 2010 (COM 2010).

Table 10.1 Savings potential identified in VerMat programme

	Mean	Median
Annual savings potential (absolute)	210,000 Euro	110,000 Euro
Savings potential per employee	3,000 Euro	1,600 Euro
Savings potential as % of annual turnover	2.1 %	1.3 %

Basis: 569 reports, Source: Schmidt and Schneider (2010), p. 185

Table 10.2 Improvement in resource efficiency and resource conservation due to EMAS (savings in EUR per annum)

Company size	Water	Energy	Waste volume	Material
Small (1–50 jobs)	100–5,000	50–12,000	30–30,000	800–50,000
Medium (51–250 jobs)	600–25,000	500–315,000	1,500–4,000,000	100–50,000
Large (>250 jobs)	4,000–3,000,000	9,000–800,000	2,000–3,500,000	5,000–500,000

Source: Adelphi (2009)

10.3.8 Consulting and Environmental Management Systems

In many cases companies only make investments with very short payback periods and tend to ignore the potential for medium-term cost savings through improvements in resource efficiency. They also often overestimate the costs and payback periods of resource efficiency measures. Company-specific efficiency consulting services can solve these problems. A comprehensive consulting approach covers the examination of technical aspects and operational workflows with the aim of reducing consumption of raw materials, energy and water. The findings usually identify efficiency potentials which yield direct economic benefits for the companies concerned and which in the long term lead to an improvement in their competitive position.

For example, in the course of the VerMat program, through which the Federal Ministry of Economics and Technology funds company-specific consulting by the German Material Efficiency Agency demea to improve material efficiency, substantial savings potential was identified in almost all companies. An evaluation of 569 potential analyses showed that the average annual material savings potential was around 210,000 EUR per company. In terms of company turnover, the savings opportunities averaged about 2.1 %. The greatest savings potentials – in terms of annual turnover – were found in small companies; in some cases they were more than 5 % of turnover (UBA, BMU 2011) (Table 10.1).

Another option is to promote environmental management systems like EMAS because they enable the systematic detection and exploitation of the resource saving potentials. 2011 there were more than 7,900 registered EMAS sites in the EU. Resource-intensive companies in the manufacturing sector in particular have achieved significant reductions in their material and energy consumption as a result of EMAS (UBA, BMU 2011). In an online survey of EMAS-certified companies and organizations in Germany, nearly all stated that energy and resource efficiency were important or very important to them. In some cases these measures led to substantial savings (Table 10.2)

10.3.9 Knowledge Transfer and Networking

Some savings opportunities can only be exploited on an inter-company basis and through coordination with customers and suppliers. In such cases, company networks can make a valuable contribution to resource conservation. In order to improve and accelerate knowledge transfer it is also necessary to promote networking and collaboration between enterprises, research and science, coupled with the promotion of technology clusters.

Knowledge transfer is also needed with respect to consumers. The need for resource efficiency is still far from being an everyday part of public awareness. Providing easily understood target group specific information on resource efficient activities is therefore important, as is integrating resource efficiency in school and vocational initial and further training.

10.3.10 Training and Qualification: Managing the Transformation of Skills

Numerous studies show that some resource efficiency markets offer high growth rates and employment potentials. To realize this potential, employees with the necessary qualifications have to be available. The shortage of skilled personnel is already evident in some areas (COM 2012a, b; Cedefop 2010; Strietska-Ilina et al. 2011). For example in Germany there is a particular lack of skilled workers in professions with a technical focus (BMU 2009) and in the field of energy-saving building refurbishment (Mohaupt et al. 2011). There is a need to anticipate the required qualifications and to step up efforts to provide environment-related training and qualification by integrating this aspect extensively in environmental strategies and programs (UBA, BMU 2011; COM 2012a, b).

10.3.11 Lead Market Strategies

As prospects for a strong global growth of resource efficiency markets in the coming decades are excellent, countries can benefit economically if they anticipate this process and act as a frontrunner. From this point of view establishing and strengthening markets for resource efficient products and services can be seen as a strategy of industrial policy directed to take a leading position in green markets.

A lead market can be defined as "… a market for a product or a service in a given geographical area where the diffusion process of an internationally successful innovation (technological or non-technological) first took off and is sustained and expanded through a wide range of services" (COM 2005). To pursue a lead market strategy can be economically attractive because it offers the opportunity to realize first mover advantages for the domestic economy, especially if policies anticipate or are in line with international trends in environmental protection (Porter and van der Linde 1995). At the same time such a strategy can significantly accelerate resource efficiency on the global scale.

Lead market strategies are more ambitious than politics that only intend to stimulate resource efficiency on the national level. They require a coherent political strategy which strengthens innovation, demand and international diffusion. A too narrow defined national lead market policy – only focusing on the demand advantage of the market – may not necessarily lead to first mover advantages. Therefore it is reasonable to complement the lead market policy by a lead supplier strategy "which corrects for the problem that the domestic industry may not participate sufficiently from the growth of the national market due to the demand advantage." (Rennings and Cleff 2011)

The ability of a country to use a lead market strategy for generating first-mover advantages depends on several factors (Waltz et al. 2011). High innovation dynamics and high potential learning effects of the technology are essential because they work against cost-driven relocation of production facilities and thus help to maintain first mover advantages. Also relevant are, for example, the domestic demand towards innovative products and the openness of the country, its knowledge base and technological reputation, the competitiveness of related industry clusters in the country and an innovation-friendly regulation.

Emerging countries are normally not in the situation to pursue a lead market strategy but they can act as second movers to participate in the growth of green markets. Theoretical arguments as well as empirical examples show that second movers can get competitive advantages, e.g. by free-riding on first mover investments and using spill over effects (Rennings and Cleff 2011). A prominent example is the market for solar cells, where China has gained a leading position as a second mover.

10.4 Outlook

Improving resource efficiency is a precondition for sustainable development on the national and global scale. The volume of investments needed to make our world more resource efficient is tremendous, as well as the need for technical and social innovations. Economic and demographic megatrends as the growth in world population and the economic catching-up of emerging and developing countries make this challenge even bigger. A new industrial revolution has to take place in the next decades replacing traditional resource intensive products and business models by new innovative resource efficient products and services. This will result in fundamental changes of many markets, as it can be seen yet e.g. in the market of power generation where renewable energies become more and more competitive.

Whether these fundamental changes comes in time and will be intense enough to reduce the resource consumption to sustainable levels is open. This depends crucially on the ability to establish a policy which promote systematically resource efficient innovations and remove barriers which prevent up to now the market success of resource efficient products and services. Such a policy is not only needed with respect to environmental but also by economic reasons because establishing and strengthening markets for resource efficient products and services will become a key factor for competitiveness and welfare in the next decades.

The international race for leading positions on green markets is already full in swing and competition is getting keener (BMU 2009).

Emerging countries like China are more and more aware that an economic model based on cheap labour and resource intensive production and consumption patterns is not sustainable and that the transition to a green economy offers great economic opportunities (The Association of Sciences in Asia 2011). Companies from these countries are therefore increasingly in competition with companies from developed countries which up to now dominate most markets for resource efficient technologies and products. Industrialized countries which still have a leading position in most of these markets will have to make additional efforts to defend their position and not get left behind.

This development could serve as a catalyst to increase resource efficiency because enhanced international competition lowers the costs for resource efficient products and services, stimulates innovation and market growth and enables learning curve effects. At the same time it strengthens the economic pressure on countries to develop integrated approaches for improving resource efficiency.

But even a faster progress in increasing resource efficiency will, however, be insufficient to secure a sustainable development if resource intensive lifestyles in industrialized countries continue and the rest of the world adapts them. Therefore an ambitious and well balanced resource policy is needed which on the one hand promotes markets for resource efficient products and services and on the other hand develops strategies to fight rebound effects and supports sustainable, resource extensive lifestyles.

References

Adelphi (2009) EMAS in der Praxis – Ergebnisse einer Umfrage. Studie im Auftrag des BMU

Bio Intelligence Service (2011) Implementing EU waste legislation for green growth. Final report prepared for the European Commission DG ENV

BMU (2009) Green Tech made in Germany 2.0. Environmental Technology Atlas for Germany, Munich

BMU (2012) GreenTech made in Germany 3.0. Environmental Technology Atlas for Germany. www.bmu.de/N49124-1/

Cedefop (2010) Skills for green jobs. European synthesis report. Publications Office of the European Union, Luxembourg

COM (2005) Commission communication, Implementing the Community Lisbon Programme: a policy framework to strengthen EU manufacturing – towards a more integrated approach for industrial policy, COM (2005) 474 final

COM (2009) European Commission, Directorate General Environment, Bridging the Valley of Death: public support for commercialisation of eco-innovation, Executive Summary

COM (2010) European Commission, National GPP Action Plans (policies and guidelines)

COM (2011) European Commission, Energy Efficiency Plan 2011. Available at: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0109:FIN:EN:PDF

COM (2012a) European Commission, EU environment policy priorities for 2020: towards the seventh EU Environment Action Programme, Consultation document

COM (2012b) European Commission, Exploiting the employment potential of green growth, Commission Staff Working Document, Strasbourg

Distelkamp M, Meyer B, Meyer M (2010) Quantitative und qualitative Analyse der ökonomischen Effekte einer forcierten Ressourceneffizienzstrategie. Ressourceneffizienz Papier 5.5., MaRessProjekt, Wuppertal

ECORYS (2011) The role of market-based instruments in achieving a resource efficient economy, Rotterdam, October 2011

EEA (2012) European Environment Agency. http://www.eea.europa.eu/data-and-maps/figures/growth-in-the-productivity-of-1

Federal Statistical Office (2010) Statistisches Jahrbuch 2010 für die Bundesrepublik Deutschland

Friends of Earth (2010) More jobs, less waste – potential for job creation thorough higher rates of recycling in the UK and EU, London

GWS (2011) Macroeconomic modelling of sustainable development and the links between the economy and the environment, Report for the European Commission, DG Environment, Osnabrück. http://ec.europa.eu/environment/enveco/studies_modelling/pdf/report_macroeconomic.pdf

International Energy Agency (IEA) (2011)World Energy Outlook 2011, Fact Sheets. http://www.iea.org/publications/worldenergyoutlook/resources/factsheets/

Kristof K, Hennicke P (2010a) Final report on the material efficiency and resource conservation (MaRess) Project, Wuppertal Institute for Climate, Environment and Energy, Resource Efficiency Paper 0.4., Wuppertal

Kristof K, Hennicke P (2010b) Core strategies for a successful resource policy and the instruments proposed for their effective implementation. Executive summary of the policy recommendations of the MaRess Project, Wuppertal, October 2010

Maibach M, Sieber N, Bertenrath R, Ewringmann D, Koch L, Thöne M, Bickel P (2007) Praktische Anwendung der Methodenkonvention: Möglichkeiten der Berücksichtigung externer Umweltkosten bei Wirtschaftlichkeitsrechnungen von öffentlichen Investitionen, Umweltbundesamt

Mohaupt F, Konrad W, Kress M, Rebmann K, Schlömer T (2011) Employment effects and needs for vocational training and qualification in the field of energy-saving building refurbishment, Environment, Innovation, Employment Nr. 1/2011. Published by the German Federal Environment Agency and the Federal Ministry of Environment, Nature Conservation and Nuclear Safety, 2011. http://www.umweltbundesamt.de/uba-info-medien-e/4148.html

Porter M, van der Linde C (1995) Toward a new conception of the environment-competitiveness relationship. J Econ Perspect 9(4):97–118

Rennings K (2000) Redefinig innovation – eco-innovation research and the contribution from ecological economics. Ecol Econ 32:319–332

Rennings K, Cleff TH (2011) First and second mover strategy options for pioneering countries on environmental markets – from national lead market to combined lead market and lead supplier strategies, Working paper no. 3 within the project: Lead Markets, funded under the BMBF Programme “WIN 2”

Schade W et al (2009) Gesamtwirtschaftliche Wirkungen von Energieeffizienzmaßnahmen in den Bereichen Gebäude, Unternehmen und Verkehr, Umweltbundesamt, Climate change nr. 08/2009

Schmitt M, Schneider M (2010) Kosteneinsparungen durch Ressourceneffizienz in produzierenden Unternehmen. In: UmweltWirtschaftsForum

SEC (2011) Impact assessment accompanying the energy efficiency plan, Brussels
Strietska-Ilina O, Hofmann C, Haro MD, Jeon S (2011) Skills for green jobs: a global view. Published by the International Labour Organisation and Cedefop. http://www.ilo.org/skills/projects/WCMS_115959/lang--en/index.htm
Sumaila UR, Khan A, Dyck A, Watson R, Munro G, Tyedmers P, Pauly D (2010) A bottom up re-estimation of global fisheries subsidies. J Bioecon 12:201–225
The Association of Sciences in Asia (2011) Towards a sustainable Asia: green transition and innovation. Science Press/Springer, Beijing/Heidelberg
UBA (2010) Federal Environment Agency, Environmentally harmful subsidies in Germany – update 2010. http://www.uba.de/uba-info-medien/4123.html
UBA BMU (2011) Report on the environmental economy 2011. Published by the German Federal Environment Agency and the Federal Ministry of Environment, Nature Conservation and Nuclear Safety
UBA/BMU (2011) Report on the environmental economy 2011. http://www.umweltbundesamt.de/uba-info-medien-e/4339.html
UNEP (2011) Decoupling natural resource use and environmental impacts from economic growth. A report of the Working Group on Decoupling to the International Resource Panel. http://www.unep.org/resourcepanel/Publications/Decoupling/tabid/56048/Default.aspx
UNEP-FI (2009) United Nations environment programme financial initiative, fiduciary responsibility legal and practical aspects of integrating environmental, social and governance issues into institutional investment. Report by the Asset Management Working Group of the UNEP Finance Initiative, New York, Nairobi
Waltz R, Krail M, Köhler J, Marscheider-Weidemann F (2011) Towards modeling lead markets in environmental technologies – indicators and modeling approach. Working paper no. 5 within the project: Lead Markets Funded under the BMBF Program “WIN 2”
WBGU (2012) Financing the global energy-system transformation, Policy paper nr. 7, Berlin. http://www.wbgu.de/en/policypaper/policypaper-7/
WEF (2011) The future of long-term investing. A World Economic Forum Report in Collaboration with Oliver Wyman, New York

Chapter 11
Business Models for Material Efficiency Services

Minna Halme, Markku Anttonen, and Mika Kuisma

11.1 Introduction

Business enterprises are still not making the best possible use of the many opportunities for energy and material efficiency improvements although there is abundant research on eco-efficiency and growing recognition of the need to dematerialize the economy. More than a decade ago Porter and van der Linde (1995) presented compelling evidence that efficient resource use can be a major competitive advantage for an enterprise. More efficient resource use not only reduces the environmental burden from industrial operations, but often translates into lower procurement and waste management costs as well (Schmidt-Bleek 1998; von Weizsäcker et al. 1997; Hinterberger et al. 1997). From an ecological point of view, inefficient use of materials or energy causes pollution, destroys ecosystems and depletes natural resources. The imperative of saving natural resources and minimizing pollution by using them more efficiently in industrial production is acknowledged at both national and international levels. Several political measures have been planned and introduced to minimize environmental harm by steering manufacturing and other economic activity. For instance, the European Union and the OECD are aiming to decouple economic growth and the use of natural resources (OECD 2002; European Union 2002) and have looked for innovative strategies and business models to meet these targets (OECD 2003, 2004; European Union 2008). The United Nations has also joined the quest for more efficient use of natural resources (United Nations 2002) and is for example promoting through its industrial development organization UNIDO more sustainable ways for industrial use of chemicals (Jakl and Schwager 2008).

M. Halme (✉) • M. Kuisma
Department of Management and International Business, Aalto University
School of Business, P.O. Box 21230, 00076 Aalto, Finland
e-mail: minna.halme@aalto.fi; mika.kuisma@aalto.fi

M. Anttonen
Hermai Services, Owner, entrepreneur, 00280 Helsinki, Finland
e-mail: markku.anttonen@aalto.fi

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_11,

A number of reasons prevent business enterprises from using their resource saving potential to the full. Firstly, quite a few enterprises lack the expertise to recognize other than the most obvious opportunities for material or energy saving. This is especially true for energy and auxiliary materials that do not lie in the organization's area of core competence. Negligent use of resources is frequently aggravated by the fact that in most firms, resource efficiency is not a high priority since constant improvements in extraction techniques have made resources ever more inexpensive. Secondly, even if enterprises do recognize opportunities for material or energy efficiency improvements, they do not necessarily act upon them. All too often and all too easily, there is a tendency not to go into any improvements that would require investment – even with relatively short payback periods – or that would add to the workload of management or staff (Halme et al. 2005; Kontoniemi 2004).

This situation opens up business opportunities for various service providers offering material or energy efficiency services. The basic idea is that the service provider takes over the efficiency improvement, and that compensation to the provider is tied to the cost savings achieved from that improvement. As distinct from other types of eco-efficient services, this is usually called a result-oriented service. Compared to product-based or use-oriented services, for example, result-oriented services arguably hold the greatest promise in terms of eco-efficiency (Tukker 2004).

Result-oriented services, however, are relatively unconventional form of business and they are therefore not necessarily readily accepted in the market. Result-oriented services focus on fulfilling customers' needs, providing lit or warm space, for example (Roy 2000; Hockerts 1999). They can include various forms of contracting, such as energy contracting, facility management, waste minimization services (Heiskanen and Jalas 2003; Vine 2005; EPA 2009; Tellus Institute 2002) or chemical management services (CSP 2004, 2009; OECD 2004; Kortman et al. 2007). In essence, the aim of result-oriented services is to "sell functional results". This not only breaks with traditional economic thinking, but in some instances also creates difficulties with regard to some financial stipulations, as will be discussed later in this chapter (Bertoldi et al. 2006; Heiskanen and Jalas 2003; Vine 2005).

Eco-efficient products and services, which can help significantly to reduce the use of natural resources while still meeting people's needs, have attracted a lot of research and led to numerous innovations since the launch of the concept in the mid-1990s. However, despite the abundance of innovation and ideas, only few eco-efficient products and services have made their way to the marketplace (Tukker 2004). One of the reasons for the marginal market penetration of eco-efficient services is the slow rate of change in institutions and in ways of thinking. Another hindrance to spreading of radical eco-efficiency improvements is that business models of eco-efficient services are fuzzy to many practitioners. The main focus has been on the technical design of eco-efficient services (Bleischwitz 2003). The shortcomings in understanding the business perspective around eco-efficient services became apparent a couple of years ago. It was widely recognized that one of the reasons for the failure of what seemed to be sound eco-service concepts was the lack of attention paid to the market viability of such services. Hence the term 'business model' has proliferated in the discussion on eco-efficient or sustainable services (Tukker 2004; Mont et al. 2006).

However, while the business model terminology has now been widely adopted by those promoting and researching sustainable services, it is still very rarely that any explanation is offered as to what exactly it means (Tukker and van Halen 2003); sometimes it is understood simply as a revenue model (Vercalsteren and Gerken 2004) or in terms of flowcharts portraying 'service logistics' (Tempelman 2004). This is not surprising because there is no established or comprehensive definition of the term 'business model' (Timmers 1999; Wüstenhagen and Boehnke 2006). However, if we are to gain a better understanding of the business opportunities of eco-efficient services, then some kind of conceptualization or framework for business models is called for.

This chapter introduces a conceptual framework for the analysis of different business models for eco-efficient services and applies the framework to material efficiency services. Three business models are outlined and their feasibility is studied from an empirical vantage point. In contrast to much of the previous research, special emphasis is laid on the financial aspects.

In this chapter we propose a conceptual framework that has its roots in the work of Normann and Ramirez (1994), Räsänen (2001) and Magretta (2002), and also draws on Hamel (2000). The proposed business model framework allows us to analyze the competitive advantage of the services, the customer benefits, the resources and capabilities of the services providers, and the financing arrangement. After presenting the framework, we apply it to the material efficiency services offered by outside service providers to client organizations. The actual material efficiency improvements made by individual companies within their own facilities thus fall outside the scope of our study. Likewise, we exclude services targeted for waste that has already accumulated. The feasibility of these business models will also be assessed. The chapter ends with a brief review of the different means of promoting material efficiency in industry.

11.2 The Research Design

We were interested to look into opportunities for material efficiency services in the paper and food industries. Most interviewees represented paper and food branches, as the potential customers for material efficiency services. Beyond the demand, we sought to gain a better understanding of the potential supply of material efficiency services, as well as the necessary financial and regulatory mechanisms. For that purpose we interviewed representatives of four finance institutions, two waste management companies, four ESCOs (energy service companies), a distributor of chemical products, a manufacturer of pine oil based industrial washing chemicals as well as environmental policy makers and regulators. Altogether the empirical data consist of material collected in 70 thematic interviews and three focus group discussions organized in 2004 and 2006 (see Appendix).

In the paper industry we set out to explore the interest in and obstacles to using material saving services by interviewing representatives of ten different units at four corporations. In the food industry we focused on three companies: a meat processing company, a coffee roaster and a dairy firm. In addition to personal interviews, we organized three focus group discussions in order to elaborate the design, the conditions of interest and the potential opportunities for the use of material saving services. It soon became clear that it would make sense to focus on specific cases, because production processes and thereby the material efficiency instances in the food industry involve more variation than in the paper industry. The food industry cases were concerned with opportunities to: (1) reduce grease waste in food production, (2) reduce gut waste in sausage production, (3) prevent harmful coffee packaging waste (aluminium laminate) and (4) prevent packaging waste by introducing reusable milk packaging (Kontoniemi 2004; Halme et al. 2005).

Additional data were also sought from archival material on energy services and from chemical management services from the United States and Europe. Moreover, data were obtained in the form of feedback from the research project's final seminar, which was attended by 40 industry representatives.

11.3 Business Models of Material Efficiency Services

Structured assessment of business models for eco-efficient services would make it easier to establish why some models are successful in the market and others are not. As mentioned above, the whole idea of 'business model' is quite commonsensical, but in order to provide a more solid foundation for systematic discussion about business models, we propose here a simple framework which captures most of the relevant aspects that determine the viability of a service concept in the market. The framework consists of four questions for probing the market viability of a service.

- What benefits can users or customers derive from the service (compared to more traditional ways and means of fulfilling their needs) – added value to the customer;
- What kind of competitive advantage does the sustainable service offer;
- What capabilities and other resources does the provider or the network of providers have; and
- How the service is financed (formation of the income flow)?

In this section we sketch three business models for material efficiency services. The models are named as follows:

- The MASCO model
- Material efficiency as additional service
- Material flow management service

One can question whether the three business models proposed here are genuinely separate models or whether indeed some of them are variations of the same model. The logic applied is that when even one of the above factors (customer benefit, competitive advantage, capabilities or finance arrangements) is different, the focal business is different from that in the other models.

Moreover, we only outline business models, which involve some untraditional element vis-à-vis the arrangement between supplier and user. It is possible that there are other prominent novel business models too, which were not identified under the auspices of this research project.

11.3.1 The MASCO Model

This is a business model that follows the ESCO concept (energy service company) as applied in the energy field (Motiva 2000). An enterprise specialized in material efficiency (MASCO, material service company) makes the material saving investment in the customer company and is compensated on the basis of the cost savings achieved.

A MASCO takes charge of the whole material efficiency project within the customer company. The service relationship often begins with a materials audit at the customer's premises. However, the customer may also bring in a MASCO to implement a material savings investment that it already has in mind, and in this case there is no need for an audit. In other words, the customer may specify the tasks it wants the service provider to carry out on its behalf. A MASCO project may comprise all or some of the following elements:

- Site survey and preliminary evaluation;
- Identification of possible material saving and efficiency improving actions;
- Assessment of material and cost savings;
- Acquisition of project financing;
- Engineering, project design and specifications;
- Procurement and installation of equipment;
- Project management, commissioning and acceptance;
- Final design and construction;
- Operation and maintenance for the contract period and
- Measurement and verification of the savings results.

The MASCO will probably subcontract some or most of these tasks. In theory it could do everything itself, depending on its qualifications, but in practice it is unlikely that MASCOs will deliver all services in-house.

The customer benefit is that no financial or personnel resources are tied to the investment and project planning. The costs of the project will be covered by the savings achieved. The added value results from the tailored material efficiency solution and the improved production process. The competitive advantage comes from the financing model in which the customer company only pays for actual results. Compared to the traditional engineering or consulting business model in which the customer pays for hours worked, the MASCO model is more attractive for the customer. In addition, if a MASCO specializes in certain techniques or technologies, that has the potential to add to the cost efficiency of the business. In our food industry study, the respondents felt that one of the competitive advantages is that the same party is responsible for financing, implementation and maintenance. In this situation it is more likely that the investment (equipment) functions according to plan.

What competencies and capabilities does a MASCO need? Its capabilities should include management and implementation of the basic functions of a material efficiency project. On the one hand, this means finding the best suppliers for various project parts and phases. Unlike energy services, materials and related technologies differ considerably between industries and therefore it is likely that material efficiency companies would specialize in certain branches of industry, or even in certain technologies or production lines within an industry. Another, often more challenging task is to secure the necessary financing. Judging by earlier ESCO experiences, this is likely to be a stumbling block for small MASCOs offering only material efficiency services. A MASCO should also have the ability to find customers and projects where a material efficiency investment can yield profits for both partners. For the time being this is not easy since potential customers are not yet familiar with the service.

The income flow consists of the annual service fee, which is tied to the savings achieved with the help of the investment. When the service period ends, all savings will benefit the client company. The challenge for the MASCO is that it must be able to assess accurately the amount of future savings in advance and, furthermore, carry out the project in such a way that the projected savings actually materialize.

To give an example, the first MASCO project in Finland was conducted in 2004 at the Tako Board mill in Tampere between M-real Ltd., a pulp and papercompany and Inesco, an ESCO. The project aimed especially at increasing the efficiency of fibre recovery at Tako. The mill had been built up in several stages during many decades, making the process all too complicated and ineffective. The management of waste fibre had also caused increasing waste management costs for the mill. As a result of this MASCO project, the production process at the mill was streamlined and simplified, more fibre could be recovered from the effluent flow for reuse as a raw material for board, waste management costs were cut and even the quality of the product was improved. Inesco invested in the fibre recovery equipment and Tako payed back this investment by means of the savings from the more efficient process. The total costs of the MASCO project were approximately one million euros and the payback time was 18 months (Halme et al. 2005; Viljakainen 2004).

11.3.2 Material Efficiency as Additional Service

Some companies can offer material saving services in addition to their main service; examples include waste management firms, maintenance companies and equipment providers. This business model is grounded in the same premise as the model above: the provider takes charge of the material efficiency investment from financing to implementation throughout the investment period. The competitive advantage and the provider's competence, however, are composed differently.

Customer benefit shares some features in common with the MASCO model. The client does not need to tie up any resources in the investment in production efficiency. An additional benefit is that the client does not have to negotiate with new service providers. The fact that the service provider already has a relationship with the customer and therefore has a thorough knowledge of the customer's operations, or at least parts of them (e.g. waste management, equipment or machinery), is the main competitive advantage. This means that the provider is often in the position to recognize opportunities for material savings. It emerged clearly in the interviews that clients prefer familiar providers for this kind of service. Transaction costs are lower in situations where the business partners know and trust each other. Project administration is also likely to be more efficient.

The competence component is also different from the MASCO model. In this concept, the service company can often take charge of a larger part of the project itself, which means it needs fewer subcontractors. For instance, a waste management company that is familiar with the customer's processes will know how much waste is accumulated in these processes, so it will probably also be able plan and possibly implement process improvements. However there still remains the challenge of providing the necessary funding. Equipment providers may be an exception here: because of the nature of their core business (sales of industrial equipment and machinery), they have more experience of offering financial arrangements for customers.

The income flow is formed in the same way as in the MASCO concept. The only difference is that the customer simultaneously pays the service provider for a basic service (e.g. maintenance, waste management) according to the traditional model.

The growing interest in outsourcing non-core functions will probably lead to an increasing number of business partnerships. Already many major production units at industrial facilities have personnel who are employed by cleaning, waste management and technical service companies. This is a particularly useful model in situations where the service provider and the client company are in a development-oriented partnership.

Material efficiency services offer considerable new business potential for waste management companies. The trend and commitment in modern society to reducing waste volumes means that there is no long-term growth in sight for traditional waste treatment businesses, and it is crucial therefore that waste management companies find new business areas. However, starting up a business that in the short term appears deliberately to try and reduce the volume of current waste treatment business is a major challenge for the management logics of these companies (Phillips et al. 1998; Ligon and Votta 2001). The trend, however, is inevitable. For instance Upstream WM, a business unit of Waste Management Inc. offers so-called resource management services. The aim of the service is to reduce the costs and environmental effects of waste streams and, furthermore, continuous improvement of customers operational processes. Its services offers waste minimization programmes, cost follow-up and third party management and its personnel works in customers' sites. Upstream's compensation is based on its ability of to achieve the customer's waste- and cost-reduction goals. Not just the volume of waste handled (Upstream 2006;

Nidumolu et al. 2009; WM Greensquad 2011). There are also other waste management companies, whose services resemble those of Upstream, but not all of them explicitly conceptualize their services as resource management services.

11.3.3 Management Service for Material Flows

The third business model, 'management service for material flows' is distinctively different from the two previous ones, and it has also more practical applications. Many of them are in the category of chemical materials and some in the field of the so-called resource management. In this model, a service provider takes over the management of a certain materials group, e.g. chemicals. In other words, its business is not based on a one-off material saving investment, but on a long-term partnership with the customer. This kind of service will typically cover 'support materials' in which the client organization does not have strong expertise. There are many instances where a professional service provider can be more effective in the management of support materials. This type of model can be applied not only to chemicals, but other material groups as well. Resource Management (EPA 2006, 2009; Ligon and Votta 2001; Ligon et al. 2000) is based on a similar idea: in this concept the aim is to align the relationship between service provider and the customer in a way that they both have incentives to move from traditional hauling and disposal contracts towards increased prevention and to decouple service providers' income from the quantity of the handled waste (Ligon and Votta 2001; OECD 2004).

The customer benefit results from a more professional operator taking control of part of the production process which is not core business for the client organization. For instance, chemicals are crucial to the operation of air carriers and other transport companies, but they are not an immediate part of their production and therefore not core business. The service provider can take over a more limited or extensive set of responsibilities: buying the chemicals, handling them throughout the production process, storing, and reporting together with environmental and health and safety responsibilities (Jakl et al. 2004). In the most extensive service, the 'shared savings relationship', the service provider may even participate in production planning or managing certain parts of the customers manufacturing processes (Stoughton and Votta 2003; Bierma and Waterstraat 2000; Reiskin et al. 2000).

Competitive advantage results from a more efficient organization of the production process. Chemicals management services can help to increase process efficiency by combining orders, replacing more expensive chemicals with cheaper alternatives, and streamlining internal logistics. This is possible because the service provider has more competences and capabilities in the material (e.g. chemicals) and the processing of that material. In a short term, benefits usually accrue from centralized purchasing, better stock management and diminished waste management costs. According CSP (2009), the first year cost savings vary from the 5 to 50 %, where service providers tend give higher figures compared to customer organizations. Case studies from Europe and from UNIDO support substantial cost savings through reductions in chemicals usage, diminished amount of hazardous waste and through energy savings (Jakl and Schwager 2008).

Corbett and DeCroix (2001) argue that long-term partnerships usually offer the greatest benefits to the service provider and user (see also Ligon and Votta 2001). For instance, long-term benefits from better maintenance and operation of manufacturing machinery can generate savings by diminished downtime and chemical substitution. However, some perceive that savings are highest during first years of service period, and get more even during the later years. Developing and maintaining such relationships requires particular capabilities on the part of the service provider, especially when it has multiple competing customers in the same branch of industry (Corbett and DeCroix 2001). The North American experience seems to support this to some extent. Majority of the providers studied in the 2009 industry report say that they can deliver 11–20 % cost savings even at the tenth year of their service contracts (CSP 2009, 37).

The conceptual roots of material flow management lie in the broader concept of performance-based contracting, within which the service provider offers efficiency services and gains revenues from the cost savings generated by optimized processes and reduced material consumption and waste (Ligon et al. 2000). The customer company pays for the performance, not for the chemicals purchased or waste accumulated. Cost savings are the basis of the income flow to the service provider. In chemicals management, savings accrue because the cost of chemicals consists not only of their purchase price, but there are also various other expenses related to different parts of the chemicals life cycle, such as handling, storage and waste treatment. It has been estimated that for every dollar spent on purchasing chemicals, an extra 1–10 dollars has to be spent on these additional "hidden" costs (CSP 2006; Oldham and Votta 2003).

The idea of chemical management services is carried under concepts as chemicals management services (CSP 2004; Oldham and Votta 2003), chemical product services (Kortman et al. 2007) or chemicals leasing (Jakl et al. 2004, Jakl and Schwager 2008). We see that above definitions include the same result-oriented service aspects and use the chemicals management services (CMS) as a single concept including all the above concepts. We have identified four crude CMS types, but the types are by no means definitive (Anttonen 2010; Anttonen et al. 2006). Firstly, some companies seem to concentrate on supply side by purchasing chemicals, taking care of deliveries, reporting and subcontracting waste management. Sweden-based AGA (part of the Linde Group) that offers CM services in the Nordic countries and USA based Avchem are such examples.

Second type are companies that concentrate more on managing chemicals, especially fluids such as coolants, cutting fluids or cleaners in customer's processes. North American Houghton (European Commission 2008) is a good example of these kinds of services. Chemicals leasing (Jakl et al. 2004; Jakl and Schwager 2008; CSP 2009) as concept can be seen concentrating perhaps more towards this part of the chemical supply chain. Thirdly, we can distinguish companies that offer mainly ICT-based solutions for chemical management including e-procurement, chemicals tracking and labeling, Material Data Safety Sheets (MSDs, USA) or Safety Data Sheets (SDSs, Europe) management and so on. US-based Chemical Safety is example of this kind of service provision. Fourth, some multinational companies such as Ashland or BASF have type of full service approach to chemical management services. They offer broad variety of services from purchasing, planning customers operations and ICT services to waste management. BASF is interesting example of this type of service provider. To our knowledge they are the only company that offers eco-efficiency and social profile analysis (Seebalance©) for the customer as part of their chemical management services. The aim of these analyses is to find out more eco- and cost-efficient and safe ways to use chemicals in the customer's manufacturing process (Kircherer et al. 2007; Saling et al. 2002, 2007).

This classification should be interpreted as indicative. A good number of chemical management companies offer both supply and process management services including ICT based solutions.

It is possible to combine MASCO-investment element to material flow management service. For instance Kemira Operon, a subsidiary of Kemira Corporation, offers chemical management services for waste water treatment plants. It takes over customers' waste water and sludge treatment with the aim to reduce waste and stop waste streams to landfill. The primary aim is to make customer's process more material efficient by internal optimization, reuse and recycling. When that is not possible, Kemira Operon seeks to find new uses and customers for the material streams that are waste from one of their customers. They also extract compounds from the sludge for their own water purification chemicals manufacturing. This is made possible considerable R&D capabilities of Kemira, as well as the large customer base of the corporation. Operon builds industrial ecology type geographically limited networks of waste accumulating facilities and the facilities that use the respective waste fragment in their processes. It can also invest in equipments installed in customer's facilities. Like in the above described MASCO-model, the pay-back of the investment accrues from the material savings resulting from the investment. However, the customer pays it as part of the service fee. Unlike in the MASCO-model, the investment is only a supportive element, not centre of the business model (Table 11.1).

We would like to emphasize that the above business models are suited to situations where considerable savings can be expected, and where for financial or other reasons it makes sense to contract out the management of the efficiency improvements to a service provider. Yet there are many instances where an ordinary consultancy service paid by the hour is a more appropriate solution. If no substantial savings are anticipated, but other reasons such as regulatory pressure or image benefit speak a material efficiency improvement, and the firm's own personnel is not in the position to do the job, material efficiency consultancy may be a better option.

11.4 Financing Challenges and Feasibility

Are the above models feasible in practice? We address this question by looking at the financing aspect in material efficiency services and the instances to which the various business models are best suited.

Table 11.1 Summary of business models for material efficiency services

	MASCO	Materials efficiency as additional service	Management service for material flows
How does the customer benefit from the service?	Does not tie up client's funds or (operational) resources, for example time of personnel	Does not tie up client's funds or (operational) funds	Outsourcing non-core operations to a specialist firm
What is the competitive advantage of the service?	Financing model: customer pays only for results; cost-efficiency	Existing contact between provider and customer: trust and low transaction costs	More efficient organization of operations
What capabilities does the service provider have?	Arranging financing, finding suitable know-how (subcontractors), finding customers on a regular basis	Knowledge of client's processes or of them, for example waste management or maintenance of machinery	Profound knowledge of material/s and its processing
How is the service financed (income flow)?	From the savings gained from the material efficiency investment	From the savings gained from the investment, but client simultaneously pays fees for other services	Charges are based on results instead of volumes of material/s
What kind of instances is the business model suited for?	Large, one-off projects	Material efficiency improvements that complement the provider's service (equipment, waste management or maintenance providers)	Long-term strategic partnerships, for example CMS

11.4.1 Financing Challenges

The financing challenges related to material efficiency depend on the business model. In the MASCO and ‘material saving as additional service’ models, the [main] challenge is usually related to finding the necessary initial funding, because the model involves a substantial early investment. The ‘management service for material flows’ model, on the other hand, does not involve any up-front investment. The financial challenges centre on determining the service company’s compensation.

Finance questions in investment-based material efficiency services (includes the MASCO model and ‘Material efficiency as additional service’ model).

To begin with the financing of investment-based material saving services, we can draw some inferences from the energy service business where there are three broad financing options: the energy efficiency project is funded by the ESCO, by the customer or by a third party. If these funding options are applied to material saving agreements, the financing options could be as follows (cf. Bertoldi et al. 2006).

In MASCO financing, the investment would be financed by the MASCO’s own internal funds. Lack of own funds would limit the MASCO’s capability to implement projects on a continuous basis. The second alternative is customer financing, backed by a material savings guarantee provided by the MASCO. Third-party financing refers solely to debt financing from a third party, such as a finance institution. The finance institution may either assume the rights to the material savings or it may take a security interest in the project equipment. The money is borrowed either by the MASCO or by the client. In case the customer takes out a loan from a finance institution, it is backed by a (material) savings guarantee by the MASCO. The purpose of the savings guarantee is to demonstrate to the bank that the project for which the customer is taking out the loan will generate savings that cover the debt repayment. In other words the guarantee trims the bank’s perception of risk, which in turn will have implications for the interest rates. The ‘cost of borrowing’ is very much influenced by the size and credit history of the borrower. Small and/or undercapitalized MASCOs that cannot borrow significant amounts of money [from the financial market] cannot finance material efficiency investments (cf. Bertoldi et al. 2006; Halme et al. 2005; Parviainen 2004).

The two major performance contracting models used in energy service contracts are guaranteed savings and shared savings (NAESCO 2006). To continue with the energy field analogy, under a shared savings contract the cost savings are split for a pre-determined length of time. In shared savings arrangement a MASCO would assume responsibility for financing, either financing the investment with its own funds or by taking out a loan. According to Bertoldi et al. (2006) the shared savings concept is a good introductory model in markets where energy (or material) saving services are still at the early stages of development because customers assume no financial risk. However, this model does tend to create barriers for small companies; it could be expected that small MASCOs implementing projects based on shared savings might rapidly become too highly leveraged and unable to contract further debts for subsequent projects (Bertoldi et al. 2006).

A guaranteed savings contract is a scheme where the MASCO guarantees a certain level of material savings and in this way shields the customer from any performance risk. It arranges the necessary funding, but technically speaking customers are financed directly by a bank or financing institution; they repay the loan and the credit risk remains with the lender (Bertoldi et al. 2006). The guaranteed savings scheme has been applied in energy saving contracts. In the United States, for instance, 90 % of ESCO projects are financed under a guaranteed savings arrangement (Hansen 2002). However the guaranteed savings model is usually considered less appropriate for markets where ESCO (or MASCO) business is newly developing. If the customer's own funds are tied to the investment, many will find the service less attractive, and consequently the market penetration of ESCO (or MASCO) business will probably be slower (Parviainen 2004). Guaranteed savings contracting is probably a viable solution only in countries with an established banking structure, where there is high familiarity with project financing, and where there is sufficient technical expertise, even within the banking sector, to understand energy efficiency (or material efficiency) projects (Vine 2005; Bertoldi et al. 2006).

In the management service for material flows, model, financing is a less complicated issue, but nonetheless challenging enough especially in the most extensive service relationships. To take chemicals management as an example, service use usually begins with simple additional services such as concentrating the procurement or provision of environmental data for compliance and reporting. In limited chemical management programmes, the fee structure usually includes a dollar or euro-per-kilo fee plus services and management fees (Bierma and Waterstraat 2000).

In the most advanced chemical management service (CMS), a shared savings relationship, the provider and customer align their financial interests to reduce the overall chemical volume. In this model the chemical user no longer buys the chemicals, i.e. the payment to the supplier is not tied to the chemical volume. Instead, the supplier receives a fee in exchange for meeting certain performance expectations. Within a shared savings business model there are different ways of determining the compensation: fixed fees, unit pricing and gainsharing. Under a fixed fee structure, suppliers are typically paid a fixed monthly fee, against which the supplier agrees to meet certain performance expectations negotiated for the plant. The monthly fee is usually determined by historical chemical costs. The supplier can increase its profits by decreasing chemical volumes. Ultimately, some of these savings must be shared with the chemical user so that both parties have an incentive to pursue cost reductions (Bierma and Waterstraat 1999, 2000).

A unit price is a fee paid to the service provider for every unit of product produced by the chemical user. For example, the supplier might be paid five euros for each car or washing machine produced by the plant. If a gainsharing agreement is applied, the cost savings will be shared between the service provider and the user. Succeeding in unit pricing and shared savings contracts requires that the baseline (production costs, materials, quality of finished products, liabilities, etc.) is thoroughly defined by the customer and the service provider together. That is the only way to ensure that the performance expectations can be defined and met. Should a supplier's idea or innovation generate savings for the buyer, those savings are

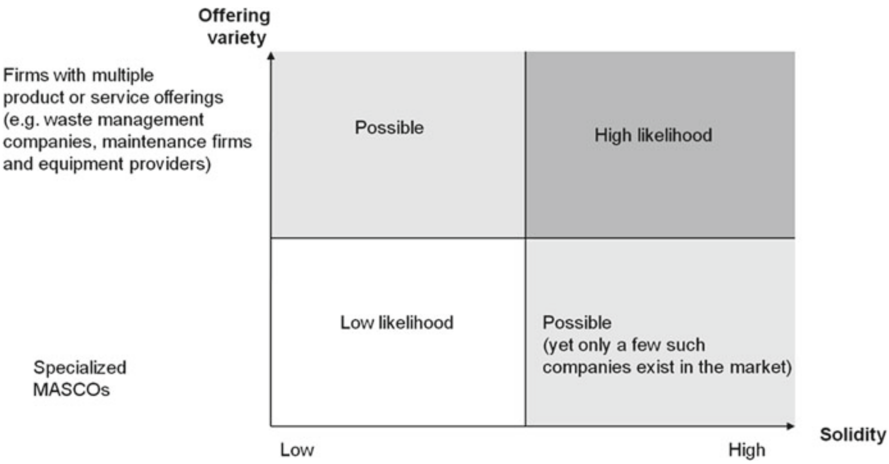


Fig. 11.1 Likelihood of different types of enterprise to offer investment-based materials efficiency services. *Dark shade* indicates higher likelihood

divided between both parties. This strengthens the alignment of the buyer's and the supplier's financial interests. Because gain sharing can be extended to any savings, including those unrelated to chemicals, it increases the potential benefits of the service relationship. It is typical of this arrangement that if financial losses accrue, they too should be divided between the service provider and user (CSP 2004).

11.4.2 Feasibility of the Business Models

The idea of material efficiency services is still very much in its infancy. At this early stage, we believe that the most viable business models are 'material efficiency as additional service' and 'management service for material flows'. The former requires an initial investment – usually a considerable one – and the service provider should be able to arrange the necessary financing. Reliability and credibility in the eyes of financing institutions is therefore crucial to whole service concept. Companies that will probably be seen as reliable include equipment providers, waste management companies (some of which already call themselves environmental service companies) or ESCOs with good solidity and a track record in energy services (upper right hand corner in Fig. 11.1). Start-up MASCOs, on the other hand, will probably have difficulties as long as material efficiency services remain unknown among financing institutions (lower left hand corner in Fig. 11.1) (Halme et al. 2005, cf. Vine 2005; Bertoldi et al. 2006). If these services become better known in the future, it is possible that specialized MASCOs will enter the market as well. Figure 11.1 describes the propensity of various types of enterprises to offer investment-based material efficiency services.

Our empirical evidence about customer preferences indicates that there are certain preconditions for investment-based material efficiency services. One factor that needs to be taken into account is that materials and technologies differ considerably between different industries. For instance, in the paper industry material efficiency can be improved by recovering raw material for reuse in the process, whereas in the food industry this is not possible for reasons of hygiene. The implication is that some industries may lend themselves more readily to investment-based material efficiency services. Namely, one of the prerequisites for the economic viability of such services is that the investment is technically easy enough to conduct with relatively little variation across multiple facilities. This is preferable for at least two reasons. Firstly, excessive resources should not be devoted to planning the investment in order to keep the costs manageable. Perhaps more importantly, the technology should be known and the solutions reliable so that the service provider (MASCO) can accurately assess the savings and not run the risk of negative returns.

Secondly, the willingness of potential client companies to use the service appears to depend on their size and solidity. For example, most of the paper industry companies interviewed were large corporations with a solid financial situation and strong in-house engineering expertise. Except for material audits, they did not feel there was a need for efficiency services. The food industry representatives, on the other hand, showed a keen interest in the whole palette of a MASCO's services. However, despite these differences, the empirical data allows us to identify some general conditions under which the MASCO model and the 'material efficiency as additional service' model appears to be most suitable (Halme et al. 2005):

- The potential for economic savings from the material efficiency investment is big enough
- The investment is so big that the customer company feels that planning and implementation is too difficult or time-consuming
- The payback period is more than 3 years
- The project focuses on a side stream of production rather than on the customer's core business

If there is only minor potential for economic savings, and if there is no other incentive such as regulatory pressure or an image benefit, the reward will appear too insignificant for client companies to engage in a project. Another point mentioned by the interviewees in favor of using the services of a MASCO was the extent of the investment: if it is so big that the client considers planning and implementation too complicated or time-consuming, then the service alternative becomes more attractive. Payback time is yet another determinant. Not surprisingly, the empirical evidence suggests that companies are more willing to use their own funds when the investment has a short payback period. Three years was typically considered as the watershed. Finally, organizations prefer to keep core products or business lines under their own control. Side streams or support materials are more easily trusted to outsiders. Material efficiency services are particularly suitable for those instances because even economically profitable investments may be ignored year after year, while funds are used for core business improvements.

As for the management of material flows, that is a service that can be offered for instance by chemical suppliers who despite being engaged in chemicals production can see a business opportunity in services aimed at reducing chemicals use. In the United States, approximately 33 % of CMS providers represent this type of companies (CSP 2009). Recent industry study shows that the shares of the service provider types have clearly changed in the US market. Five years ago (CSP 2004) approximately 75 % of providers considered themselves in this category and the service-based companies formed 25 % of the supply side. In 2009 (CSP 2009) 67 % of the service providers considered themselves service-based companies, without own chemicals manufacturing (CSP 2009, 17). This may indicate that smaller, service-based companies such as chemicals distributors can successfully provide chemical management services. Hazardous waste management companies can also develop new business out of material efficiency services aimed at reducing the production of hazardous waste. In both types of firms a dramatic change is needed in ways of thinking because the income flow would no longer be based on the amount of chemicals sold or waste treated, but on the service that supports customers' production processes. One solution is to set up a subsidiary, but some problems may still remain. According to CSP (2004), subsidiaries are biased to push their own products to service users even if a competitor's product were cheaper or more appropriate. This problem is less likely to emerge if the service is provided by a separate firm operating in a different field than the service (e.g. AGA Gas of the Linde Gas Corporation, a gas company offering CMS (AGA Gas 2010), or if the service provider is an engineering firm or consultancy without its own production. As mentioned in previous paragraph, at the US markets majority of the service providers consider themselves as service-based companies (CSP 2009), which may indicate demand side preference for independent providers of CMS.

To sum up the above, the following types of firms can be expected to offer material flow management services are:

- Chemical producers (offer CMS) or waste management companies (offer resource management services)
- Engineering or consultancy firms specialized in management of certain material group (usually chemicals)
- Production firms or chemical distributors that do not have own production of the material group for which the service is offered (e.g. AGA gas that offers CMS)

There might be a mismatch between the supply and demand side. As mentioned earlier, large corporations with good solidity and strong in-house expertise are not that keen to use material efficiency services, whereas smaller or medium-sized enterprises see more benefits in these services. The study by Mont et al. (2006) on chemical management services, on the other hand, indicates that CMS providers seek large customers because of economic feasibility. Consequently, the large potential clients that are preferred by providers tend to have in-house expertise, whereas small and medium-sized clients needing these services are not considered lucrative prospect by providers.

11.5 Conclusions and Implications for the Future

In addition to a reduced environmental burden and cost savings, material efficiency services can offer new business for environmental service companies. The latter is particularly important in many Western (European) countries which are seeking to create new job opportunities in the service sector in order to compensate for the steady decline in industrial employment. Over and above skilled employment, industrial services offer a long-term source of competitive advantage. This is because they are less tangible and more dependent on competencies and thus much more difficult for competitors to imitate (*Economist* 2000; Oliva and Kallenberg 2003). A recent global study also shows that profitability of business-to-business services is up to 75 % better than that of manufacturing operations (Deloitte 2006). Moreover, if first developed domestically, environmental service businesses may in time evolve into a new type of industrial expertise for export (Ekins 2005). Despite its benefits, the business of selling "functional utility" is not common in current business thinking. Therefore the alternative business models need to be carefully scrutinized so as to increase knowledge and awareness about them.

The conceptual framework introduced in this chapter for purposes of analyzing different business models of eco-efficient services comprises the competitive advantage of these services, the customer benefits, the resources and capabilities of the service providers, and the financing arrangements. Applying this framework, we identified three business models for result-oriented material efficiency services: the MASCO-model, the material efficiency as additional service model and the material flow management service model. In the MASCO model, an enterprise specializing in material efficiency makes the material saving investment in the customer company and is compensated according to the savings achieved. The additional service model is essentially the same, but the service provider and user have an existing business relationship, typically in the field of maintenance, waste management, or equipment provision. The provider takes charge of a material efficiency investment from financing to implementation throughout the investment period. Apart from the fees for the ordinary service, the provider is compensated on the basis of the cost savings achieved through the investment. The third model differs from the former two with respect to the investment. Here the service provider takes over the management of a certain materials group, such as chemicals. In other words, the customer company outsources the management of a material flow to a service provider, and the compensation can be tied to an agreed result measuring the outcomes of the client's facility, e.g. the number of coated washing machines. It is also possible for service providers to combine two business models. Namely, the service provider that takes charge of the management of the material flow could also offer a financing service for material efficiency investments. Depending on the business model, prominent material efficiency service providers differ from large companies that offer multiple products and/or services to smaller, specialized providers.

Potential clients typically lack the resources (expertise, management's time or initial funds) to conduct material efficiency improvements themselves. The competitive advantage of these services relates to the increased efficiency that is achieved from the handing over of an activity to a professional operator. Regardless of the business model, enterprises seemed to be more willing to use material efficiency services for side stream materials than for core business operations. That said, it should be emphasized that not all manufacturers necessarily benefit from these services. Companies with abundant funds of their own and/or in-house expertise in materials efficiency improvements, may be best off going it alone. Potential client organizations with a strategy of outsourcing support activities and with experience of outsourcing are keener to use material efficiency services. If the organization has experience of outsourcing more straightforward functions such as cleaning or catering, it will more readily outsource more complex activities as well. This experience is needed because even if the materials that need to be servicized are auxiliary materials, they are still usually closely interwoven in productive operations and their management requires a certain level of professional skills.

Service providers should possess strong expertise and know-how in the materials concerned and related technologies. In the case of investment-type services, they must also be capable of arranging the necessary financing and recruiting a network of cooperators to whom to subcontract various parts of the investment process. Which firms, then, are most realistically able to offer material efficiency services? Here we must make a distinction between investment-based services and those for the management of material flows. Investment-based services are most likely to be offered by firms that have an existing business relationship with the client, such as waste management companies. These firms should be viewed by financing institutions as reliable partners so that they can arrange the necessary funding for the investment. Secondly, ESCOs can also extend their business to MASCO. If and when the business becomes more commonplace, it is likely that enterprises will emerge that specialize exclusively in material efficiency investment projects. For the time being small, specialized MASCOs do not enjoy sufficient credibility among financiers, and they usually do not have enough funds of their own to invest in projects on a continuous basis. Material flow management services are most typical in chemical management. Most of the providers are service providers without their own production whereas the remaining third are subsidiaries of major chemical companies (CSP 2009).

What is the point of exploring all these options in one study instead of concentrating on one of them, say chemical management services? By putting all the various material efficiency services in one picture, we should be able to gain a fuller understanding of the ways and means of introducing material efficiency to enterprises through external agents. Different types of customers need different types of services. It goes without saying that co-operation is more intense and deeper in material flow management services than in investment projects. The latter are one-off projects and have a fixed end point, whereas in the former case an employee working for the provider will usually be assigned to work at the client's site and the service relationship will run on a continuous basis, i.e. it is not usually projected to finish at a certain point in time. Sometimes it may be a more attractive option to give one single efficiency project to an outside provider rather than to outsource the management of an entire material.

Since the models represent new ways of doing business, there are a number of organizational and institutional aspects that ought to be taken into account. As for the organizational aspects, the service provider has to convince its potential customers that the efficiency measures will be profitable, that it is capable of handling the technological solutions and that it is capable of managing extensive projects that are (usually) closely interwoven with the customer's production or operational process. The client organization, for its part, has to sell the idea of the innovative service at many organizational levels. Here attitudes, experiences and contacts between people and organizations are of crucial importance.

What about the future of these services? In spite of the economic and ecological benefits foreseen, some mechanisms of promotion would certainly boost the demand for these services and help them move on from the initial stage. These mechanisms can range from well-designed legislation and regulation to a variety of voluntary measures (Halme et al. 2005). The chemicals regulation REACH is likely to accelerate the emergence of material efficiency services in Europe, because it increases the need for better data and data management on chemicals and also pushes the development of chemicals substitution. Other means that could be utilized are environmental permits and BAT reference documents under the EU's Integrated Pollution Prevention Control (IPPC) Directive; government grants for material efficiency projects; and the promotion of material efficiency in public procurement and the imposition of environmental taxes on selected materials (cf. Ekins 2005). Voluntary agreements, when properly designed, have also proved a useful way to promote both energy and material efficiency (Bressers and de Bruijn 2005; ten Brink 2002; Delmas and Terlaak 2001; Hardgroves and Smith 2005; Kautto et al. 2000). Access to data on material use at industrial sites would facilitate efficiency comparisons between different sectors and encourage lower performers to make improvements. In Denmark and Finland there are experiments where the public authorities provide benchmarks by gathering data on raw material use and waste creation at industrial sites and by making these data publicly available (Danish EPA 2003; YTV 2006; Jokinen 2005). In Finland, the government has established a Material Saving Centre (in connection to Motiva, the Centre for Energy Efficiency). Its tasks will consist of multiple measures with which to advance material efficiency in the industry. For the future development of MASCO model it will also be interesting to see and worth to study in what way ESCO and MASCO can be connected simultaneously in single project or business model.

The approach presented here, material efficiency services, need to be coupled with other measures such as innovation of novel environmentally benign materials, as well as legislation and economic instruments supporting material efficiency. The attraction of this solution lies in the fact that it could be aligned with the economic interests of business enterprises, on which it largely depends whether the intake of materials in the economy can be reduced.

Appendix: Interview Summary

Enterprise/organization	Sector	Number of interviews
AGA Sisource	Chemicals management services	1
BASF	Success business unit	1
Chemical Strategies Partnership, CSP	Non profit organization, chemicals management	3
Ekokem Oyj	Hazardous waste management	2
Enespa	Esco	1
Finnvera	Finance	1
Government	Departments of Environment and Trade and Industry	7
HK Ruokatalo	Food industry (meat processing)	6
Inesco	Esco	3
Ingman	Food industry (dairy)	3
Kemira Industrial Environmental Services KIES (Kemira Operon Oy since 2010)	Industrial waste water management services	2
Kesko Oyj	Retailing	1
Lassila & Tikanoja	Waste management	3
M-real Tako Board	Paper	3
M-real Äänekoski Paper	Paper	4
Myllykoski Paper	Paper	2
Nordea bank	Finance	1
OP-Rahoitus	Finance	1
Oy Gustav Paulig	Food industry (coffee brewer)	4
Safechem	Chemicals management services	2
Stora Enso Anjalankoski	Paper	1
Stora Enso Imatra	Paper	1
Stora Enso Kotka	Paper	3
Stora Enso Oulu	Paper	3
Stora Enso Varkaus	Paper	1
Suomen Lämpöpumpputekniikka	HPAC engineering, heat pumps, Esco	1
Tekno-Forest	Chemicals and cleaning systems	3
UPM-Kymmene Jämsänkoski	Paper	1
UPM-Kymmene Rauma	Paper	1
Würth Finland	Fixing and assembly of materials (incl. chemicals), inventory management and delivery systems	3
YIT Kiinteistöhuolto	Building management and maintenance, Esco	1
Total		**70**

References

AGA Gas (2010) SISOURCE® chemical management services. Retrieved 10 Mar 2010, from http://www.aga.se/international/web/lg/se/likelgagase.nsf/docbyalias/newbusiness_sisource

Anttonen M (2010) Greening from the front to the back door? A typology of chemical and resource management services. Bus Strategy Environ 19(3):199–215

Anttonen M, Kuisma M, Halme M (2006) Materiaalitehokkuutta edistävistä palveluista ympäristömyötäistä liiketoimintaa ja asiakaskumppanuuksia (MASCO2) [Generating business and creating business partnerships out of material efficiency services]. http://www.hse.fi/MASCO

Bertoldi P, Rezessy S, Vine E (2006) Energy service companies in European countries: current status and a strategy to foster their development. Energy Policy 34(14):1818–1832

Bierma T, Waterstraat F (1999) Cleaner production from chemical suppliers: understanding shared savings contract. J Cleaner Prod 7(2):145–158

Bierma T, Waterstraat F (2000) Chemical management: reducing waste and cost through innovative supply strategies. Wiley, New York

Bleischwitz R (2003) Cognitive and institutional perspectives of eco-efficiency. Ecol Econ 46(3):453–467

Bressers H, Bruijn T (2005) Conditions for the success of negotiated agreements: partnerships for environmental improvement in the Netherlands. Bus Strategy Environ 14(4):241–254

Corbett CJ, DeCroix GA (2001) Shared-savings contracts for indirect materials in supply chains: channel profits and environmental impacts. Manag Sci 47(7):881–893

CSP (2004) Chemical management services. Industry report 2004. Chemical Strategies Partnership, San Francisco

CSP (2006) What is CMS? Chemical Strategies Partnership. Retrieved 10 Feb 2006, from http://www.chemicalstrategies.org/mission_and_goals.htm

CSP (2009) Chemical management services. Industry report 2009. Chemical Strategies Partnership, San Francisco

Danish EPA (2003) The Danish green accounts: experiences and internal effects. Danish Environmental Protection Agency. Retrieved 21 Feb 2006, from http://www.mst.dk/indu/05050000.htm

Delmas M, Terlaak A (2001) A framework for analyzing environmental voluntary agreements. Calif Manag Rev 43(3):44–63

Deloitte (2006) The service revolution in global manufacturing industries. Deloitte Research 24:23–33. Available at http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/US_deloittereview_The_Service_Revolution_aug07.pdf. Visited latest in 4 Nov 2013

Economist (2000) In search of Fiat's soul. The Economist, 1 June 2000, pp 69–70

Ekins P (2005) Eco-efficiency: motives, drivers, and economic implications. J Ind Ecol 9(4):12–14

EPA (2006) WasteWise resource management: innovative solid waste contracting methods. Retrieved 10 Mar 2010, from http://www.epa.gov/osw/partnerships/wastewise/wrr/rm.htm

EPA (2009) "Green Servicizing" for a more sustainable US Economy: key concepts, tools and analyses to inform policy engagement. Retrieved 10 Mar 2010, from http://www.epa.gov/waste/partnerships/stewardship/docs/green-service.pdf

European Commission (2002) Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme. Retrieved 21 Feb 2006, from http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&type_doc=Decision&an_doc=2002&nu_doc=1600&lg=en

European Commission (2008) Promoting innovative business models with environmental benefits, Final report November 2008. http://ec.europa.eu/environment/enveco/innovation_technology/pdf/nbm_report.pdf

Halme M, Heino E, Anttonen M, Kuisma M, Kontoniemi N (2005) Materiaalinsäästöpalveluista liiketoimintaa – Kohti jätteiden synnyn ehkäisyä [Generating business out of] material efficiency services – towards source prevention. Suomen Ympäristö, 767. http://www.ymparisto.fi/download.asp?contentid=37553&lan=fi

Hamel G (2000) Leading the revolution. Harvard Business School Press, Boston
Hansen S (2002) Manual for intelligent energy services. Marcel Dekker Incorporated, New York
Hardgroves K, Smith M (eds) (2005) The natural advantage of nations. Business opportunities, innovation and governance in the 21st century. Earthscan, London
Heiskanen E, Jalas M (2003) Can services lead to radical eco-efficiency improvements? – A review of the debate and evidence. Corp Soc Responsib Environ Manag 10(4):186–198
Hinterberger F, Luks F, Schmidt-Bleek F (1997) Material flows vs. 'natural capital': what makes an economy sustainable? Ecol Econ 23(1):1–14
Hockerts K (1999) Innovation of eco-efficient services: increasing the efficiency of products and services. In: Charter M, Polonsky J (eds) Greener marketing: a global perspective on greening marketing practice. Greenleaf Publishing, Sheffield
Jakl T, Schwager P (eds) (2008) Chemical leasing goes global: selling services instead of barrels: a win-win business model for environment and industry. Springer, Wien
Jakl T, Joas R, Nolte RF, Schott R, Windsperger A (2004) Chemical leasing: an intelligent and integrated business model with a view to sustainable development in materials management. Springer, Wien
Jokinen V (2005) Pääkaupunkiseudun palvelujen sekajätteen määrä. Toimistot, sairaalat, koulut, ravintolat ja hotellit sekä kaupat [Mixed waste generated by service industries in the Helsinki metropolitan area: offices, hospitals, schools, restaurants, hotels and grocery shops]. Pääkaupunkiseudun julkaisusarja, C 2005:1. Retrieved 21 Feb 2006, from http://www.ytv.fi/FIN/tietoa_ytv/julkaisusarja/2005/
Kautto P, Melanen M, Saarikoski H, Ilomäki M, Yli-Kauppila H (2000) Suomen jätepolitiikan ohjauskeinot: vaikutukset, vaikuttavuus ja kehittämistarpeet [Waste policy instruments in Finland – effects, effectiveness and development needs]. Suomen ympäristö 430. http://www.ymparisto.fi/default.asp?contentid=91921&lan=fi
Kircherer A, Schaltegger S, Tschohohei H, Ferreira Pozo B (2007) Eco-efficiency. Combining life cycle assessment and life cycle costs via normalization. Int J Life Cycle Manag 12(7):537–543
Kontoniemi N (2004) Materiaalinsäästöpalvelun mahdollisuudet elintarviketeollisuudessa [Material saving services as business in the food Industry]. Master's thesis, Helsinki School of Economics
Kortman J, Theodori D, van Ewijk H, Verspeek F, Uitzinger J, La Roca F, Ferrer G, Esteve E, Gensch C-O, Dietlinde Q (2007) Chemical product services in the European Union. European Commission Directorate-General, Joint Research Centre – Joint Institute for Prospective Technological Studies. Retrieved 5 May 2007, from http://www.resourcesaver.org/file/toolmanager/CustomO16C45F70883.pdf
Ligon P, Votta T (2001) Strategic contracting increases waste prevention and materials recycling. Resour Recycl: N Am Recycl Compost J: 1–4. Retrieved 21 Feb 2006, from http://www.epa.gov/epaoswer/non-hw/reduce/wstewise/pubs/rr_rm.pdf
Ligon P, Mishra PN, Votta T (2000) New paradigm for disposal contracts: waste service providers become resource managers. BioCycle: J Compost Org Recycl:51–52. Retrieved 21 Feb 2006, from http://www.jgpress.com/BCArticles/2000/040051B.html
Magretta J (2002) Why business models matter? Harv Bus Rev 80(5):86–92
Mont O, Singhal P, Fadeeva Z (2006) Chemical management services in Sweden and Europe – lesson for the future. J Ind Ecol 10(1–2):279–292
Motiva (2000) ESCO-toiminnan yleisperiaatteet ja MotivaESCO-konsepti [General principles of ESCO activity and the MotivaESCO concept]. Motiva publications, 3. Helsinki Centre for Energy Conservation
NAESCO (2006) What is an ESCO? National Association of Energy Service Companies. Retrieved 15 Feb 2006, from www.naesco.org/about/esco.htm
Nidumolu R, Prhalad CK, Rangaswami MR (2009) Why sustainability is now the key driver of innovation? Harv Bus Rev 87(9):56–64
Normann R, Ramirez R (1994) Designing interactive strategy: from value chain to value constellation. Wiley, Chichester

OECD (2002) Working together towards sustainable development: the OECD experience. OECD, Paris
OECD (2003) Voluntary approaches for environmental policy. Effectiveness, efficiency and usage in policy mixes. OECD, Paris
OECD (2004) Strategies in chemicals industry and related areas. OECD Environment, Health and Safety Publications. Series on Risk Management, 17. In: Workshop on experiences and perspectives of service-oriented strategies in the chemicals industry and related areas, Vienna, Austria, November 2003
Oldham J, Votta T (2003) Chemical management services – greening the supply chain. Greener Manag Int 41(1):89–100
Oliva R, Kallenberg R (2003) Managing the transition from products to services. Int J Service Ind Manag 14(2):160–172
Parviainen J (2004) Energiansäästöpalveluiden rahoitukselliset ratkaisut ja niiden hyödynnettävyys materiaalinsäästöpalvelu-liiketoiminnan kannalta [Finance solutions for energy efficiency services and their applicability in materials efficiency business]. Master's thesis, Helsinki School of Economics
Phillips PS, Gronow B, Read AD (1998) A regional perspective on waste minimisation: a case study of the East Midlands of England. Resour Conserv Recycl 23(3):127–161
Porter M, van der Linde C (1995) Green and competitive: breaking the stalemate. Harv Bus Rev 73(5):120–134
Räsänen K (2001) Kehittyvä liiketoiminta: Haaste tulevaisuuden osaajille [Business in development: Challenging capabilities]. Weilin & Göös, Helsinki
Reiskin E, Kauffman Johnson J, Votta T (2000) Servicizing the chemical supply chain. J Ind Ecol 3(2):19–31
Roy R (2000) Sustainable product-service systems. Futures 32(3–4):289–299
Saling P, Kicherer A, Dittrich-Krämer B, Wittlinger R, Zombik W, Schmidt I, Schrott W, Schmidt S (2002) Eco-efficiency analysis by BASF: the method. Int J Life Cycle Manag 7(4):203–218
Saling P, Grosse-Sommer A, Alba-Peréz A, Kölch D (2007) Using the eco-efficiency analysis and SEEbalance in the sustainability assessment of products and processes. Presentation given in the 4th BMBF-Forum for Sustainability: Sustainable Neighborhood – from Lisbon to Leipzig through Research (L2L), Leipzig
Schmidt-Bleek F (1998) Luonnon uusi laskuoppi: Ekotehokkuuden mittari MIPS [Das MIPS-Konzept. Weniger Naturverbrauch – mehr Lebensqualität durch Faktor 10]. Gaudeamus, Helsinki
Stoughton M, Votta T (2003) Implementing service-based chemical procurement: lessons and results. J Cleaner Prod 11(8):839–849
Tellus Institute (2002) Assessing the potential for resource management in Clark County, Nevada. A report prepared for US EPA Region IX. Retrieved 15 Feb 2006, from http://www.epa.gov/epaoswer/non-hw/reduce/wstewise/pubs/clarkrm.pdf
Tempelman E (ed) (2004) SusProNet report. PSS for need area food: an overview. Retrieved 15 Feb 2006, from http://www.suspronet.org/fs_reports.htm
ten Brink P (ed) (2002) Voluntary environmental agreements: process, practice and future use. Greenleaf Publishing, Sheffield
Timmers P (1999) Electronic commerce: strategies and models for business-to-business trading. Wiley, West Sussex
Tukker A (2004) Eight types of product-service system: eight ways to sustainability? Experiences from SusProNet. Bus Strategy Environ 13(4):246–260
Tukker A, van Halen C (2003) Innovation scan for product service systems. Retrieved 11 June 2005, from http://www.suspronet.org/
UN (2002) Report of the World Summit on sustainable development. United Nations, Johannesburg, South Africa, 26 Aug–4 Sept
Upstream (2006) Customized services. Retrieved 7 Dec 2006, from http://www.wmupstream.com/customized/resource.asp
Vercalsteren A, Gerken T (2004) Suspronet report WP11: need area households. Retrieved 15 Feb 2006, from http://www.suspronet.org/fs_reports.htm

Viljakainen S (2004) Materiaalinsäästö paperiteollisuudessa – materiaalinsäästöpalvelu apuvälineenä [Materials savings in the paper industry: materials efficiency services as a tool]. Master's thesis, University of Helsinki

Vine E (2005) An international survey of the energy service company (ESCO) industry. Energy Policy 33(5):691–704

Von Weizäcker E, Lovins A, Lovins LH (1997) Factor four: doubling wealth, halving resource use. Earthscan, London

WM Greensquad (2011) Services. Retrieved 7 Mar 2011, from http://www.wmgreensquad.com/services/waste_reduction/

Wüstenhagen R, Boehnke J (2006) Business models for sustainable energy. In: Munch Andersen M, Tukker A (eds) Perspectives on radical changes to sustainable consumption and production. Proceedings of the SCORE! conference. Retrieved 7 Dec 2006, form http://www.score-network.org

YTV (2006) Jätebenchmarking [Waste benchmarking]. Pääkaupunkiseudun yhteistyövaltuuskunta YTV. Retrieved 15 Jan 2006, from http://www2.ytv.fi/jateh/benchmark/index.html

Chapter 12
Requirements of an International Natural Resource Policy

Judit Kanthak and Michael Golde

12.1 Introduction

> We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect. Aldo Leopold (1886–1948)

Do we need a worldwide internationally coordinated resource policy? Why can't we leave the exploitation and use of natural resources simply to the business sector and the countries concerned, relying on market forces? Why do we need coordinated policy action in the field of natural resources and how should policy react to increasing resource use?

In this contribution we argue that there is a need for an international managed resource policy and we will show its components and main requirements. We will first show the urgent need for resource conservation, resource efficiency and more sustainable resource use and outline main fields of action. We focus on policies that are improved by and become more effective through international coordination.

12.2 The Need for a Natural Resource Policy

The use of natural resources is inevitable for our society. Until now it has shown a permanent tendency to increase. This leads to increasing pressure on resource availability and on the environment with all its negative consequences for the economy and society. When we look at the drivers of resource use on the one hand

---

J. Kanthak (✉) • M. Golde
Federal Environment Agency (Germany), Wörlitzer Platz 1,
06844 Dessau-Roßlau, Germany
e-mail: judit.kanthak@uba.de; michael.golde@uba.de

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_12,

and the environmental and social impacts and costs that are caused by this use on the other hand, we will recognize the need for policy actions in the field of natural resources.

12.2.1 Drivers of Resource Use

Natural resources form *the base of our economic activities and our prosperity*. The fulfilment of many basic needs such as housing, infrastructure or communication is very material intensive (see, e.g. SERI 2009). To meet these basic needs we need long term sustainable solutions that guarantee every human a decent livelihood.

The *technological change* expected to take place within the next decades will be accompanied by an additional increase in the demand for minerals and metals. Emerging technologies such as thin layer photovoltaic, permanent magnets, micro capacitors and lithium-ion batteries require a range of raw materials in continuously increasing amounts. These are not only base metals like copper or aluminium but also so called critical materials such as gallium, neodymium, tantalum or cobalt.

Inefficient resource use is a very important reason for our overuse of natural resources. Until recently there were not enough efforts to increase resource efficiency. In the last decades resource efficiency has not increased as much as labour efficiency. In addition, recycling rates are much lower than is technically and economically possible. Recycling rates remain relatively low for most metals. For example, at the global level, it is estimated that 26 % of extractable copper is not recycled and is lost. For zinc this rate is 19 % (Gordon et al. 2006). Another problem evolves from the dissipative use[1] especially of critical materials. So the recycling rates of specialty metals are often below 1 % (UNEP 2011). Dissipative use often makes recycling impossible or much more difficult, more costly and less efficient and thereby it leads to *dissipative losses*.

Another important driver of increasing resource use is the *growth of the world population*. The UN estimates that by the year 2050, the world population will have increased from the present figure of about seven billion to more than nine billion (UN 2011). At the same time the *world economy will continue to grow*. This means that the quantity of produced goods and services and as a consequence also the consumption of raw materials will strongly increase worldwide. Even during the economic crisis, in the period 2006–2009, world output growth, measured on purchasing power parity (PPP) basis that adjusts for price differences among countries, was 2.3 % per year on average (UN 2012). Emerging economies showed even higher economic growth over the last years. Global resource use grew accordingly. For example, from 2000 to 2010 world iron ore production increased by a factor of 2.4, copper production increased by 22 % and indium production increased by about

[1] This term refers to the wide spatial distribution of raw materials due to the use of low quantities in a multitude of products.

80 % (USGS 2011). Currently developed countries are the largest consumers of resources. The OECD countries – which account for about 15 % of world population – consume 50 % of mineral resources (not including fossil fuels) (Bleischwitz/Bringezu 2007). Should emerging economies in future require the same material input per capita as developed countries, raw material extraction would have to be drastically increased. In business-as-usual scenarios (e.g. OECD 2008a), the exponential growth of global material flows will continue. Our society not only depends on natural resources, our dependency is increasing; the use of natural resources is growing constantly.

In view of this situation and against the background of limited[2] resource availability we have to find solutions for how to satisfy our demand for resources without undermining long term prosperity and sustainable economic and environmental development.

12.2.2 Impacts of Resource Use and Environmental Costs

The increasing demand for raw materials will intensify the pressure on natural resources. The production and processing of raw materials is always associated with *land take* and *consumption of material and energy* as well as with the *emission of greenhouse gases and pollutants* and with *waste generation*. For example the primary production of a tonne of copper causes the emission of 3.4 tonnes of CO_2, the primary production of a tonne of indium generates 142 tonnes of CO_2 (Hagelüken 2008). The production of cement and steel alone accounts for about 15 % of global CO_2 emissions (BMU/UBA 2009). The use of non-energy resources has a considerable impact on our climate; therefore resource policy can contribute to a reduction of greenhouse gas emissions.

Waste generation is a serious environmental problem in many parts of the world. The uncontrolled dumping of waste on the outskirts of megacities for example has created serious problems for public health, the local environment and the global climate. The OECD (2008a) estimates an increase in municipal waste generation in OECD countries by 1.3 % annually until 2030. Mining is one of the biggest waste producing industries. Large scale mining of metals always produces waste rock and tailings. Tailings ponds and rock-waste areas can reach a size of over 1,000 ha; tailings heaps can grow over 200 m high. The main environmental impacts from tailings and waste-rock management facilities are impacts associated with the land use as well as potential emissions of dust and effluents during operations or in the aftercare phase. Furthermore, accidents in mining activities can cause severe environmental damage – and even loss of human life.

[2] Limited does not mean necessarily limited in absolute terms. Resource availability is also limited by other factors such as low ore grade and thus prohibitively high mining costs, environmental concerns (including climate change), economical or geo-political constraints.

Mining activities such as extraction, mineral processing, and shipment of the products and management of the residues have a range of adverse impacts including

- Land use, change of landscape and the destruction of natural habitats;
- High water consumption that may result in changes in water ecology and groundwater levels;
- Contamination of sediments leading to river pollution;
- Land instability and subsidence that may cause damage to infrastructure and buildings;
- Emission of pollutants due to auxiliary materials such as cyanide compounds in gold mining and release of elements such as heavy metals;
- Soil contamination;
- Emission of particulate matter;
- Emission of methane.

In order to meet the growing demand for raw materials, more and more deposits with lower metal content in ore are exploited and raw materials are extracted in remote, previously untouched sensitive regions such as arctic and subarctic regions or primeval forests. Negative environmental impacts increase and resource extraction becomes more costly.

Existing political instruments often do not prevent these damages, or reduce them insufficiently, and do not provide for a recovery of the costs of environmental effects from mining. Frequently these costs are not even known because no thorough socio-economic and environmental impact analysis is carried out before starting mining operations. Raw material production cause frequently high social costs (e.g. health costs, loss in agricultural production). Policy makers should prevent medium- and long-term damages when these are higher than the short-term benefits of raw material production.

The link between raw material use and waste generation is manifold. Less raw material extraction will lead to less tailing waste, better recycling will reduce the need for raw material extraction on the one side and reduce the waste pile on the other. Less use of material and thus fewer or lightweight products will produce less waste in the end.

12.2.3 Economic Implications and Consequences for Resource Policy

The use of natural resources is inevitable but causes problems and costs for the environment and society across their whole lifecycle. This causes direct and indirect impacts on the economy. The long term goal should be to reduce the negative impacts of resource use. This can be achieved by reducing consumption on the one hand (including improved recycling) and reducing the negative impacts of unavoidable resource use on the other.

Therefore the *highest priority must be given to an absolute reduction of resource consumption worldwide*. To reach that goal it is necessary to set targets for an absolute reduction of resource use with regard to all direct and indirect resource extractions.[3] It is not sufficient to look only for selective improvements of resource efficiency because this often leads to a shifting of problems. Substitution of materials is an often desired effect but as, for example, the introduction of biofuels showed, it can also be dangerous and its sustainability questionable. The rebound effect is a further serious issue that shows that efficiency improvements alone are not sufficient to make resource use sustainable.[4] Alcott (2010) argues that efficiency strategies do not necessarily reduce the environmental impact of resource use. He goes even further with his conclusion that only rationing or a Pigouvian tax is able to lower environmental impact.

Even though an absolute reduction is desirable and should be the most important goal of resource policy it is not sufficient to concentrate only on this, as there will still be unavoidable resource extraction in future. A policy is needed which aims to achieve a *responsible* – and as far as possible sustainable – *extraction and use of raw materials* with lowest possible environmental impact and taking into account all social impacts.

The extraction, use and disposal of resources often have negative *external effects* on the environment and humans. They occur when an economic actor does not have enough incentive to reduce negative impacts caused by his economic activity. Costs caused by him, for example, in the form of environmental damage, must be borne by society. This leads to inefficient, highly polluting activities. In such a case the government should increase incentives to reduce polluting activities or enforce pollution prevention. Following the classical theory, in economic optimum marginal costs of pollution prevention should equal the marginal benefits of the pollution reduction thus achieved. Government should adopt legislation or employ economic instruments to reduce pollution. This offers economic advantages for all of society such as savings in cleanup measures, reduced health costs, reduction of waste disposal costs.

Furthermore, a responsible and efficient use of resources has *direct economic advantages* for all economic actors that use resources: A responsible and efficient resource use can contribute to an improvement of economic competitiveness.[5] Less resource use reduces the negative economic effects of volatile raw material prices and it reduces the overall costs of resource use. Thereby it frees up capital for investment in non material aspects of human welfare.

The supply of raw materials increasingly depends upon only a few countries, regions or companies. Even worse, some of these countries are situated in politically instable regions. Brazil, Chile, Peru, The Republic of South Africa, Congo and Zambia will dominate the supply of mineral and metallic raw materials increasingly

[3] For details see the Chap. 3.

[4] For a comprehensive overview on the rebound effect see, e.g., Jenkins et al. (2011).

[5] For further details see Chap. 10.

(Bleischwitz/Bringezu 2007). In contrast to those countries, the EU, as one of the world's largest users of metals, imports more than 95 % of the metals it uses (COM 2005). This means that the *vulnerability of raw material supply* and the danger of supply disruptions will increase. This alone is an important reason to reduce our resource dependency by means of less resource consumption and more recycling. Furthermore this dependency is a very strong reason to promote better international cooperation and coordination of resource policy.

12.3 Approaches for a Sustainable Resource Use Across the Entire Lifecycle of Products and Services

From a *technical* point of view increasing resource efficiency and reducing environmental impact through application of best available technology is the most promising approach for a sustainable use of natural resources. The different stages of the lifecycle of a product or a service offer a number of different approaches for reducing resource use. Resource efficiency can be increased in extraction and processing as well as in the design and use of products and the provision of services. Recovery of secondary raw materials from by-products and waste products is a further crucial efficiency factor. In this section we show the technical opportunities. In the following section we will show different political and economic measures and instruments on national and international level that helps to implement these technical potentials.

12.3.1 Raw Material Extraction and Processing

There are two types of mining – large scale mining and small scale mining (including artisanal mining). Large scale mining is usually undertaken by big companies which continue the operations until the mineral or metal deposit is economically exhausted. Small scale mining is generally understood to refer to any operation with less than 50 employees, while artisanal mining is the very basic, low-tech, informal type of mining which is often illegal and seasonal. Small scale mining occurs in countries such as Suriname, Guyana, Laos, Sri Lanka, Zambia, Madagaskar and Central Africa.

Problems facing small scale miners include

- Lack of access to information and technology for more efficient and safer mining practice;
- Poor working conditions and lack of regulation;
- Smuggling and corruption;
- Lack of records on previously mined areas.

Occasional projects supported by the European Investment Bank and the World Bank aim to make adequate geological data readily available to small scale miners; improve small scale miners' ability to manage their business; equip miners with adequate mining, safety, valuation and processing skills; improve access to capital and equipment and introduce fair trade. Regardless, there is a great need for concerted and coordinated support for a responsible raw material extraction worldwide.

Both large scale and small scale mining are generally very destructive to the environment. In the last few decades, metal mining on a worldwide scale has moved away from underground operations towards larger mining in open pits. As a consequence today larger amounts of overburden have to be removed to gain access to the ore. Mining waste is in most cases responsible for the large ecological rucksacks carried by relevant products. Mining waste can be defined as the leftover materials that result from the exploration, mining and processing of substances, and which are a part of all the materials governed by mining and quarrying legislation. The volume of mining waste depends on the mining method and the type of raw material. For example, at a gold grade of 5 g/t, 200,000 tonnes of ore have to be mined to produce 1 ton of gold (assuming 100 % recovery of gold).

The Reference Document on Best Available Techniques (BAT) for the management of tailings and waste-rock in mining activities (EC 2009) covers activities related to tailings and waste-rock management of ores that have the potential for a significant environmental impact. The following metals are covered: aluminium, cadmium, chromium, copper, gold, iron, lead, manganese, mercury, nickel, silver, tin, tungsten and zinc. The following industrial minerals are also included: barites, borates, feldspar, fluorspar, kaolin, limestone, phosphate, potash, strontium, talc.

BAT is used to prevent and/or reduce the generation of tailings/waste-rock and to investigate possible uses and treatments of tailings and waste-rock such as selective handling of specific wastes, removal and disposal of hazardous waste, treatment of non-hazardous waste and recycling. BAT is also used to backfill both tailings and waste-rock under certain conditions. Coal and limestone tailings are also often used as aggregates for other external purposes such as earth construction (landscape modelling), road construction and landfill construction.

Safety performance in the mining industry is heterogeneous. It varies among companies and countries. We know that many risk situations extend beyond the boundaries of a site. Towns, villages, rivers, wetlands, farmlands and roads are all potential 'risk objects'. Therefore it should be standard practice to be ready for emergencies and to have appropriate contingency and emergency preparedness plans in place. The United Nations Environment Programme (UNEP) publication "APPELL for Mining" (UNEP 2001) provides further guidance on emergency preparedness. For the European Member States the Directive 2003/105/EC extended the scope of the Seveso II Directive on the control of major-accident hazards involving dangerous substances to cover the processing and storage of minerals containing dangerous substances extracted in mining and quarrying, and the tailings disposal facilities used in these activities.

12.3.2 Product Design, Construction

Product design has an influence on many stages of a product's life, from manufacturing and use to recycling or disposal. Important aspects include the use of efficient materials with a small "ecological rucksack", well designed miniaturisation and dematerialisation of products, better adaptation to the need to be covered, improved material and energy efficiency during the lifecycle as well as the construction of durable, recyclable and repairable products. According to a guide to improve environmental performance through product development, 80 % of a product's environmental profile is determined in the concept creation stage (Danish EPA 2008). Likewise it is claimed that around 80 % of a product's environmental impacts can be eliminated through better design.

The analysis of design strategies that could lead to greater material productivity showed that design is a key factor to realize greater amounts of recycling and waste prevention. Different design strategies can be applied to achieve greater material productivity, even though this may have different side-effects. For example, increasing the material efficiency of a product may result in a less durable product with a shorter functional life. Composite materials or a dissipative use of metals may prevent efficient recycling. Furthermore, lighter materials are not necessarily less material intensive than heavier materials (e.g. many small portable electronic devices have large "hidden material flows" that are necessary to produce them) (EC 2011). For this reason design strategies need to be carefully considered in relation to the entire lifecycle of the individual product or product group.

Design-oriented product policies in the European Union such as the Ecodesign Directive and the Packaging and Packaging Waste Directive have already shown material savings. There is evidence that both packaging and electrical and electronic equipment have benefited considerably from ecodesign approaches (EC 2011). Moreover in order to promote further sustainable consumption and production, the European Commission will establish a common methodological approach to enable Member States and the private sector to assess, display and benchmark the environmental performance of products, services and companies based on a comprehensive assessment of environmental impacts over the life-cycle (COM 2011). The next step will be the expansion of this hopefully successful development to the international level. As announced in the Roadmap to a Resource Efficient Europe, the Commission and the Member States support the effective implementation of international agreements to make global consumption and production patterns more sustainable.

12.3.3 Resource Efficient Production

The idea of a resource efficient production is not new. It is already taken up by the concept of Lean Production. The main idea of Lean Production (or Lean Manufacturing) is the technique of stripping all non-value-added activities from the production process, thereby using the minimum possible amount of resources to accomplish manufacturing goals. Initially developed by Toyota for car assembly lines the principles of lean production have been widely adopted in the manufacturing sector and have even proved to be applicable to other sectors such as the food and construction industries as well as public service offices.

Optimization of existing and development of new production technologies is particularly important in resource intensive fields such as the construction sector, the food industries, the automotive industries, the energy sector and the cross-sectional fields information and telecommunication as well as automation. There is much room for optimisation of resource efficiency and thus cost reduction in production especially in the chemical industry, in metal and steel making, in recycling as well as in the production of construction materials.

Technologies can be utilised in the following ways (Rohn et al. 2009):

- New resource efficiency technologies replace existing technologies or the state of the art in an existing application field in order to increase resource efficiency (competing/substitute technologies),
- Innovative functionalities of new technologies lead to new applications resulting in higher resource efficiency (new technology field).

In many systems, resource efficiency potentials can only be utilized with individual support from assistive technologies as "enabling technologies". For example, the use of renewable energies requires suitable storage media. Another example is the application of membrane technology in drinking water treatment or in the food industry.

12.3.4 Product Use and Supplying Services

The use phase usually represents a considerable part of the resource consumption of a product. One important approach to reduce resource consumption is business models which turn material suppliers and manufacturers into providers of services stimulate new incentive for the efficient use of resources (see also Chap. 11).

Thus, for example, car manufacturers could in future become suppliers of mobility services. Their motivation would not consist in selling as many and as big vehicles as possible, but in being able to offer users a comfortable and convenient means of transport.[6] Complementing products with services is also feasible in the raw material branch.

Enterprises which just sell raw materials and energy run the risk of being edged out of the market by others who use efficient technologies or alternative materials. Instead, they should offer services to the downstream side of the value added chain. The customer would not buy the raw materials, but only pay for their use. This removes the incentive for suppliers to sell largest possible amounts of raw materials.

---

[6] For example, there are already projects from different car manufacturers who implement mobility concepts based on flexible car sharing in several European and US towns.

Resources can be also used more efficiently when the use occurs in so-called "cascades". Thereby not only secondary raw materials but also products and by-products can be used more than once – along the whole life cycle and across branch borders (industrial symbiosis). An example of the cascade use of waste wood is the following line: wood-based furniture → particle board → pulp and paper → recycled paper → thermal use.

12.3.5 Closing Material Cycles

The industry in European countries is strongly dependent on secondary raw materials recovered from end-of-life products (e.g. glass, paper, iron and non-iron metals). Yet, until now recycling rates have remained relatively low for most metals at the global level.

In recycling processes usable raw materials from by-products and waste products are recovered and returned to the material cycle as so-called secondary raw materials. Recycling and the substitution of primary raw materials by secondary raw materials are a determining factor of the future development of the global consumption of raw materials.

Moreover further material flows in waste streams should be identified and their potentials for increasing resource efficiency should be promoted. For example, in the field of electrical and electronic equipment, recycling has to be increased above all with regard to critical raw materials such as indium, tantalum, gold and palladium. Another example is waste water as the municipal waste flow with the highest potential for phosphorus recovery.

Buildings and infrastructure in European countries represent an anthropogenic source of raw materials. "Urban mining" is the reuse and recycling of minerals, metals, plastics, glass, wood, etc., "hidden" in residential buildings or industrial buildings and infrastructures such as railways, roads, communication infrastructure. In general, used material will be available for recycling after a utilisation phase of 10 or more years in case of modernisation and technical upgrading, e.g. of communication infrastructure, or after a phase of 30 or more years in case of reconstruction or deconstruction. The concept of "urban mining" explores the potential of these reservoirs. Early investment in urban mining would not only give a competitive advantage, but would also prevent the wastage of a significant part of precious metals and other resources currently occurring.

12.4 Requirements for Global Resource Management

In Sect. 12.2 we have shown that resource extraction and use has considerable environmental, social and economic effects. Reaching an optimal allocation of resources requires government intervention. The previous section highlighted the potential of resource saving measures across the whole lifecycle of products and services. Resource use can be influenced at many stages of the resource use cycle. Most of these measures can be implemented at national level. Especially industrial and environmental policy can contribute to this. However most raw materials are traded internationally and through the supply chains of those materials all countries are interdependent. There are also a number of materials whose supply depends only on a few countries. This shows the international dimension of resource policy. Efficient solutions require a collaboration and coordination of resource policy across the whole resource use cycle.

The implementation of resource saving measures may bring some direct benefits such as savings in material costs. But often the benefits from resource saving measures are also public goods that can be gained fully only through globally coordinated efforts. Furthermore one can argue from an ethical point of view that the consumers of raw materials share responsibility for the negative external effects they cause through raw material extraction and processing in other countries. As many resources are non-renewable there is also the aspect of intergenerational justice. We should leave future generations enough accessible resources to satisfy their needs. The global interdependency in resource use means that national efforts for a natural resource policy are fundamental first steps but are not sufficient. There is a need for international cooperation to achieve a sustainable use of resources and thus sustainable development.

12.4.1 Important Elements of a Sustainable Management of Resources Worldwide

An effective and efficient instrument to reduce natural resource use in absolute terms is either to implement a cap on resource use or to *influence the price* through a Pigouvian tax. In energy and climate policy these instruments are already widely used (e.g. the EU Emissions Trading System and the energy taxes applied in many countries). Such market based instruments as a resource tax[7] affect the behaviour of economic actors and thus reduce the demand for resources. They also avoid the rebound effect. Higher prices impede spending for other resources. For locally produced and consumed resources such as land, water or building materials it is easily possible to implement a national solution (e.g. an aggregate tax; for further details see, e.g. EEA 2008). As economic instruments are very effective and efficient it can be expected that in the long run they will be applied more often. However as commodities are traded internationally huge difficulties arise. Border Tax adjustments may be needed. In this context a lot of unresolved legal, technical and administrational questions exist. Therefore it will be a very long way until internationally coordinated economic instruments are in place.[8] Meanwhile it will be necessary to

[7] For further details see, e.g. Chap. 14.

[8] For a deeper discussion of practical challenges of resource taxes see Eckermann et al. (2012).

implement other measures and instruments that help to reduce resource use and the pressure it exerts on the environment. The following measures can be implemented within the current policy framework and delegated to already existing international organizations and structures.

Promoting behaviour change towards sustainable consumption will lead to more resource efficiency. There are two general types of instruments, working through incentives or deterrence, to encourage sustainable behaviour: economic instruments (e.g. refunds, subsidies, charges, taxes) and communication instruments (e.g. environmental labelling, information campaigns) to raise awareness and educate consumers. Taxes and subsidies, e.g. can be based on the quantity of raw materials extracted/imported or waste generated (e.g. landfill tax) in order to increase material productivity. Charges can be levied on hazardous substances in order to shift consumption to products with lower environmental impact. As data quality on resource use of certain products is often only poor, other simpler tax schemes are also imaginable. In all cases financial stimulus is used to change consumer behaviour. Communication instruments such as labels exist already in many countries. A tighter international coordination could help to spread such label more and to involve international players.[9]

Other measures should support approaches and business models that seek *to prolong or optimize product lifetime* by increasing sharing, renting, leasing or pooling of products. The idea behind this is to offer services instead of products. Collective use refers to the sharing of products among a number of individuals, either simultaneously (such as carpooling) or in succession (such as refurbishment of used products). Collective use of products or equipment can lead directly to resource efficiency by providing individuals with the option of sharing a product instead of buying one of their own. This contributes to less consumption of certain product types, and ultimately to less raw material extraction and manufacturing. One indirect result of collective use is a decreased need for related infrastructure (for example, fewer car parks needed for vehicles).

One area where significant material savings can be made is *Green Public Procurement* (GPP). Purchasing by public authorities worldwide accounts for a considerable share of GDP, which represents a correspondingly large amount of products and materials consumed. The European Commission quantifies a share of 16 % of GDP that is spent by public authorities (COM 2008). If guided by eco-labelling GPP does have the potential to increase material productivity.

Product design should also be considered in an international context: As regards material flows, products are created from raw materials entering the domestic economy during production, but they may also be produced in other parts of the world and be imported and thus enter the domestic economy as a semifinal or final product. Conversely, products created in the domestic economy can result in material flows as exports to other countries. More international cooperation, not only between

[9] Already existing examples for international labels are the labels by the Marine Stewardship Council or the Forest Stewardship Council. Other labels as the "Energy Star" was designed for the US market but it is now widely used also in Europe.

governments but also between companies may help to increase incentives for a resource efficient product design. Developing and emerging nations need access to resource efficient products, services and technologies.

Policy Governance in Practice

The European Commission has devoted one of the seven flagship initiatives under the Europe 2020 strategy to the goal of creating a resource-efficient Europe. A detailed roadmap on this was adopted in September 2011. The "European Resource Efficiency Platform", an advisory panel of expert for the implementation of the roadmap, recommends among others (EC Memo 2012)

Promotion of innovation and investment in resource efficient technologies;
Regulations to create a level playing field, leading to reward, support and turning into account the social and international implications;
Integration of resource efficiency into other policies;
Abolishing environmentally harmful subsidies and tax breaks;
Creation of better market conditions for products and services that have lower impact during their life-cycle and are repairable and recyclable;
Development of resource use indicators covering also the consumption of land, raw materials, water, biodiversity and CO_2 emissions.

There is a need for *knowledge and technology transfer*. This can be done, e.g. by foreign direct investment, export of relevant products or technologies or through training programs. Measures should be designed in such a way that less developed countries are able to organize them on their own responsibility. Suitable strategies and technologies are needed. These may also include low-cost and low-tech technologies which can quite have an impact on reducing environment degradation. For the dissemination of high-tech technologies, a detailed account of best available technologies for a multitude of industrial production processes as well as for the management of mining wastes is for example provided by the BREF (Best Available Technique Reference) documents prepared by the European IPPC office in accordance with the IPPC Directive (EC 2008) and the Mining Waste Directive (EC 2006).

Raw material production often involves negative environmental and sometimes even negative social impacts, thus hindering sustainable development. On the other hand raw material production makes an important contribution to the economic development of countries producing these materials. For many countries raw materials make up the bulk of their exports; e.g. ore and metals account for about 90 % of Guinea's exports (OECD 2008b). Mining is an opportunity but often also a danger to the development prospects of poorer countries. The potential negative economic and social effects of mining that emerge in an instable political environment are called “resource curse”.[10] The abundance of natural resources itself and their exploitation does not lead automatically to development and prosperity.[11] The political framework conditions are crucial. The exploitation of raw materials should contribute to the economic development of a country without endangering its long term development. Of course this is primarily a national task but weak countries, strong international integration and dependency also make it an international task. An international raw materials policy should aim to *prevent corruption, minimize distribution conflicts and fight poverty*; it should comprise measures for crisis prevention, conflict resolution and promotion of education and health. In the same way development policy should include a resource policy that aims at resource conservation on the one hand and supports environmentally, economically and socially sustainable exploitation of raw materials on the other hand (UBA 2009). This would also reduce risks that may arise for developed countries from unstable raw material supplies, from ecological devastation or from failed states.

Industrialized countries should promote the development of a *suitable environmental legal framework for mining*. International trade law must not allow barrier-free access to raw materials produced without regard to environmental requirements. Instead state parties should be free to adopt stricter environmental regulations as long as these do not conflict with relevant international legal provisions laying down environmental protection standards. International (trade) law should not exert pressure on poor nations to relax or ignore regulation in order to attract investment.

There is the need for an *international political dialogue* with producers and users of raw materials on sustainable resources management with the following goals:

- Development of an initiative to strengthen the social and environmental responsibility of mining companies;
- Development of certification procedures for important non-energy raw materials;
- Creation of internationally binding instruments and incentives for resource conservation;
- Development of product standards that take into account the manner of raw material extraction.

12.4.2 Policy Approaches for a Global Resource Policy Development

International resource policy should be based on the elements described above.

In the following some possible instruments and policy elements are described.

Any resource policy will influence various other policies such as trade or environmental policy and land planning. It is important to maintain *coherence*

[10] In an economic context the phenomenon of decreasing competition through high raw material extraction and export is called “Dutch disease”.

[11] See, e.g., Auty (2004) who finds that in the last decades the economies of resource-abundant nations have grown much slower than those of resource-poor nations.

with other strategies, measures and policies. In the current discussion there is a tendency to give security of raw material supply and cheap exploitation of raw materials priority over other policy goals. Priority is granted, in effect, mainly to short term economic goals over long term sustainable development and economic prosperity. One example is oil drilling in environmentally sensitive regions. It causes local destruction of nature, influences the climate and obstructs the overdue change of the energy supply system. This short term thinking is dangerous because it puts sustainable development at risk and will aggravate future problems.

The international dependency on raw materials means that *provisions relating to raw materials* need to be *incorporated into bilateral and multilateral trade agreements*. These should not only secure the short term supply of raw materials but should also allow raw material producing countries to apply strict environmental and social standards.

Agreements that help *to close material cycles and improve recycling* will become increasingly important. International flows of recycled and recyclable goods are increasing (CSCP 2008). Currently large amounts of raw materials are lost due to a lack of or insufficient recycling. International agreements may help to organize the flow of goods and wastes in such a way that an effective recycling is possible. This is especially necessary for critical materials, since in their case efficient recycling poses technical problems (Wilts et al. 2010).

Another policy field that needs to be changed is our *development policy*. Resource rich countries need support for a more efficient, environmentally and socially responsible use of raw materials. But countries without many natural resources also need a development policy that takes care of resource related issues. These countries are affected by increasing raw material prices and can also contribute to a more efficient resource use through more efficient recycling and closing of material cycles. Governmental cooperation can help to address shortcomings in implementation and enforcement of environmental standards in the extractive sector (CSCP 2008).

Policymakers need to call for/require more transparency as regards the origin of raw materials, the environmental and social impacts of raw material extraction and associated financial flows. The EITI initiative is a good starting point. More *certification schemes* need to be established.[12] They can help to reduce conflicts and negative environmental impacts connected with and caused by raw material extraction and thereby reduce supply related risks. Demanding more transparency and certification schemes are examples of how to include companies into sustainable resource management. Pressure must be applied to increase the Cooperate Social Responsibility of companies. This can be done directly for example by a green public procurement policy which takes raw material saving and efficiency aspects into account.

[12] For diamonds such a scheme already exists (Kimberly process). The German Federal Institute for Geosciences and Natural Resources is currently working on a pilot project about certification of coltan, cassiterite, wolframite and gold in Central Africa (BGR 2009).

12.5 Conclusions

Improving resource efficiency is among the top priorities in today's world, as governments, businesses and civil society are increasingly concerned about natural resources use, environmental impacts, material prices and supply security.

There is a need to foster international cooperation and partnerships on resource efficiency: among governments, members of the private sector, and representatives of civil society involving the EU, OECD, UNEP, the G8, and others.

For the reasons mentioned above, political leaders should adopt a strategy of resource governance seeking international agreements on world-wide targets for natural resource extraction and consumption (per capita), targets for sectors and branches, and specific to different kinds of raw material.

Capacity building and awareness raising are needed to improve resource efficiency. Differentiated solutions are called for at the local, regional and global levels. Developing countries have specific needs. In addition to capacity building they need access to technologies, information, financing, and enhanced institutional capacity. They also need improved skills in resource-related assessments, management and governance. Poor countries should be involved as partners in waste management and recycling.

References

Alcott B (2010) Impact caps: why population, affluence and technology strategies should be abandoned. J Cleaner Prod 18(6):552–560, Growth, recession or degrowth for sustainability and equity? April 2010

Auty RM (2004) Resource abundance and economic development. Oxford University Press, Oxford

BGR (2009) Certified trading chains in mineral production project outline and status. Federal Institute for Geosciences and Natural Resources, Hannover. http://www.bgr.bund.de/cln_144/nn_326194/EN/Themen/Min__rohstoffe/Downloads/CTC-update-Nov09,templateId=raw,property=publicationFile.pdf/CTC-update-Nov09.pdf

Bleischwitz/Bringezu (2007) Globales Ressourcenmanagement, Konfliktpotenziale und Grundzüge eines Global Governance-Systems. Stiftung Entwicklung und Frieden. Policy paper 27. October 2007

BMU/UBA (2009) *Umweltwirtschaftsbericht*, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) und Umweltbundesamt (UBA), Berlin

COM (2005) Annex to the communication on the thematic strategy on the sustainable use of natural resources, impact assessment. COM (2005) 670 final

COM (2008) Public procurement for a better environment. COM(2008) 400 final

COM (2011) Roadmap to a resource efficient Europe. COM(2011) 571 final

CSCP (2008) Herrndorf M, Kuhndt M, Tessema F (2008) Raising resource productivity in global value chains – spotlights on international perspectives and best practice. UNEP/Wuppertal Institute Collaborating Centre on Sustainable Consumption and Production, Wuppertal

Danish EPA (2008) McAloone T, Bey Niki B (2008) Environmental improvement through product development – a guide. Danish Environmental Protection Agency. www.kp.man.dtu.dk/English/Research/areas/Ecodesign/guide.aspx

EC (2006) Directive 2006/21/EC of the European Parliament and of the Council on the management of waste from extractive industries and amending Directive 2004/35/EC. 15.03.2006
EC (2008) Directive 2008/1/EC of the European Parliament and of the Council concerning integrated pollution prevention and control. 15.01.2008
EC (2009) Reference Document on Best Available Techniques (BAT) for the management of tailings and waste-rock in mining activities. BREF (01.2009)
EC (2011) Analysis of the key contributions to resource efficiency. Bio Intelligence Service. March 2011
EC Memo (2012) Manifesto for a resource efficient Europe. Memo/12/989
Eckermann F, Golde M, Herczeg M, Mazzanti M, Montini A, Zoboli R (2012) Resource taxation and resource efficiency along the value chain of mineral resources, ETC/SCP working paper 3/2012. October 2012
EEA (2008) Effectiveness of environmental taxes and charges for managing sand, gravel and rock extraction in selected EU countries. EEA report 2/2008
Gordon RB, Bertram M, Graedel TE (2006) Metal stocks and sustainability. Proc Natl Acad Sci U S A 103(5):1209–1214
Hagelüken C (2008) Opportunities & challenges to recover scarce and valuable metals from electronic devices, Vortrag, OECD-UNEP conference on resource efficiency, Paris, 24 Apr 2008
Jenkins J, Nordhaus T, Shellenberger M (2011) Energy emergence, rebound and backfire as emergent phenomena. Breakthrough Institute
OECD (2008a) Environmental outlook to 2030. Organisation for Economic Co-operation and Development, 2008
OECD (2008b) Natural resources and pro-poor growth: the economics and politics. Part II, Chapter 11. Organisation for Economic Co-operation and Development, 2008
Rohn H, Lang-Koetz C, Pastewski N, Lettenmeier M (2009) Identification of technologies, products and strategies with high resource efficiency potential – results of a cooperative selection process. MaRess paper resource efficiency 1.3. Wuppertal Institute. September 2009
SERI (2009) Overconsumption, our use of the world's natural resources. SERI, GLOBAL 2000, Friends of the Earth Europe. September 2009
UBA (2009) Vorschläge des Umweltbundesamtes zur Gestaltung der Europäischen Rohstoffinitiative KOM (2008) 699. Umweltbundesamt. Dessau. March 2009
UN (2011) World population prospects: the 2010 revision, population database. United Nations. http://esa.un.org/wpp/. Accessed Jan 2013
UN (2012) World economic situation and prospects 2013. Pre-release. United Nations, New York. http://www.un.org/en/development/desa/policy/wesp/index.shtml
UNEP (2001) APELL for mining: guidance for the mining industry in raising awareness and preparedness for emergencies at local level. Technical report 41. http://www.uneptie.org/pc/apell//publications/publication_pages/mining.html
UNEP (2011) A report of the Working Group on the global metal flows to the International Resource Panel. In: Graedel TE, Alwood J, Birat J-P, Reck BK, Sibley SF, Sonnemann G, Buchert M, Hagelücken C (eds) Recycling rates of metals – a status report. UNEP, Paris
USGS (2011) Historical statistics for mineral and material commodities in the United States. http://minerals.usgs.gov/ds/2005/140/. Accessed Jan 2013
Wilts H, Bleischwitz R, Sanden J (2010) A Covenant for closing material cycles in the recycling of end of life vehicles. MaRess paper resource efficiency 3.5. Wuppertal Institute. December 2010

Chapter 13
Innovations for a Sustainable Resource Use – Reflections and Proposals

Martin Jänicke

13.1 Introduction

The current economic situation is essentially a crisis of resource-intensive industrial mass production based on cheap resources. The success story of this model in the twentieth century has come to its end.

This development does not come unexpected and it has been discussed already in the early 1970s (Meadows et al. 1972). Nearly nothing is new in the discussion as far as the limits to resource-intensive growth are concerned. Already in the early 1970s, material flows were critically analysed in terms of environmental deterioration, even in the Soviet Union. According to Gofman et al. (1974), in the Soviet Union 98.6 % of the material inputs into the production processes were wasted before consumption. (The collapse of the SU was in part due to an extremely inefficient use of resources – this may have been an early warning also for the "Western countries".)

Possible solutions to meet the challenge of resource-intensive growth have been known for a similarly long time. As early as 1974, the Japanese MITI proposed a model of resource-efficient, knowledge-intensive and environmentally friendly industrial production. Later on this MITI vision influenced the concept of "ecological modernisation" in Germany (Jänicke 1984, 2012a). As early as 1978, the German Council of Environmental Advisors (SRU) stressed the "economic advantage" of a "resource-saving environmental policy"; "…technical innovations induced by environmental policy" were seen as an opportunity "for more efficient production processes" and "improved products" (SRU 1978).

M. Jänicke (✉)
Freie Universität Berlin, Ihnestr. 22, D-14195 Berlin, Germany
e-mail: hauptman@zedat.fu-berlin.de

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_13,

However, the respective shift of paradigm has taken a long time. Today – finally – it has become a mega-trend (Jänicke 2012a). "Eco-efficient innovation" has become a core concept in the EU. The concepts of a "Green New Deal", a "Third Industrial Revolution" (Rifkin 2012) or a "Resource Revolution" (McKinsey Global Institute 2011) symbolize the breakthrough of the old idea of resource-efficient and environmentally friendly production and consumption.

One could ask why it took so long to realize such a trivial idea?

13.2 Dimensions of Material Flows: Environment, Productivity and Employment

13.2.1 Environmental Impacts

Material flows are at the core of resource use. The starting point here is the fact that "more than 95 % of the resources lifted from nature are wasted before the finished goods reach the market. And many industrial products – such as cars – demand additional resources while being used" (Reid and Miedzinski 2008). This is also the central issue of the environmental discourse. Material flows from mining to waste management are associated with related flows of energy use, transports, water and land use. All these carry environmental impacts from emissions and waste to the loss of species and ecosystem functions (Fig. 13.1). Only a part of these impacts is subject to environmental protection. Also in this regard, reducing or substituting material flows very often is the best preventive solution.

Even without scarcity of material resources there is an ecological necessity to use resources in a more sustainable way.

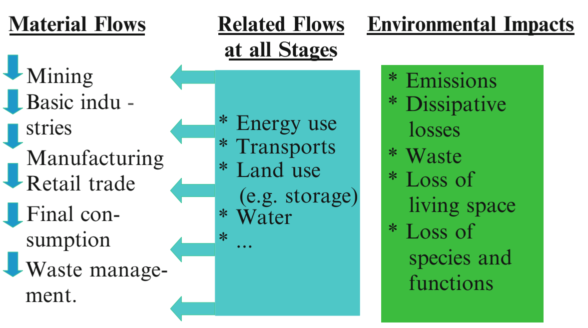


Fig. 13.1 Environmental impacts of material flows

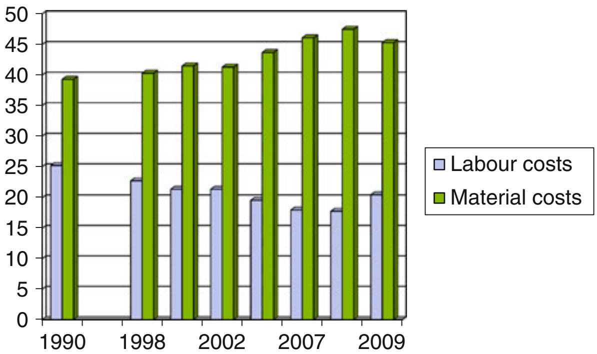


Fig. 13.2 Labour and material costs in German industry 1990–2009 (Source: Statistisches Bundesamt 2011)

13.2.2 Resource Productivity and Labour Productivity

Innovations in the context of sustainable resource use are legitimised not only by the environmental impact of the extensive use or potential scarcities of resources. The traditional mechanism to increase productivity via substituting labour with cheap energy has reached its limits too. Although there has always been some increase in energy and material productivity, throughout the history of industrialisation, the main focus has been put on labour productivity. Even in times of increased cost for materials, this priority has remained unchanged. In the German industry for example the (high) material costs have grown since 1990 (Fig. 13.2). Nevertheless, the focus was on labour costs.

In the twenty-first century we need a new sustainable model of productivity which increases resource efficiency without destructive effects on both, labour and the environment.

13.2.3 A Booming Industry of Eco-Efficient Resource Management

In the last few years it has become clear that there is a high potential for employment if we focus on eco-efficient resource management. A strategy for sustainable resource use can have multiple positive effects on employment: It typically creates "green jobs" in the eco-tech industry, reduces production costs and can lead to increased competitiveness. It may also change investment priorities from labour productivity to resource productivity; a change which could be supported by changes in the tax system.

Table 13.1 Green jobs – different estimates

USA:	>9.0 million in 2007
EU-27:	3.4 million in 2010 (narrow definition)
	19 million 2010 (broader definition)
Germany:	1.934 million in 2008 (narrow definition)
UK:	0.9 million 2007/2008, 1.3 million planned (2017)
Japan:	1.4 million
	2.2 million planned for 2020 (2009)
South Korea:	1 million jobs 2012

Source: UNEP (2009), Federal Ministry… (2011), ASES/MISI (2008), Ecorys (2012)

"Green jobs" and the growing environmental industry are the new promise in the present situation. This is plausible, because the importance and dynamics of this kind of economic activity have been underestimated by far. This underestimation is due not only to imprecise definitions or lack of statistical data: The main reason is the fact that there are not only specialised producers of environmental technologies (the environmental industry). Within environmentally intensive sectors such as chemical or car industry there is a similar tendency to react to environmental pressure by internal innovations, including resource management or eco-design in terms of life-cycle assessment (LCA). There are far more "green jobs" than the jobs which are provided by specialised eco-industries such as waste management or power from renewable energies. If environmental considerations were fully integrated into product design and LCA, it would be difficult to discern a specific "environmental industry" (Jänicke 2012a). Counting "green jobs" in different sectors is at least an additional option (Table 13.1).

The environmental industry must also be differentiated in another respect: actually, this industry has two faces. On the one hand there are (1) producers of *pollution control* technology (services included). On the other hand (2) producers of eco-efficient technology offer means for better *resource management* (Ernst and Young 2006; Ecorys 2012). Traditional pollution control or "end-of-pipe" treatment can be highly effective and also highly innovative as far as certain pollutants are concerned. For example, sulphur dioxide in coal-fired power stations can be reduced by more than 90 %. But the necessary desulphurisation technology requires additional resources (lime). Similarly, Carbon Capture & Storage (CCS) could reduce CO_2 emissions in coal-fired power stations; however it would significantly reduce the resource efficiency of power production. Generally, end-of-pipe treatment has rather negative effects on resource productivity. This is where the resource management part of the eco-industry is different: The positive environmental impacts of resource management are caused by the reduction of resource use. In other words, its contribution to productivity is generally positive.

It is important to know that the boom of the environmental industry in Germany and other OECD countries comes from the resource management part of this industry (Fig. 13.3).

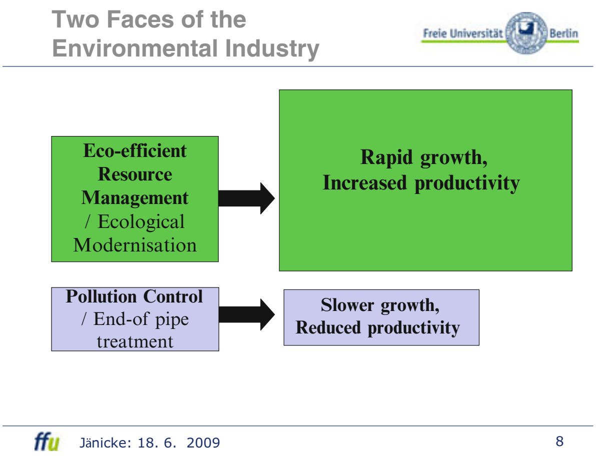


Fig. 13.3 Two faces of the environmental industry

13.3 The Role of Eco-Efficient Innovations

Innovation management is central to the model of eco-efficient resource use. Eco-efficient innovation or ecological modernisation is a necessary condition for long-term industrial growth if critical external damage is to be prevented. In a world of limited resources and sinks, industrial growth has to be "neutralised" by better, more eco-efficient technology. This is an imperative which cannot be ignored in the long run because from time to time it becomes manifest through environmental crises, protests or high damage costs. Since this imperative is associated with long-term industrial growth the technical improvement must be permanent – comparable to the increase of labour productivity. Long-term industrial growth needs eco-innovations *at ever higher levels*. The present crisis of resource-intensive growth and the danger of catastrophic climate change have given an additional urgency to eco-innovation: today, there is a particular necessity to *increase the intensity, scope and speed of eco-innovation*. In other words, the specific improvement of eco-innovations should be more than incremental, for example to overcome rebound effects. Their diffusion should be global and not restricted to niche markets. The speed of the innovation and the learning process (e. g. cost reductions) should be as high as possible. This is more than the market can offer.

Environmental innovations are therefore essentially "policy-driven" (Ernst and Young 2006). Eco-innovations aimed at overcoming the present crisis depend even more on government intervention. They depend on pioneers and national trend-setters, which exert competitive pressure on others. The good news is that countries with a high political and technological capacity can benefit from being more ambitious than others (Jänicke 2012a).

Definitions

"*Ecological modernisation*" is the innovation and diffusion of marketable technologies which provide both, environmental and economic benefits through more efficient use of resources. The concept includes supporting policies and services. The core idea is to "green" the logic of competitive modernisation which is inherent in capitalist market economies (Jänicke 1984). Ecological modernisation differs from "end-of-pipe treatment" (or pollution management) by having a positive impact on resource use.

Eco-efficient innovation, actually a synonym, is the creation and diffusion of new competitive goods, processes and services designed to preserve or improve the environment with a minimal life-cycle use of natural resources.

The *Green New Deal* essentially refers to a *forced political strategy for eco-efficient modernisation* implying a new role of government. It could also be defined as a strategy to increase systematically the intensity, scope and speed of eco-innovation.

It is the imperative of eco-innovation as a condition of long-term industrial growth that has become a strong motor of global markets. And since this imperative is permanent and growth-related, this kind of market has a calculable long-term future. In other words, the process of eco-innovation is not only driven by urgent pressure for change. More and more the advantages of green markets have become visible also to established economic institutions (OECD 2011; World Bank 2012). Eco-efficient innovation has become a dimension of competition. The present boom of eco-friendly technology has come late but it is not at all incidental. The same is true of the learning processes of governments on how to use eco-innovation in stimulus programmes or how to succeed in global regulatory competition for environment-friendly technologies.

13.4 Governance for Sustainable Material Use

13.4.1 Using the Present Crisis, Riding on Mega-trends

So far governments have not been in a strong position to start a Green New Deal and to implement ambitious strategies for sustainable development. Nevertheless, there are strong drivers that could be used and supported by government policies:

The most important driver is the present crisis of the model of mass production based on cheap resources. This crisis has been induced by rising prices of material resources and environmental problems, the most dangerous being climate change. It also has to do with the challenge of *globalisation without global government*. Crises can be perceived as pressure for change. And indeed, the crisis mechanism has become a strong motor of change and innovation. This can be observed not only in the field of energy and climate policy. Not least, the crisis of global government has supported policy learning in the direction of *concerted actions of governments*. Pioneer countries play an important role here, as policy innovators, trend-setters and challenging competitors. There are indeed strong drivers and trends towards improved global and national governance that can be used and strengthened.

13.4.2 General Policy-Design

Governance for eco-efficient innovations generally depends on the policy-design as well as on the optimal points of intervention. There has been broad research on the general policy-design for eco-innovations (Ekins and Venn 2006; Ashford et al. 1985; Jänicke et al. 2000; Klemmer 1999; Reid and Miedzinski 2008). Each eco-innovation may need to be considered separately. But some general insights can be derived:

(1) Ambitious, broadly accepted and reliable *targets* are a necessary condition. The reliability of targets depends on credible implementation measures. If targets are not ambitious there will be no innovation. (2) A *flexible policy mix* supporting the innovation cycle from invention to innovation to diffusion and back to invention is the next necessary step. Regarding invention, targeted support for R&D is essential from the outset. The dynamics of the process strongly depend on successful support for the diffusion of a new environmentally friendly technology. This is a necessary condition for the learning process, i.e. cost reduction and technical improvements. This feedback of the innovation cycle can be forced by government policy. To give an example: when the red-green German government after 1998 started with massive market support for renewable energy, an explosion of new patents for these technologies could be observed. (3) There is no single ideal instrument available in environmental policy. As a rule a *policy-mix* will be necessary. Eco-innovations need a "multi-impulse approach" (Klemmer 1999). However, for many reasons, both the price mechanism (taxes, charges, certificates, market incentives) and regulation (e. g. dynamic standards) play an important role within the policy-mix. The price mechanism can provide general incentives to support certain general tendencies. Specific regulation can mobilise specific innovation potentials and it can help to overcome specific obstacles. The example of the Japanese dynamic top-runner regulation has resulted in remarkable specific improvements. However rebound effects sometimes have reduced the general effect of energy-efficiency increases. This could be counteracted by taxes. In addition, instruments such as dynamic labelling, green public procurement, EMAS, et cetera typically play a supportive role within the policy-mix. (4) Finally, clusters and competent inclusive *networks* have proven to be important in the process of innovation.

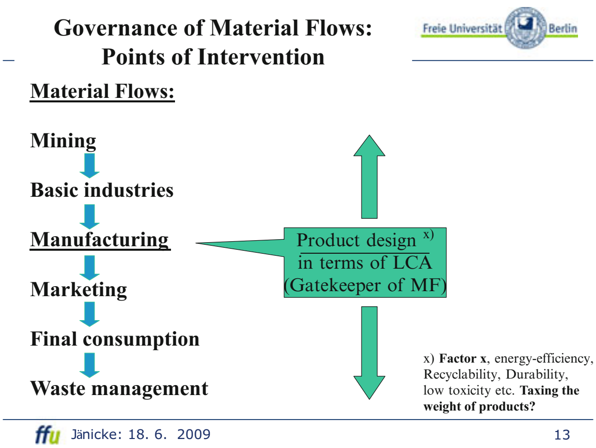


Fig. 13.4 Governance of material flows: points of intervention

13.4.3 Points of Policy Intervention

The *points of intervention* to stimulate eco-innovation have become an important topic particularly in the debate on resource management: we have learned that the designers and *producers of final products* (cars, food, or buildings) are the gate-keepers of material flows within the supply chain. Eco-design in terms of life-cycle assessment has become a strategic concept for eco-efficient management of both, products and processes. Final producers and also retailers are capable of influencing material flows through *their* demand – a direct influence which governments will never have (although their *indirect* influence on the framework conditions may be essential). "Greening the supply chain" (Sarkis 2006) by manufacturers or retailers is comparably easy because it is mainly *the supplier* who carries the burden of technical change.

There are several possible points of intervention along the supply chain up to final waste management (Fig. 13.4). Eco-innovation can take place at all stages.

The first stage of the supply chain is mining (or the import of resources). At first sight this seems to be the optimal point of intervention, particularly if input-taxes are concerned. Taxes on sand in Denmark are an example. For many reasons however taxes on mining have proven to be difficult in terms of politics. A new field of possible intervention is "urban mining", which can provide new kinds of resources from urban infrastructures or products in the final stage of their "life". However, except for construction materials, it is not part of general resource management so far. Here we need a better knowledge base.

At the stage of basic industries, incentives to use (and to improve) recycled materials may be a possible instrument. The construction sector in Germany for example has a high recycling rate. However the use of recycled materials for new buildings is still insufficient. This depends on innovation. The potential for new materials can be enlarged e. g. by using coal as raw material instead of burning.

Beyond the already mentioned stage of manufacturing, marketing and demand-side management offer room for potential improvement. It may be the second best point of intervention, because here relevant actors can be addressed: retailers, public administration (green procurement) and the business sector and its demand, which can be influenced e.g. by EMAS and ISO rules. The role of consumers should not be overestimated. They have no control over the process and their capacity for concerted action is generally low. There is no alternative to calculable general government rules for suppliers. Nevertheless consumers play an important role and their information and acceptance is a necessary condition for any demand-side strategy.

The final stage of waste management has for a long time been the preferred point of intervention. We have learned that this often meant no more than fighting symptoms. Resource management in terms of LCA however certainly has to include this stage. Recycling or take-back rules, for example, play an important role in this context.

Contrary to the old-fashioned "instrumentalism" in environmental policy – with its endless search for a single optimal instrument (Jänicke 1996) – we need a broad spectrum of instruments, as mentioned above. There is not only a broad spectrum of points of intervention in resource management. It is also open to a multi-impulse strategy (Klemmer 1999). Such a strategy does not rely on one single strong impulse (e. g. taxes which may be "high enough" but politically unfeasible). Instead it relies on a plurality of impulses at different points.

We still need some trial and error to optimize this management strategy for *material* flows. The knowledge base of *energy*-flow management is by far better. Here we have longstanding experience, including on the role played by international concerted action. Here we are also experiencing a breakthrough of substantial innovations. Are there lessons for material-flow management to be learned from present energy and climate policy? I will discuss this briefly in the context of the German climate policy since 1998.

13.4.4 "Policy Acceleration": Lessons from Climate Policy?

Climate policy in Germany has traditionally been oriented towards technological innovation. Since 1998 it has been explicitly conceived as "ecological modernisation" (e.g. in the coalition treaty). The Kyoto target was ambitious (21 % GHG reduction 1990–2012). Its fulfilment was particularly difficult because not only fossil fuels but also nuclear energy had to be reduced. To a certain degree this policy can be interpreted as an experiment. Only a few points can be mentioned here (without any differentiation).

The German climate policy experiment has become a success story, in terms of both ecology and economy (for similar cases see Jänicke 2012b). The ambitious Kyoto target was significantly surpassed in 2012. The expansion of green power has surpassed its target too. And the economic success is manifested by a fast growing, highly competitive "climate protection industry", which contributes about 5–6 % of GNP. According to studies the cost balance of the present climate programme will show a surplus (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety/Umweltbundesamt 2011).

The applied policy was a goal-oriented multi-impulse strategy using economic and regulatory core instruments (eco tax, feed-in tariffs, emissions trading, but also standards) within a broader policy mix. It encompasses several policy measures with different points of intervention. Most important: the policy started with an ambitious target which was not only credible and agreed upon across party lines, but it was also followed by effective market support for climate-friendly technologies. This successful diffusion of new technologies caused a *feedback of the innovation cycle*: there was an explosion of new patents for renewable energies after 1998. The speed of the innovation process can be illustrated by the example of energy-efficient buildings. Here the technological potential evolved from "energy-efficient heating" to "low energy houses" to "passive houses" and finally to "plus-energy houses", which even supply power for an electric car.

This feedback of the innovation cycle could have been expected as far as the learning curve was concerned. However something was new. We may call it *"policy acceleration",* which could be described as follows: (a) an ambitious policy starting with a certain technological potential for improvement, (b) a process of innovation and diffusion stimulated by this policy leading to, (c) a higher technical potential for improvement and to market success of domestic innovators, which finally suggested even stricter policies (d). It need not be mentioned that such a development tends to enhance general public acceptance. Here another example may be given: There was a broad campaign in Germany against both, the eco-tax (2000) and the Renewable Energy Sources Act. However the success story of both instruments finally made this opposition irrelevant. In 2009 62 % of the population agreed that a strict climate policy is "an economic advantage" (Infratest Dimap).

Eco-efficient management of *material flows* is a more complex field of action compared with energy and climate policy. The materials as well as their prices, options and subsequent problems are often quite different. However, as a first step, the public discourse could be improved. The general environmental impact of material flows (including the related flows of energy, water etc.) would be better perceived if discussed in the context of resource productivity. Including the tax system with its negative impact on employment would provide the third strong argument in this discourse. Based on a better, more targeted public debate a goal-oriented multi-impulse approach to eco-efficient resource management – combining general economic incentives with specific dynamic regulation – could play at least a role similar to the one it has in energy/climate policy. Instead of a "green tax" (often stimulating a too narrow ecological discussion) a general "resource efficiency tax" on products (or their weight) would be preferable. It should be partly used to reduce social security contributions and partly recycled to increase resource productivity in the same sector. Starting with a low tax rate may be necessary to take public resistance into account. Regarding specific regulations the European eco-design policy for products in terms of LCA points in the right direction. However, more ambitious targets for selected goods are necessary. Even tentative strict targets could be helpful if they are open to revision according to the success of their implementation. Specific regulation is necessary both, to overcome specific obstacles and to use specific opportunities. Dynamic regulation and dynamic labels are required to push technologies beyond the present state of art. Long-term targets should it make clear that the innovation process will continue. Selective market support for certain products is required to create success stories. Stimulating markets for resource-efficient products as well as market competition are necessary conditions for policy acceleration. Needless to say, a good infrastructure for research and development is the basis for all this.

Finally, as in climate policy, it may be helpful to support national policies both, by international policy co-ordination and by creating an international policy arena for pioneers and trendsetters of sustainable resource use. There is also a lesson to be drawn from EU climate policy: strict green regulation of the European market not only has stimulated domestic eco-innovation and competitive advantages, but has also forced other countries and foreign firms to adapt to European policies. This has created a regulatory dominance of the EU which has become a strong driver for the diffusion of advanced policies.

13.5 Conclusion

It is time to be more ambitious regarding the eco-efficient management of material flows. The reason is not only the present crisis of resource-intensive industrial growth. The good news is that increasing material productivity beyond the normal trend will provide co-benefits in many other policies: from energy, climate and environmental policy to employment and the general competitiveness of the national economy. Material productivity will surely become a dimension of international competition comparable to energy efficiency. Therefore more ambitious targets together with market incentives and/or dynamic regulation for domestic (lead) markets make sense, at least in countries with advanced innovation capacity. A process of policy acceleration could be stimulated for certain products. Trial and error will be necessary – as always if innovation is concerned. However, without ambition there will be neither innovation nor success in the long run.

References

American Solar Energy Society/Management Information Services Inc. (ASES/MISI) (2008) Defining, estimating and forecasting the renewable energy and energy efficiency industries in the U.S. and in Colorado. http://www.greenbiz.com/sites/default/files/document/CO_Jobs_Final_Report_December2008.pdf

Ashford NA, Ayers C, Stone RF (1985) Using regulation to change the market for innovation. Harv Environ Law Rev 2(9):419–466

Ecorys (2012) The number of jobs dependent on the environment and resource efficiency, Final report (EU Com, DG Environment)
Ekins P, Venn A (2006) Assessing innovation dynamics induced by environmental policy. Policy Studies Institute, London
Ernst, Young (2006) Eco-industry, its size, employment, perspectives and barriers to growth in an enlarged EU. Commissioned by EU Commission, DG Environment, Sept 2006
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety/Umweltbundesamt (2011) Report on the environmental economy 2011. BMU/UBA, Berlin
Gofman KG, Lemeshev MY, Reimers NF (1974) The economics of nature management, objectives of a new science (Translation from the Russian Original, published in: Nauka i Shism, No. 6, June 1974, pp 12–17). In Fischer-Kowalski M (ed) The work of Konstantin G. Gofman and Colleagues: an early example of material flow analysis from the Soviet Union; iff Social Ecology working papers 94, pp 13–22
Jänicke M (1984) Umweltpolitische Prävention als ökologische Modernisierung and Strukturpolitik. WZB IIUG Discuss Pap 84(1):1–44
Jänicke M (1996) Was ist falsch an der Umweltdebatte? Kritik des umweltpolitischen Instrumentalismus. In: Altner G (ed) Jahrbuch Ökologie 1997. C.H. Beck Verlag, München, pp 35–46
Jänicke M (2012a) Megatrend Umweltinnovation. Zur ökologischen Modernisierung von Wirtschaft und Staat. 2. Aufl. Oekom-Verlag, München
Jänicke M (2012b) Dynamic governance of clean-energy markets: how technical innovation could accelerate climate policies. J Cleaner Prod 22:50–59
Klemmer P (ed) (1999) Innovationen und Umwelt. Analytica Verlagsgesellschaft, Berlin
McKinsey Global Institute (2011) Resource revolution: meeting the world's energy, materials, food, and water needs, November 2011, McKinsey & Company
Meadows DH, Meadows D, Zahl E, Milling P (1972) Die Grenzen des Wachstums. Bericht des Club of Rome zur Lage der Menschheit. DVA, Stuttgart
Ministry of International Trade and Industry (MITI) (1974) Direction for Japan's industrial structure. Ministry of International Trade and Industry, Tokyo
OECD (2011) Towards green growth. OECD, Paris
Reid A, Miedzinski M (2008) Eco-innovation. Final report for sectoral innovation watch. Technopolis
Rifkin J (2012) Die Dritte Industrielle Revolution. Campus, Frankfurt am Main
Sachverständigenrat für Umweltfragen (SRU) (1978) Umweltgutachten 1978. Kohlhammer, Stuttgart u. Mainz
Sarkis J (2006) Greening the supply chain. Springer, London
Statistisches Bundesamt (2011) Statistisches Jahrbuch 2011 – Für die Bundesrepublik Deutschland mit "Internationalen Übersichten". Statistisches Bundesamt, Wiesbaden
UNEP (2009) Global green new deal – an update for the G20 Pittsburgh summit. www.unep.org/pdf/G20_policy_brief_Final.pdf
World Bank (2012) Inclusive green growth: the pathway to sustainable development, Washington, DC

Part IV
Proposals for Implementation

Chapter 14
Reducing Resource Consumption – A Proposal for Global Resource and Environmental Policy

Paul Ekins, Bernd Meyer, Friedrich Schmidt-Bleek, and Friedrich Schneider

14.1 Introduction

Recently, the world has witnessed how market failures and foresight incompetence impaired the stability of the global financial system and with it the entire economy. Insufficient accounting methods and incomplete early warning systems, missing competence in systems analysis and unwillingness to implement precautionary policies, short-term profit maximization and wrong prices of products were among the key causing factors. As one consequence, even the CEOs of leading financial institutions have called for a framework of rules capable of avoiding a similar disaster in the future. As another, thousands of billions of Euros were committed by governments to limit the potential damage inflicted upon civil society by just one industry.

While the ecological crisis does not as yet seem as acutely threatening as the financial disaster, it does have some of the same roots. Here, too, market failures and

P. Ekins (✉)
UCL Energy Institute, University College London, Central House,
14 Upper Woburn Place, London WC1H 0NN, UK
e-mail: p.ekins@ucl.ac.uk

B. Meyer
Gesellschaft für Wirtschaftliche Strukturforschung mbH,
Heinrichstr. 30, D-49080 Osnabrück, Germany
e-mail: meyer@gws-os.com

F. Schmidt-Bleek
Factor 10 Institute, Teplitzer Strasse 19, Am Roseneck, 14193 Berlin, Germany
e-mail: biovar@orange.fr

F. Schneider
Department of Economics, Johannes Kepler University Linz,
Altenbergerstrasse 69, A-4040 Linz, Austria
e-mail: Friedrich.Schneider@jku.at

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_14,

foresight incompetence, short-term profit maximization and wrong prices of products are among the key causing factors. The current market process itself is thus prominently responsible for the continuing and long-term destruction of the life-sustaining ecosystem services. While the health of the financial system can eventually be restored, this is not possible for lost ecosystem services, putting ultimately into question the very survival of humankind on earth.

Given the similarities between the drivers for the financial disaster and the ecological crisis, there is a window of opportunity for a systemic structural change that is crucial to avoid ecological collapse. The paper at hand addresses this chance and proposes pragmatic adjustments to the present economic framework. But time is running out. There is no hope for replacing lost ecosystem services by technology. "*Business as usual*" could lead to a very critical situation within decades.

The most fundamental technical requirement for moving towards a sustainable human economy is to dematerialize[1] the production of human welfare and the provision of energy. In Germany, SMEs could eliminate some 20 % of their resource costs already today without jeopardizing their competitiveness. On average, more than 90 % of the resources lifted from nature are turned into waste before goods reach the market. And yet, a vast range of technical options exists to achieve radical dematerialization. But systematic eco-innovation[2] remains largely unimplemented because of a lack of economic incentives to do so.

In addition to concerns about diminishing eco-system stability through resource consumption, an emerging resource scarcity is increasingly driving technological change. Globalizing the current patterns of Western consumption and resource use is *not* possible because of insufficient availability of natural material resources, useable water and land on planet earth.

Among the potential added benefits of radically dematerializing the economy are these: Arresting climate change; reducing the loss of forests, species and soil; reducing dependence on resource-rich countries; avoiding conflicts resulting from regional scarcity of water, land, and other resources; and lessening the probability of ecological surprises in the future.

The human economy must be constrained to function within the limits of the environment and its resources and in such a way that it works with the grain of, rather than against, natural laws and processes. This argues for a strong conception of sustainability, whereby the economy respects and adapts to ecological imperatives,

---

[1] Dematerialization in this context is taken to mean the radical reduction in the use of all materials by humans, where materials comprise, metals, non-metallic minerals, fossil fuels, water (marine, fresh, renewable and non-renewable), the atmosphere, and renewable resources such as ecosystems, forests and fish. With respect to the latter especially, a very important additional consideration is the limitation and regulation of land-use by humans.

[2] Eco-innovation was defined in the INNOVA EUROPE Report of the European Commission as: "The creation of novel and competitively priced goods, processes, systems, services and procedures that can satisfy human needs and bring quality of life to all people with a life-cycle-wide minimum use of natural resources (material, including energy carriers and surface area) per unit output, and a minimal release of toxic substances (Reid and Miedzinski 2008)."

rather than seeking to substitute manufactured for natural capital where the former fails to deliver the full range of functions and services of the latter.

It has been argued that by 2050 the total global mobilization of natural resources for human use should no longer exceed 5–6 tons per person-year, while the emission of climate-changing greenhouse gases should be limited to 2 tons of CO_2-equivalent per person-year. These goals imply an enormous increase in the resource productivity of industrial economies: in Germany, for example, a Factor 10, in Japan 8, and in the USA a Factor of 18. Only by dematerializing their economies on this scale will the industrial countries free up the necessary resources and ecological space to allow an economic growth in developing countries that does not exceed the natural limits of the global environment.

This paper presents a proposal for a globally coordinated environmental policy that might help to solve the problems. In Sect. 14.2 the theoretical basis is developed, which is broadly in line with the central ideas of ecological economics, and recommends a focus on resource extraction rather than on emissions. In Sect. 14.3 a global policy suggestion is presented that advocates a dual strategy for the reduction of CO_2 emissions and resource extraction using economic instruments. Section 14.4 discusses some examples of currently available resource-efficient technologies and products that would be more widely used if only the prices took account of the environment. Some conclusions in Sect. 14.5 close the paper.

14.2 The Theoretical Basis

The twin fields of neoclassical environmental and resource economics are the predominant way in which economists currently seek to understand the interaction between the economy and the natural environment, and prescribe for the optimal use of the latter by the former. The enormous, global-scale environmental destruction and degradation being experienced in many countries, in the oceans and in the atmosphere, with climate change as the principal result of the last of these, bears witness to the failure of the neoclassical conceptualisation of these issues to influence the overall functioning of the economy.

Environmental economics focuses largely on the emissions of residuals from the economic process into the natural environment, and their mitigation. Through microeconomic partial analysis different emission problems are analysed, monetary valuations of environmental damages are carried out and policy recommendations are made as to how emissions can be reduced such that the marginal costs of emissions become equal to the marginal benefits from the activities that produce them. The emissions are thereby identified as technological external diseconomies and treated as “freakish anomalies in the process of production and consumption” (Ayres and Knees 1969, p. 287). The policy recommendation is the internalisation of the externalities either by regulation or, preferably, by market-oriented instruments like subsidies, taxes and pollution rights (Baumol and Oates 1998, pp. 177).

For policy purposes, the approach tends to interpret the different emission problems as separate and independent. It formulates distinct programmes for CO_2, dust, NOx, sulphur etc., and other emissions into air, water and soil. Many of these programmes have been successful in their own terms (for example, emissions of SO_2 have fallen by a factor of 10 in many European countries since around 1980). However, the approach fails to recognise the systemic issue that emissions are an inherent and to some extent inevitable part of the economic process, that they appear at many locations with different impacts, and that the emissions are not independent from each other (Ayres and Knees 1969, p. 287). One result is that the dependence between emissions means that instruments such as pollution rights which focus on emissions separately may not necessarily be the most efficient instruments to reduce emissions. Much more important, focusing on emissions distracts attention from the issue of resource extraction, whereby materials enter the economy in the first place. In fact, all emissions are the ultimate result of extraction. Extraction, however, falls into the domain of resource economics.

The predominant concern of resource economics is optimal depletion, and the price and other conditions which can bring it about. The environmental consequences of extraction, which can be very great, tend to be treated as 'externalities', like emissions (see, for example, Kuuluvainen and Tahvonen 1995, p. 113). However, in many resource-producing countries there is little consideration given to such externalities beyond what the extracting companies themselves decide to implement, so that the prices of many extracted resources little reflect the environmental costs of extraction that have been incurred.

Even more importantly neoclassical production functions pay little attention to the unique qualities of particular natural resources which tend to give them their utility. Rather they tend to assume that factors of production, including natural resources, are highly substitutable for each other, an assumption which, in Solow's words, implies that "The world can, in effect, get along without natural resources" (Solow 1974, pp. 11).

The emphasis in environmental policy on the reduction of particular emissions, rather than on resource flows starting at the point of extraction, tends to displace environmental problems rather than resolve them. Most particularly, the mitigation of emissions does not necessarily reduce extractions, and their associated environmental degradation. For example, the mitigation of CO_2 emissions through the technique of carbon capture and storage (CCS), whereby in the case of coal power stations the CO_2 emissions would be captured after combustion and stored underground, incurs a significant energy penalty which would increase the extraction and transport of coal and produce new emissions, which would have to be stored. Similarly, CO_2 mitigation through increased construction of nuclear power stations would induce a substantial increase in material extraction, as well as radiation and other emissions. The policy focus on reducing CO_2 emissions has also already induced growing demand for biofuels, with a whole range of consequent economic, social and environmental problems.

An alternative approach as the basis for global environmental policy is required. Fortunately, such an approach going under the name of 'ecological economics' has

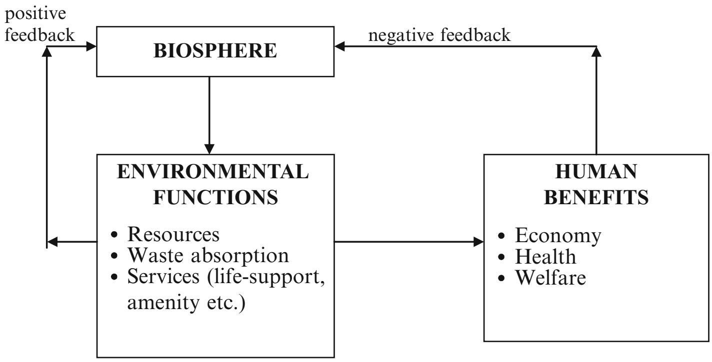


Fig. 14.1 The relationship between environmental functions and human benefits (Source: Ekins 2003, p. 154)

now been developed in some detail over many years, by writers such as Hueting (1980, 1992) and Daly (1991, 1992, 1996), and summarised in Ekins (2001). The essentials of this approach may be briefly outlined as follows.

The natural environment, or biosphere, performs environmental functions of three broad kinds, as shown in Fig. 14.1: the provision of resources, the absorption and neutralisation of wastes, and the generation of services ranging from life-support services (such as the maintenance of a stable climate) to amenity and recreation services (see Pearce and Turner 1990, pp. 35 ff. for more detail on this categorisation). These three sets of functions collectively both maintain the biosphere itself (the positive feedback on the left of the diagram), and contribute to the human economy, human health and human welfare. However, the economy's use of the environment can impact negatively on the biosphere (the negative feedback on the right of the diagram), which can in turn impair its ability to perform its environmental functions. While the human population and its economic activity were small in relation to the biosphere, their negative environmental impact did not greatly affect the biosphere as a whole, although there are many examples of such impacts having devastating effects on particular localities (see for example Diamond 2005). Now, however, the scale of materials and energy utilised by the economy is having a globally destabilising impact on the biosphere, the clearest sign of which is climate change.

Bizarre as it may seem to ecological economists, representations of the economy from which the ecological dimension is completely absent are by no means unusual. As Daly (1991, p. 33) has observed, all too often the economy is conceived as an abstract flow of exchange value between households and firms, and, through taxes and transfers, between these and governments. Social and ethical issues may be considered in such a framework, through such questions as: who should get what? Or, through what institutions should production and consumption be mediated? But issues of resources and environmental quality often do not arise.

This omission is rectified in the formulation of the relationship between the human economy and natural world shown in Fig. 14.2, which emphasises the

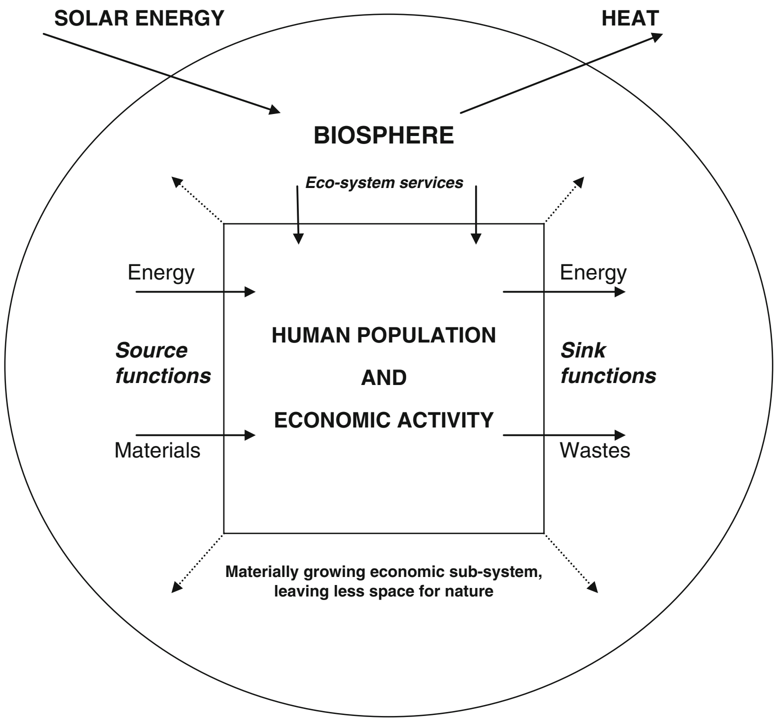


Fig. 14.2 The finite global ecosystem relative to the growing economic subsystem (Source: Adapted from Goodland 1992, p. 5)

ecological scale of the economy compared to the planetary ecosystem, or biosphere, of which it is a subsystem. Human populations and economic activities extract high-grade energy, materials and ecosystem services from the natural environment, and discharge low-grade energy and wastes back into it, with consequent degradation of the ecosystems that produce the services. Initially (before the industrial revolution, say) the economy was relatively small compared to the global ecosystem, of which it is a subsystem, as already noted. Such an economy would be likely to experience at most local environmental constraints. However, as economic activity has expanded, so has the throughput of energy and materials. The physical requirements of, and consequent wastes from, a much bigger economy are more likely to cause global environmental disruption. Clearly such expansion cannot continue indefinitely in a biosphere of finite size. A relevant question in such circumstances is how much the human economy can expand?, Or, as Herman Daly (1991, p. 34) asks: “How big should the subsystem be relative to the total ecosystem? Certainly this, the question of optimal scale, is the big question for environmental macroeconomics”.

It is important to be clear that the metrics relating to Daly’s question about the size of the economic sub-system are physical rather than financial. The relevant units are tonnes (of matter) or petajoules (of energy) rather than dollars or euros.

Much confusion has been generated in the past in discussions about whether or not there are limits to economic growth by the failure to distinguish clearly between these metrics and specify which is being considered at any particular time. Thus, in a finite biosphere, there clearly are limits to the amount of matter that can be mobilised by an economy and, because all such mobilisation requires energy, and human economies are subject to the laws of thermodynamics, to the amount of material mobilisation and energy use that can be accommodated by the biosphere before its essential functions are affected and begin to deteriorate. With respect to greenhouse gas emissions, such limits have clearly already been surpassed. But this is very different to the financial scale of the economy, which is what economists are normally interested in. Whether economic growth in financial terms has a deleterious effect on the environment depends on the extent to which it is accompanied by growth in energy use and material throughput. Historically, growth in material and energy use have tended to be correlated with economic growth in financial terms, but there is no imperative why this should be so, and it is theoretically possible for this link to be broken by public policy (see Ekins 2000 for further discussion of this issue). Indeed, aspirations for large-scale reductions in greenhouse gas emissions while economic growth continues reflect the widespread belief in this theoretical possibility, although it has yet to be realised in a sustained manner anywhere in practice.

Such considerations from ecological economics lead to a clear policy proposition. In summary, and as shown in Fig. 14.2, there is a recognition that the economy is embedded in nature and receives resources extracted from nature and ejects materials in the form of emissions into nature. There is a material flow from extraction to emissions, powered by the use of energy, and the total amount of emissions in physical units differs from the amount extracted only in the amount of material inputs that become embodied in the physical capital stock during the period. In terms of physical material flows there is no 'final use' of products, but use by the economy's production and consumption activities of services from the material flow, which changes the physical structure of the material flow. Furthermore, the need for energy to power the flow of materials through the different stages of production and consumption itself induces the extraction of materials. Both activities – emissions and extraction – have negative, and now serious, impacts on the biosphere. To reduce these impacts to levels which do not disrupt the biosphere's key environmental functions, such as climate stability, will require a very substantial reduction in the flow of materials mobilised through economic activity.

These insights suggest that environmental policy should be targeted on *material extraction* and not on emissions. Emissions will fall as policies reduce extraction, but there is no guarantee that reducing emissions will reduce extraction, and the impacts associated with it, and may increase it, as in the examples of nuclear power and CCS above. Policies to reduce extraction will seek to increase resource productivity through all stages of production, and to reduce resource use in consumption. To inform and provide direction for such policies, an international process is needed to define time paths of targets for resource consumption of the major resources, measured in tons per capita (similar to the greenhouse gas reduction commitments that are being sought under the UN Framework Convention on Climate Change), for all countries with significant resource use. The next section discusses the major elements of the policy approach that will be required.

14.3 The Public Choice Approach to Environmental Policy

14.3.1 Introduction

Today we observe that market-based environmental policies are only marginally used at all or at least to a much lesser extent than most environmental (and ecological) economists demand. The reason might be that the main actors of environmental policy, especially the bureaucrats in environmental protection agencies and the managers of the relevant industries, have a strong interest either to prevent it altogether or to apply traditional bureaucratic measures. This is what the Public Choice approach tries to show. And, as will be demonstrated below, Public Choice offers convincing arguments for the situation of today's environmental policy.

Thus, while we are still far away from general acceptance and widespread application of market-based environmental policies, we must ask what the reasons are for the little progress made by environmental policy so far.

14.3.2 The Important Actors

The usual way following the Public Choice approach is to single out the different (groups of) actors which are engaged in environmental policy making and to ask for their (selfish) interests in the application of the different instruments which could be applied. Following Frey (1992), Kirchgässner and Schneider (2003, p. 343ff.) and Kollmann and Schneider (2010), typically, four groups of actors are considered: (i) the voters, (ii) the politicians, (iii) the public bureaucrats, and (iv) the 'economy', i.e. the owners, managers and employees of the industries that are affected and their interest groups.

14.3.2.1 The Voters

Over the last three decades, the sensitivity of voters with respect to environmental issues has certainly increased.[3] Thus, the approval of voters for ecologically sustainable policies should become more and more likely. However, it should be taken into account that ecological objectives 'compete' with other interests, especially with 'pure' and individual economic objectives of the voters.

[3] See, e.g., the results of the IMAS-surveys for Austria (IMAS 1996, 2000, 2005, 2007) or the results for Germany presented in Horbach (1992).

Assuming that the improvement of environmental quality is a national (or, in the case of the reduction of CO_2 emissions, even an international) public good, the most relevant question regarding the behaviour of voters is: Who will pay the costs? If the price elasticity of demand is low and/or if the supply elasticity is infinitely elastic, as in the case of mineral oil prices in small countries, where the consumer price of these products is determined by the prices on the international spot markets,[4] the consumers have to bear the costs. This implies that the majority of voters directly pays for such a policy. But if price elasticity is high, only a small part of the burden of an environmental measure which increases the production costs of a good can be passed on to the consumers. Thus, the producers, shareholders, managers as well as workers of these firms, have to bear the costs. Consequently, the resistance to environmental programs might be higher in regions with a high share of producer interests which oppose such a policy, because a higher burden can lead to reduced profits, wages and employment in these regions.

In Germany, empirical evidence for such a trade-off between the reduction of unemployment and ecological objectives was found. Already Horbach (1992) demonstrates that in regions with a high unemployment rate the Green Party receives fewer votes in elections than in other regions. Moreover, he also argues that the more important the chemical and steel industries are in a certain region, the worse the election chances are for the green parties, because their ecologically oriented economic policy program might weaken the position of these industries. Thus, selfish and short-sighted voters are an obstacle for the approval of any kind of environmental policy.

In the international discussion of the double dividend, an additional argument is the implementation of incentive-oriented environmental tax policies, which need not be accompanied by an increase of the tax burden but can also be realised through a shift in the tax burden. In such a case there is no immediate trade-off between fighting unemployment and enforcing stricter environmental policies. On the contrary, many simulations show that it might even be possible to have a small gain in employment.[5] On the one hand, as a study of the OECD (1997) shows, a large number of winners among different economic sectors and new firms might be generated. On the other hand, there would be a few distinct losers among the firms whose economic position could deteriorate quite substantially. Thus, at first sight, politicians might be expected to enact such a tax alternative in response to the preferences of the majority of voters instead of caring for the minority of losers. However, as Public Choice theory tells us, "… a small concentrated identifiable, and intensely interested pressure group may exert more influence on political choice making than the much larger majority of persons, each of whom might expect to secure benefits in the second order of small units …".[6] Thus, even if a double dividend can reduce unemployment overall by enforcing stricter environmental policies in the economy

[4] See, e.g., Kirchgässner and Kübler (1992) for Germany and Kirchgässner (1994) for Switzerland.

[5] See, e.g., the review of such studies in Kirchgässner (1998), Schneider and Stiglbauer (1995) or Schneider (1998) with results for Austria, Kirchgässner et al. (1998) with results for Switzerland or Koschel et al. (1999) as well as Scholz (2000) with results for Germany.

[6] Buchanan and Tullock (1975, p. 142).

there will still exist opposition to such an incentive-based environmental policy from a small, intensely interested, and highly influential group of potential losers.

However, the case of a double dividend where employment is rising with a stricter environmental policy, which to a large extent depends on the existence of involuntary unemployment, is an exception in environmental policy making.[7] In many situations there is still a trade-off between the production of better environmental quality and the production of consumer goods, i.e. the voters have to make a choice between better environmental quality and higher real incomes.[8] In such situations, the decision of voters depends on their information about the consequences of environmental problems, the lag between the time when the policy measure is taken and the time when the environmental situation improves, and of their discount rate. Especially with respect to measures which are mainly to the benefit of future generations, narrow self-interested individuals would generally not be willing to bear high costs. This is one of the main obstacles against efficient CO_2-reduction policies. Consequently, it can be expected that in many cases voters care more about short-term economic development than about the environmental situation. This might delay or even prevent the approval of ecologically-oriented politics by the majority of voters. Even if a citizen is to some extent altruistic, well-educated and well-informed it is not obvious that she/he as a 'rational' (even long-term oriented) voter will support ecologically oriented economic policies in elections.[9]

This can lead to an undersupply of such policies. It should, however, not lead to the introduction of inefficient environmental policies. Thus, it is difficult to explain why voters should be in favour of command and control instead of market-oriented environmental policies. Nevertheless, voters seem to prefer a traditional policy of regulations and prohibitions. One of the reasons for this could be that the costs of the traditional policy are less visible than the costs of market-oriented policies. There might be a kind of cost-illusion, i.e. voters may have the impression that an improvement of the environment could be reached by means of regulations and prohibitions without costs, i.e. without reducing the income of the average citizen. Thus, voters might be (partly) responsible for the undersupply of environmental policies, but any responsibility they may have for the lack of market-oriented measures in this policy is likely to be inadvertent rather than deliberate.

14.3.2.2 The Politicians

Elected politicians want to pursue certain policies (quite often ideologically oriented) as long as there is no considerable resistance from either the bureaucracy or powerful interest groups. Thus, if voters accept or even demand an undersupply of environmental policies, a government which wants to maximise

[7] See, the corresponding simulation results in Kirchgässner et al. (1998).

[8] Consider the most recent debates in both U.S. Houses about a law of reducing CO_2 emissions!

[9] The role of altruistic/moral behaviour in such decisions is discussed in Kirchgässner (2000).

its re-election probability gets no incentive from the voters to provide a better environmental quality.

However, even a democratic government is hardly ever only seeking re-election. According to the partisan hypothesis first developed by Hibbs (1977; see also 1992) and incorporated into the politico-economic models of Frey and Schneider (1978a, b, 1979) re-election is more of a constraint which the government has to respect than an objective in itself. Thus, if a coalition government includes a 'green' party and/or if the dominating party of the government has a clientele which has an especially strong environmental orientation a government might provide a stronger environmental policy than is demanded by the voters overall (the median voter) as long as this does not endanger its re-election prospects.

In the typical European political system where the government is elected by a majority of the parliament the parliamentarians have nearly the same interests as the government. Thus, we only discuss the role of the government. This situation is different in the U.S. where the election of the government is independent from the elections of the members of the congress and in Switzerland where – according to the system of half-direct democracy at the federal level – the government is actually quite independent from the parliament. In both countries, each single member of the parliament has much more independence from the official line of their party than their colleagues in the representative systems of the other European democracies. Consequently, they are closer to the citizens of their constituencies and, therefore, there is also much wider variation in the environmental policy they favour.

Even if the level of environmental activities is (on the average) too low, the question again arises whether the remaining policies in this field are carried out in an efficient way. If there is no pressure by the voters but if they are, instead, in favour of more visible but less efficient policies, the use of bureaucratic instruments might be more in the interest of politicians than the use of economic instruments.

Against this argumentation, two remarks can be made:

First, because the government should be better informed than the average voter, it should take into account that the higher efficiency of an environmental policy which uses economic instruments allows resources to be used for other purposes and – in this way – to satisfy more of the demands of its own clientele and/or to improve its re-election prospects. For this reason, the government should be more in favour of applying economic instruments than the average voter, ceteris paribus.

Second, environmental taxes might have a special attraction for governments because they create revenues which can be used to cut other taxes and/or to finance additional projects. This can be advantageous for the government if the tax resistance against 'green taxes' can be expected to be lower than against other taxes. This holds especially if the clientele of the government is more environmentally oriented than the average voter.[10] On the other hand, as the opposition

[10] Acknowledging this, several opponents of the introduction of environmental taxes do not really argue against the use of environmental taxes per se but they are anxious that, given the less severe tax resistance, the government might be successful in increasing the total tax load. See e.g. Zimmermann (1996).

will probably argue strongly against introducing or raising such visible taxes the leeway of a government to pursue such a policy is limited.

Additionally, it is possible to present environmental taxes as acceptable measures to the voters, if these taxes are characterised as 'punishment' for polluting the environment and if they are applied mainly to industrial polluters. Politically, it might be more difficult to sell the creation of a market for tradable permits to the voters because these can be considered as 'licences to pollute the environment' which – from a moral point of view – might be seen as morally unsound by those people who are especially strongly engaged for the natural environment.[11] Moreover, at least as long as grandfathering is used as the method for the original distribution of the emission rights, the government is much less interested in using tradable permits than in using ecological taxes.

Taking all these arguments together, the interests of a government might in the average lead to a less than optimal level of environmental policy, but some environmental policy actions are undertaken. Therefore, those who really oppose such incentive orientated environmental policies, are the public bureaucracy and/or private business, i.e. the regulated industries and their interest groups.[12]

14.3.2.3 The Affected Industries and Their Interest Groups

Officially, representatives of the industries which are to be regulated by environmental policy are in favour of an incentive-orientated environmental policy. But whenever the application of such instruments is discussed in their particular area, they are at least very hesitant and in most cases in strong opposition to such a policy. If, e.g., ecological taxes are discussed, they argue against it and instead favour voluntary agreements, which are just the opposite of an economic instrument of environmental policy, command and control policies or – at the most – tradable permits.[13] For the latter, however, they demand grandfathering of the original distribution of the emission rights. Thus, if there are any economic instruments used at all, besides subsidies the regulated industries prefer tradable permits which are distributed by grandfathering. In any case, they prefer a policy of command and control to a policy applying ecological taxes.[14]

---

[11] For a discussion of ethical aspects of international emissions trading see Ott and Sachs (2000).

[12] Additional arguments why a government might prefer taxes to tradable permits are given in Haucap and Kirstein (2003).

[13] See Horbach (1992) who shows that two thirds of the German companies favour standards whereas only one third favours levies and taxes.

[14] There are some producer organisations which are in favour of environmental policy and which support the use of environmental taxes. However, the members of these associations represent often companies which have only few emissions and which are, therefore, affected by environmental policy only to a small extent.

But why should the polluters, especially the industrial polluters, oppose the use of market-oriented environmental policy instruments? After all, using these instruments the same ecological impact could be reached ‘more cheaply’ i.e. at lower costs, which finally should be in the interest of the relevant industrial sectors as well. It is obvious that the profit interest of any single producer which has a relevant amount of emissions is against any environmental regulation because it reduces its expected profits. But why is there a quite special opposition against economic measures of environmental policy?

The two main reasons for this opposition are probably the high efficiency of such a policy and distributional questions:

- At the level of the economy as a whole, the high efficiency of economic instruments means that the desired ecological objectives can be reached with minimal (social) costs. For the single firm, however, the situation is quite different. As long as a policy of command and control is pursued, it has a (sometimes considerable) leeway for negotiations with its environmental protection agency. In these negotiations it has an informational advantage; it knows the processes and the potential costs if the emissions have to be reduced by a certain amount, and it can threaten a reduction of employment or even the displacement of the firm if the regulations are too strict. On the other hand, if environmental taxes are used, the firm can pollute as much as it wants, but it has to pay for it. Reductions of a tariff which has been fixed in the parliament and written into a law are much more difficult to negotiate than the extent of a regulation which is necessarily – more or less – individual for each firm. Thus, it can be expected that on the average the regulation will be less strict with a command and control policy than if incentive-orientated instruments of environmental policies are used.
- There are also, however, important distributional consequences. Let us assume that the firm uses the same technology and has the same emission in both regimes, under a command and control and under an economically oriented environmental policy. Thus, at the margin everything is the same, the same technology, the same marginal costs, and the same prices of the goods produced. Moreover, the costs for reducing the emissions are the same. Inframarginally however, if taxes or tradable permits are used the firm has to pay for its emissions while under a policy of command and control it gets them for free. Thus, to the extent of the legal emissions it gets an additional rent.[15] If wages are given, this rent can be appropriated by the owners. However, the employees (and/or their organisations, the trade unions) will realise that there is a possibility for a wage increase; they will demand their share of this rent. On the other hand, if taxes are used (and, for example, the revenue is used to cut other taxes) the general public benefits. Thus,

[15] This argument has first been put forward by Buchanen and Tullock (1975). More recently, Aidt (1998) presents a model where lobbying of interest groups forces the government to select an efficient tax instrument. However, he does not compare (efficient) taxes with (inefficient) command and control measures, but only (inefficient) output with (efficient) resource taxes. Moreover, for the resulting political equilibrium being optimal it is necessary that all interests are organised in lobby groups (with equal political power).

shareholders (employers) as well as employees have an interest to prevent the use of incentive-orientated environmental policies.

A similar argument holds if one compares grandfathering with auctioning tradable permits. If there is competition, at the margin both systems lead to the same condition. That implies that the prices for the goods produced will be the same. If the permits are auctioned, there is additional revenue for the government which can be used to cut other taxes and which – in this way – may be to the benefit of the general public. If grandfathering is used, however, as, e.g., in the case of the sulphur dioxide allowance-trading program in the United States, or with the CO_2 emissions trade program in the EU,[16] the existing firms get an additional rent. Moreover, they get a competitive advantage against newcomers in the market who do not get this rent because they have to pay for all the permits they need: grandfathering of pollution rights creates a barrier to entry against new firms.[17] Thus, it is no surprise that the existing companies as well as their interest groups favour the grandfathering of tradable permits.[18]

Given this situation and the at least partial conformity of employer and employee interests it is no surprise that the industries which are to be regulated generally oppose the use of incentive-orientated policies, especially of ecological taxes.[19] Moreover, their organisations are well organised and they are important players in the political game. There are five main reasons why these interest groups are not only better organised than environmental interest groups but also better suited to achieve their self-interested goals:

- In contrast to environmental interest groups, the respective industry and business associations usually have sufficient financial backing which is used for effective lobbying.
- Producers themselves are closest to the origins of environmental problems in the production sector. This is the reason for substantial information asymmetries. Therefore, 'green' groups often have difficulties in getting information about pollution effects as well as about the feasibility of alternative technologies.
- Based on this information asymmetry, industry and business associations often have considerable influence on public opinion through their publications as well as through their impact on the media.

---

16 See Joskow et al. (1998, p. 671): "Allowances are given to existing electric generation units and those under construction, according to fairly complicated rules … . For our purposes here it suffices to note that essentially all of the allowances were allocated 'free' to incumbent sources." A more detailed description of the initial allocation can be found in Joskow and Schmalensee (1998).

17 To counter this effect the EU Emissions Trading System has a new entrants' reserve of emission permits.

18 See for this also Dewees (1983) as well as Svendsen (1999). Dewees (1983) also points to the fact that firms prefer measures which are more strict for new than for old plants. They might even prefer such measures to no measures at all.

19 There seems to have been some change of the opinion in the United States. According to Svendsen (1999), private business interest groups are today more in favour of a grandfathered permit market, and no longer so much in favour of a command and control policy, but they still reject a tax policy.

- The 'market power' of these interest groups is a crucial factor in the achievement of their objectives in the political arena. It is not only important in the goods and services markets but in the labour market as well, especially in the form of the threat of transferring production abroad.
- Quite often these associations gain personal representation in legislative institutions, in the parliament and its committees, which makes it possible to postpone or even reject environmental issues.

To sum up, representatives of industrial and business interest groups are able to influence legislative proposals in their early stages through active lobbying in hearings and in parliamentary committees. For that purpose, they provide detailed information about environmental measures. This has the effect of linking together lobbyists and members of the legislative bodies. As a result of this relationship, arrangements are made between the political administrative system and 'private' interest groups representing business interests. In Germany, such agreements have become common practice in more than 50 industrial committees and 'voluntary self-obligations' as well as in several hundred committees for the definition of the 'best available technology'.[20]

Compared to their counterparts of business and the economy, environmentally oriented interest groups are in a weaker position. In most cases, they only have the possibility of organising spectacular actions, a strategy which is often used by Greenpeace which might be the best known of these groups. In doing so, in special situations they can have a strong impact on public opinion, influence private consumption and in this way influence the policy of single companies,[21] they might also have some impact on the decisions of voters, but they rarely have the same direct impact on the parliamentary system and the public bureaucracy economic interest groups have.

14.3.2.4 The Public Bureaucracy

Considering the available evidence at least in Europe many members of the public environmental bureaucracy are in strong opposition to the application of market-based environmental policy. They rather prefer the use of command and control. In most cases they favour, of course, policies which improve the situation of the natural environment; most members of the 'green bureaucracies' are highly motivated to pursue this goal.[22] However, they do not necessarily favour efficient policies. More important for them is that a policy strengthens their personal position in the environmental policy game. This means that the environmental administrations will try to

[20] See Maier-Rigaud (1996) or Helbig and Volkert (1999).

[21] The best known case is that in 1995 Greenpeace succeeded in preventing Shell from sinking the oil platform Brent Spar into the North Sea. See for this Huxham und Sumner (1999).

[22] For a model which employs this assumption to explain the results of international climate protection policy see Congleton (1995).

implement those environmental policy measures which require high administrative controls. To increase their leeway they want the political authorities to regulate as little as possible so that they have the greatest possible leeway (and budget) for their own decisions.[23] Discretionary budgets are also necessary in order to meet the demands of those lobbies for which the different environmental sections of German ministries have become even more important than the parliament with its committees.

Economic instruments and especially environmental taxes are much less attractive for the public bureaucracy. While command and control policies can only exist with high labour costs and other expenditures, the use of taxes requires much less expenditure and less staff. Hence, a budget increase or a rise in the importance of environmental authorities is less likely than with the use of standards. Furthermore, a change from the current system of environmental standards to a system of taxes would require a high degree of flexibility in the environmental agencies.

Using taxes or tradable permits would of course reduce the information requirements of the public environmental bureaucracy considerably. Detailed information is only necessary for the tolerable total burden, for the 'correct' total emission amount derived from it, and – in the case of taxes – on the reactions of the industries to the taxes, which can be obtained in a kind of trial-and-error procedure by a gradual increase of the tax rate over a longer time span, but no detailed information about the prevention costs of different producers is needed, which is difficult to acquire. Thus, the efficiency of the bureaucracy could be increased considerably. But this is not necessarily in the interest of the members of the bureaucracy, as the lower information requirements make it rather difficult to justify a large budget and a large staff.

14.3.3 Concluding Remarks

Taking all arguments together, the industries which are to be regulated and the members of the environmental bureaucracy are the ones who are most in favour of command and control environmental policies, and both have a strong impact on the design of the actual policy. Thus, it comes as no surprise that incentive-oriented environmental policies showing a strong steering effect, like environmental taxes or tradable permits, are hardly used. On the other hand, with respect to the extent of the environmental program the interest of these two groups of actors are quite opposite: While the bureaucrats favour strict, most industries strive for rather soft, environmental policies. Thus, whether a policy is really strict or not depends mainly on the preferences of the voters (and of the clientele of the party (parties) in government). Taking into account the behaviour of voters, the environmental policy might be strict in those areas which already today have a direct, noticeable impact, but rather loose in those areas which would mainly benefit future generations. And this is

[23] See the results of the surveys described in Gawel (1994, 1995).

exactly what we observe. There have been, e.g., considerable improvements in the water quality of our lakes and rivers, but up to today there is hardly any effective policy to prevent or even slow down global warming.

14.4 Suggestions for a Globally Coordinated Dual Environmental Policy

One can avoid the emission of CO_2 and other greenhouse gases by focusing environmental policy only on the use phase of raw materials, rather than their extraction. But, because a focus on the use phase may engender further emissions upstream, the risk still exists that climate targets may not be achieved. This suggests that a dual approach might be followed by simultaneously setting an emissions target for greenhouse gases and a target for the use of raw materials. Because it is a dual approach that is being suggested, it should be clear that there is no intention to challenge climate policy. A dual environmental policy, as discussed here, is not to be seen as alternative but additional to climate protection policy.

14.4.1 Aims

The basis of a global system has to be a recognition of the right of equal access to the use of resources for all the world's population. This has to be reached at some point in the future – say, around the year 2050 – in every country. Calculations of the use of resources would need to include internal extraction and the import of resources, as well as resources included in import goods minus resources included in export goods. Furthermore, not only the weight of raw materials themselves should count, but also the total material removed during extraction. Damage to nature correlates closely with the weight of materials. Transport, distribution and converting resources have severe consequences for the use of energy, particulate matter emissions, noise generation, destruction of bio-diversity and many more damaging effects on nature. Therefore, it makes sense to calculate the use of resources in tons, in a standardized way. Estimates by natural scientists consider a use of 6 tons per capita (used and unused material extractions) in the year 2050 with a population of nine billion as acceptable, excluding the use of water and oxygen in combustion (Schmidt-Bleek 2007, 2009). This compares with around 20 tons per capita used today (Giljum et al. 2008; Lutz et al. 2010).

In accounting for the emission of greenhouse gases, the values (evaluated in tons) of emitted gases have to be corrected with the climate equivalence. If global warming is to be limited to 2 °C, then, with a global population of nine billion people in the year 2050, CO_2 emissions should be limited to an average of 2 tons CO_2 per capita (Stern 2008, p. 28). The current value is around 6.3 tons per capita (World Resources Institute 2013).

14.4.2 Instruments at an International Level

Timelines for the annual target attainment have to be defined for all countries that join the system. The timelines for the target values of the input amount of raw materials and greenhouse gas emissions should assess the actual, current values. It would be unrealistic to assume that the Kyoto target values of greenhouse gas emissions could be used as a starting point for industrial countries, because many countries like, for example, the USA, are far away from these values (Olmstead and Stavins 2006). The amount of raw material input has to be understood as the total extraction in the home country plus imports plus indirect raw materials (included in import goods) minus the indirectly included raw materials of exports. Only linear developments can be provided for target ranges, based on current, actual input amounts of raw materials or greenhouse gas emissions. With these target ranges, rights for the use of raw materials and rights for greenhouse gas emissions are distributed which can be traded between the countries. In this way it is assured that the global aim will be reached in any case and that, at the same time, the different target attainment potentials will be used in several countries in the best way.

The group of countries which decides in favour of participation in the system would tax all import goods from non-participating countries to avoid distortions in international trade (Stern 2008, p. 25), provided that these countries have a use of raw materials per capita or CO_2 emissions per capita that is above the average of those countries in the system. This would produce pressure to join the system provided that a reasonable number of important industrial countries are already involved during its take-off phase. Should a developing country or emerging nation reach the average use of resources per capita or the average CO_2 emissions of the countries involved in the system, then their exports would become subject to the compensation charge of those countries in the system. No pressure would be exerted on a country to join the system, as long as its use of resources per capita or the emission of harmful materials lay below the average of countries within the system. Thus, a minimum of justice, based on the level of flows, would be assured. Of course, with a view to the stocks of CO_2 in the atmosphere, industrial countries have already contributed more than their fair share.

Of course, this begs the important question of measurement. Many countries do not currently measure their use of materials, nor do they have the institutional capacity to do so. Yet it is essential that countries acquire this capacity (as for CO_2 emissions) if global materials management is to become a reality. Countries should be supported through the UN to acquire the ability to measure their resource use (this could be delivered as an extension to the UN support with national economic and environmental accounting). By the time a country reaches a certain level of income, it should also have in place an internationally approved materials measurement system that is open to independent international verification. Failure to deliver this would trigger the materials tax on its exports irrespective of its level of materials use.

Finally there is the issue of the still excessive environmental damage caused by much of the extraction of materials. Again this needs to be managed, and reduced, through a mechanism of global cooperation. One proposal (Ekins and Vanner 2009, pp. 300 f.) is for the establishment of Sustainable Commodity Agreements, which would entail a charge on all commodity exports to go into an international fund that would go back into the extraction sector to fund projects to reduce the environmental impacts of extraction.

14.4.3 Instruments of National Environmental Policy

Each of the countries involved in the system will be interested in lowering the use of raw materials and greenhouse gas emissions, to reach the target settings. Otherwise, corresponding rights have to be bought on the international market. Freedom has to be given to every country in its choice of instruments. It is not easy to give recommendations taking into account different economic constitutions, cultural and trading conditions. Therefore, the differences identified in the perfect world of eco-economic literature cannot lead to a result whereby the decisions taken for every country regarding taxes, marketable rights of use, subsidies, information and communication tools and regulations, lead to the same results (Stern 2008, p. 23). The preference noticeable in the microeconomic literature for marketable environmental rights (cf. e.g. Baumol and Oates 1998, p. 177) does not have to mean that marketable emissions rights are superior to regulatory solutions within climate protection systems, in general. Particularly the intention to create a global market for emissions rights with the greatest possible static efficiency, in which companies can act internationally as providers and consumers directly (cf. Flachsland et al. 2008), can cause, in a dynamic perspective, serious problems: it is to be expected that waves of speculation on international capital markets will encroach on the market for environmental rights. Therefore, it would be reasonable to allow indirect linking of national markets only via CDM. It is also important to see the path dependency of political processes and their meaning for enforceability of measures. For Europe this would mean that the European Emissions Trading System (EU ETS), while by no means perfect, would be preserved within the frame of climate protection, as its foundation was very complex.

Through the EU ETS an extensive global system of marketable emissions rights exists in Europe. Essentially, it contains organisations in primary industry which burn fossil fuel sources. That means that in Europe the emissions from upwards of 10,000 industrial combustion processes have to be measured. Even with this considerable complexity it is only possible to cover approximately 50 % of CO_2 emissions. Seeking to control emissions of other industries and, especially, those of private households with these instruments would cause a multiplication of complexity. The adoption of ‘Personal Carbon Trading’ for private households has now been studied intensively (e.g. Fleming 2007), but the UK British Government decided on the basis of its own assessment (DEFRA 2008) that such a scheme would be too complex, too difficult to understand and too expensive. No other European country has come so close to the idea of an extensive system of marketable emissions rights.

Therefore, it is likely that Europe will remain with a hybrid system for climate protection in which taxes and regulation have their places, alongside emissions trading. It is very unlikely that other countries are about to create conditions that are necessary for the complete surveillance of CO_2 emissions across the whole country on the level of both companies and households. There will be only a few energy-intensive industries with large companies that will be a part of an emissions trading system. A hybrid policy system for climate protection need not be excessively costly. The results of calculations with the global eco-economic model GINFORS (Lutz and Meyer 2009) for several hybrid scenarios shows that a development path of CO_2 emissions that is compatible with the climate aim of 2050 can be reached by 2030 with comparatively low costs (certainly when compared with the costs of unabated climate change).

Turning to non-CO_2 emitting resources, the reduction of their use is possible by marketable rights of use and/or by taxation. Marketable rights of use have to be valid for all companies of the respective country which use raw materials as a production factor. In contrast, in case of taxation, only the few companies that extract raw materials, as well as importers of raw materials need to be included. Thereby, only importers who belong to a country that does not join the system have to be taxed. Therefore, the amount of input required during the raising of a resource tax is far less than with a system of marketable rights of use.

The raw material tax can be conceived of as a volume tax which is charged per unit of weight of raw materials. The general approach, on which the valuation of the raw material target in tons was based, acts on the assumption that extraction, further processing and transport of raw materials causes external effects which are dependent on weight. With the raw material tax the generation of those goods will become more expensive at all production levels which have a directly and indirectly high level of raw materials. Thus, there will be an incentive on every production level of intensive consumers of raw materials to lower their input of these materials. Through consumption, goods which are raw-material intensive will be substituted by other goods in consequence of their increasing prices.

One could abstain from an additional taxation on fossil fuels within a policy for increasing resource productivity, in a country with established and successful equipment for the avoidance of CO_2 emissions. In contrast, in a country without a climate protection policy, resource tax could include fossil fuels.

The levying of a resource tax would avoid the formerly described negative effects of some CO_2 strategies which are marked with the fact that they substitute fossil fuels with other natural resources and thereby produce other environmental problems.

Companies in the countries affiliated to the international system have no competitiveness effects to fear if the import of goods from other countries would incur a compensation charge. At first, it could be that the threat of a compensation charge will only be applied to a few countries, which are important for trade. The level of the compensation charge would be chosen to equalise, as far as possible, the resource tax levied on comparable domestic and imported goods. The import company could appeal.

The income from energy taxes, resource taxes and auction proceeds of emissions rights (if auction is undertaken) should be returned to the relevant national economy (Binswanger 1980). Companies are protected by compensation charges. Households have to pay increased prices for goods, some of which (for example, energy) might affect lower income groups more than upper income groups. Costanza (1991, p. 340) suggests a lowering of the income tax rate at the lower end of the income chart or even the adoption of a negative income tax, to realize distributive justice. An alternative would be to redistribute some part of the revenues as an 'Eco-bonus' on an equal per capita basis.

Part of the revenues should be for increasing awareness of resource-efficient technologies and products, so that price signals can lead to required profound behaviour modifications. This can include information campaigns as well as special events which inform people about the developments in several technical fields. To raise customer awareness of the issues, quality labels and seals of environmental quality could be of help for their daily consumption decisions. The revenues may also be used to support research into resource efficiency.

Clearly these policies to reduce the use of resources in general, need to be supplemented by a continuation or intensification of policies which are addressed at specific hazardous materials, in order to protect human health and the environment.

14.4.4 An Alternative Regime

For the regime discussed above it is essential that the taxation of imported goods has to take place to avoid negative competition effects in international trade from those countries which do not belong to the club and have higher emissions per head and higher resource consumption per head than the average of the club. Problems of measurement and administrative costs may also occur which could prevent the success of the regime.

As an alternative, establishing a world-wide tax rate on extracted and imported resources would not require target paths for every country, and the exchange of intergovernmental emissions and resource consumption rights through intergovernmental certificate trading. The tax rate on fossil fuels would have to be in line with the emission targets, and together with the tax rates on the other resources have to be in line with the resource consumption target. The advantage would be that no additional institutions would be necessary (Stern 2007, pp. 532–533). If all industrialized countries and all developing countries were to follow this agreement, a time path for the tax rates would need to be established that guarantees the meeting of the target for 2050. It is in fact doubtful that from the beginning all industrialized and developing countries would be part of the system, and of course the developing countries would need direct public transfers from the industrialised countries to get an incentive for joining the commitment.

14.5 Conclusions

Human societies face profound environmental and resource challenges, which demand a systematic and comprehensive policy response. Chief among the challenges is climate change. The requisite global response to this challenge is beginning to emerge (though still far too slowly), but it is important to recognise the other challenges of environment and resources – biotic and abiotic – and to produce appropriate policy responses.

It has gradually become recognised that there are limits to the human appropriation of natural resources, and their accumulation in natural systems as wastes, if the earth is to remain habitable for large human populations. With regard to greenhouse gas emissions, the limit has been set to be about 2 tonnes of CO_2-equivalent emissions per person per year by 2050, falling to 1 tonne per person per year by 2100. This paper has argued that current material resource use of about 20 tonnes per person per year will need to fall to about 6 tonnes per person in 2050 – more than a halving of resource use in absolute terms. This is a formidable challenge, to achieve which policy has barely begun to be formulated.

In climate policy, a focus only on greenhouse gas emissions reduction runs the risk (through such technologies as CCS) of increasing the unsustainable use of raw materials. Climate policy therefore needs to be complemented with a broader policy focus on resource use.

Greenhouse gas (especially carbon) emissions arise from many small, as well as some large, emitters. It might have been best to seek to tackle it through carbon taxation, but carbon taxes now seem unlikely to supplant the carbon emissions trading schemes that have been or are being established. However, they can be used to reinforce trading schemes. Regulations also have their place for more targeted interventions (for example, the energy efficiency of buildings, vehicles and appliances). Climate policy therefore seems likely to continue, and be developed, as a hybrid policy approach.

The policy approach advocated in this paper is for an international system of marketable permits for use of natural resources, with the number set to decline by 2050 to the per capita limit mentioned above. The permits would be traded only between countries. Countries would be invited to join this system as soon as their resource use exceeded the average personal global allowance on the declining trajectory to 2050. The group of countries which decides in favour of participation in the system would tax all import goods from non-participating countries to avoid distortions in international trade, provided that these countries have a use of raw materials per capita or CO_2 emissions per capita that is above the average of those countries in the system. The tax would also be applied to those countries that had failed to develop an adequate system for the measurement of resource use in their territory. On the national level countries would be free to choose their own instruments, but the paper recommends a tax on the extracted materials.

Such a scheme would doubtless need much elaboration to cope with the complexities of the real world, and this paper is hoping to start the debate that will lead to such elaboration. It will also be necessary, in parallel with the broad scheme of resource taxation and the trading of resource use permits suggested here, to maintain the local regulation of specific substances according to their hazardous properties. And it has further been suggested here that special new international Sustainable Commodity Agreements should be entered into specifically to address and reduce the environmental impacts of resource extraction.

An alternative approach would be to establish worldwide tax rates on the extraction and import of resources. This would avoid problems in international trade and the construction of complex institutions. But this would only work if all industrialized and developing countries agreed to be part of the system, which implies that direct public transfers from industrialised to developing countries would need to be paid.

In this way the resource and environmental policy framework would both regulate and reduce the macro-material impacts which are currently so threatening the future of humanity, while continuing to control the local environmental hazards of pollution.

References

Aidt T (1998) Political internalisation of economic externalities and environmental policy. J Public Econ 69:1–16

Aidt T (2009/10) Green taxes: refunding rules and lobbying. J Environ Econ Manag 60(1):31–43

Ayres RU, Knees AV (1969) Production, consumption, and externalities. Am Econ Rev 59(3):282–297

Ayres RU (2008) Sustainability economics: where do we stand? Ecol Econ 67(3):281–310

Baumol WJ, Oates EO (1998) The theory of environmental policy, 2nd edn. Cambridge University Press, Cambridge

Binswanger HC (1980) Modell einer umweltkonformen Marktwirtschaft – ein Weg zum qualitativen Wachstum. In: Küng E (ed) Wandlungen in Wirtschaft und Gesellschaft, Festschrift für W. A. Jöhr. Mohr, Tübingen, pp 201–211

Buchanan JM, Tullock G (1975) Polluters' profits and political response: direct controls versus taxes. Am Econ Rev 65:139–147

Congleton RD (1995) Return to Rio: on the political economy of environmental treaties. Universität Konstanz. Diskussionsbeiträge des SFB 178, Nr. 280, Serie 11

Costanza R (1991) Assuring sustainability of ecological economic systems. In: Costanza R (ed) Ecological economics: the science and management of sustainability. Columbia University Press, New York, pp 331–341

Daly HE (1991) Elements of environmental macroeconomics. In: Costanza R (ed) Ecological economics: the science and management of sustainability. Columbia University Press, New York, pp 32–46

Daly HE (1992) From empty world to full world economics. In: Goodland R, Daly HE, Serafy SE (eds) Population, technology and lifestyle: the transition to sustainability. Island Press, Washington, DC

Daly HE (1996) Beyond growth: the economics of sustainable development. Beacon, Boston

DEFRA (2008) DEFRA information bulletin 135/08, of 8 May 2008

Dewees DN (1983) Instrument choice in environmental policy. Econ Inq 21:53–71

Diamond J (2005) Collapse: how societies choose or fail to survive. Viking Books, New York

Ekins P (2000) Economic growth and environmental sustainability: the prospects for green growth. Routledge, London/New York

Ekins P (2001) Key issues in environmental economics. In: van Ierland E, van der Straaten J, Vollebergh H (eds) Economic growth and valuation of the environment. Edward Elgar, Cheltenham, pp 90–133

Ekins P (2003) Sustainable development. In: Proops J, Page E (eds) Environmental thought. Edward Elgar, Cheltenham, pp 144–172
Ekins P, Vanner R (2009) Reducing the impacts of the production and trade of commodities. In: Ekins P, Voituriez T (eds) Trade, globalization and sustainability impact assessment. Earthscan, London, pp 277–308
Flachsland C, Edenhofer O, Jakob M, Steckel J (2008) Developing the international carbon market. Linking options for the EU ETS. Report to the Policy Planning Staff in the Federal Foreign Office, Potsdam
Fleming D (2007) Energy and the common purpose: descending the energy staircase with tradable energy quotas (TEQs), 3rd edn. The Lean Economy Connection, London
Frey BS (1992) Umweltökonomie, 3rd edn. Vandenhoeck, Göttingen
Frey BS, Schneider F (1978a) An empirical study of politico-economic interaction in the United States. Rev Econ Stat 60:174–183
Frey BS, Schneider F (1978b) A politico-economic model of the United Kingdom. Econ J 88:243–253
Frey BS, Schneider F (1979) An econometric model with an endogenous government sector. Public Choice 34:29–43
Gawel E (1994) Umweltpolitik zwischen Verrechtlichung und Ökonomisierung. ORDO 45:63–103
Gawel E (1995) Bürokratie, Theorie und Umweltverwaltung: Ökonomische Einsichten in verwaltungsrechtliches Handeln im Umweltschutz. Zeitschrifit für angewandte Umweltforschung 8:79–89
Giljum S, Behrens A, Hinterberger F, Lutz C, Meyer B (2008) Modelling scenarios towards a sustainable use of natural resources in Europe. Environ Sci Policy 11:204–216
Goodland R (1992) The case that the world has reached limits. In: Goodland R, Daly HE, Serafy SE (eds) Population, technology and lifestyle: the transition to sustainability. Island Press, Washington, DC, pp 3–22
Haucap J, Kirstein R (2002) Government incentives, when pollution permits durable goods. Public Choice 145(3):1020–1041
Haucap J, Kirstein R (2003) Government incentives when pollution permits are durable goods. Public Choice 115:163–183
Helbig J, Volkert J (1999) Freiwillige Standards im Umweltschutz. Physiker/Springer, Heidelberg
Hibbs DA (1977) Political parties and macroeconomic policy. Am Polit Sci Rev 71(4):1467–1487
Hibbs DA (1992) Partisan theory after 15 years. Eur J Polit Econ 8(4):361–373
Horbach J (1992) Neue politische Ökonomie und Umweltpolitik. Fischer, Frankfurt
Hueting R (1980) New scarcity and economic growth. North Holland, Amsterdam (Dutch edition first published 1974)
Hueting R (1992) The economic functions of the environment. In: Ekins P, Max-Neef M (eds) Real-life economics: understanding wealth creation. Routledge, London/New York, pp 61–69
Huxham M, Sumner D (1999) Emotion, science and rationality: the case of the Brent Spar. Environ Values 8:349–368
IMAS (1996) Umfrageberichte von IMAS-International. IMAS-International, Linz (Austria)
IMAS (2000) Umfrageberichte von IMAS International. IMAS-International, Linz (Austria)
IMAS (2005) Umfrageberichte von IMAS International. IMAS-International, Linz (Austria)
IMAS (2007) Umfrageberichte von IMAS International. IMAS-International, Linz (Austria)
Josko W, Schmalensee PLR (1998) The political economy of market based environmental policy: the U.S. acid rain programme. J Law Econ 41(1):37–84
Josko W, Schmalensee PLR, Bailey EM (1998) The market for sulfurdioxide-emissions. Am Econ Rev 88(4):669–685
Kirchgässner G (1994) Nationale und internationale Bestimmungsfaktoren der schweizerischen Mineralölpreise: Eine Anwendung der Kointegrationsanalyse. Schweizerische Zeitschrifit für Volkswirtschaft und Statistik 130:575–598
Kirchgässner G (1998) Ökologische Steuerreform: Utopie oder realistische Alternative. In: Krause-Junk G (ed) Steuersysteme der Zukunft. Duncker & Humblot, Berlin, pp 279–319

Kirchgässner G (2000) Die Bedeutung moralischen Handelns für die Umweltpolitik. GAiA 9:41–49
Kirchgässner G, Kübler K (1992) Symmetric or asymmetric price adjustment in the oil market: an empirical analysis of the relations between international and domestic prices in the Federal Republic of Germany, 1972–1989. Energy Econ 14:171–185
Kirchgässner G, Schneider F (2003) On the political economy of environmental policy. Public Choice 115(4):369–396
Kirchgässner G, Müller U, Savioz MR (1998) Ecological tax reform and involuntary unemployment: simulation results for Switzerland. Schweizerische Zeitschrift für Volkswirtschaft und Statistik 134:329–353
Kollmann A, Schneider F (2010) Why does environmental policy in representative democracies tend to be in equate? A preliminary public choice analysis. Sustainability 2010(2):3710–3734
Köschel H, Wünsche A, Eckerle T (1999) Was bringt die ökologische Steuerreform der deutschen Wirtschaft? ZEW Konjunkturreport 2(1):6–9
Kuuluvainen J, Tahvonen O (1995) The economics of natural resource utilization. In: Folmer H, Landis Gabel H, Opschoor H (eds) Principles of environmental and resource economics. Edward Elgar, Cheltenham, pp 106–135
Lutz C, Meyer B (2009) Environmental and economic effects of post-Kyoto carbon regimes. Results of simulations with the global model GINFORS. Energy Policy 37(5):1758–1766
Lutz C, Meyer B, Wolter MI (2010) The global multisector/multicountry 3E-Model GINFORS. A description of the model and a baseline forecast for global energy demand and CO_2-emissions. Int J Global Environ Issues 10(1–2):25–45
Maier-Rigaud G (1996) Für eine ökologische Wirtschaftsordnung. In: Altner G, Mettler-von Meibom B, Simonis UE (eds) Jahrbuch für Ökologie 1996. C.H. Beck Verlag, München, pp 71–79
OECD (1997) Environmental policies and employment, Paris 1997
Olmstead SM, Stavins RN (2006) An international policy architecture for the post-Kyoto era. Am Econ Rev 96:35–38
Ott WE, Sachs W (2000) Ethical aspects of emissions trading. Wuppertal Pap 110:4–21
Pearce D, Turner RK (1990) Economics of natural resources and the environment. Harvester Wheatsheaf, Hemel Hempstead
Reid A, Miedzinski M (2008) EUROPE INNOVA. Final report for the EU sectoral innovation watch panel on eco-innovation. www.europe-innova.org
Schmidt- Bleek F (2007) Nutzen wir die Erde richtig? Von der Arbeit des Menschen und den Leistungen der Natur. Fischer, Frankfurt
Schmidt-Bleek F (2009) The earth: natural resources and human intervention. Haus Publishers, London
Schneider F (1998) Induzieren ökologische Steuerreformen einen Lenkungseffekt oder nur volle Staatskassen? IAW-Mitteilungen 26
Schneider F, Stiglbauer AM (1995) Makroökonomische Auswirkungen verschiedener Energiesteuermodelle in Österreich. Wirtschaftspolitische Blätter 42:121–126
Scholz CM (2000) Environmental tax reforms and the double dividend: a theoretical and empirical analysis for Germany. Mohr Siebeck, Tübingen
Solow R (1974) The economics of resources or the resources of economics. Am Econ Rev 64(2):1–14
Stern N (2007) The economics of climate change. The Stern review. Cambridge University Press, Cambridge
Stern N (2008) The economics of climate change. Am Econ Rev Pap Proc 98(2):1–37
Svendsen GT (1999) U.S. interest groups prefer emission trading: a new perspective. Public Choice 101:109–128
World Resources Institute (WRI) (2007) 2013 CAIT 2.0: WRI's climate data explorer. http://cait2.wri.org/wri#CountryGHGEmissions?indicator=TotalGHGEmissionsExcludingLUCF&indicator=TotalGHGEmissionsIncludingLUCF&year=2010&act=Argentina&sortIdx=&sortDir=desc&chartType=. Accessed 19 Aug 2013
Zimmermann KW (1996) Zur politischen Ökonomie von Ökosteuern. ORDO 47:169–194

Chapter 15
Towards a More Sustainable Use of Resources: A View from the World Resources Forum

Bas de Leeuw, Xaver Edelmann, and Katharina A. Meijer

15.1 Background

The global consumption of limited natural resources is rising at a fast pace. In spite of the remarkable success attained in solving some environmental problems, today's economic and environmental policies have not been able to solve other problems which pose serious threats to the life-supporting services of nature.

Currently at around 60 billion tonnes each year, human extraction and use of natural resources has increased by 50 % in the last 50 years (SERI and GLOBAL 2009, p. 9). These figures are expected to grow further, with an estimated 80 billion tonnes of resources extracted by 2020 (OECD 2008, p. 37). Furthermore, these activities are connected with a substantial environmental burden: extraction namely disrupts habitats as well as ecosystems and alters landscapes in the region where it takes place.

As Fig. 15.1 shows, increasing resource extraction in the last few decades has been closely correlated with demographic as well as economic growth. Between 1980 and 2007, world GDP (in constant prices) rose by 120 % while global population increased by more than 50 %. Over the same period, resource extraction followed this trend closely with a 62 % increase (SERI 2010).

B. de Leeuw (✉)
World Resource Forum Secretariat, Empa Building, Lerchenfeldstr. 5,
CH-9014 St. Gallen, Switzerland
e-mail: bas.deleeuw@worldresourcesforum.org

X. Edelmann
Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA),
Lerchenfeldstr. 5, CH-9014 St. Gallen, Switzerland
e-mail: xaver.edelmann@worldresourcesforum.org

K.A. Meijer
University of St.Gallen, St. Gallen, Switzerland
e-mail: katharina.meijer5@gmail.com

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_15,

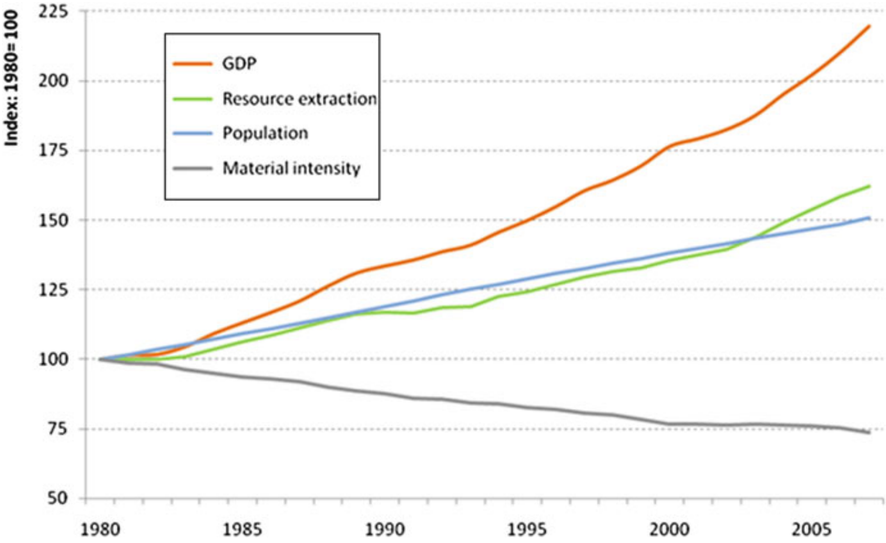


Fig. 15.1 Trends in global resource extraction, GDP and material intensity (SERI 2010)

According to the latest UN statistics, the world population is expected to grow constantly in the coming decades, reaching 9.3 billion in 2050 and peaking a bit later (United Nations Department of Economic and Social Affairs/Population Division 2010; medium scenario).

Less developed countries especially are expected to face dramatic demographic growth. In order for them to ensure rising individual wealth and quality of life, GDP per capita will need to continue growing as well. This is a legitimate requirement in less industrialized countries but it will go along with higher resource use and higher environmental impact.[1]

And even though material intensity has been falling since 1980, meaning that today's world economy needs significantly fewer natural resources to raise GDP than it did 30 years ago (SERI 2010), several concerns still remain.

One problematic aspect of global resource use is that many resources, e.g. fossil fuels and metal ores, are non-renewable. Another challenge is the fact that despite diminishing material intensity, environmental pressures have declined only relative to economic activity but not in absolute terms (see Fig. 15.1).

Therefore, to be able to reconcile the need for economic development with the imperative of environmental sustainability, two types of decoupling will be required (UNEP 2011a, pp. 1–6). On the one hand, resource use will have to grow at a much

[1] Krausmann et al. (2009) and Brigezu and Bleischwitz (2009) deal extensively with GDP growth and corresponding increased resource use and environmental impact.

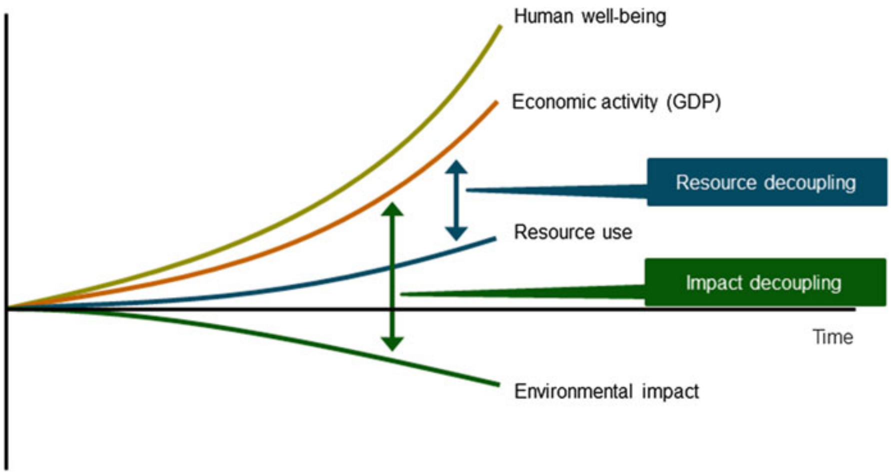


Fig. 15.2 Stylized representation of resource decoupling and impact decoupling (UNEP 2011a, p. 5)

slower pace than GDP. This is what the UNEP International Resource Panel[2] has coined *resource decoupling*. On the other hand, resource use will also need to be decoupled from environmental impact, that is, *impact decoupling* will be required as well (Fig. 15.2).

Reports by UNEP[3] explore the idea of decoupling in depth and provide some examples on how to implement it. Governments and businesses need to understand this concept and incorporate it in their policies and strategies.

In addition to this, decoupling will also require further increases in resource productivity, which can only effectively address the challenges at hand if they are supported by concrete actions from the international community:

- Policy developments need to be supported by *quantitative targets* as real change is only possible if it can be measured. These targets are crucial for encouraging consumers and businesses to partake in sustainable consumption and production.
- National and international governing bodies need to develop and implement *concrete roadmaps*, along with *clear plans* for transforming legal frameworks and shifting fiscal pressure towards resources and pollution and away from labour.

[2] The UNEP International Resource Panel was officially launched in 2007. It is expected to provide the scientific impetus for decoupling economic growth and resource use from environmental degradation. The overall objective of the Resource Panel is therefore to provide independent scientific assessment of the environmental impacts due to the use of resources over their full life cycle, and advise governments and organisations on ways to reduce these impacts (UNEP 2010c).

[3] See UNEP (2010a, b, 2011a, b) on decoupling and sustainable options for natural resource management.

- Radical change and ground-breaking *innovations* are needed in developing countries and emerging economies as *resource efficiency* is essential for poverty eradication.
- Individuals need to be *empowered* to take action and be supported by an ethical framework which addresses both the environmental and social impact of consumption.

15.2 Shaping the Future of Natural Resources

The Swiss Federal Laboratories for Materials Testing and Research (Empa), part of the prestigious ETH Domain, has with much success (co-)organised international conferences on recycling and re-use of resources (R-conferences) since the early 1990s. In 2009 these conferences were upscaled and mainstreamed to become the World Resources Forum, resulting from an initiative of Prof. Dr. Friedrich Schmidt-Bleek (Factor Ten Institute) and Dr. Xaver Edelmann (Empa). The initiative became an independent association early 2012, led by former UN diplomat Bas de Leeuw as its Managing Director.

The WRF is the global science-based platform for sharing knowledge about the economic, political, social and environmental implications of global resource use. WRF promotes innovation for resource productivity by building bridges among researchers, policymakers, business, SMEs, NGOs and the public. Flagship activity is the annual WRF Conference.

For that purpose, the WRF brought together an interdisciplinary network of scientists, engineers and economists who recognize the necessity of establishing economic principles that respect the physical properties of resources and the laws of nature. The WRF serves as a neutral, international platform for debate on global resource consumption issues and as an advocate of innovation for resource productivity. The forum develops recommendations for practical steps to be taken towards a sustainable economy.

The specific approach of the first WRF in 2009[4] was to bring together two separate, but interlinked discourses on global resource consumption, one among natural scientists and engineers and the other among economists. This encounter led to the formulation of a joint declaration[5] which advises to seek international agreements on world-wide per-capita targets for natural resource extraction and consumption, the overarching objective being to bring about an absolute decoupling between economic development and resource use.

The participants further urged to introduce effective policy measures that greatly enhance resource productivity and curb demand over time. Examples of such measures are standards, cap and trade mechanisms or higher taxes on natural resource use. This also means that the framework conditions of the economy should be reshaped

[4] September 16, 2009 in Davos/Switzerland.

[5] See: www.worldresourcesforum.org/wrf_declaration

to account for the scarcity of natural resources. On the same note, the plenary agreed that research and development needed to focus on increasing resource productivity.

Moreover, a societal consensus on ecological and economic indicators[6] – beyond GDP – that are in tune with the laws of nature needs to be reached. The participants acknowledged the necessity to seek a dialog with the business community to help redesign business models so that revenues increasingly derive from quality of services rather than from selling material products. At the same time, the plenary recognized the need for extraction and sale activities to promote an environmentally sustainable development of the countries in which they take place.

The participants of the WRF 2009 discussed about initiating a process to rethink lifestyles and help develop consumption patterns based on sufficiency as well as careful use of natural resources. Education should help raise awareness for resource limitations, especially among economists, and foster the ability of decision-makers to analyse long-term, systemic trends as well as to implement sustainability-driven innovation.

15.3 Fourteen Steps Towards the Green Economy

During the WRF 2011[7] over 400 participants from more than 40 countries and various backgrounds exchanged their views on best practices, policy options and research concerning natural resource management as well as the promotion and implementation of the Green Economy. They called upon the hosting Government of Switzerland and others to inform the Rio +20 process about the outcomes of the Forum and agreed to review progress of implementation at the next WRF to be held in 2012 in China.[8]

The participants especially urged governments, businesses and civil society to take immediate action in order to accelerate progress towards a green economy, to double the current level of resource productivity by 2020 and to reach at least a fivefold increase by 2050. Although change is underway, the implementation of activities needs to be drastically speeded up and existing fears of change need to be overcome.

The WRF 2011 concluded:

1. There is an urgent need to take effective steps towards achieving a resource-efficient, climate-resilient Green Economy. A true sense of urgency that is magnified by numerous crises[9] should be translated into concrete actions.
2. Economies are locked in unsustainable consumption and production behaviour. Radical change in developed countries as well as leapfrogging in developing countries is needed. For developing countries, resource efficiency is essential for the eradication of poverty.

[6] At micro-, meso- and macro-levels.

[7] September 19–21, 2011 in Davos/Switzerland.

[8] October 21–23, 2012 in Beijing, China.

[9] Financial, food, climate change.

3. For developing countries, technology transfer, access to resource-efficient technologies and financial support for making the transition is necessary, as well as effective governance, resource-efficient infrastructure and education. Higher prices of resources provide an opportunity for commodity-exporting developing countries to address those critical challenges. Using these resources in an unsustainable way could pose risks to social stability and environmental sustainability. In addition, security, social and economic challenges relating to natural resources in fragile states were identified as an emerging issue. Unfair international trade rules need to be firmly addressed.
4. Data and indicators should be improved, since one cannot manage what one cannot measure. Overconsumption of the rich needs to be addressed and basic needs of the poor satisfied. Concrete roadmaps should be established, with clear plans for implementing financial and legal instruments. Individuals, particularly the poor and vulnerable, need to be empowered to take action. An ethical framework for consumption (addressing both environmental and social impacts) should be part of a new global plan on resource efficiency.
5. Housing, sanitation, mobility and food are key sectors. Critical metals require urgent attention due to their potential for essential sustainable technologies and products. International governance structures for resource efficiency, including for minerals and metals, need to be strengthened.
6. Resource productivity is expected to become a key driver for economic development in the next decades. Key instruments for developing resource-efficient economies include establishing clear indicators and goals, as well as taxing resources and pollution instead of taxing labour. Ecological, water and carbon footprints are emerging concepts that can also encourage transparency towards the consumer.
7. New paradigms and ways of thinking are needed, since one cannot solve the problems with the same kind of thinking one used when creating such problems, and ‘business as usual’ is not an option. Improvements of resource efficiency by a factor 2, 5, 10 or even 50 are possible. More research to underpin these targets is needed, but at the same time, immediate action to move towards these goals is urgent.
8. Circular economy approaches require not only technical but also institutional changes and social innovation. Eco-design and upgrading products and production processes and product service systems will boost a transition to a green economy and strengthen the competitiveness of industries concerned.
9. The Green Economy can only be accomplished through the measurement of performance and transparency as well as through partnerships between governments and businesses, and businesses and civil society. Governments also need to create a framework for innovation.
10. At the same time, it has to be recognized that not everything that can be counted counts and not everything that counts can be counted. Values, emotions, mind-sets, and underlying driving forces for consumption, such as status, need to be taken into account as well.

11. Youths need to be equally involved in the discussions about the future of our natural resources. Intergenerational dialogue such as that which took place at this WRF should be encouraged. Youths, and in particular young women in developing countries, should be empowered to be part of the solution.
12. It was felt that although change is underway, the implementation of activities should be accelerated with the greatest sense of urgency, and increasing demand for change should be transformed into action.
13. Considering all of the above, the Davos World Resources Forum calls on governments, businesses and civil society to take immediate action to double the current level of resource productivity by 2020 and reach at least a fivefold increase by 2050.
14. This recommendation is not only directed towards governments, business and civil society, but also serves as a commitment to ourselves in our capacity as individuals and the most valuable resources of the planet.

15.4 Towards an International Platform for Resources Governance

Governments need to be alert to the growing spider web of bilateral resource agreements, in particular those involving developing and emerging countries. This was the main message of WRF 2012, held in Beijing, China, from 21 to 23 October 2012, with the support of the Chinese Academy of Sciences (CAS). Over 700 participants coming from more than 50 countries discussed this and other priority issues.

Better international resource governance, they concluded, is beneficial for all, since it leads to more stability and lower prices. Establishing a neutral international platform for resources comparable to the existing International Energy Agency (IEA) should be considered. Unlike the IEA which was built up by OECD countries, this platform should from the start involve developing and emerging countries, such as China. The recommendation is part of the chairman's summary, which along with a full meeting report and all presentations can be accessed online.[10]

There was consensus that the topic of resources and environment is a common problem facing all countries in the world, with serious challenges for economic development, consumption and production patterns, and poverty eradication. Scarcity of resources, increasing prices, and unsustainable use of resources can hinder economic development, lead to poverty and social unrest and poses risks for global stability.

The Chinese approach of a harmonisation of economy and ecology, and similar international initiatives by other countries, need to be implemented and followed by all. Phasing out or drastically diminishing dependencies on fossil fuels, in particular

[10] See www.worldresourcesforum.org/WRF-2012

the global economy's addiction to oil and coal, was considered to be technically and economically feasible for the next decades, with each country choosing its own path. Policies for sustainable resource management and changing consumption and production patterns need to be based upon solid research, not only engineering but also behavioral oriented scientific findings.

Cities were seen as very important actors of change for decoupling strategies, as well as for preserving biodiversity and increasing the quality of life for its citizens at the same time.

As can be concluded from the recent WRF conferences, resource challenges and the necessity to implement a resource-efficient green economy is gaining increasing attention. New ways of interdisciplinary joint research as well as policy making and governance options have been suggested. Particular attention needs to be paid to accelerating the integration of scientific research and findings in global policy programs, which will continue to be discussed in the next annual conferences as well as targeted workshops, held in Davos, Switzerland, and throughout the world.

References

Bringezu S, Bleischwitz R (2009) Sustainable resource management – global trends. Visions and Policies, Sheffield

Krausmann F, Gingrich S, Eisenmenger N, Erb K-H, Haberl H, Fischer-Kowalski M (2009) Growth in global materials use, GDP and population during the 20th century. Ecol Econ 68(10):2696–2705

OECD (ed) (2008) Measuring material flows and resources productivity. Synthesis report. Online: http://www.oecd.org/dataoecd/55/12/40464014.pdf. 11 Oct 2011

SERI (2010) Global material flows database. Trends in global resource extraction, GDP and material intensity 1980–2007. Online: http://www.materialflows.net/index.php?option=com_content&task=view&id=32&Itemid=48. 12 Oct 2011

SERI and GLOBAL (2009) Overconsumption? Our use of the world's natural resources. Online: http://old.seri.at/documentupload/SERI%20PR/overconsumption--2009.pdf. 11 Oct 2011

UNEP (2010a) Assessing the environmental impacts of consumption and production. Priority Products and Materials. Online: http://www.unep.org/resourcepanel/Portals/24102/PDFs/PriorityProductsAndMaterials_Report.pdf. 12 Oct 2011

UNEP (2010b) Metal stocks in society. Scientific Synthesis. Online: http://www.unep.org/resourcepanel/Portals/24102/PDFs/Metalstocksinsociety.pdf. 12 Oct 2011

UNEP (2010c) Resource panel. Introduction. Online: http://www.unep.org/resourcepanel/Introduction/tabid/54040/Default.aspx. 13 Oct 2011

UNEP (2011a) Decoupling natural resource use and environmental impacts from economic growth. A report of the Working Group on Decoupling to the International Resource Panel. Fischer-Kowalski M, Swilling M, von Weizsäcker EU, Ren Y, Moriguchi Y, Crane W, Krausmann F, Eisenmenger N, Giljum S, Hennicke P, Romero Lankao P, Siriban Manalang A. Online: http://www.unep.org/resourcepanel/decoupling/files/pdf/Decoupling_Report_English.pdf. 12 Oct 2011

UNEP (2011b) Recycling rates of metals. A status report. Online: http://www.unep.org/resourcepanel/Portals/24102/PDFs/Metals_Recycling_Rates_110412-1.pdf. 12 Oct 2011

United Nations Department of Economic and Social Affairs/Population Division (2010) World population prospects: the 2010 revision. Online: http://esa.un.org/unpd/wpp/Analytical-Figures/htm/fig_1.htm. 12 Oct 2011

Chapter 16
From Resource Efficiency to Responsible and Dematerialized Societies

Matthias Koller and Jens Günther

16.1 The Policy Landscape – Where We Are

As far back as 1713,[1] the German Johann Carl von Carlowitz described the necessity of a regardful and careful handling of nature and its resources in his publication Sylvicultura oeconomica[2] as a direct reaction on the wood scarcity and high degradation of forests at this time. Today his work on forestry within the natural regeneration capacity is seen as the starting point of the term "sustainability". In 1798, the British economist Thomas Malthus recognized that population growth and the increased production of the means of substances might not have the same pace and suggested the inevitability of a hunger crisis.[3] To tackle this, he already supported measures as we discuss today, like duties on imported resources to boost domestic production and guard against the dependency on foreign states. These are just two examples showing that resource scarcity and the overuse of natural resources, exceeding the natural regeneration capacity, are not new phenomena in politics.

With its prominent publication Limits of Growth[4] the Club of Rome brought back the discussion on finite resources as limiting factors on economic development on the political agenda, whereas the starting point of our today's discussion on the sustainable use of natural resources was set on the Earth summit 1992 in Rio de Janeiro. Here, politicians worldwide recognized the problem of an unsustainable use of natural resources and started various initiatives to tackle this. On the world

[1] Independently from the developments in Germany the Concept of a sustainable forestry had already evolved in Japan at the end of the seventeenth century, see e. g. http://de.wikipedia.org/wiki/Nachhaltigkeit_%28Forstwirtschaft%29#Die_eigenst.C3.A4ndige_Entwicklung_in_Japan

[2] Carlowitz (1713).

[3] Malthus (1977).

[4] Meadows et al. (1977).

M. Koller (✉) • J. Günther
Federal Environment Agency (Germany), Wörlitzer Platz 1, 06844, Dessau-Roßlau, Germany
e-mail: matthias.koller@uba.de; jens.guenther@uba.de

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_16,

summit on sustainable development in Johannesburg in 2002 the protection of our natural resources was set as the basis of all our economic activity and therefore as a fundamental principle of sustainable development. Currently this was assured at the Rio+20 conference in Rio den Janeiro in 2012. In the final declaration "The future we want" 191 states agreed on the concept of a Green Economy, for which a sustainable and efficient management of the natural resources is essential. With respect to these high level and meaningful conferences on nearly all levels from international to local, various policy initiatives with relevance to natural resources were started and sustainable use of natural resources is continuously rising on the political agenda.

Although all of these manifold initiatives, strategies and processes are addressing the sustainable use of natural resources in one way or another, their main foci differ. The first cluster is characterized by embedding sustainable use of natural resources, resource protection or a sustainable resource management as an important pillar of sustainable development and future growth in an overall strategy and is therefore directly linked to the Earth summit in 1992. The Agenda 21 document, the Marrakesh process on sustainable consumption and production, most of the national sustainable development strategies worldwide as well as the different green growth strategies under development can be included here for example. The initiatives and strategies in this cluster are setting qualitative, overarching targets on sustainable resource management, but mostly lacking clear visions on how to implement the concept or actual policy measures and quantitative targets on resource use. On the other hand, these overarching processes with its social, ecological and economical dimensions allow system-wide approaches and offer different entry points for policy measures to foster a sustainable resource use.

The activities of the European Union are dominating a second group of initiatives. Based on the agreements of the Earth summit and recognizing the importance of a sustainable resource management for future growth, the EU started several initiatives and strategies to implement a sustainable use of natural resources: the Gothenburg Strategy,[5] the sustainable development strategy of the EU, in 2001, the Thematic Strategy on sustainable use of natural resources[6] in 2005 and the flagship initiative "A resource-efficient Europe",[7] one of the seven flagship initiatives under the Europe 2020 strategy. The detailed implementation of the flagship initiative is described in the "Roadmap for a resource-efficient Europe".[8] All these documents underline the need for a sustainable use of natural resources for a sustainable growth of the EU and to secure our well-being today and in future. They tackle a wide range of natural resources including raw materials, energy resources, land, soil and water. Although all strategies include actual policy measures and visions, the Roadmap for a resource-efficient Europe provides the most detailed set of instruments including some targets and indicators.

[5] COM (2001) 264.

[6] COM (2005) 670.

[7] COM (2011) 21.

[8] COM (2011) 571.

The third cluster of initiatives is narrowing the sustainable use of natural resources mostly to raw materials, but therefore offers also the most concrete set of policy implementation. The main principle “Reduce, Reuse, Recycle” in this cluster is described for example in the 3R-Initiative of the G8. Along the whole product chain several policy measures should reduce the material input to the economy and increase the proportion of reused products and recycled materials. This policy approach is described by the OECD as “Sustainable Materials Management (SMM)” and represents the different impacts of the raw material production or harvesting (source of material), material processing along the production chain and the end of life of products. The OECD SMM policy approach can be classified by natural resource policies addressing raw material extraction or harvesting, product life cycle policies dealing with material flows in the industrial and societal systems and waste management policies addressing the end of life of products.[9]

On the national level the SMM approach is used for example in Germany or Austria. The Germany Government adopted in February 2012 the German Resource Efficiency Programme (ProgRess).[10] The goal of ProgRess is to structure the extraction and use of natural resources in a sustainable way and to reduce associated environmental pollution as far as possible. Based on four guiding principles for a global sustainable resource management, the programme identified 20 strategic approaches from securing a sustainable raw material supply, raising resource efficiency in production, making consumption more resource-efficient, enhancing resource-efficient closed cycle management and using overarching instruments.

Nearly all of the strategies and programmes following the main policy approach of a sustainable materials management describe the implication of our consumption levels, relate the steady increase of resource consumption with the supposed locked-in in a perpetual economic growth and see an important trigger for resource conservation in a transition into “dematerialized” society. But most of them are only focusing on technical approaches for the efficient use of resource in production and product policy, whereas just a few provide also detailed policy measure on e.g. change behaviour or a reduction of consumption.

16.2 Challenges

> We have a decade to act before the economic cost of current viable solutions becomes too high. Without action, we risk catastrophic and perhaps irreversible changes to our life-support system. (Ostrom 2012)

Despite the above described political activities on national and international level, the natural resources are still exploited and managed in unsustainable ways. Every day 75 million tons of carbon dioxides are emitted into the atmosphere,

[9] OECD (2012).

[10] BMU (2012).

350,000 tons of fish caught, 20,000 ha of arable land converted or deteriorated, up to 100 species extinct and 50,000 ha of forests destroyed.[11] In the last century the size of global social metabolism has increased by a factor eight with a transition from the dominance of renewable biomass towards mineral materials.[12] The extraction of construction materials grew by a factor of 34, ores and minerals by a factor of 27, fossil fuels by a factor of 12 and biomass by a factor of 3.6.[13] A relative decoupling can be observed within some countries following very different development paths,[14] but no absolute reduction as extraction and consumption grow faster than improvements in resource productivity. The overarching objective to reduce resource consumption and the associated environmental pressures in a way that the ecological boundaries are fully respected and without jeopardizing the welfare of present or future generations is within the current policies out of reach.[15] That would imply an absolute decoupling of resource consumption from the development of the economy and an absolute reduction of the environmental impacts caused by resource consumption. The decoupling report of the UNEP states that such a (absolute) decoupling will require significant changes in government policies, corporate behaviours and consumptions patterns by the public.[16]

Still fundamental questions like the followings are so far not sufficiently addressed:

- To whom belong the natural resources in a globalized world and which institutions and policy settings we need to manage them accordingly?
- How can we achieve a fair distribution of natural resources and the access to them within the current generations but also with respect to future generations?
- What means well-being for humankind with respect to resource use and which material standards for living are globally feasible within the planetary boundaries[17]?
- What levels of sufficiency are imposed on mankind by living within the ecological boundaries and how would the economic systems then look like on national and supranational level?
- Which priorities must be taken when managing limited resources to make sure that basic human needs like food, safe water, housing, closing an mobility are fulfilled?
- How should resource policies be connected accordingly with other policies to avoid unwanted side effects and how can conflicting interests be solved in a peaceful and constructive way?
- What balance do we need between resource efficient and resilient infrastructures?

---

[11] Sources: OECD (2008), Meadows et al. (2004).

[12] Krausmann et al. (2009).

[13] UNEP (2011).

[14] For more details see UNEP (2011) and Dittrich et al. (2012).

[15] We suppose that in Germany a reduction of resource use at least by a factor of 10 by 2050 is necessary in order to achieve a level of 6–10 tons per capita and year, which seems acceptable according to current knowledge; for more details see Chap. 3.

[16] UNEP (2011).

[17] Rockstroem et al. (2009).

On the policy level, one of the biggest challenge for designing effective resource policies seems to be to find the right balance between more single resource specific implementation orientated approaches, which risk to be too narrow and too much focused on single aspects, such as resource efficiency and broader concepts which deal with the inter-linkages between the various natural resources and integrate all aspects of sustainability, but risk to be too general, complex and not being suitable for implementation. In the following section we outline some building blocks, which we think are essential for a more fundamental change towards a society which manages their natural resources in a sustainable way.

16.3 Building Blocks for a Responsible and Sustainable Resource Management

16.3.1 Getting Fair, Responsible and Just

The history of anthropogenic use of natural resources has been in many cases a history of depletion of non-renewable resources, of the irreversible destruction of ecosystems, of the violation of human rights, of wars and armed conflicts, of unfair distribution of the revenues, of an organized irresponsibility and ignorance of the needs of current and future generations, of an “don’t see, don’t hear, don’t talk” approach of all the relevant stakeholders.

Whereas most countries have committed themselves to the concept of sustainable development and its basic idea that the needs of the present should be met without compromising the ability of future generations to meet their own needs,[18] the mankind depletes and disperses resources that nature has build up and accumulated over millions of years within a few generations. As future generations cannot have a saying and voting now, it’s about us to give them a voice and not to limit their options by restricting their access to the richness of natural resources. The concept of strong sustainability which argues that the stock of natural resources and ecological functions are irreplaceable has therefore to be deeply anchored in the way we manage the natural resources. “Leave the earth as reach as you have found it” could and should be a general maxim for every generation for dealing with natural resources. As this won’t happen by itself, guardianships who take care of the interests of future generations should be institutionalized. These stewards should have a saying when decisions to which degree natural resources are exploited, are taken.

Besides taking care of possible needs of future generations a more even distribution of resources and its benefits amongst the current living generations has to be achieved. Currently roughly three quarter of the global raw materials are consumed by just 20 countries, whereas the 100 countries with lowest material consumption

[18] UN (1987).

used together only 1.5 % of the global material extraction.[19] But in a world with limited resources the overconsumption in the industrialized world is limiting the possibilities and chances of less developed countries. To give the developing countries a chance to meet their increasing material needs, the industrialized countries have to reduce their resource consumption at least by a factor 5.[20] With respect to a fair distribution of the revenues of the resources the terms of trades between resource importing and resource exporting countries should comply with internationally agreed high standards of mutual fairness and a readiness by the industrialised countries to support the less developed countries in building up their own industries and by this enabling them to get a higher share of the revenue generated along the value chain. International trade policies and initiatives like the 'General System of Preferences' (GSP)[21] and 'Everything but Arms' (EBA)[22] should be maintained and further developed according to the needs of the developing countries and not be used a political weapon against the respective countries in case of trade disputes.

Trade importing countries and its public and private enterprises must also be aware of their responsibility for the possible impacts of their activities on the environment and on human right issues (human rights due diligence). The import of resources must not endanger the environment and ecosystems or destroy the livelihood of the people in those countries. By doing so, it can reduce the risk of resource motivated regional conflicts and provide stimuli for a peaceful and sustainable development in the supplier countries. This must also include the questions of occupational health and safety and child labour. The extraction and processing of resources has to go hand in hand with development of transparent and participatory concepts and regulations which improve the living conditions of the people substantially and with a long term perspective. All countries should comply with the 'Guiding Principles on Business and Human Rights: Implementing the United

[19] Dittrich et al. (2012).

[20] UNEP (2011), Dittrich et al. (2012).

[21] Under GSP schemes of preference-giving counties, selected products originating in developing countries are granted reduced or zero tariff rates over the MFN rates. The least developed countries (LDCs) receive special and preferential treatment for a wider coverage of products and deeper tariff cuts (source: http://unctad.org/en/Pages/DITC/GSP/About-GSP.aspx)

"… the objectives of the generalized, non-reciprocal, non-discriminatory system of preferences in favour of the developing countries, including special measures in favour of the least advanced among the developing countries, should be:

(a) to increase their export earnings;
(b) to promote their industrialization; and
(c) to accelerate their rates of economic growth." (Source: Resolution 21 (ii) taken at the UNCTAD II Conference in New Delhi in 1968).

[22] In February 2001, the EU Council adopted Regulation (EC) 416/2001, the so-called "EBA Regulation" ("Everything But Arms"), granting duty-free access to imports of all products from LDCs, except arms and ammunitions, without any quantitative restrictions (with the exception of bananas, sugar and rice for a limited period), for more details see http://ec.europa.eu/trade/wider-agenda/development/generalised-system-of-preferences/everything-but-arms/index_en.htm

Nations "Protect, Respect and Remedy" Framework'[23] which were endorsed on 16 June 2011 by the UN Human Rights Council. By these guiding principles for the first time a global framework for the implementation of the protection obligation of the state and of the corporate responsibility with respect to business and human rights was created. This may include efforts of the importing states and enterprises to take care that in the supplying countries good governance is build up and strengthened, that rights and livelihood of the local and indigenous populations are protected and that environmental and social standards are supported. The state should only award exports credits, investment guarantees and untied loans when enterprises can prove that impact assessments on the environment and on human rights have been conducted which must be certified by independent experts. Enterprises should also comply with ISO 26000[24] which give guidance how enterprises can comply with the requirements of corporate social responsibility.

16.3.2 Changing Institutions and Institutional Standards

To enable a transformation towards a sustainable management of resources the economic, financial, education and legal framework must be changed in a way that a sustainable resource use will be better rewarded by the market and the society. This may require as well a change of the institutional settings as a change of culture within the institutions.

16.3.2.1 The Policy Framework

The sustainable use of natural resources is a global task and cannot be handled only at a regional or a national level. And some natural resources such as the climate, the atmosphere, the oceans and the rainforests are already increasingly acknowledged as global goods which are or should be managed and taken care of by international institutions and international conventions and regulations. But especially raw materials are still mostly considered as an national issue and asset. This could lead to

---

[23] Source: A/HRC/17/31. These Guiding Principles are grounded in recognition

(a) States' existing obligations to respect, protect and fulfil human rights and fundamental freedoms;
(b) The role of business enterprises as specialized organs of society performing specialized functions, required to comply with all applicable laws and to respect human rights;
(c) The need for rights and obligations to be matched to appropriate and effective remedies when breached

and apply to all States and to all business enterprises, both transnational and others, regardless of their size, sector, location, ownership and structure. For further information see also http://www.business-humanrights.org/Home

[24] ISO 26000:2010. Guidance on Social Responsibility.

discrimination of those countries, which depend on imports of these resources and could cause violent conflicts and wars when these countries want to make sure that they have sufficient access to these resources.[25] As few countries produce all of the raw materials required for use in their industries, it is imperative that global standards are established for the fair and sustainable trade of these resources. One approach could be to further investigate if the concept of common goods could be successfully applied to the management of raw materials. Research by Ostrom[26] and other has shown that goods can be very fairly and effective managed when certain rules[27] are observed and the necessary institutional settings are available. But especially the policy field of raw materials is characterized by a startling lack of international regulation. And while there are already multilateral environment agreements and various international organisations a high level umbrella institution that is coordinating them is still missing. This role could be filled out by establishing a United Nations Environmental Organization (UNEO) as it was proposed after the 58th meeting of the UN General Assembly by the member states of the European Union to transform the UNEP into the United Nations Environmental Organization. A strong UN Organisation would have a better standing to systematically pool the scientific knowledge on sustainability and environmental issues and help to define global environmental strategic guidelines.

This could also include activities on the development of internationally accepted framework agreements[28] and sustainability and transparency standards and corresponding certification procedures and processes. The current practice of bilateral resource partnerships has to be watched carefully as their main purposes are to establish exclusive access on land and strategic resources as rare metals. Also the role of existing international organisation of high relevance like the WTO[29] should

---

[25] Especially as some of these raw material such as rare earth metals are of high strategic importance for industrialized economies.

[26] See among other Ostrom (1990) und Ostrom and Hess (2006).

[27] Ostrom (1990):

- Clearly defined boundaries (effective exclusion of external un-entitled parties);
- Rules regarding the appropriation and provision of common resources that are adapted to local conditions;
- Collective-choice arrangements that allow most resource appropriators to participate in the decision-making process;
- Effective monitoring by monitors who are part of or accountable to the appropriators;
- A scale of graduated sanctions for resource appropriators who violate community rules;
- Mechanisms of conflict resolution that are cheap and of easy access;
- Self-determination of the community recognized by higher-level authorities;
- In the case of larger common-pool resources, organization in the form of multiple layers of nested enterprises, with small local CPRs at the base level.

[28] As e.g. recommended by the German Advisory Council on the Environment (SRU) with respect to raw materials (SRU 2012).

[29] For a critical discussion how the WTO could better pursue its commitment to sustainable development see Cosbey (2009).

be critically discussed with respect to how they could better enable a sustainable management of natural resources.

But also at the local, regional and national level the political institutions should be transformed in a way, that the concepts of sustainability and of sustainable resource management are taken into consideration in all relevant policy processes and that instead of a single or few overarching binding agreements there is a variety of overlapping policies at city, sub-national, national, and international levels, which is then more likely to provides essential safety nets should one or more policies fail.[30]

Numerous laws and regulations have direct or indirect impacts on resource efficiency but don't address resource efficiency explicitly.[31] Therefore, when developing new or revising existing regulations, the governments should ensure that the concept of sustainable use of natural resources is integrated in an adequate way. The observance of human rights should be anchored as extraterritorial duty of states. The governments should also think about issuing a specific 'resource conservation' law, which could define general aspects of a sustainable use of natural resources like principles, objectives and terms and also include cross sectional approaches and instruments. That may include the obligation for the governments to report regularly on measures taken to ensure a sustainable management of natural resources.

16.3.2.2 The Financial and Economic Sectors

The financial and economic sectors have to be aware of its responsibility for a sustainable management of natural resources[32] too. But so far especially in the financial sector sustainable resource use is only of minor importance. When it comes e.g. to evaluate the performance of enterprises, the relevant indicators so far don't reflect whether the enterprise is taking care of a sustainable resource management. Therefore it is important to establish responsible and sustainable use of resources as a key decision factor for investors within the financial sector and to develop resource related behaviour standards and certificates like developed within the Kimberley process,[33] the extractive Industry transparency Initiative (EITI)[34] or laid out in the sections 1502–1504 of the of the so called Dodd-Frank Act[35] which could provide a guidance for evaluating and monitoring, how far an enterprise is taking care of sus-

[30] A.o. see Ostrom (2012).

[31] In Germany e.g. the Federal Mining Act (Bundesberggesetz), Regional Planning Act (Raumordnungsgesetz), Environmental Audit Act (Umweltauditgesetz), Construction Products Act (Bauproduktegesetz), EIA-Act (UVP-Gesetz).

[32] For an impressive case study on the dubious role of Switzerland as a hotspot for the trade of raw material commodities see Erklärung von Bern (2011).

[33] See http://www.kimberleyprocess.com/

[34] http://eiti.org/

[35] Dodd-FrankWall Street Reform and Consumer Protection Act. Section 1502: Conflict Minerals; Section 1503: Reporting requirements regarding coal or other mine safety; Section 1504: Disclosure of payments by resource extraction issuers.

tainable resource management. Sustainable resource use related key performance indicators (R-KPIs) could serve as a basis for assessment and decision-making processes within the financial sector. They could be used at the various levels within the financing system in order to integrate resource issues in the daily work of financial service providers. These standards and R-KPIs should also be used by the financial supervisory authorities in further developing the legal rules for the risk management and ethical behaviour carried out by financial service provider sand could also be fed into international processes for the regulation of financial markets (e.g. Basel III) and be an obligatory part of business reporting. Also a stronger regulation of over-the-counter-trade in speciality metals as well as safeguards against anti-competitive practices could help ease market tensions and bottlenecks.[36] Generally the trade system should contribute to correct the imbalance between rich and poor countries, to reduce the problem of exclusion and social marginalization, to promote good governance and the rule of law and to return the use of natural resources and ecosystems to sustainable levels.[37]

Economic instruments like environmental taxes have become a regular part of economic and environmental policies. They may have steering effects and give stimuli for a more efficient management of natural resources. Taxes induce higher costs at first but lead in the medium term to an increase in efficiency, innovation rate and competitiveness of enterprises. With respect to natural resources, enterprises become less dependent on raw materials and are less threatened by insecurities of supply and/or volatile prices. As the building and construction sector is very resource intensive, a first approach could be to impose a tax on the extraction and import of primary construction materials, a measure which produced very positive results in Great Britain (EEA 2008). The use of primary construction materials such as sand, gravel and crushed rock has a massive direct and indirect environmental impact along the entire value chain. Imposing a tax on primary construction materials supports a shift to secondary materials.

Often state subsidies hamper a sustainable and efficient use of natural resources by stimulating the consumption of resources.[38] In Germany the state promotes for example saving for building purposes by means of the home building bonus (Wohnungsbauprämie), the employee savings allowance (Arbeitnehmer-Sparzulage) and the Home Ownership Pensions Act (Eigenheimrentengesetz). These subsidies increase the incentive to build individual homes favour and therefore may cause higher resource consumption than the refurbishment of existing buildings. Another example is a distance-based income tax deduction for commuters. Employed persons can set off expenditure on journeys to and from work against income tax as a business expense. The loss of tax revenue due to the distance-based tax allowance amounts to €4.350 billion (Umweltbundesamt 2011). This offers incentives to live

[36] Lee et al. (2012).

[37] Cosbey (2009).

[38] A report of the German Federal Environment Agency indicates that the total volume of environmentally harmful subsidies amounted to around 48 billion EUR in 2008 (Umweltbundesamt 2011).

in the countryside and causes additional resource consumption (e.g. fossil resources for commuting and land use). Governments should therefore systematically identify all subsidies that directly or indirectly contribute to the squandering of natural resources in order to reduce and/or abolish those subsidies.

16.3.2.3 Strengthening Education, Research and Transfer of Technology and Knowledge

Governments should support education systems in particular, since today's children and students will not only be tomorrow's leaders and relevant stakeholders in science, politics and industry but will also have – as consumers – the highest impact on future resource consumption patterns. Education in sustainable management of natural resources should therefore already start in the childcare systems and be more explicitly addressed in secondary schools and universities. Especially engineering students should be systematically trained in environmental issues during their studies, e.g. by attending courses at a "virtual resource university".[39] The realization of a dematerialized society needs a sound scientific understanding of the underlying complex issues, which requires research and explorations in many directions. Engineers must investigate the potentials and possibilities for more resource efficient products and production processes along the whole value chain and for substituting scarce or environmentally harmful materials and substances by more abundant or less problematic ones. Social scientists should explore how the necessary cultural and social transformation can be initiated; economist should identify the necessary economic framework conditions. Ecologists and natural scientists could provide a better understanding of the impacts of the exploitation and use of natural resources. Another important aspect is the management of existing knowledge. Governments should support initiatives and institutions which collect information about research projects, approaches, instruments and best practice examples concerning resource efficiency and make it available in a user-friendly way.

Research results and expertise must also be transferred to operational level of enterprises. However for many enterprises it is very challenging to cope with such complex issues as the sustainable management of natural resources. Especially small and medium enterprises often lack the necessary information and know-how as well as financial and technical capacities. They need support and external competence to further increase resource efficiency within their processes and products. On a national level the governments should therefore continuously seek dialogue with industry and further extend and strengthen existing networks and institutions for resource efficiency, to build up where appropriate institutions for resource efficiency competency and systematically train and qualify intermediaries. Regionally and locally based consultants should go to enterprises to help them to identify paths

[39] The idea behind the concept of a virtual resource university is to a create synergy potential by networking of existing research units working on the subject of resource efficiency. Such a network could e.g. develop, initiate and carry out joint interdisciplinary research projects.

for a more sustainable resource management which shouldn't be limited to efficiency improvement but also include stimulating awareness and responsibility for the social and environmental issues. These consultants should be continuously further trained to make sure they always provide state of the art expertise. Enterprises also can profit by cooperating within resource efficiency networks where they can exchange information and experiences as for most entrepreneurs, the most convincing examples are other entrepreneurs who have successfully moved.

16.3.3 Integrated Approaches – The Nexus

Resource policy is a cross cutting issue with many links to other, not only environmental, policies. The nexus approach explores the complex inter-linkages between various resources such us renewable resources, land and soil, water, climate and biodiversity. It provides a more integrated view and allows a better understanding of resource-related questions that would be difficult to answer in the more traditional pillared approach.[40] And it integrates the various environmental policies and approaches in a way that conflicts between the different objectives are reduced to an unavoidable minimum and advantage is taken of potential synergy potentials as far as possible. A prominent example is the conflict between food, feed, fuel and fibre. The increasing demand for food and other biomasses for energetic or material use intensify the pressure on land use and other natural resource with critical ecological and social consequences. Already today agriculture contributes around 15 % of the total greenhouse gas emissions. A further expansion of land use for agriculture will induce a further loss of forest ecosystems, additional greenhouse gas emissions and increase the pressure on biodiversity and on the buffering capacity of soil, water and air. NO_2 emissions, land degradation, scarcity of water supply, salination are typical consequences of a non sustainable land use which not only impose additional pressure on ecosystems but also endanger the base for human food. But an use of land and biomasses which doesn't properly take care of the basic needs of human cannot be considered sustainable, even if done in a resource efficient way.[41] Another example is the use of renewable energy like wind energy. In many countries the use of wind energy can contribute considerably to a renewable energy supply and by this support climate protection. But the provision of the necessary resources for the wind energy plants such as steel, concrete, copper and rare metals induces additional pressure on the environment such as recession of ground water levels, acidification of soils, ground subsidences, erosion and destruction of habitats.

Therefore all measures and approaches for a sustainable use of resources must be mutually checked for their impacts on and consistency with other policies and follow a better policy approach as described by the OECD: "Better policies should be

[40] Andrews-Speed et al. (2012).

[41] Umweltbundesamt (2012).

based on sound evidence and a broad focus: not only on the peoples income and financial conditions, but also on their health, their competencies, on the quality of the environment, where they live and work, their overall life satisfaction. Not only on the total amount of the goods and services, but also on equality and the conditions of those at the bottom of the ladder. Not only on the conditions "here and now" but also those in other parts of the world and those that are likely to prevail in the future."[42] Likewise it is necessary that other policies like economic policy, development policy, foreign policy take the aspects of sustainable resource management adequately into consideration.

16.3.4 Sustainable Resource Use in the Practice of Daily Life

16.3.4.1 Social Innovations, Models of Change

The social trends of consumption are still moving in the wrong direction, because the individual concepts of well-being are not adequately connected with the objectives of resource protection and a healthy environment. Therefore, a fundamental cultural transition will be a necessary key towards a sustainable use and management of natural resources. Promoting such kind of a cultural transition requires new approaches within environmental policy, which are based on social innovation and new forms of environmental communication. Social innovations are often bottom-up processes and promoted and supported by civil society. The governments should establish and support structures which enhance and facilitate e.g. cooperation and networking for new ways of sharing products and services such as car sharing, second-hand services, swap shops and pioneer resource efficient civil society projects and transition communities.

16.3.4.2 Sustainable Consumption

Consumers influence the resource consumption of products from purchase to disposal. It's the buying decision of the consumer that finally decides on the economic success of green and resource efficient products. Distributors/retailers are a decisive link between producers and consumers and must assume the task of enabling the consumer to become a "green consumer", e.g. by better cooperation through consumer information systems such as eco-labelling, by a better placement of resource efficient products and by promoting and offering consumer friendly take back systems. As more and more goods are sold via e-commerce systems these actions must also address electronic trade platforms with specific approaches. Resource policies should stimulate and support the extension of consumer counselling services, the

[42] See OECD (2011).

further development of product information systems and the inclusion of sustainable resource use related aspects in existing environmental labels like the EU eco-label or the labels of the Forest Stewardship Council and the Marine Stewardship Council.

16.3.4.3 Communication and Awareness Rising

To build up dematerialized societies is a task which requires the engagement of the whole society. It's not only a question of optimizing the exploitation and management of resources and increasing the resource efficiency of production processes and products, it's also question of how we live and what kind of material wealth we aspire. Communication about resource efficiency must therefore address all the relevant stakeholders (including the general public) by target group specific approaches. The communication should be connected with and attuned to ongoing and future communication measures on other relevant environmental issues like protection of biodiversity and climate protection as well as to the discussion on green economy and sustainable lifestyles. As any communication campaign requires a considerable amount of financial and human resources, priority target groups and measures should be identified.

16.4 Outlook

A world in which the natural resources a managed and used in a sustainable way will be very different from the one we currently know, and it will be a world where humans have learnt, that with limited resources an economy which builds on concepts of unlimited growth is not feasible, even when we achieve a higher level of dematerialisation, efficiency and consistency.[43] It will be a world, in which sufficiency is not a concept politicians and economist don't dare to talk about, but a broadly accepted target for societies, which want to move forwards towards sustainability. Reducing resource use in absolute terms won't be possible by measures aiming only at increasing resource efficiency and productivity. In order to avoid efficiency gains being offset by an increased demand for resources and goods more paths towards dematerialized societies have to be developed.

Giving our lifestyle a more sustainable direction will require a higher awareness of and sensitivity for the issue of sustainable resource use as well as a fundamental cultural change. As long as we need material goods as positioning goods and for building up our self-esteem, we won't get on a sustainable track. To get sustainable resource management deeply anchored in the social and economic society a new attitude towards the natural resources is necessary, from ownership to stewardship, a new way of sharing responsibility for global well being and justice, new

[43] See a.o. Meadows et al. (1977), Paech (2005), Jackson (2009).

perspectives on sustainable global economy as an ecommony,[44] new policies with integrated approaches instead of sectoral approaches which don't take care of the mutual inter-linkages and cross-impacts. We need not only smarter and more resource efficient material infrastructure and less resource consuming business models but also new mental infrastructures,[45] which prevent us from continuing to fix the problems by the means, which caused and created them. A change of the way we think and act towards a more sustainable resource use needs inspiration by good practice examples, needs front runners and courageous people who show that more sustainable ways of living are not only possible but also fulfilling and joyful. It needs societies which encourage their citizens to participate and to explore new ways, it needs open spaces and time to experiment with less materialized lifestyles.

It is still unclear how the political, social, cultural and economic system in such world could look like and how we will get there. But at least we have rough guidance in which direction we have to walk and we can expect that the road becomes clearer as long as we are walking.

References

Andrews-Speed P, Bleischwitz R, Boersma T, Johnson C, Kemp G, VanDeveer S (2012) The global resource nexus – the struggles for land, energy, food, water, and minerals. Transatlantic Academy, Washington

BMU (2012) Federal ministry for the environment, nature conservation and nuclear safety. German Resource Efficiency Programme – Programme for the sustainable use and conservation of natural resources. Berlin

Carlowitz HC von (1713) Sylvicultura oeconomica. Anweisung zur wilden Baum-Zucht/Hannß Carl von Carlowitz. – Reprint der Ausg. Leipzig, Braun, 1713/bearb. von Klaus Irmer und Angela Kießling. TU Bergakademie Freiberg und Akademische Buchhandlung, Freiberg

COM (2001) 264. A sustainable Europe for a better world: a European Union strategy for sustainable development

COM (2005) 670. Thematic strategy on the sustainable use of natural resources

COM (2011) 21. A resource-efficient Europe – flagship initiative under the Europe 2020 strategy

COM (2011) 571. A roadmap to a resource efficient Europe

Cosbey A (2009) A sustainable development roadmap for the WTO. Trade and Investment Program. International Institute for Sustainable Development

Dittrich M, Giljum S, Lutter S, Polzin C (2012) Green economies around the world? Implications of resource use for development and the environment. SERI, Vienna

EEA (2008) Effectiveness of environmental taxes and charges for managing sand, gravel and rock extraction in selected EU countries. EEA Report No 2/2008. Copenhagen

Erklärung von Bern (2011) Rohstoff. Das gefährlichste Geschäft der Schweiz. Zürich

Habermann F (2009) Halbinseln gegen den Strom. Anders leben und wirtschaften im Alltag, hrsg. v.d. Stiftung Fraueninitiative, Königstein

[44] Habermann (2009).

[45] Welzer (2011).

Jackson T (2009) Prosperity without growth – economics for a finite planet. Earthscan/Routledge, London/New York

Krausmann F et al (2009) Growth in global materials use, GDP and population during the 20th century. Ecol Econ 68(10):2696–2705

Lee B, Preston F, Kooroshy J, Bailey R, Lahn G (2012) Resources futures. A Chatham House Report

Malthus T (1977) Das Bevölkerungsgesetz. dtv-bibliothek 6021, dtv-Taschenbuch, München (Originaltitel: An essay on the principle of population as it affects the future improvement of society, with remarks on the speculations of Mr. Godwin, M. Condorcet, and other writers, übersetzt von Christian M. Barth)

Meadows HD et al (1977) Limits to growth: a report for the Club of Rome's Project on the predicament of mankind. Universe Books, New York

Meadows D et al (2004) Limits to growth: the 30-year update. Chelsea Green, White River Junction

OECD (2008) OECD-UNEP conference on resource efficiency: opening remarks by Mr. Pier Carlo padoan, OECD Deputy Secretary-General, 23 Apr 2008, Paris, France

OECD (2011) How's life? Measuring well-being. OECD Publishing

OECD (2012) Sustainable materials management: making better use of resources. OECD Publishing

Ostrom E (1990) Governing the commons. The evolution of institutions for collective action. Cambridge University Press, Cambridge

Ostrom E (2012) Green from the grassroots. http://www.project-syndicate.org/commentary/green-from-the-grassroots

Ostrom E, Hess C (eds) (2006) Understanding knowledge as a commons: from theory to practice. The MIT Press, Cambridge, MA

Paech N (2005) Nachhaltigkeit zwischen Konsistenz und Dematerialisierung: Hat sich die Wachstumsfrage erledigt? Natur und Kultur 6/1(2005):52–72

Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin E, Lenton TM, Scheffer M, Folke C, Schellnhuber H, Nykvist B, De Wit CA, Hughes T, van der Leeuw S, Rodhe H, Sörlin S, Snyder PK, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell RW, Fabry VJ, Hansen J, Walker B, Liverman D, Richardson K, Crutzen P, Foley J (2009) Planetary boundaries: exploring the safe operating space for humanity. Ecol Soc 14(2):32

SRU (2012) Umweltgutachten 2012. Verantwortung in einer begrenzten Welt

Umweltbundesamt (2011) Environmentally harmful subsidies in Germany – update 2010. Dessau-Roßlau

Umweltbundesamt (2012) Globale Landflächen und Biomasse nachhaltig und ressourcenschonend nutzen. Umweltbundesamt. Dessau-Roßlau. 99 S

UN (1987) United Nations. 1987. Report of the world commission on environment and development. General Assembly Resolution 42/187

UNEP (2011) Decoupling natural resource use and environmental impacts from economic growth. A report of the Working Group on Decoupling to the International Resource Panel

Welzer H (2011) Mentale Infrastrukturen. Wie das Wachstum in die Welt kam. Schriftenreihe der Heinrich-Böll-Stiftung. Band 14

Chapter 17
About the Need of Resource Efficiency Programs: The Editors' View

Michael Angrick, Andreas Burger, and Harry Lehmann

Climate protection has come to be a principal public concern in many countries of the world. Policymakers have realized that taking action is a necessity if a climate catastrophe is to be prevented. It took far more than two decades to gain this insight. There are still significant barriers, and unfortunately, the outcome is uncertain. However, it also has been clear for a long time that environmental protection is a good deal more than just climate protection. The conservation of natural resources is another important module of a comprehensive protection of the environment. In its case, it was not until recent years that public interest in the complex relationships could be won. The aspect of ensuring supplies of raw materials has played a major role for countries poor in resources but having a high demand for them, and it is, of course, of particular importance for a high-tech country such as Germany. It is an irrelevant aspect in terms of an all-encompassing protection of the environment; it can, however, be used as a lever to change minds and attitudes. Protecting natural resources covers much more than establishing security of raw material supplies, which is a country-specific and therefore highly egocentric endeavour. Protecting natural resources means raising the issue of their efficient use and, far beyond that, the issue of our production and consumption patterns and therefore, of our lifestyles. The majority of the public has not (yet) realized that probably we and certainly our children and grandchildren will see major changes. In a few years' time, oil – the raw material our dreams are made of – will not be available on the same scale as it is today, not because politically unstable countries in the Near or Middle East will cut off our supplies, but simply because the reserves will become exhausted. We will see a similar development for a number of other raw materials and yet others will be so scarce that there will be conflicts over access to them. Therefore, it is high time that policymakers take up this issue in all its breadth and depth and make provision to ensure that there will be no conflicts with uncertain outcome or massive

M. Angrick (✉) • A. Burger • H. Lehmann
The Federal Environment Agency, Wörlitzer Platz 1, 06844 Dessau-Roßlau, Germany
e-mail: michael.angrick@uba.de; andreas.burger@uba.de; harry.lehmann@uba.d

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_17,

interventions in our environment in order to make the last reserves of those scarce resources accessible to us. The German Federal Government has in fact embarked on such a course and commissioned the Federal Environment Ministry to develop a "resource protection program", which has been adopted by the Cabinet as "Resource Efficiency Program" (ProgRess) on February, 29 2012.

In its raw materials strategy of 2010, the German Government already promised to launch the development of a national resource efficiency program.

ProgRess provides an overview of existing activities, identifies need for action and describes measures to increase resource efficiency in order to achieve the goal, set in the Sustainability Strategy of 2002, of doubling raw material productivity by 2020 compared to 1994. ProgRess builds on the National Sustainability Strategy und its progress reports and focuses initially on abiotic, non-energy resources and the use of biotic resources for production of materials.

In order to successfully implement the measures addressed in ProgRess, many activities need to be carried out by numerous players in society on their own responsibility, and there must be close cooperation between the political, economic and scientific spheres and, ultimately, the participation of all parts of the population. The program is intended to provide all players with a sound and long-term framework as regards the goals and priorities of sustainable resource use. The implementation of ProgRess will help to preserve the ecological basis of our existence and promote economic capacity, employment, social cohesion and international justice.

Regular evaluation and updating are envisaged to ensure progress and successes under the national Resource Efficiency Program. This will enable early recognition of any need for adjustment and the initiation of targeted modifications. Figuratively speaking, the program as it stands represents version 1.0., i.e. it can be assumed that it will be further developed. Mild or loose phrasing initially contained in the program in the interests of compromise between the ministries can be honed and concretized in later versions.

The German Resource Efficiency Program will be guided by four ideas:

- Resource policy combines ecological necessities with economic opportunities, innovativeness and social responsibility
- Global responsibility is a key theme for a national resource policy
- The dependency of the economy and production in Germany on the consumption of newly extracted raw materials will be lessened gradually and recycling will be improved and increased
- Sustainable resource use will be ensured in the longer term through orientation towards qualitative growth and the dematerialization of lifestyles and production methods.

The program considers the entire value-added chain and formulates approaches for the various elements which, taken together and in interplay with each other, will make an important contribution to the conservation of natural resources.

Internationally, this program will help to bring back Germany's position as a frontrunner of environmental policy.

As early as 1972, global awareness of the issue of resource protection was raised for the first time by the Club of Rome report "The Limits to Growth". Since then, the protection of natural resources has become a high-profile issue at both international and European level. At the UN conference in Rio de Janeiro in 1992, Agenda 21 was adopted, a global development and environment action program for the twenty-first century which identifies the conservation and management of resources as one of its priorities.

The follow-up conference, the World Summit for Sustainable Development in Johannesburg, further addressed the protection of natural resources as an essential basis for sustainable development and gave recommendations for measures and implementation. At the UN Conference on Sustainable Development, to be held in 2012 in Rio de Janeiro, the international community will discuss options for moving towards a "green economy"; resource efficiency will play a key role in these deliberations.

The EU also has sustainable development as an overarching goal which applies to all policy sectors and actions of the Union. The EU Sustainable Development Strategy of 2006 identifies the conservation of natural resources as a key challenge, with the main focus on improving the management and avoiding overexploitation of natural resources.

With its program, Germany will also make an important contribution to the implementation of the European Commission's Thematic Strategy on the sustainable use of natural resources of 2005, which already called on Member States to develop national strategies. Since then, the resource efficiency issue has been gaining in importance in the EU. The Europe 2020 Strategy, adopted in 2010 by the European Council, devotes one of its flagship initiatives to a "Resource-efficient Europe". The goals of this initiative are to decouple economic growth from resource use, encourage the transition to a low-carbon economy, promote energy efficiency and the use of renewable energy sources, and modernize the transport system. In 2011, the European Commission presented a "Roadmap to a resource-efficient Europe" for implementation of the flagship initiative.

Further activities, for instance the World Resources Forum, are seen as good opportunities to develop the communication between countries and to improve the understanding for acting.

It is indeed urgently necessary that efforts at European level towards the conservation of natural resources be stepped up and that the European Union shows that it is prepared to play a role in the world and in global environmental protection that is appropriate to its political weight.

Index

M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6, © Springer Science+Business Media Dordrecht 2014

H

I

P

Q

R