



SOCIO-ECOLOGICAL TRANSITIONS: DEFINITION, DYNAMICS AND RELATED GLOBAL SCENARIOS

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THIS DOCUMENT CONTAINS THE FOLLOWING:

KEY ASSUMPTIONS ON SET / MILESTONE No. 1&2
STATE OF THE ART REPORT No. 6/D 1.1

GLOBAL SCENARIOS / MILESTONE No. 3
WORKING PAPER / D 1.2

APRIL 2012



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Abstract

This report tackles three issues. It outlines an intellectual framework for understanding “socio-ecological transitions” as transitions between different societal energy regimes and co-dependent ecological changes. It is shown that while Europe has completed its “historical” transition into the fossil fuel based industrial regime and has reached an energetic and material stabilization phase (at high levels), its “new” transition, away from fossil fuels, while inevitable in the long run, has just barely begun. At the same time, globally, a number of very large societies right now undergo the “historical” transition, the transition into a fossil fuel energy regime. This creates a very complex situation for Europe’s “new” transition. Secondly, the report analyses, in a radical approach transcending the “green jobs” concept, in which way the “historical” transition has fundamentally transformed human labour, and what can be learned from this, and from changed framework conditions, for labour in the “new” socio-ecological transition. Thirdly, it screens a large array of literature (extensively documented in the appendices to the report) to extract well grounded and so far possible quantitative assumptions about how global framework conditions are evolving, up to 2025 and later. It characterizes six global megatrends, three originating from natural, and three originating from societal drivers, that will impact upon Europe, either in a more “friendly” or more “tough” fashion. Finally, the report sketches possible policy strategies in which way Europe might interpret and pursue the “new” socio-ecological transition; it distinguishes between “no policy change”, “ecological modernization” and “sustainability transformation”. This marks the starting point for a further more detailed analysis by other working groups of the project NEUJOBS, as well as scenario and modelling efforts of the future of human labour in Europe.

Technical note:

This report covers two deliverables namely D.1.1 – State of Art (SoA) report: “Review on socio-ecological transitions and assumptions on socio-ecological key transitions” (addressed in chapters 2, 3 and 4) and D.1.2 – Working Paper (WP): “Global scenarios” (addressed in chapter 4, 5 and the appendices A and B).



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EXECUTIVE SUMMARY

Definition of “socio-ecological transition”

A socio-ecological transition, as used in this project, is a transition between two different societal energy regimes (sources and dominant conversion technologies of energy). Transition is a process starting off from one system state and ending up in another, with typical phases of “take off”, “acceleration” and “stabilization”. Each energy regime is coupled to a particular way of using, and thereby transforming, the natural environment.

For the time horizon under consideration, we see

- a socio-ecological transition from the agrarian regime, energetically based upon solar energy and land-use, to the industrial regime, based upon fossil fuels and a wide variety of conversion technologies (“historical” transition), and
- a socio-ecological transition away from fossil fuels, towards solar and other low carbon energy sources (“new” transition). This transition will inevitably occur, due to the limitations of fossil fuels, but it may be actively accelerated, mainly to avoid catastrophic climate change.

In different parts of the world, both transitions may and actually do occur simultaneously, and they may be driven intentionally or happen spontaneously; in both cases, they enfold their own dynamic and cannot be fully controlled.

In a socio-ecological transition, what is changing is not just the source of energy and technologies, but many other features of society change as well: the economy, the demography, the settlement patterns, the social relations and the very make-up of human personalities. In co-dependence, the natural environment changes, partly resulting from deliberate interventions, partly as unintended side-effects of society’s practices.

NEUJobs makes an effort at anticipating some of the possibly fundamental changes, in particular with regard to the future of labour in Europe, that result both from the long-

term consequences of the “historical” transition, and from the on-going or future “new” transition.

Both the “historical” and the “new” socio-ecological transition are on-going, but at a very different pace. The global trend outcome is highly unsustainable.

On a biophysical level, in terms of energy and materials use, most European countries, but also the USA and Japan, have reached the “stabilization phase” of the “historical” socio-ecological transition and now remain on steady high levels of per-capita material/energy consumption. This phase-shift can be observed since the early 1970s, closely linked to the “oil crisis” of that time. It is not reflected in an equally marked phase shift in GDP. On the biophysical macro-level we are investigating, signs of a “new transition” towards low-carbon energy and reductions of energy/material use are yet sparse.

Simultaneously, a number of (often large) “emerging economies” undergo the “historical” transition from agrarian to industrial at an unprecedented pace. This means they do not only gradually catch up with the high energy/material consumption levels of the mature industrial economies, but also follow their pathway of carbonization of the energy system.

Globally, both trends together result in a dynamic of biophysical growth that is not only fully unsustainable with regard to maintaining the climate targets Europe stands for, but also running up to serious resource constraints already signified in an unprecedented long boom (or continuing rise) of commodity prices. In response to this, UNEP’s International Resource Panel has published scenarios conveying the message that the on-going global convergence of material/energy consumption standards can only realistically happen at half the consumption level of the current mature industrial countries. The conclusion, “current trends cannot be sustained”, resonates through much of the relevant recent literature (WBGU 2011, EEA 2012, UNEP-GEO5 2012, WB 2009).

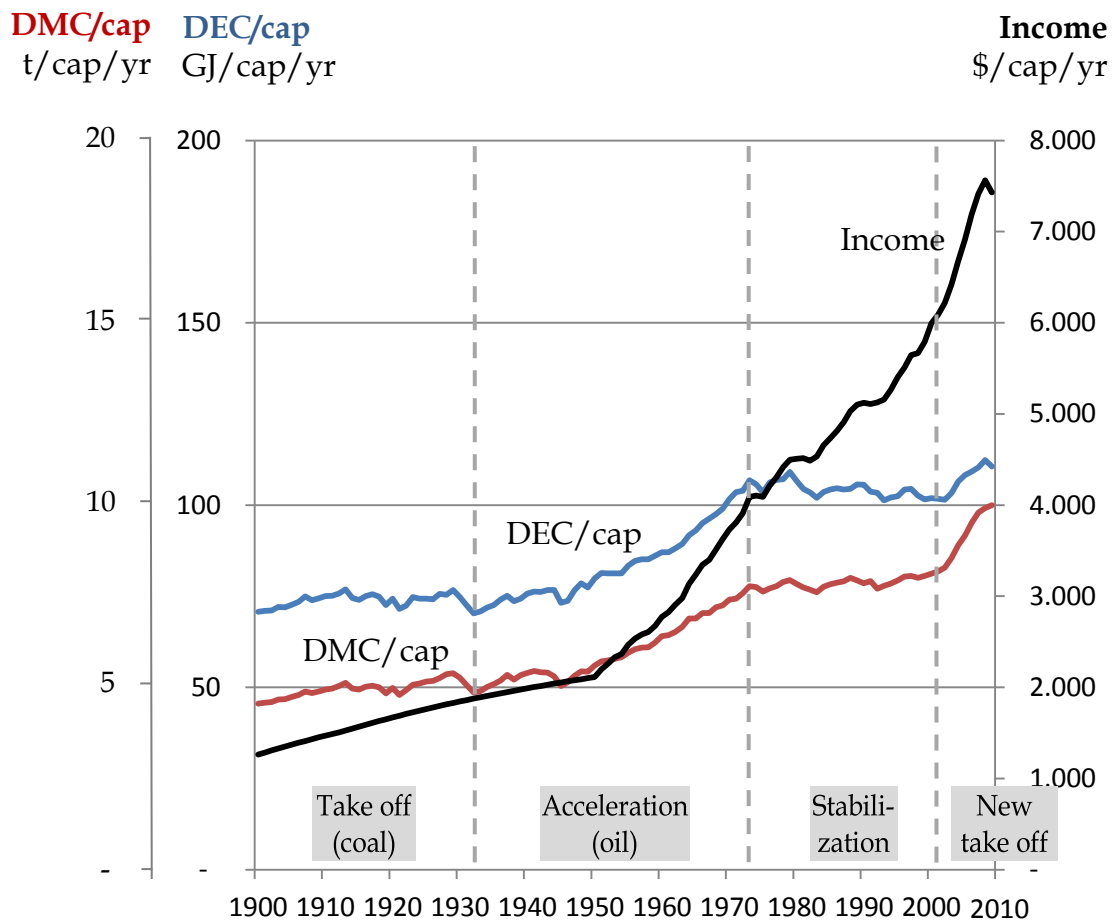


Figure 1: Transition phases of global material, energy and economic growth per capita (in international \$, DMC domestic material consumption, DEC domestic energy consumption = total primary energy supply plus food and feed (Source: SEC Database)

In effect, the challenge of a “new” socio-ecological transition for Europe may not just consist in greening the energy system and further improving efficiency, but be more fundamental in requiring substantial biophysical de-growth. Depending on how it is organized this may still be compatible with comfortable and rich lives, but adaptation to this requires institutional, cultural and economic changes. It is highly uncertain what the appropriate time horizon for such changes will be, and highly uncertain what the alternatives are.

Labour was and will be strongly affected by a socio-ecological transition, much beyond the conceptual grasp of “green jobs”

To our knowledge, this is the first attempt to relate labour to socio-ecological transitions on a more general level. In order to grasp structural change, labour has to be conceived of in all its forms, and be related to human lifetime. Gainful employment, family work and contributions to community life may all be functionally considered as labour and have been completely reorganised in the historical socio-ecological transition.

Qualitative changes: In agrarian society labour mainly relied on human *physical power* and endurance and was not supported by any educational effort; human labour was the most important source of mechanical power. With the industrial transformation, coal and the steam engine provided for mechanical power and for more (not less) human physical labour: there was a positive relation between energy supply and labour demand. Later, with oil and electricity, fossil energy substitutes for human physical labour (the relation between energy input and labour turns negative), but invites and educates *intellectual/knowledge labour power*. White collar labour becomes more abundant than blue collar labour. Gradually, *communicative abilities/empathy*, before an exclusive domain of (“non-working”) women, become an essential quality of human labour.

Quantitative changes: The conceptually best way to compare the amount of labour across long time periods is to relate the total amount of labour hours to the total lifetime of the population. From time use studies (some reconstructing historical situations) we know that a little more than 11 hours per day have to be invested for the reproduction of the self (sleep, eating & hygiene, sickness, resting, training and education ...), thus roughly 12 hours or 50% of human lifetime is available for labour. The best estimates for agrarian societies amount to between 2,5 to 4,4 hours for agricultural work (or 20 – 37% of lifetime) and – fairly consistent – about 2,1 hours for household work, that is another 17% of lifetime. Roughly 90-95% of the population are occupied by agricultural work (in Europe still at 1800) – thus about 10 agricultural workers are required to feed one urban citizen. In the first (coal) phase of industrialization there are indications that the work load may have even increased,

gradually shifting from agriculture to manufacture, mining and industry. Only in the second phase of the industrial transition there is a trend towards reducing labour hours in the economy, supported by the abolishment of child labour, pensions and a longer lifetime. This reduction of labour hours is not as massive as one might think (work in the economy comes down to about 21% of lifetime), and work in household and family seems to have risen above pre-industrial levels (smaller families, higher standards, much time for shopping and servicing the household's increasing equipment). In total, it could be that labour has fallen just below 50% of available lifetime, while it used to be somewhat above that before the transition. Labour time for food production in agriculture has drastically declined – now one agricultural worker feeds 20 people occupied in a wide range of different jobs.

Changes in the *institutional form of labour*: under agrarian conditions, the by far dominant form of labour was within manorial systems, with a degree of personal dependency, or even slavery, and within personally interdependent household systems. Other kinds of collective, often compulsory services (military, prisoner's camps, cloisters...) had a certain share, while free labour directly relating to a market (selling produce as self-employed trader or artisan, or wage labour) amounted to no more than a few percent. These institutional forms were subject to substantial change: personal dependency from the manor and slavery were abolished mostly in the early phases of the transition, free labour became available for markets, and the organizers/consumers of labour, the capitalists, in contrast to the former aristocratic landowners became a ruling class that conceived of itself as hard-working. Family dependency of household labour was maintained for a long time throughout the transition, with a much sharper boundary between the "production sphere" and the family as a "reproduction sphere" with women often enclosed in it. This gender role differentiation was substantially macerated only in the final stabilization phase of the transition.

What can be learned from this for the course of the next, the "new" socio-ecological transition?

The following figures make an – admittedly highly speculative – effort at incorporating the elements of structural change we can anticipate for SET into our imagination of the future of work.

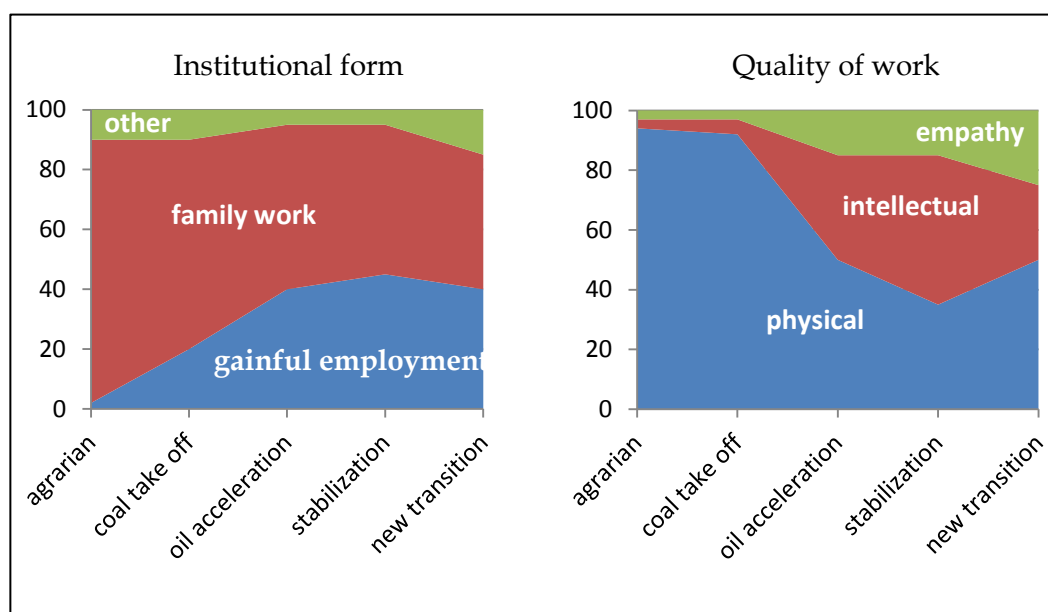


Figure 2: Variation of quality of work and its institutional form by socio-ecological regimes (work including market oriented employment, non-market subsistence work incl. household & non-market community work; Europe only)

We anticipate that the proportion of physical work, after a long period of decline, might rise again. This follows from the expected rising costs of energy and declining energy return upon energy investment (EROI). We assume this will lead to a reduced substitution of human labour by mechanical energy, and possibly an increasing use of very intelligent but mechanical tools and devices. The existing “green jobs” reports (such as UNEP et al. 2008, or the European Strategy Agenda 2020) do not elaborate on their quality; a recent study for the USA and for Austria identify forestry and agriculture, the construction industry, waste management and trade and transport as main sectors of new “green jobs”. Beyond the more narrow assumptions related to the shorter time horizon of these studies, we also refer to the increasing frequency of climate extreme events as a source of additional physical labour, be it in the form of gainful employment in infrastructure maintenance, as non-market civil services or as family labour in coping with such events.

Another consideration is a continuing process of substitution of (particularly medium qualified) intellectual or knowledge work by ICT, and eventually – facilitated by the use of ICT – its global outsourcing to lower income countries. The only services that are very difficult to substitute by ICT and almost impossible to outsource to other countries are activities that involve face-to-face contact with the resident population: various form of service and caretaking. In view of an aging and culturally increasingly heterogeneous and demanding population we therefore above assume an increase in the type of work that is based upon empathy (at the expense of medium qualified intellectual work), and both in the institutional form of gainful employment and as voluntary work.

After many decades of decline, there now is a sharp rise of prices of all raw materials (commodities). We assume commodity prices (including energy) continuing to be high or even rise further, and anticipate a shift in the dominant mode of cost reduction from labour to resources. In this case, not the increase of labour productivity would be the key measure, but the saving of resources, possibly at the expense of more labour. Macroeconomically, this would mean that there is a shift in relative prices between material goods and human labour, and consequently a decline in demand for material goods and increasing demand for human labour. As far as macroeconomic growth depends on rising labour productivity, it would be impaired. Increasing the share of work in caretaking, as assumed above, would have an impact in the same direction, as with caretaking labour productivity cannot be much enhanced. In effect, the purchasing power of workers would be reduced, and distributional conflicts about wages become more frequent.

Finally, our societies may become less energy intensive. If the world seeks to avoid dangerous climate change, most simulations assume a global decline in primary energy use, in the order of magnitude of 1% annually (see for example WBGU 2011). If this assumption were to be realized globally, the required decline in primary energy use for Europe would need to be much steeper. Part of this decline can be realized by avoiding losses, but more expensive energy might more generally lead to lower use. Could our societies slow down again?

Policy choices to cope well and to increase the pace of the socio-ecological transition in Europe

Europe will be just as much driven into a socio-ecological transition, as it may proactively fashion its future under changing conditions. Actively driving structural change towards a socio-ecological transition in Europe (away from un-sustainability) would encompass, from a socio-ecological perspective:

- an energy shift away from fossil fuel use towards renewables
- a production and consumption shift away from energy- and materials-intensive products towards services enhancing human resources & capacities
- a dietary shift towards lowering the consumption of animal based products
- an institutional shift towards low-vulnerability, low-maintenance infrastructures
- lowering energy consumption (efficiency increases, saving, moving...)
- lowering use of (virgin) raw materials (efficiency increases, recycling, reduced consumption, re-designing, avoiding waste, waste mining...)
- probably, under considerations of international equity: European self-sufficiency in biomass and water.

These shifts will be partly facilitated, and partly even driven by global changes. These global changes are to a large extent causally related to the – in many parts of the world still on-going – “historical” transition to a fossil fuel based industrial society.

We see the European policy option space in relation to six global megatrends on which Europe has a limited influence. The megatrends themselves are fairly uncertain, in particular concerning their speed (how fast does it change?) and concerning their intensity (how extreme may it get?). We condense this uncertainty and complexity into the distinction of “friendly” and “tough” for each megatrend. In a next step, for the purpose of quantitative simulations, we may condense this further into just two contextual alternatives: a “friendly world” and a “tough world”. By our state of the art analysis, the “friendly world” will already be quite different to the world now, even upon the short time horizon of 2025.

Of the three megatrends in **natural conditions**, **climate change** has been researched best and provides the strongest reason (and also the strongest European policy commitments) for not just wait and let SET happen, but driving it proactively. Almost the same holds for global **energy transitions**. Less research efforts have so far been invested in **rising challenges to resource security**, but undoubtedly this is a major problem, underlined by recent substantial increases of commodity prices.

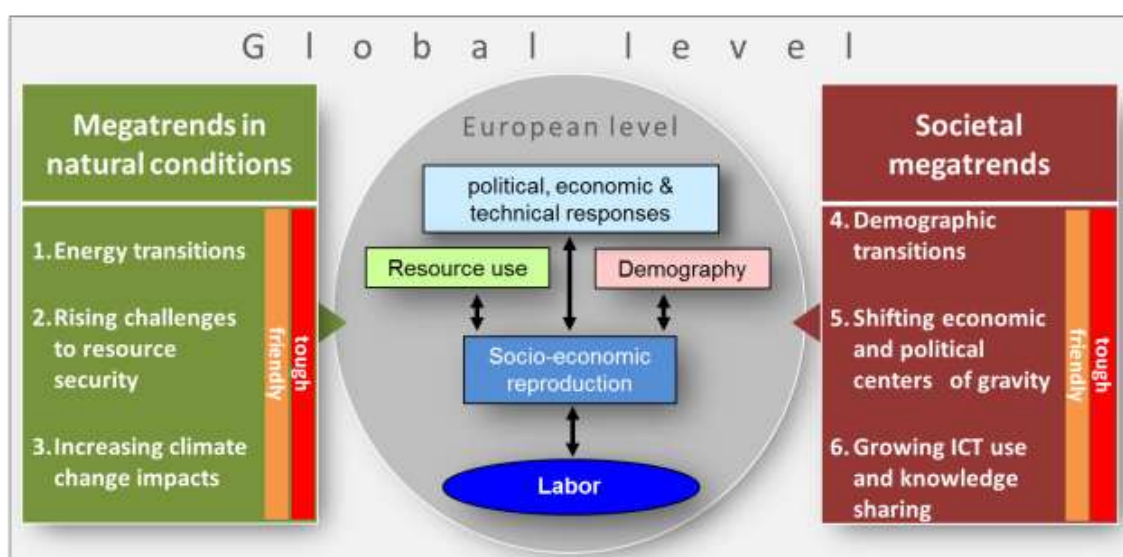


Figure 3: The future socio-economic reproduction of Europe in a global context

Of the three **societal megatrends**, **demographic change** (global population growth and aging, and probably a population peak in this century at 8-12 billions) globally is well identified, but the consequences for Europe in terms of migration are much less clear. **Shifting the world's centre of gravity** towards Asia is somewhat contested in its consequences, particularly as the international policy setting may vary between collaborative and confrontational. Placing **growing ICT use and knowledge sharing** on that level as a technological, cultural and possibly also political megatrend is a unique feature of this report. Again uncertainties dominate: cheap and ubiquitous access to the world's knowledge base, or a continuous struggle for the protection of intellectual property and maintaining secrets? Excellent tools for dealing with complex systems, and perfect tools for surveillance and intrusion into privacy? Will social media contribute to social empowerment or to mass hysteria?

In adjusting to and also influencing this “friendly” or “tough” world, we distinguish three policy alternatives for Europe, without wishing at this stage to be nailed down for each of their elements:

1. **no policy change:** remain in a business-as-usual mode, and implementing existing climate and sustainability policies only partially
2. **ecological modernization / eco-efficiency:** focussing on market based instruments like emission trading, supporting investments in renewable energy sources, removing environmentally toxic subsidies, setting quantitative targets on eco-efficiency, higher taxes on energy and material intensive products, using ICT capacity for smart grids, logistics of sustainable mobility...
3. **sustainability transformation:** focusses on creating a smart, lean and fair social metabolism. **Smart** – see ecological modernization. **Lean** implies diet change to less animal based products, a freezing of net-infrastructure growth, pay-off of productivity gains in working hour reduction instead of wage increase. In particular, these measures should help avoid rebound effects. **Fair** – striving for a more equal welfare distribution in Europe and worldwide, high taxes on speculation and new work and time use priorities that better comply with age and gender needs and allow for improved work-life balances...

In a final speculative effort we relate the potential success of policy strategies to the character of the “world” they will have to perform in. We do not think **no policy change** will be able to cope with the global conditions to be expected. It will most likely have negative pay offs under both global scenario conditions, due to its insistence on the stabilization of the status quo, thereby impeding the necessary social and economic adjustments and structural changes.

For the **ecological modernization** strategy, in contrast, we expect outcomes to be the most satisfactory under conditions of a “friendly world”, but for this strategy to fail under conditions of a “tough world”. The open questions are how large the negative

feedbacks of the unattended aspects of this strategy will be and if the adjustments can happen fast enough.

The **sustainability transformation** strategy we expect to have positive outcomes under both future conditions, but to be most valuable in a "tough world", because it provides the vision and coherence socially required overcoming the hardships and challenges in a world shaped by on-going ("historical") and future ("new") SETs. In our judgment, this strategy is better suited to deal with international volatility and shocks by focusing on inter-European activities and adaptation, thereby inducing changes towards a resilient and sustainable socio-metabolic regime with a focus on societal welfare rather than on increasing economic activity. This also includes numerous technical and social innovations, thereby strengthening the role of Europe as a leader in promoting and implementing sustainable development.

Resumé: What did we aspire to and what was achieved so far?

Some quotes from the project outline: "Overall, the aim of the project is to imagine future, or rather various possible futures, under the conditions of the socio-ecological transition..., map the implications for employment overall, but also in key sectors and relevant groups and integrate all of this together under a single intellectual framework.

Specifically, we have the following objectives:

1. Conceptualize pathways for impact of the socio-ecological transition on employment
2. Produce integrated scenarios of economic, employment and skills dynamics in Europe – both

mainstream and out-of-the-box – and assess their policy implications."

We strive for a "holistic understanding of the transition not just as an environmental or economic process, but also as a cultural/ideational one, involving new conceptualization of the issue of what is a 'good job'". We wish to "advance the state of the art through better conceptualisation of the determinants of 'transitions' and to integrate insights not only from different disciplines, but also from diverse intellectual traditions."



Socio-ecological transitions are emergent changes in complex systems that make a lot of difference. They may be sometimes welcome, sometimes less so. The logic and course of socio-ecological transitions can be analytically identified insofar as they are linked to natural processes (an often disregarded feature). Beyond that, societies and their political leaders have a remarkable degree of functional independence. Thus, it is hard from a socio-ecological perspective or even impossible to conclude on issues like, say, unemployment. An objective rise in workload for a society may coincide with rising unemployment – or its opposite. A rise in physical labour may imply that people do and enjoy work instead of going to the gym, or it may imply the class of low qualified - low pay - low status people growing. At this stage, it is important to see how much is at disposition – and how much already has been very different, and may be so again. Freeing the collective mind (of project participants, at first) to see alternatives, amidst of all constraints – this at least should have been achieved by now.

1. Introduction

This report pursues three mutually intertwined objectives. It outlines an intellectual framework for understanding what “socio-ecological transitions” are, how they proceeded in the past, and how they may evolve in the future (chapters 2 and 3). Secondly, it screens a large array of literature to extract well grounded and as far as possible quantitative assumptions about how global framework conditions for ongoing and future SET may be like (appendices A and B). And thirdly, it relates the findings from this literature review to the intellectual framework spelled out and translates them into a number of key scenario assumptions about possible futures (“global megatrends, chapter 4), to finally explore some future European response strategies (chapter 5).

Chapter 2 starts off with a very abstract definition of “transitions” (namely a “flipping” between two “states” of a system) and then proceeds to specify “socio-ecological” transitions based on a certain notion of social systems interdependent and co-evolving with systems in their natural environment. Key trigger for the “flipping” of socio-ecological systems, for socio-ecological transitions, is the change of the energy base of the social system. When elaborating this storyline historically, on the basis of empirical data, we unravel one of the key findings of this report: that a socio-ecological transition (SET) is not something we may strive for in the near or more distant future, but that it is something ongoing, in our recent past and at present. This SET observed as ongoing is the transition from a biomass based agrarian to a fossil fuels based industrial regime. The SET we inevitably have ahead of us, namely a transition away from fossil fuels towards other energy sources, the “next socio-ecological transition” so to speak, should be expected to have as far reaching consequences as the last one we went through (or are going through), but we still have very little evidence of it.

Demographic and resource use data from a number of now mature industrial economies allow us to demonstrate how the SET took place, moving from an agrarian state through a take off and through an acceleration phase to a new “state” (in the sense of relative stabilization) in terms of resource use. The earlier the start of this process, the longer the duration of the transition has been. What we find now and demonstrate from data on “emergent economies” is that this very same process continues to happen, according to very similar patterns, but at a greatly increased speed. What makes this a very troubling



observation are the facts about a biophysically finite planet: the resources required to allow for this transition for – so far – about 15% of the world population will not be available to allow the same for a next 60% of the world's population. Thus, the chapter concludes (much in line with similar exercises in a number of international reports) that the track the world currently is on is not viable, the “business-as-usual-pathway” does not lead into a future that is possible.

Chapter 3 builds on the intellectual framework elaborated in chapter 2 but does not talk about how SET affects energy and resource use, but about how it affects human labour in its qualitative, quantitative and institutional dimensions. With the advent of coal use, human labour shifts gradually from agriculture to manufacture, and it changes its institutional form from serfdom or self-employment to wage labour. Quantitatively (in average numbers of hours worked per member of the population) and qualitatively (mainly low qualified physical work) there is not much change at first. Major changes of human labour occur in the transition from coal to oil within the industrial regime: technical energy now substitutes for physical work (in manufacture and in agriculture), and human labour power for the first time in history receives substantial social investment in the form of mass education and professional skill development. Average labour hours decline and wage labour finally becomes the ubiquitous institutional form, but highly differentiated internally. How will a next SET, a transition beyond the mature form of industrial societies and beyond fossil fuels, affect labour? It seems that a transition away from standard fossil fuels will in the longer run involve a reduction of society's energy density, and a worsening of the so-called EROI (energy return on energy investment). This could imply a return of (often highly skilled) physical labour, and even a return to more agricultural labour (both for energy and for quality reasons). Demographic changes (ageing) implicate a shift towards more labour in the form of caretaking, and adaptation to climate change and increasing weather extremes will tend to generate additional labour. Thus is in the medium and longer run the challenge might be increasing human labour, possibly at lower productivities (and maybe lower income) rather than mass unemployment.

This attempt at a social ecology of human labour is fairly experimental and cannot draw on much standard work done on this subject with such a broad scope. We will therefore make specific efforts at having this work critically reviewed.

Chapter 4 places future European opportunities and challenges in a framework of global megatrends. These megatrends all relate to the historical and ongoing SET in the sense of systematically being their outcome or side effect, and in the sense of constraining and enabling a next socio-ecological transition.

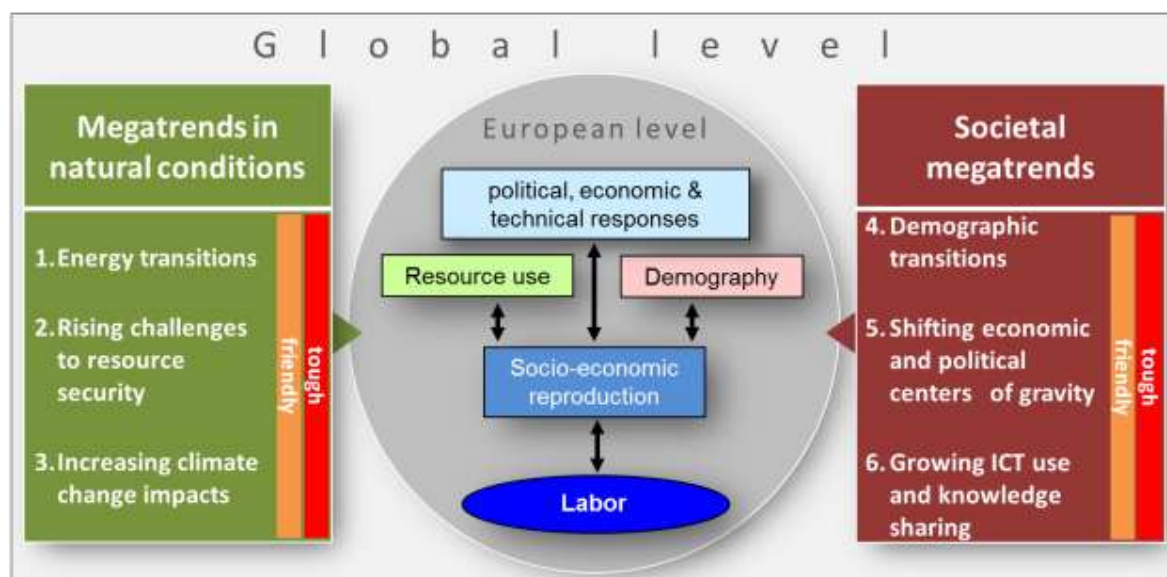


Figure 1.1: The future socio-economic reproduction of Europe in a global context

The pace at which these global megatrends proceed is contested and uncertain, as we document in our extensive literature review of the most recent forecasts and scenario exercises by international organizations, NGOs and of published scientific literature in the two appendices (appendix A for megatrends in natural conditions, and B for societal megatrends). What is clear, though, is the direction of the megatrends and that they are about to make future conditions fairly different from what Europe faced in the past and faces at present.

In concluding chapter 4, we try to simplify the findings on global megatrends and squeeze them into two potential summary conditions for the year 2025, a “friendly” and a “tough” world. (For the year 2050, which is our second reference period, we have assembled the findings but refrain from drawing such a simplified picture). In a next step, this should serve as alternative key assumptions for the scenario efforts in WP 9 and 10.

Chapter 5, finally, deals with some of the potential political, economic and technical responses (see figure above) of Europe to these changing conditions. We briefly outline three basic response strategies that may be of a different effectiveness depending on the respective

state of the world they have to deal with. The ideas developed here should be further elaborated in cooperation with other work packages of this project.

2. Socio-ecological transitions: definitions and dynamics

2.1 What is a transition?

Several disciplines use this notion in a variety of different contexts and in different meanings. In thermodynamics, the term transition is used to describe the 'phase transitions' of substances when transforming between solid, liquid and gaseous aggregate states (Stanley 1972, see also Loorbach et al., 2010).

The economic historian Karl Polanyi uses transition and transformation synonymously in his seminal book "Origins of our time: the great transformation" published in 1944. His investigation was concerned with the transformation of society into a market economy focusing on the political and economic dimensions of this process (Polanyi 1944).

Another use of the notion stems from demography. In 1945, Notestein (Notestein 1945) wrote his classic elaboration of transition theory, "Population: the long view." Populations with high growth rates would become "transition growth" ones as modernization began to affect their fertility. When industrialization and urbanization become common place, fertility would reach low levels and the population would enter into the stage of "incipient decline."

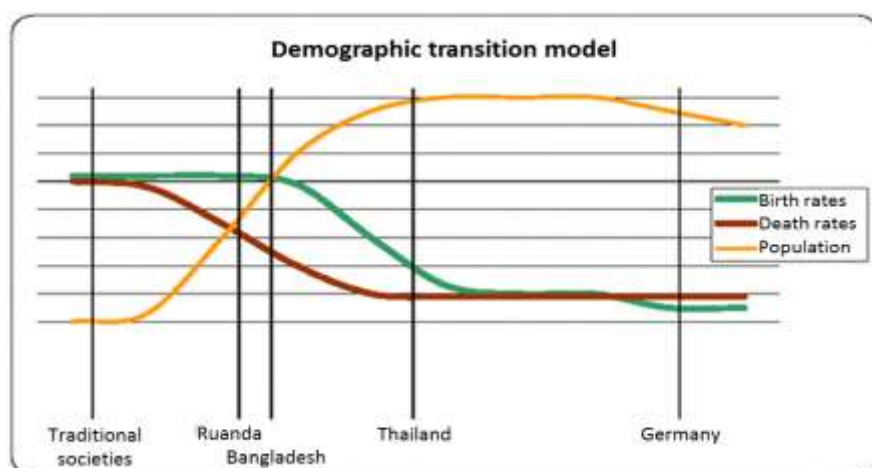


Figure 2.1: Demographic transition (Source: own translation, Münz and Ullrich 2006)

In global environmental health, the notion of risk transition has been used by Smith to describe the tendency of the last century's societal developments to shift environmental problems from smaller to larger scales (Smith, 1990). In the poorest parts of the world fuel use in households and dirty water dominate the environmental hazards (indoor pollution), and in middle income cities fuel use for industry and vehicles dominate environmental impacts (outdoor pollution). In the richest countries, local environmental risks were reduced significantly. However, these countries shifted the problem to the global level by causing climate change. This shift of environmental burdens from local to global goes hand in hand with a shift from immediate to delayed impacts.

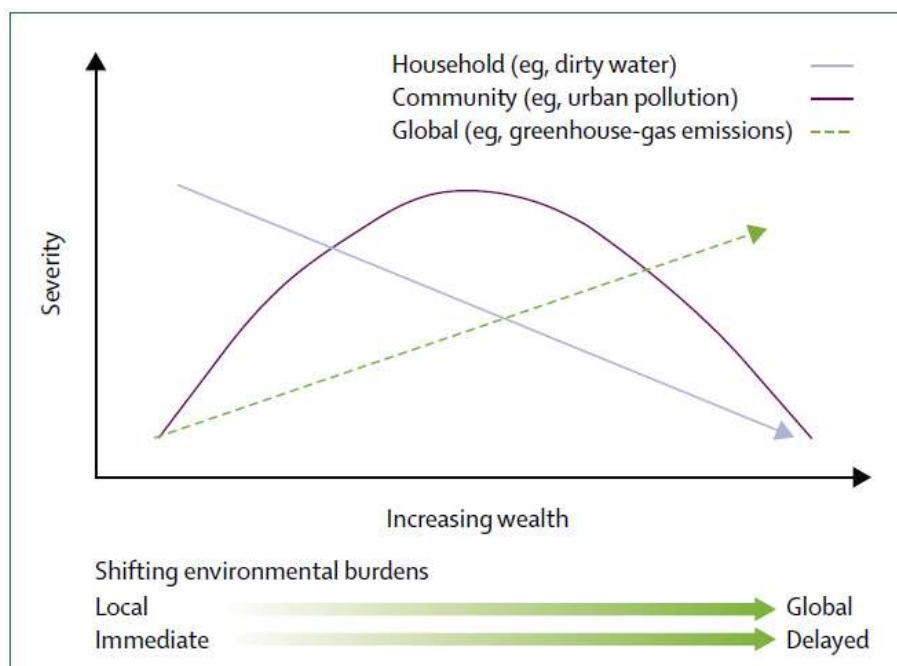


Figure 2.2: Environmental risk transition (Source: Wilkinson et al. 2007, 965-78, based on Smith 1990)

The term transition carries again quite different meaning when talking about “transition economies”. The collapse of Communism in 1989 created a new group of countries in Central and Eastern Europe, called the transition economies, that committed themselves to a more or less radical shift by strengthening market mechanisms through liberalization, stabilization, and the encouragement of private enterprise (Hoskisson, 2000).

Studies on world politics have led to the formulation of the so called power transition theory, which has become “one of the most successful structural theories” over the last decades (Lemke and Lemke, 2003, p269). While contested by some scholars (Lebow and Valentino, 2009) power transition theory tries to offer falsifiable expectations on the global political

future by looking at historical processes of great political powers overtaking each other. It is concerned with both phases of stability and of chaotic transition, including major wars, when political power shifts from one centre to another.

Under the name of transition theory a whole stock of literature concerned with societal change has been accumulated. Rooted in social theory and technology systems studies, transitions research strives for an understanding of social transformations (Rotmans et al., 2001; Foxon 2007; Grin et al., 2010; Geels, 2011). It focuses on technological, social and economic change that entails profound alterations in structures, institutions and social relations and as a result, society, or a subsystem thereof, starts operating according to new assumptions, rules and practices. Transition research comprises three important components, the multilevel heuristic (landscape, regime, niches), the multiphase scheme (predevelopment, take-off, acceleration, stabilisation), and transition management. The multilevel heuristic deals with structural arrangements and interactions in transition problems and processes, while the multiphase scheme deals with the sequencing and temporal aspects in transition processes. Transition management refers to how actors obstruct or promote change and how they adapt to and learn from transition processes (Loorbach et al., 2010).

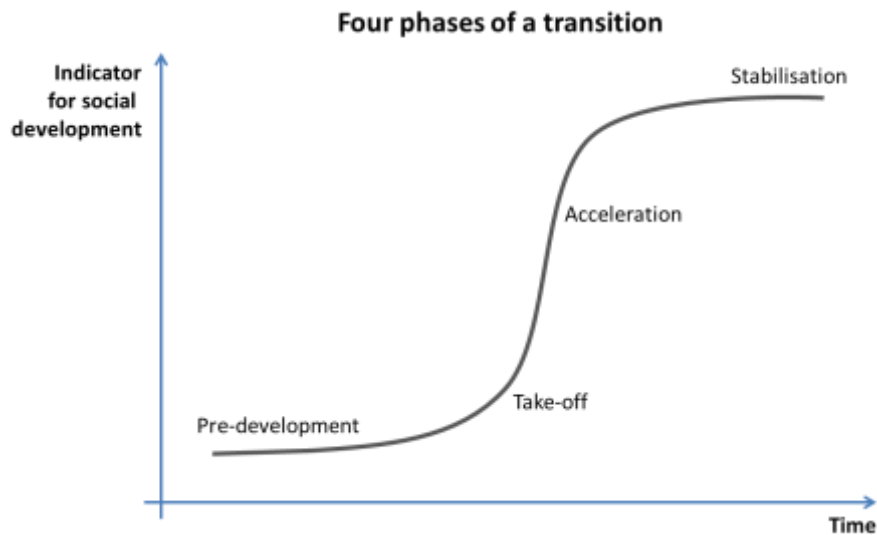


Figure 2.3: Phases of a transition (Source: Martens and Rotmans 2002)

A scientific treatment of any transition as distinct from just “change” – requires a certain conceptual clarity and self-discipline: clarity in defining the unit of analysis, in how to distinguish different phases or stages, and in how to conceptualize the directionality of time.

What is an adequate unit of analysis? The focus ought to be on a theoretically and operationally identifiable system. The system should be self-organizing and sufficiently complex to maintain itself under changing conditions. For such a system, there would be environmental boundary conditions: If they are transgressed, major features of the systems functioning will change. In the extreme case, the system may collapse (if it is an organism, die), or else it may resume its self-organization in a new “state”. Both would then be called a transition (Fischer-Kowalski, 2011).

How to distinguish stages or phases in transition processes? The typical model of alternating phases is the S-curve (Rotmans et al., 2001), although other models have also been considered, such as the so-called “lazy eight” (Berkas and Folke, 1998), lock-in situations or system collapse (Tainter, 1988), or “tipping points” in earth systems (Lenton et al., 2008). From the notion of transition, there follows an understanding that no linear, incremental path leads from one state or phase to the other, but rather a possibly chaotic and dynamic intermediate process, or a discrete “jump” from one state of the system into another. One has to be aware, though, that these distinctions are extremely sensitive to the observer’s choice of scale. From a wider perspective something may appear as a continuous process, progressing steadily. But from a closer perspective the same process may appear as whimsical, sharply fluctuating. For example, the process of walking from a certain distance looks like a linear movement; from close distance, one sees muscles contracting and relaxing again, weight shifting from one leg to the other, so the process appears as cyclical. From a still closer and shorter perspective it would appear as transition. Thus descriptions of processes as transitions or as gradual change do not necessarily exclude each other. One type of process may well be nested into the other. Nevertheless, the idea of a system gradually behaving ever more sustainably (as suggested in theories of ecological modernization sometimes, see Mol and Spaargaren, 1998) does not comply with the term “sustainability transition”.

Another consideration relates to the order of phases or stages, in other words, the understanding of directionality of time. The process of transition can be either conceived as reversible or as irreversible. In the case of thermodynamics above, there is complete reversibility: water can freeze, and melt again. For more complex systems, transitions processes are rather seen as irreversible. There is directionality of time, and it can either imply consecutive stages of a developmental type (like Herbert Spencer’s notion of evolution, or Marxist historical materialism, or Rostow’s stages of economic growth), or it may follow a Darwinian type of evolutionary theory by assuming the future to be contingent

upon the past but an open process into the future: you know the mechanisms driving it but not where it will lead to. In the first case, when a developmental model is employed, each consecutive stage follows with a certain necessity from the previous stage, and it is, as a rule, considered superior, more mature. The progress to this more mature stage can be accelerated or delayed. In the second, “Darwinian” case, the direction of change is principally unknown (Gould, 2002). Many people believe earlier transitions (such as the industrial revolution) to have been of a developmental type, simply human progress. In the socio-ecological transition approach this directionality of history is being rejected and regime transitions are rather conceptualized as contingent on the past but emergent phenomena (for further discussion on transitions see also Fischer-Kowalski and Rotmans, 2009).

2.2 Socio-ecological transitions as transitions between socio-metabolic regimes

The socio-metabolic approach to transitions makes certain choices with regard to the above mentioned distinctions. It says the appropriate unit of analysis to investigate socio-ecological transitions is society, interpreted as a socio-metabolic system (Fischer-Kowalski and Weisz, 1999) that interacts with systems in the natural environment. Particular patterns of interaction are called “socio-metabolic regime”.¹ Socio-ecological transitions, then, are transitions between socio-metabolic regimes.

A regime, according to the socio-metabolic approach, is rooted in the energy system a society depends upon, that is the sources and dominant conversion technologies of energy. The theory of socio-metabolic regimes has been developed by Sieferle (1982; 2001) and elaborated by Fischer-Kowalski and Haberl (2007). Depending on the reasons for and the speed of an energy transition, parts of the system may at a certain point in time be under different energy regimes: urban industrialized centers, for instance, may coexist with traditional agricultural communities, or industrialized countries with agrarian colonies. Such a “synchronicity of the asynchronic” (Füllsack, 2011) influences the overall course of transitions. How these processes evolve is contingent upon specific conditions. The socio-metabolic approach shares with complex systems theory the notion of emergence: neither can one state be deliberately transformed into the other, nor can the process be fully controlled. One is confronted with

¹ This is a different use of the term regime than, for example, that used in the Dutch transitions management theory (Kemp et al., 2007) which describes a transition as interference of processes at three different scale levels: macro, meso and micro. The scale levels represent functional relationships

self-organizing dynamics (Maturana and Varela, 1975) to which orderly governance or steering cannot be applied.

What drives socio-metabolic regime transitions? On such a broad and long term scale one cannot easily talk about actors and their deliberate efforts. What one can mainly analyze is structural change of interlinked social and natural systems, across a broad range of variables. Among these, the socio-metabolic approach focuses on a relatively narrow set describing the society-nature interface for which quantitative measurements can be reliably obtained in very different contexts. The advantage of this restraint is that it is possible to empirically demonstrate the interconnectedness of socio-economic changes and changes in natural systems (between population growth, diets, land use and species extinction, for example) and to generate models for important biophysical requirements and boundary conditions for system perpetuation. When an energy regime changes, society and its metabolism alter, and also the natural systems it interacts with. A regime can be characterized by the socio-metabolic pattern of the society involved, and the associated modifications in natural systems that occur either as an unintended consequence (such as resource exhaustion or pollution) or as intentional change induced by society (such as land use).²

2.3 A brief description of socio-metabolic regimes

Based upon distinctions made by Sieferle (and others), we distinguish the following sociometabolic regimes:

1. **The agrarian regime.** It is based upon active (as opposed to passive, as with hunters & gatherers) solar energy utilization. The active element consists in deliberately colonizing terrestrial ecosystems, trying to concentrate solar energy conversion in plants useful for human reproduction (as food and feed). Practically all energy depends on land use and the availability of land (in some cases also fishing grounds). This allows a lifestyle at an energy consumption level of up to 40 GJ/person (measured in DEC units)³ and year and requires very much human labour (about 80%-100% of the labour power of a population).

² Society itself is seen as a structural coupling of a communication system (Luhmann, 1995) with biophysical compartments (such as: a human population, livestock, and physical infrastructure); social metabolism serves to maintain these biophysical compartments within a certain territory (Fischer-Kowalski and Haberl, 2007).

³ DEC, domestic energy consumption, includes – beyond the technical or “commercial” energy counted as total primary energy supply (TPES) – also the food and feed energy consumed annually. (Haberl 2001)

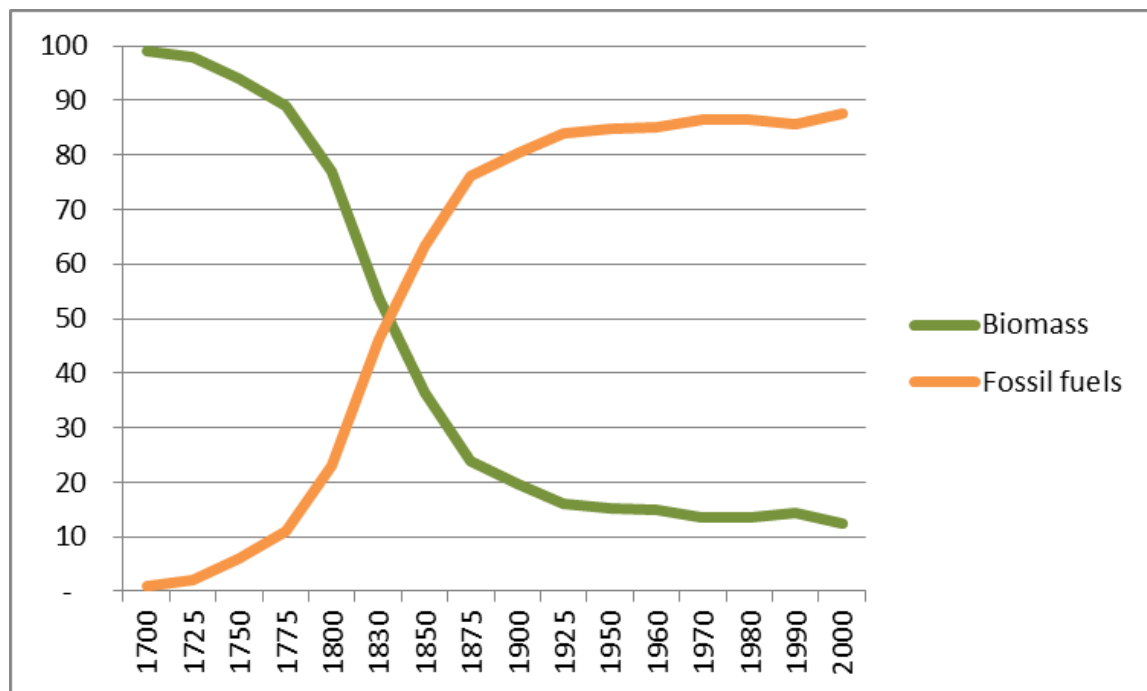


Figure 2.4: UK's historical transition from an agrarian to an industrial regime: a transition from biomass to fossil fuels as percentage of Domestic Energy Consumption (DEC)⁴ (Source: SEC database)

2. **The coal based industrial regime.** Key feature of this regime is its ability to gain substantial amounts of additional energy from fossil sources⁵. This additional energy is technologically translated into heat (for cooking and housing in urban centres) and later into mechanical power such as the steam engine, railways and steamships, and steel production, thus creating a new dimension of production, transportation and capital investment. The typical energy level at this stage is at 50-150 GJ/cap*a, and the generation of mechanical power has at least partially become independent from humans and animals, thus loosening the link to land as the key supply base.
3. **The oil based industrial regime II.** This uses, on top of and in substitution of coal, petroleum, technologically translated into car based mobility, and later aeroplanes.

⁴ Domestic energy consumption (DEC) goes beyond what is usually defined as total primary energy supply (TPES). While TPES covers all "commercial", technical sources of energy, DEC also, on top of this, includes energy intake in the form of food and feed (Haberl 2001).

⁵ just to give an impression: already at the turn to the 20th century, UK had as much energy from coal at its disposal as it could have gained from using wood from a territory 13 times the actual size of the UK (Sieferle 2001)

Electricity provides a universally applicable and locally available form of energy; electric motors allow for the mechanization of a wide variety of decentralized technical processes. Petroleum is also key to the industrialization of agriculture (“green revolution”), providing tractors, mineral fertilizers and pesticides, and creating the opportunity to substantially raise both land and labour productivity.

Industrial socio-ecological regimes date back no more than three hundred years and are mainly based upon the utilization of fossil fuels. Industrialization appears as a process which fundamentally alters size and structure of the socio-economic metabolism as well as its relation to land use and agriculture. Compared to any other energy carrier known before, fossil fuels offer very favourable features. One of the most important features is their very high energy density. While transport of biomass as energy carrier is quite limited since the energy necessary for transportation exceeds the energy contained in transported biomass already after short distances, fossil fuels contain a high calorific value in relatively low weight. Another important aspect is that agrarian societies can only count on a relatively low annual turnover of primary energy per unit of land area (average 40-70 GJ/ha); energy is more or less evenly spread across space. In contrast, fossil fuels can be extracted from concentrated large stocks and therefore compared to agricultural energy regimes need only minuscule space for extraction and production. This decoupling of energy provision from land area removed basic limits for biophysical growth inherent to agrarian societies. Thus fossil energy regimes enabled unprecedented economic, but also physical growth. Growth in agrarian regimes is mainly population driven, with the consequence that it generally leads to a decline in energy use per capita. In comparison, industrial growth is based on both population growth and a surge in per capita use of natural resources (Krausmann et al., 2008).

Based on a number of historical and contemporary case studies, typical for agrarian and industrial regimes have been reconstructed. As apparent in

Table 2.1, the socio-ecological transition between the agrarian and the industrial regime implies an increase of per capita domestic energy consumption (DEC) and domestic material consumption (DMC) by a factor of 3 – 5. During that process the importance of biomass as energy source decreases from over 95% to around 10 - 30%, with increasingly more fossil fuels being used. Absolute biomass consumption, though, does not decrease, as it is directly

linked to population size in the form of food demand⁶ (Steinberger et al., 2010), and the regime transition is associated with a demographic transition triggering strong population growth and urbanization. Population densities increase by a factor of up to 10, while the share of agricultural population decreases sharply, from over 90% to below 10% (see Table 2.1, Krausmann et al., 2008a; Krausmann et al., 2008b).

<i>Parameter</i>	<i>Unit</i>	<i>Agrarian regime</i>	<i>Industrial regime</i>	<i>Factor</i>
Energy use (DEC) per capita	[GJ/cap/yr]	40 – 70	150 – 400	3 – 5
Material use (DMC) per capita	[t/cap/yr]	3 – 6	15 – 25	3 – 5
Biomass (share of DEC)	[%]	>95%	10 – 30 %	0.1 – 0.3
Agricultural population	[%]	>90%	<10%	0.1
Population density	[cap/km ²]	<40	<400	3 – 10

Table 2.1: Typical metabolic profiles of agrarian and industrial socio-metabolic regimes

DEC, domestic energy consumption, includes the total primary energy supply (TPES) as reported by the International Energy Agency. Beyond TPES, DEC also includes the nutritional energy content of biomass used as food and feed for humans and live-stock and therefore gives a more complete picture of the energetic societal metabolism (Haberl, 2001). DMC, domestic material consumption (DMC), measured in tons, captures all the material flows induced by a national economy in a specific year, such as biomass, fossil fuels, industrial minerals and ores, and construction minerals (Eurostat, 2007). Source: Krausmann et al., (2008a)

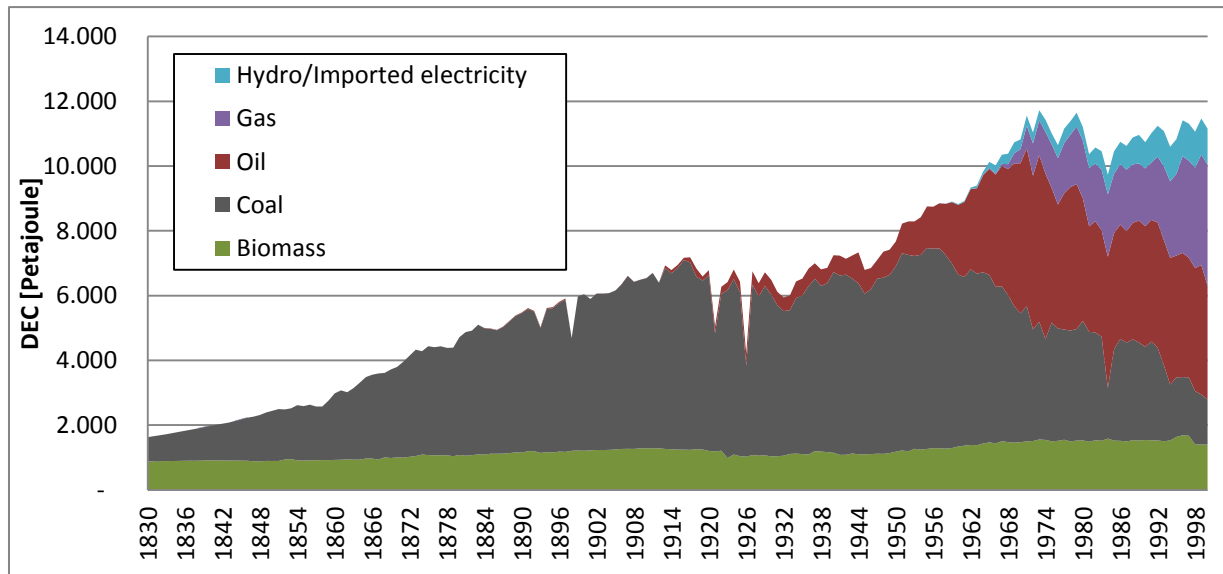
The transition process from the agrarian to the industrial regime may take several centuries, or it can happen much faster; nevertheless, there are fairly similar patterns, as we will demonstrate in the following paragraph with some examples of now mature industrial economies.

⁶ There may be a decrease of wood consumption due to the substitution of fuelwood by coal, but on the other hand human diets tend to shift towards more animal based products thus boosting animal feed consumption and keeping the overall biomass use at roughly the same level as before.

2.4 Historical socio-ecological transitions as experienced in the UK, Austria, the USA and Japan

The primary example for the transition from the agrarian to the industrial regime is of course the United Kingdom (Wrigley, 1988; Siefert, 2003; Krausmann et al., 2008b). The use of coal started already during the 17th century, when it gradually substituted for dwindling wood supplies due to widespread deforestation and allowed for textile manufacturing in growing urban centres. Much later, with the diffusion of the iron-steam engine-railroad complex (Grübler, 1998), industrialization in the more common sense of the word took off (see Figure 2.5). From the mid-19th century onward, the use of coal increased rapidly and led to the first take-off of biophysical and economic growth (Table 2.5 (Krausmann et al., 2008b)). A next pattern established itself after WW2. This pattern had started from the United States and was marked by the expansion of the petroleum-steel-auto cluster combined with electricity (Ayres, 1990a; Ayres, 1990b; Grübler, 1998). This phase of increasing mass production and consumption can be looked upon as the “acceleration phase” of the industrial transition, with rapid biophysical (and even more so economic) growth (Table 2.5). In the UK, as well as in most “first generation” industrial economies (see further down), this acceleration phase driven by cheap oil (Pfister, 2003; Smil, 2003) ended with the oil price shocks in the early 1970's and gave way to a relative stabilization at high levels (Figure 2.5).

Due to its pioneering role, it had taken the UK 350 years to go through this socio-ecological transition process from a pre-development phase, through a take-off, an acceleration phase and an eventual stabilization of its socio-economic metabolism (Krausmann et al., 2008b).



*Figure 2.5: The energy transition in the UK from 1830 - 2000 (Source: SEC database).
1 Petajoule = 1,000,000 Gigajoule (10^{15} vs 10^9)*

The socio-ecological transition from an agrarian to an industrial regime in Austria started to take-off in the second half of the 19th century and followed a similar pattern as in the UK (Krausmann et al. 2008b, Figure 2.6). Because of the availability of wood in rural and iron producing regions, biomass continued to play an important role as heat source until the acceleration phase of the post war period, when oil based industrialization, post-war reconstruction and the take-off of mass consumption led to an exponential increase of materials and energy use. As in the other mature economies, the 1970s proved to be a turning point, where resource use slowed down considerably (Figure 2.6). During the observed time period, domestic energy consumption increased by a factor of 6 (Figure 2.6) and per capita consumption increase from approximately 73 GJ in 1830 to 197 GJ in the year 2000 (Krausmann et al. 2008b).

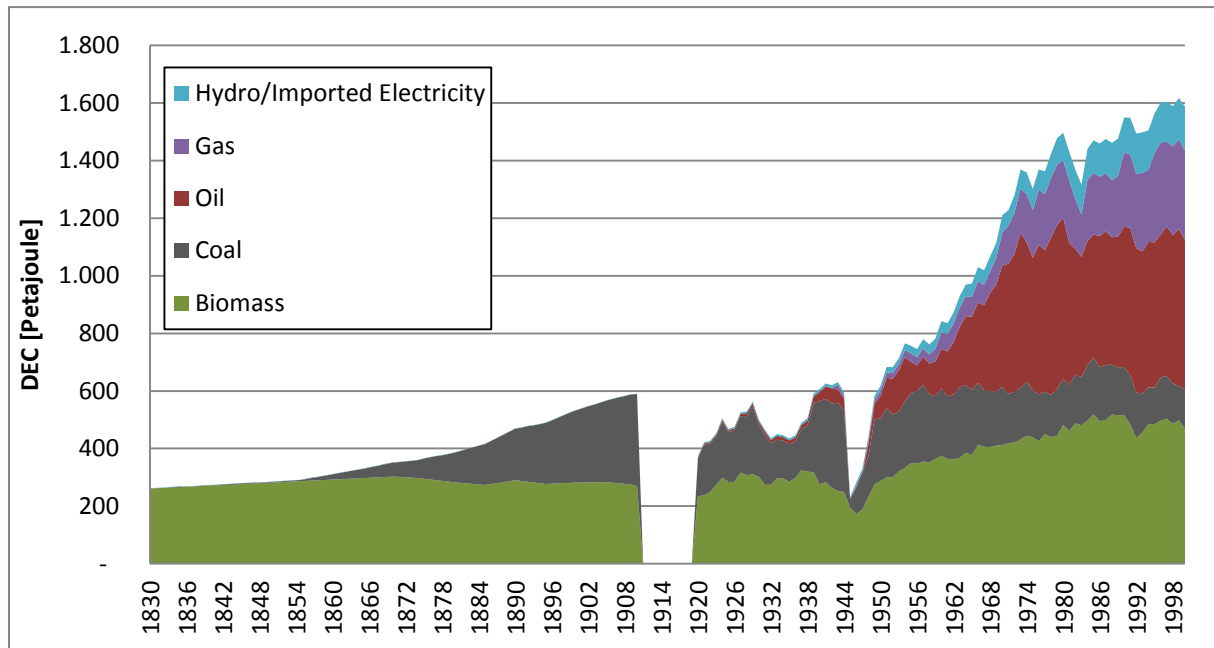


Figure 2.6: The socio-ecological transition in Austria, from 1830 - 2000 (Source: Krausmann et al. 2008b)

The socio-ecological transition in the USA started to take-off shortly after the civil war (1861-1865), with coal, steam and steel based industrialization and the expansion of the railway system (Gierlinger and Krausmann, 2011, Figure 2.7 and 2.8). The period between the Great Depression and Roosevelt's "New Deal" in combination with preparations for WW2 marked the beginning of the acceleration phase, which lasted until the oil price shocks in the 1970's. During that period DMC grew by 3.3% annually and DMC per capita more than doubled, from 13t/cap/year in 1932 to 29t/cap/year in 1970. Also during that time per capita DEC increased by a factor of 1.8, from 260 GJ in 1970 to the peak of 484GJ in 1979. After the oil price shocks energy and materials consumption per capita stabilized and even started to decline slightly and the increases of total DMC and DEC since then are only due to population growth (Figures 2.7. and 2.8., (Gierlinger and Krausmann, 2011).

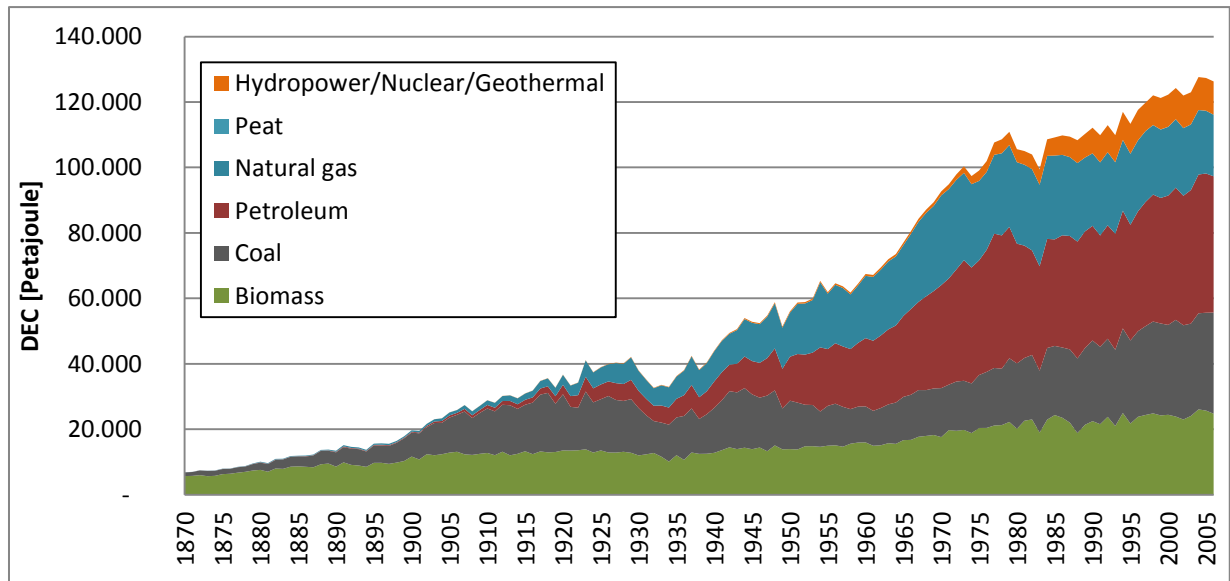


Figure 2.7: Domestic energy consumption in the USA, from 1870 – 2005 (Sources: SEC database; Gierlinger and Krausmann, 2011)

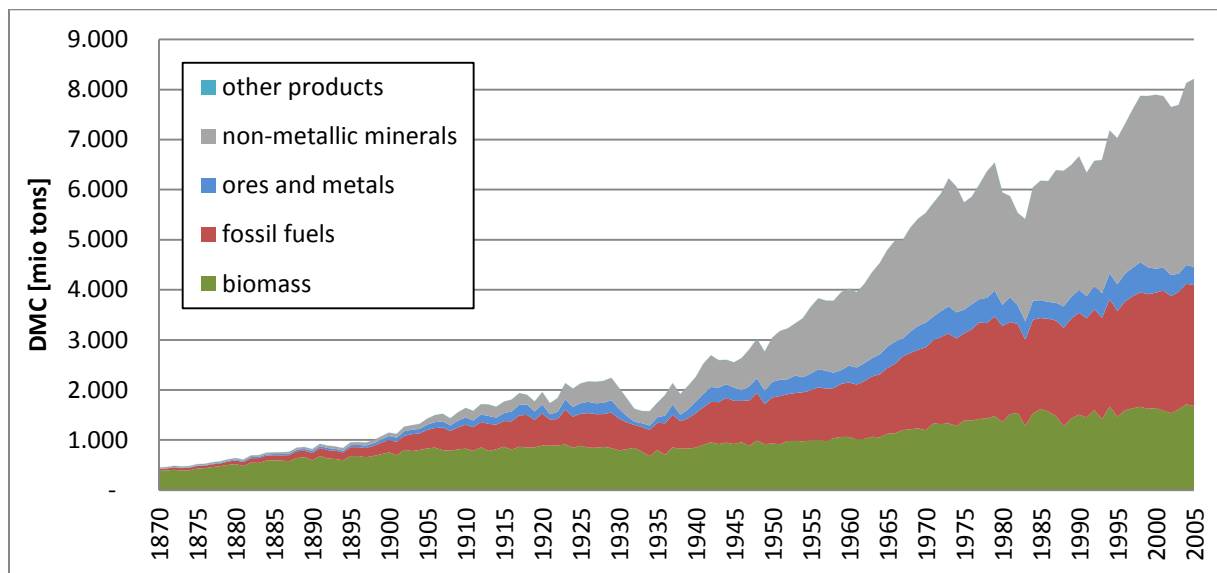


Figure 2.8: Domestic material consumption in the USA, from 1870 - 2005 (Source: Gierlinger and Krausmann, 2011)

Another very interesting and surprisingly fast case is Japan, one of the few countries where absolute dematerialization has been achieved since the mid 1990's (Krausmann et al., 2011). Japan never experienced a strong coal-driven expansion of its metabolism, but started the steep acceleration of its metabolism in the oil-age of the 1960s (Figure 2.9 and 2.10). In the observed time period from 1878 – 2005 population grew fourfold, material use (DMC) by a factor of 14 and domestic energy consumption by a factor of 50, but most of this increase

took place within only a few decades. From the mid-1970's onward fluctuations and then an eventual stabilization and dematerialization set in.

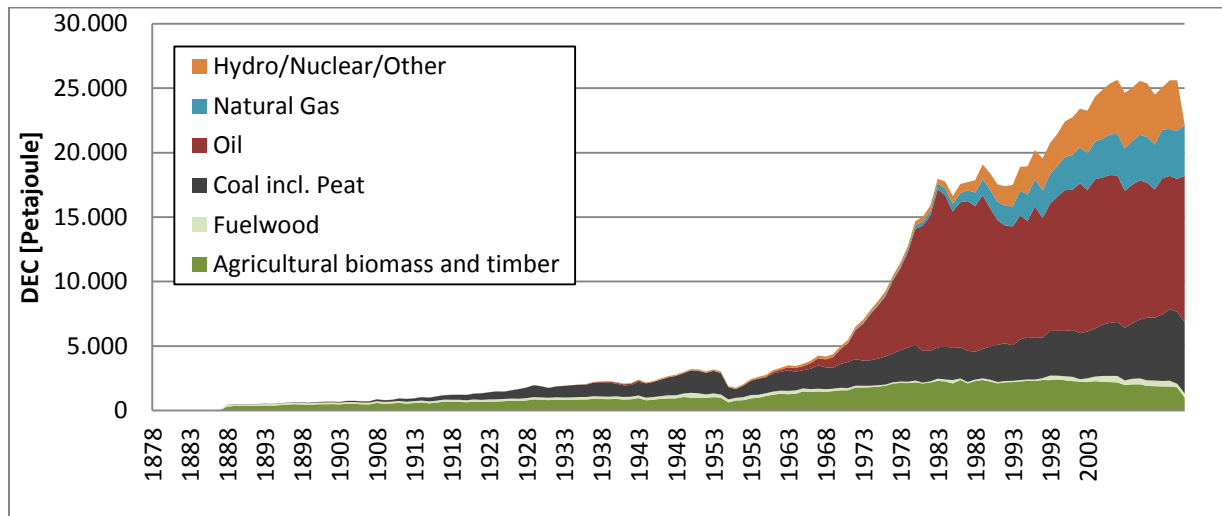


Figure 2.9: Domestic Energy Consumption in Japan from 1878 - 2006 (Source: Krausmann et al., 2011)

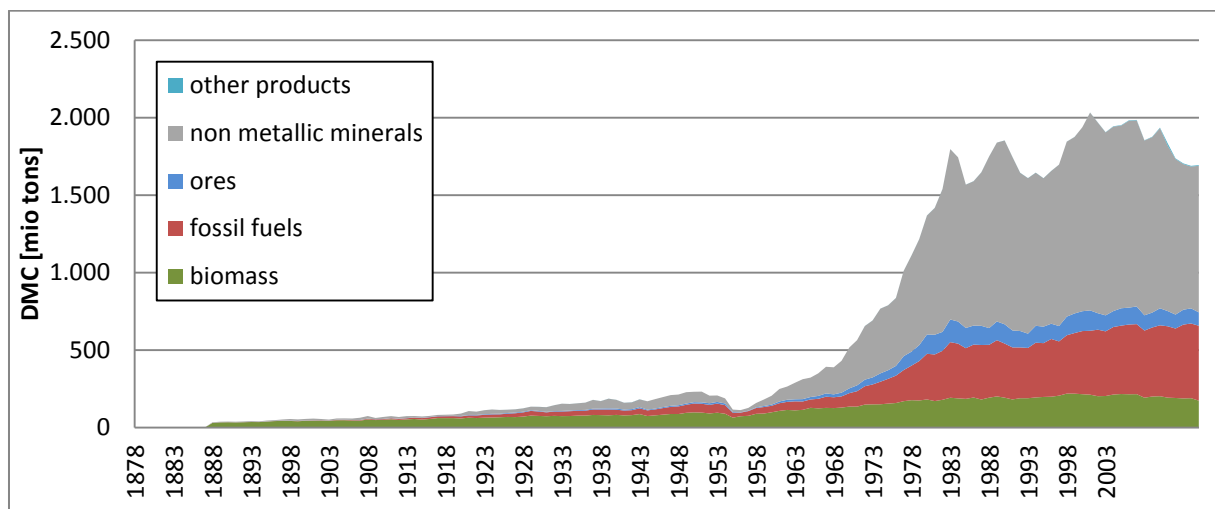


Figure 2.10: Domestic Material Consumption in Japan from 1878 - 2005 (Source: Krausmann et al., 2011)

The “historical” transition from an agrarian to an industrial regime as exemplified in these case studies has led to a certain metabolic saturation in most high income OECD countries⁷, at very high per capita levels of energy and materials use, or just slow increases due to ongoing population growth. Some selected countries like Japan, Germany and the UK even

⁷ Based on the World-Bank definition these are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Israel, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom and the USA.

exhibit slightly declining levels of resource use⁸ (Gierlinger and Krausmann, 2011; Krausmann et al., 2011; Weisz et al., 2006).

Thus since the early 1970s we can observe structural changes in the highly developed industrial countries that may signal the onset of a new socio-metabolic regime. While new energy sources play only a minor role⁹, there are technological changes that (would) allow a partial decoupling from high energy demand: Information and communication technologies. Culturally, there is a new awareness of the “limits to growth” (Meadows et al. 1972), many highly developed economies shift from manufacture to services, and their material and energy use stagnates, while income keeps rising. This change in trends is so marked that it even dominates the global trends of socio-economic metabolism (figure 2.18).¹⁰ The potential of this new situation has not yet fully unfolded, and politically this period was dominated by (partly futile) efforts to maintain the status quo, the high growth rates of the previous phase, be it at the expense of debts and speculative profits.¹¹

We feel a certain temptation to interpret this developmental phase in industrial countries as the onset of a next socio-ecological transition. In the literature, some terms are used that signify a change (such as “postindustrial”, or “postfordism”), but rarely this change is understood as start of another “great transformation” (Polanyi 1944).¹² During the same period, a number of developing countries turn into “emerging economies” and choose the

⁸ This decline has been debated recently, because these countries externalized some of their heavy industry to developing countries, thereby displacing associated energy and material use – if these tendencies were included in a consumption based accounting perspective, some of the decrease of resource use could potentially disappear (Weinzettel and Kovanda, 2009; Schaffartzik et al., 2010; Peters et al., 2011).

⁹ This refers in particular to renewables: they seem not to really take off. But also nuclear energy that had been attracting so many hopes in the previous decades plays a dominant role only in a few countries (such as Japan and France, for example), and its further expansion is impeded by a number of severe accidents and an unforeseen explosion of costs.

¹⁰ It is important to look at the global picture: To a certain degree, Europe, Japan and other OECD countries had been outsourcing their industrial production and manufacturing processes to developing countries and sustaining their continuing high consumption levels of industrial products from imports. Global data though show a worldwide decline in the growth rates of energy and material consumption (figure 3.1) for this period – so there cannot just have been a geographical shift.

¹¹ From the early 1970s onward, state debts begin to rise, although no particular social welfare gains above the achievements of the previous decades can be observed (see Reinhard & Rogoff 2010)

¹² This “historical” socio-ecological transition has had a major impact on the global bio-geospherical cycles of the world, and transformed the earth system (Rockström et al., 2009, Vörösmarty et al., 2004, Schellnhuber, 1999), most notably the climate system, the evolution of biodiversity and the deposits of non-renewable resources. These are largely irreversible changes in natural systems that future humanity will have to live with. Practically all “natural system megatrends” we shall discuss in chapter 4 and appendix A are rooted in this “historical” transition.

same materially and energetically intensive fossil fuels based pathway as the “old” industrial economies had (see for example the recent report on Asia and the Pacific by UNEP 2011c).

Thus in effect this was not a “historical” socio-ecological transition. Currently, a substantial number of countries comprising more than half of the world’s population are following the same transitional pathway at an accelerating pace.

2.5 Ongoing “historical” transitions from the agrarian to the industrial regime

From a global perspective, those countries are of special interest which are either in the acceleration phase of the agrarian-industrial transition or do show clear signs of a take-off into it.

For an illustration, we pick the countries that the economists of Goldman Sachs in their Global Economic Outlooks identified as BRIC and Next-11¹³ countries and attributed them the potential to match or even overtake the G7 economies (USA, Germany, UK, Canada, France, Italy, Japan) in terms of absolute economic activity (GDP) and create an overall impact on the world economy. These countries have been identified based on a “Growth Environment Score”, consisting of 13 sub-indices grouped into indicators covering 1) macroeconomic stability (inflation, government deficit, external debt), 2) macroeconomic conditions (investment rates, openness of the economy), 3) technological capabilities (penetration of PCs, phones, internet), 4) human capital (education, life expectancy) and 5) political conditions (political stability, rule of law, corruption) (O'Neill et al., 2005).

The BRICs are chosen because of their relative share of world GDP making them the largest economies next to the G7 already (especially when PPP standards are used, see (Wilson and Purushothaman, 2003). In combination with optimistic prospects for a continuation of their relatively high growth rates, the BRIC countries are expected to overtake the G7 in terms of world GDP shares over the next decades (O'Neill et al., 2005; Wilson and Purushothaman, 2003).¹⁴

¹³ BRIC is an acronym for Brazil, Russia, India and China while Next-11 stands for Bangladesh, Egypt, Indonesia, Iran, Korea, Mexico, Nigeria, Pakistan, Philippines, Turkey and Vietnam (GoldmanSachs, 2005 and 2007 bzw. O'Neill et al., 2005, Wilson, 2007)

¹⁴ “The BRICs story is not simply about developing country growth successes. What makes the BRICs special is that they have the scale and the trajectory to challenge the major economies in terms of influence on the world economy. Looking across the developing world today, the BRICs nations stand out on both their economic and demographic size. [...] these two criteria provide the basic foundations for the potentials we map out.” (O'Neill et al., 2005).

The so called Next-11 countries have also been identified as having large economic growth potential, again depending on large populations and labour force dynamics.¹⁵ The Next-11's contribution to global economic growth is increasing slowly across the whole group (Wilson and Stupnytska, 2007). All of the N11 have the capacity to grow at about 4% or more over the next 20 years (ibid. 2007, 4) and show potential to rival or even overtake some of the G7 countries until 2050 (ibid. 2007, 10).¹⁶

If we accept the Goldman-Sachs classification of economic dynamics and group the BRIC and the Next-11 countries together as “emerging economies”, we can compare their socio-metabolic profiles with the mature industrial countries. All countries not covered as mature industrial or emerging economies are for the purpose of this report subsumed as “rest of the world” (RoW).

¹⁵ “In thinking about other countries that might have BRICs-like potential, we focused on demographic profiles, which drive much of the analysis. Without a substantial population, even a successful growth story is unlikely to have a global impact.” (O'Neill et al., 2005). “[...] our projections confirm that many of them *do* have interesting potential growth stories, alongside reasonable scale, although their prospects vary widely and some face much greater challenges than others” (Wilson and Stupnytska, 2007).

¹⁶ South Korea already belongs to the group of high-income OECD countries and its metabolic profile suggests that it already has reached the phase of mature industrial stabilization (Table 2.2 and UNEP 2011b p47 - 78). Therefore we decided for the sake of this analysis, to remove it from the group of the Next-11.

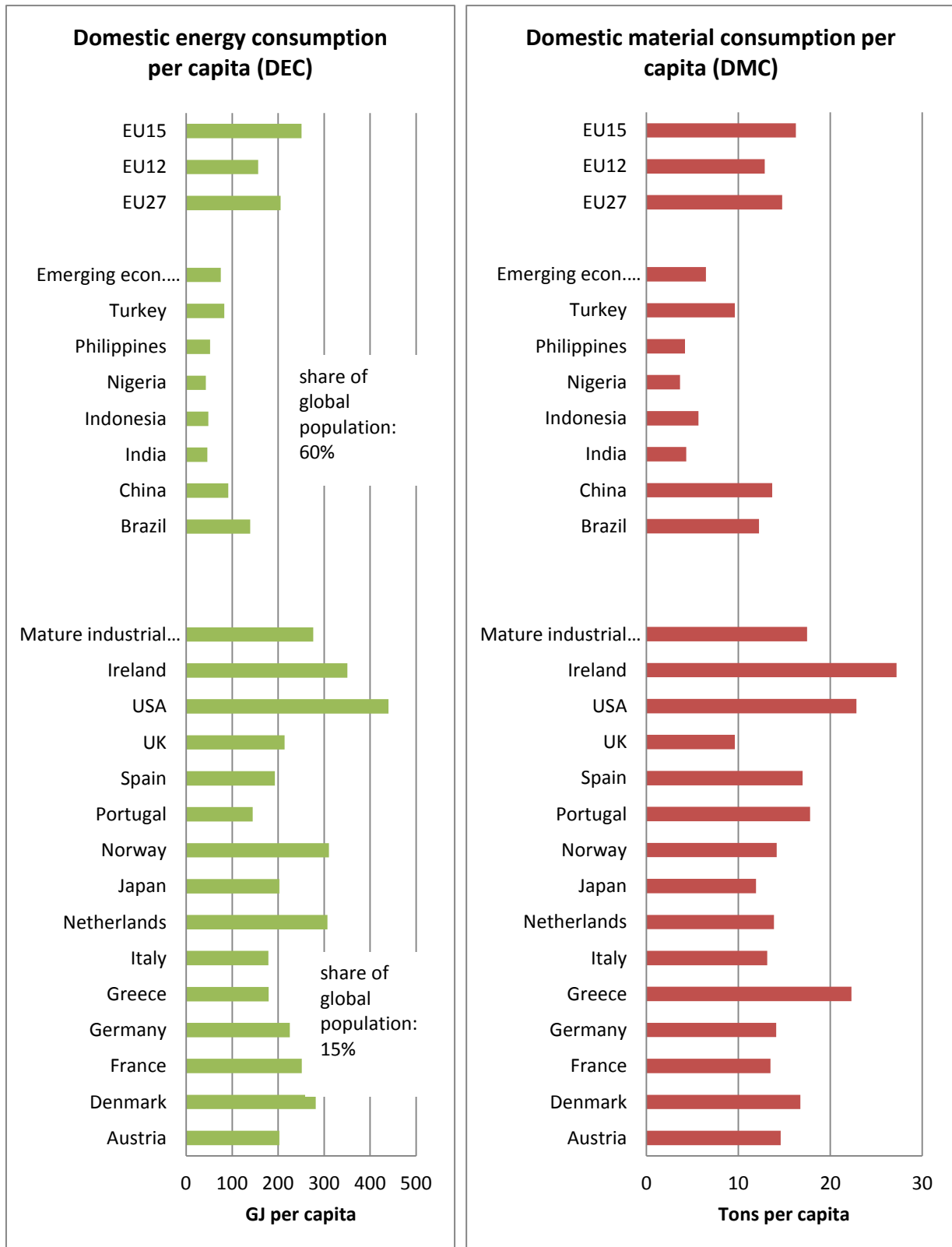


Table 2.2: Metabolic profiles of the country groups and selected cases

Sources: Data compiled from Krausmann et al. (2009); Steinberger et al. (2010); Krausmann et al. (2011); Gierlinger and Krausmann (2011); Schandl et al. (2008); Gonzalez-Martinez and Schandl (2008); Maddison (2008); CSIRO (2011); Mayer (2010); Singh et al. (2012); SEC-database

The group of mature industrial countries¹⁷ as a whole has on average a per capita DEC of 277 GJ and per capita DMC of 17 tons, while for all the emerging economies a per capita DEC of on average 79 GJ and per capita DMC of 7 tons has been calculated (Table 2.2). According to a socio-metabolic regime classification, India, Indonesia, Bangladesh and Nigeria are still very close to the agrarian pattern. India and Indonesia, according to a recent report on Asian and the Pacific countries (UNEP 2011b) display signs of take-off not only in economic, but also in biophysical terms. If all these “emerging economies” (that comprise almost 60% of the world population) adjust their metabolic rates to the pattern of mature industrial economies, it would mean a tripling of their annual per capita energy and material resource consumption. This would imply an unprecedented explosion of anthropogenic global resource use, by far surpassing all impacts demonstrated for the “historical” socio-metabolic transition of the already mature industrial countries.

Exactly such a process is already under way, as we will demonstrate in the following section for a few selected cases, namely China, India and Brazil.

China is one of the most interesting cases of the on-going SET, because of its population size and its economic dynamics. During the time period of 1970 - 2005, annual DMC per capita in China increased by a factor of 7, from approximately 2 to 14 tons (UNEP 2011b, 42). In the same time total DMC grew by a factor of 11 (Figure 2.11). Domestic energy consumption (DEC) increased per capita by a factor of 3, from 31 to 91 GJ and overall by a factor of 5 (Figure 2.12). During that time period the share of biomass in DEC decreased from 60% in 1970 to 42% in 2005. In the light of these rapid increases in materials and energy use, combined with high economic growth rates observed and projected, it seems plausible to say that China is currently in the midst of the acceleration phase of its transition from an agrarian to an industrial regime.

¹⁷ South Korea needs to be, according to socio-metabolic data, classified as a mature industrial economy: By Goldman-Sachs, it is classified as one of the Next-11. But actually, it already exhibits a metabolic profile resembling a mature industrial metabolism, with some signs of a slow-down or maybe even stabilization of the biophysical growth of the socio-economic system (Table 2.2 and UNEP 2011b, 47 and 78).

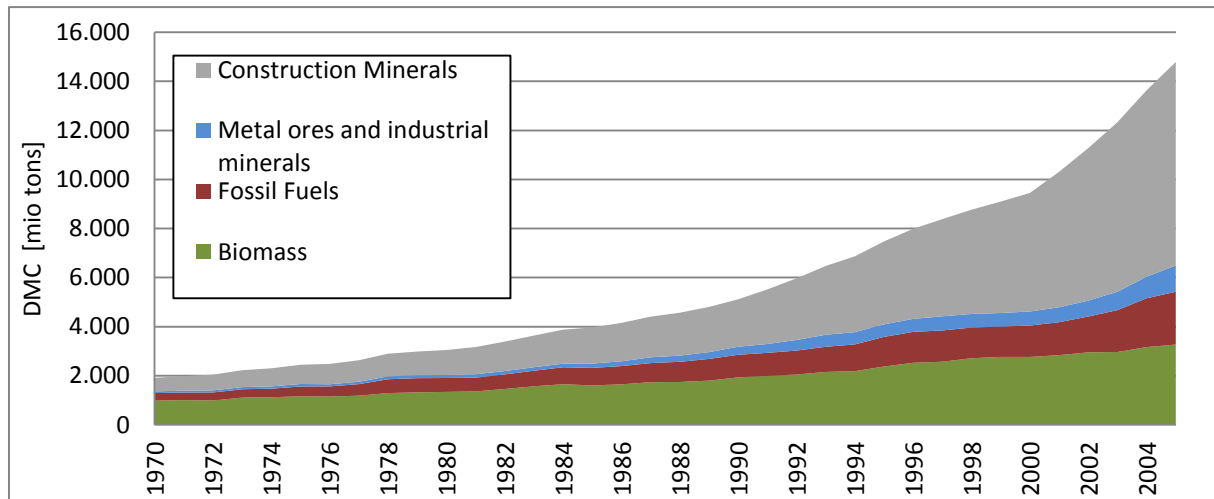


Figure 2.11: Domestic material consumption in China, from 1970-2005 (Sources: own calculations based on CSIRO 2011; IEA 2010 and SEC database)

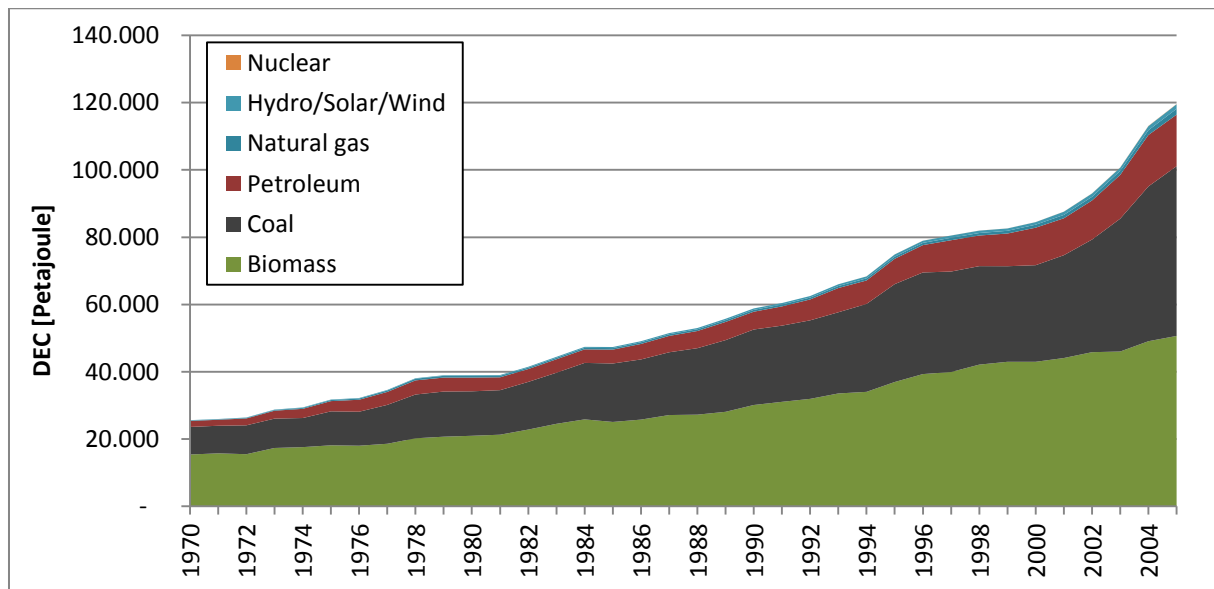


Figure 2.12: Total primary energy supply of China, 1970 - 2005 (Sources: own calculations based on CSIRO 2011 and IEA2010)

India, as the second most populous country of the world and part of the BRICs group, is also of special interest in the context of this report. Material and energy use in the year 2008 have been estimated at 46GJ and 4 tons per capita (Singh et al. 2012). These per capita values by themselves resemble rather an agrarian regime, but in the light of the dynamics of the Indian economy, they should rather be interpreted as a snapshot of the take-off phase (Singh et al. 2011 and Singh et al. 2012). Between 1961 and 2008, total DEC has increased by a factor of 3.4. Although the energetic metabolism of India is still mostly dominated by biomass, the share of fossil fuels, especially coal, is increasing rapidly, with coal at 33%, oil at 13%, natural gas at

3%, biomass at 50% of total DEC in the year 2008 (Figure 2.12, Singh et al. 2012). In the same time period material use increased by a factor of 3.8 (Figure 2.13). If one imagined that India finished its transition until 2050, with a metabolic profile resembling Japan which is currently the most efficient economy of the mature industrial countries, this “[...] development alone would lead to an increase of global material use by 30%”¹⁸ (Singh et al., 2011). As India is still in its take-off phase of the SET, it would be highly desirable to try to establish a different transition pathway than the resource intensive strategy of industrialization followed by the neighbouring booming Asian-Pacific economies (Schandl and West, 2010).

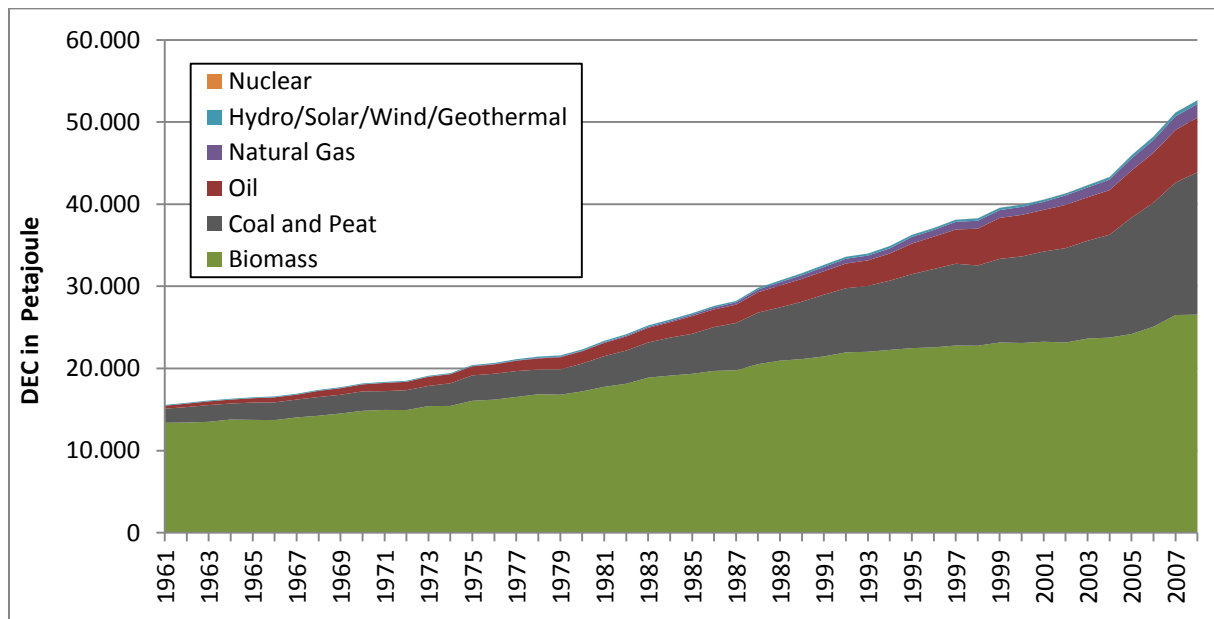


Figure 2.13: Domestic Energy Consumption in India, from 1961 - 2008 (Sources: own calculations based on Singh et al. 2012 and IEA 2010)

¹⁸ Based on UN medium fertility projections, which estimate India's population at 1.6 billion people for 2050; furthermore the 30% are expressed in comparison to total global extraction for 2005 (estimations in Singh et al. 2011)

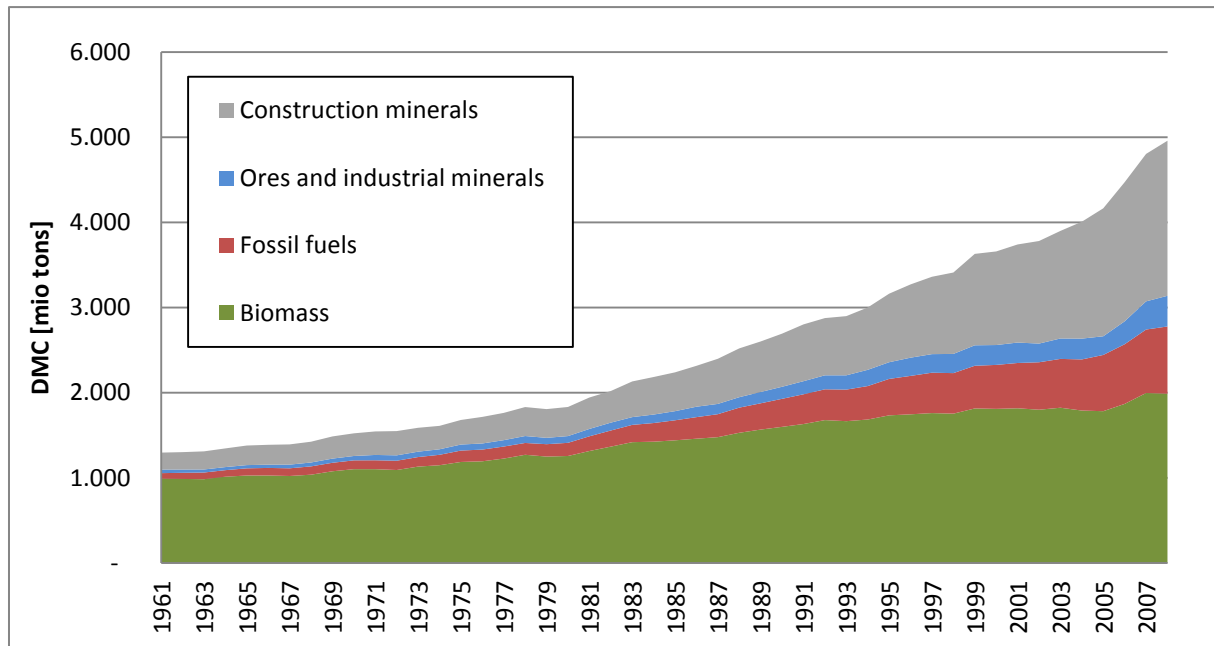


Figure 2.14: The socio-ecological transition in India, 1961 – 2008 (Source: Singh et al. 2012)

The socio-ecological transition in Brazil follows a slightly mixed pathway of industrialization, with a large share of biomass in the DEC due to high land-availability, which allows for the large scale production of modern biofuels and export oriented cash crops (Mayer, 2010). Per capita DEC and DMC for the year 2005 have been estimated at 125 GJ and 13.4 tons, respectively. During the observed time period from 1970 - 2005, overall DMC grew by a factor of 3.5, while total DEC increased by a factor of 2.8. The time series of the metabolic profile of Brazil suggests that the acceleration phase of the SET is ongoing (Figure 2.15 and 2.16).

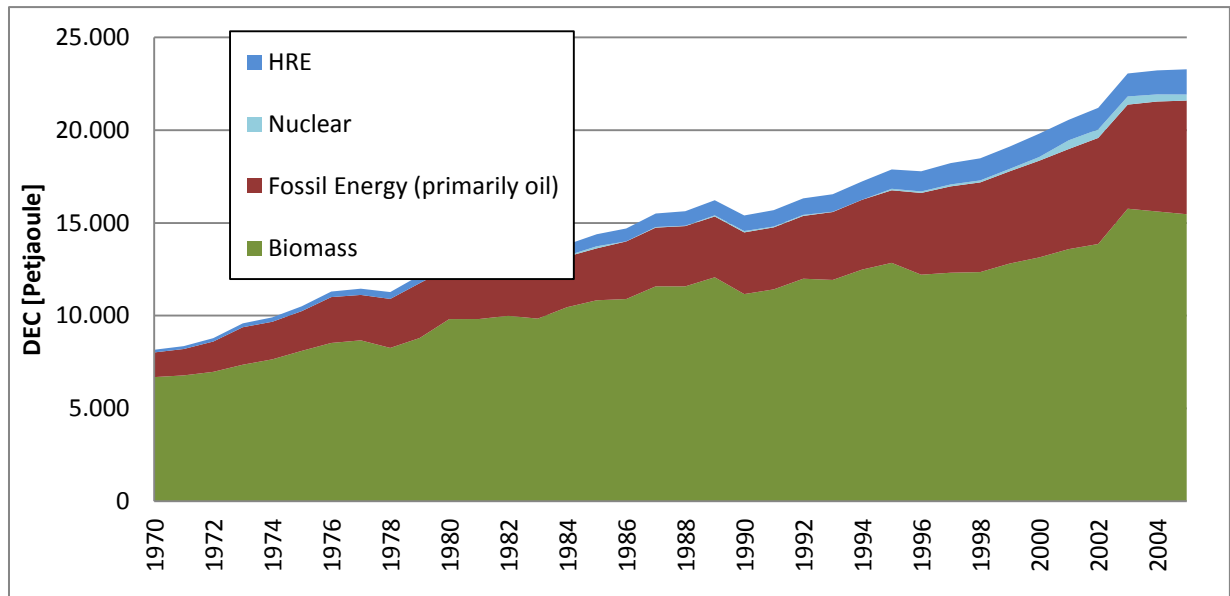


Figure 2.15: Domestic energy consumption in Brazil, from 1970-2005 (Source: Mayer 2010)

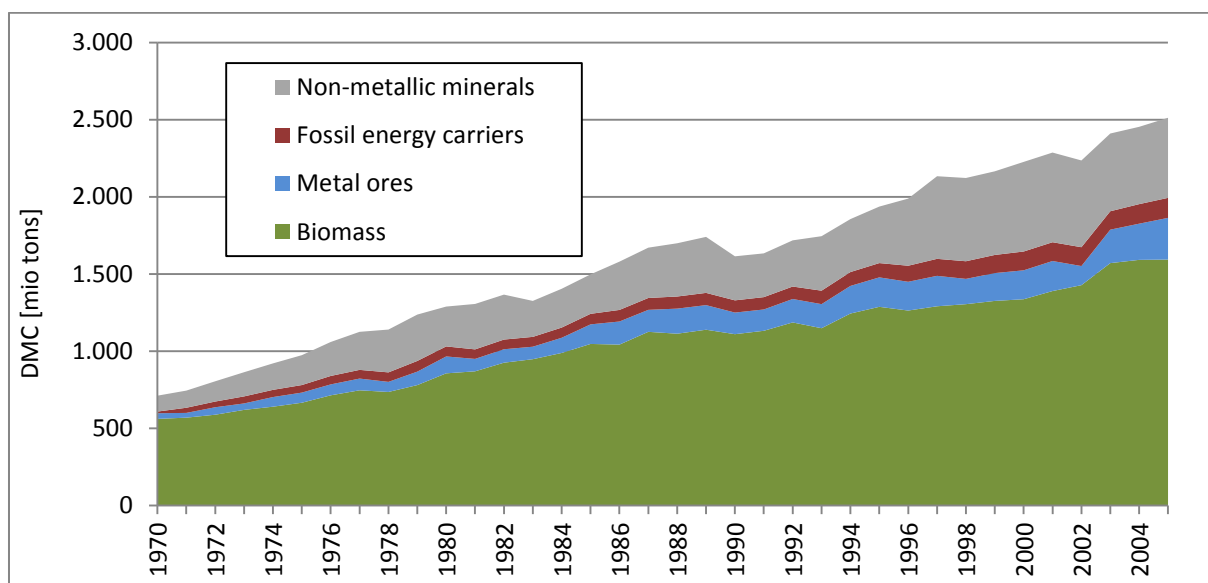


Figure 2.16: Domestic material consumption in Brazil, from 1970-2005 (Source: Mayer 2010)

In effect, it is clearly apparent that, what economists call “emergent economies”, are countries in a take-off or acceleration phase of the socio-ecological transition from the agrarian to the industrial regime, following pretty much the pathway the mature industrial countries had been taking in the centuries and decades before, based on the use of fossil fuels (increasingly again: of coal). Due to their much larger populations, the ecological impact of

their transitions, in terms of climate, biodiversity, soils, air and water pollution, depletion of fish stocks in the oceans, nutrient washout into the oceans – would be huge, much larger than the impact of the historical transitions of the mature industrial countries. From the point of view of resource scarcity, though, it remains questionable whether this process will indeed take place, or whether it will be suffocated in the middle of its acceleration.

2.6 The current global aggregate dynamics and the need for a fundamental change of trajectory

The historical and on-going socio-ecological transitions around the world have led to a 10-fold increase of global material use, and a seven-fold increase in DEC (corresponding to an even larger, namely 12-fold increase of TPES) in the time from 1900 – 2009 (Krausmann et al., 2009). During the same time world GDP¹⁹ increased by a factor of 26 and global population quadrupled (Maddison, 2008).

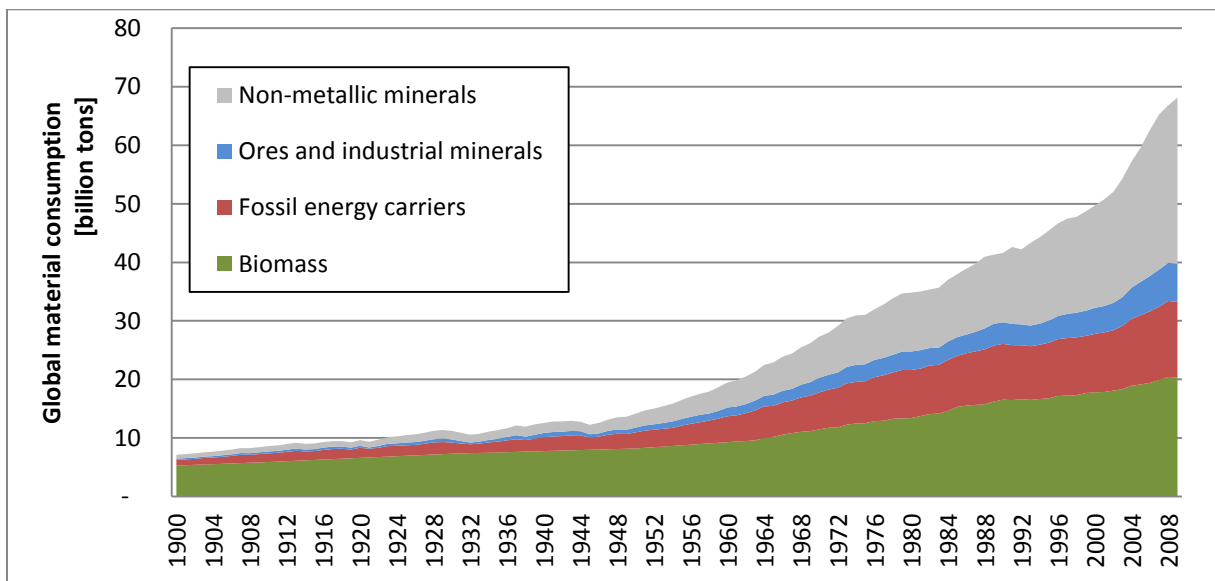


Figure 2.17: Global Material Consumption from 1900 – 2009 (Source: Krausmann et al. 2009)

¹⁹ As calculated in 1990 International Geary-Khamis Dollars, based on Maddison

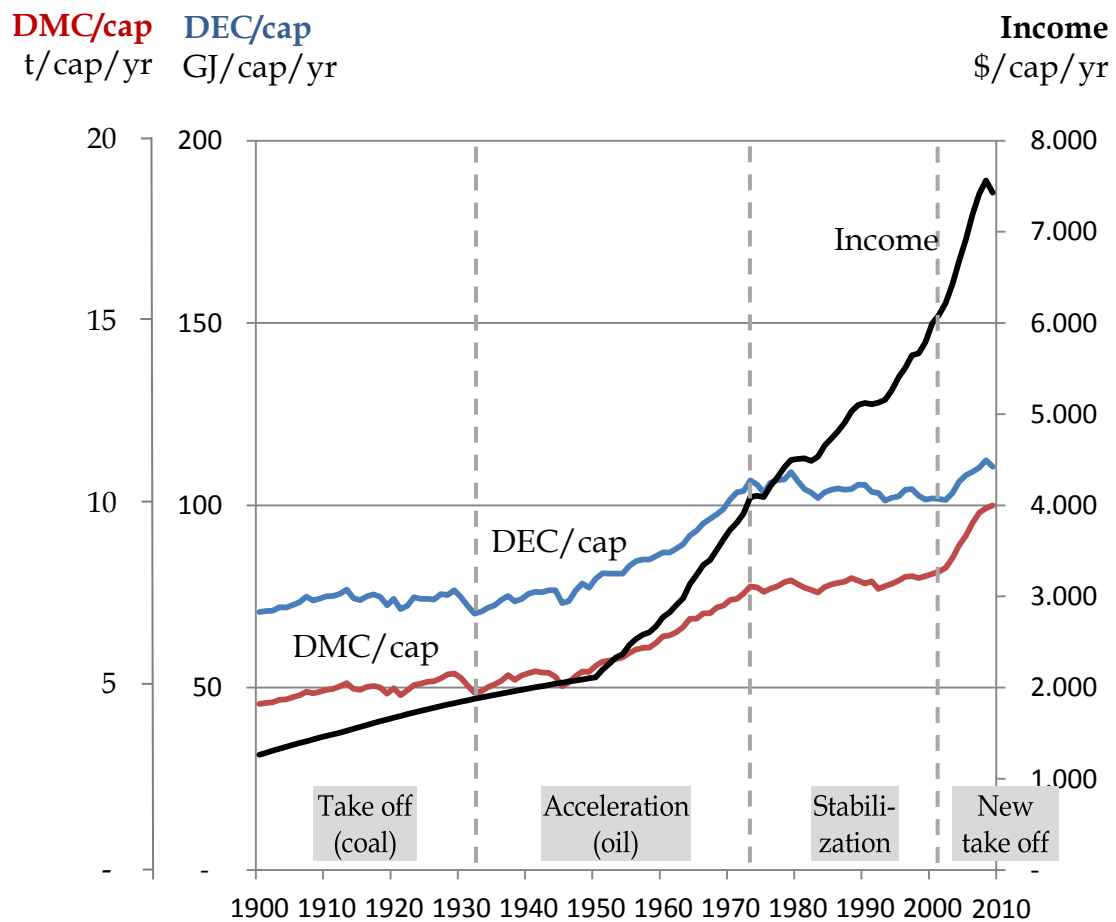


Figure 2.18: Phases of global per capita materials and energy use during the 20th century. The numbers represent the average amount of resources/energy required to sustain one person for a year (metabolic rate) (Source: after Krausmann et al. 2009).

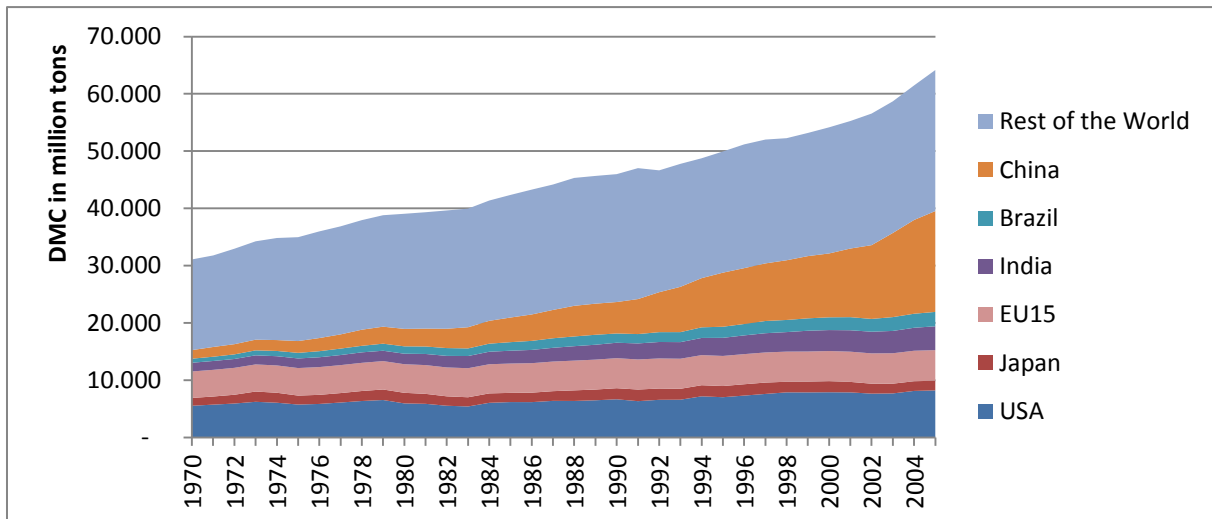


Figure 2.19: Global materials use by selected countries and rest of the world, 1970 – 2005 (Source: SEC database)

As noted above, in terms of global resource use the importance of the emerging economies relative to the mature industrialized economies is growing rapidly. While global resource use is increasing exponentially during the 20th century (Fig 2.17 and 2.18), the relative shares of selected countries shifted significantly (Figure 2.19). In 1970 the USA used 20% of global resources, the EU15 17% the UK 3%, Japan 5%, India 6%, China 6% and Brazil 3%. In 2005 large changes have happened, with the relative share of the mature countries decreasing across the board while selected emerging economies increased their shares rapidly: the USA uses 14%, the EU15 9%, the UK 1%, Japan 3%, India 4%, China 30% and Brazil 7%. During the observed time period the fossil fuelled socio-ecological transitions started to take-off and accelerate in several of the emerging economies countries, which in combination with ongoing population growth leads to a rapidly increasing importance of these countries and especially China, in global resource use.

This massive expansion of the global socio-economic metabolism was accompanied by fundamental changes in society-nature relations and an unprecedented transformation of natural systems (Hibbard et al., 2007; Steffen et al., 2007). While humans have always influenced their environments, the changes induced by the fossil fuelled socio-ecological transitions during the 20th century have been rightfully termed “something new under the sun” (McNeill, 2000), as these transformations have been unprecedented in human history. The consequences of these changes furthermore already exceed the “safe operating space for humanity” in at least three of nine dimensions – these are climate change, the rate of biodiversity loss, and the rate of interference with the nitrogen cycle (Rockström et al.,

2009a). “Transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems” (Rockström et al., 2009b). Similar conclusions regarding the deteriorating effects the expansion of the global socio-economic metabolism has had on natural systems have been reached by numerous ecological footprint studies (Wackernagel et al., 2002; Ewing et al., 2008) and the investigation of anthropogenic biodiversity loss (MES 2005).

Recently the International Resource Panel, under the auspices of the United Nations Environment Program, computed three scenarios of the biophysical consequences of global convergence of material living standards until 2050 (Figure 2.20). All scenarios are based on the UN medium fertility population projections resulting in a global population of 8.9 billion people for 2050 (UNEP, 2011a).

The first scenario is a trend scenario: mature industrial countries stabilize their per capita resource use at the level of the year 2000, and all developing countries catch up to these levels by 2050 (UNEP, 2011a, 28f). This results in a tripling of global annual resource extraction and is absolutely incompatible with IPCCs climate protection target of 2°C. It is also incompatible with FAO’s projections of food availability.

The second scenario assumes “moderate contraction and convergence”: mature industrial countries halve their resource use per capita, and developing countries catch up to these levels until 2050 (UNEP, 2011a, 29). “This scenario presupposes substantial structural change, amounting to a new pattern of industrial production and consumption that would be quite different from the traditional resource-intensive Western industrial model. [...] Given the resource productivity gains that have occurred in the past, these metabolic rates could support a comfortable middle class lifestyle for all, in both developing and developed economies.” This scenario still results a 40% increase in annual global resource extraction and the resulting GHG emissions could be expected to be in the middle range of the IPCC SRES climate scenarios (UNEP, 2011a, 31).

Finally a scenario of “tough contraction and convergence” has been modelled, where global resource consumption is frozen at the levels of the year 2000 and global resource use rates converge at approximately 6 tons per capita annually by 2050. “This scenario requires far-reaching absolute resource-use reductions in the industrialized countries, by a factor of 3 to 5. [...] Taken as a whole, this would be a scenario of tough restraint that would require

unprecedented levels of innovation” (UNEP, 2011a, 30). The GHG emissions in this scenario correspond to the lower range of IPCC emissions scenarios and would be roughly consistent with the 2°C target (UNEP, 2011a, 32).

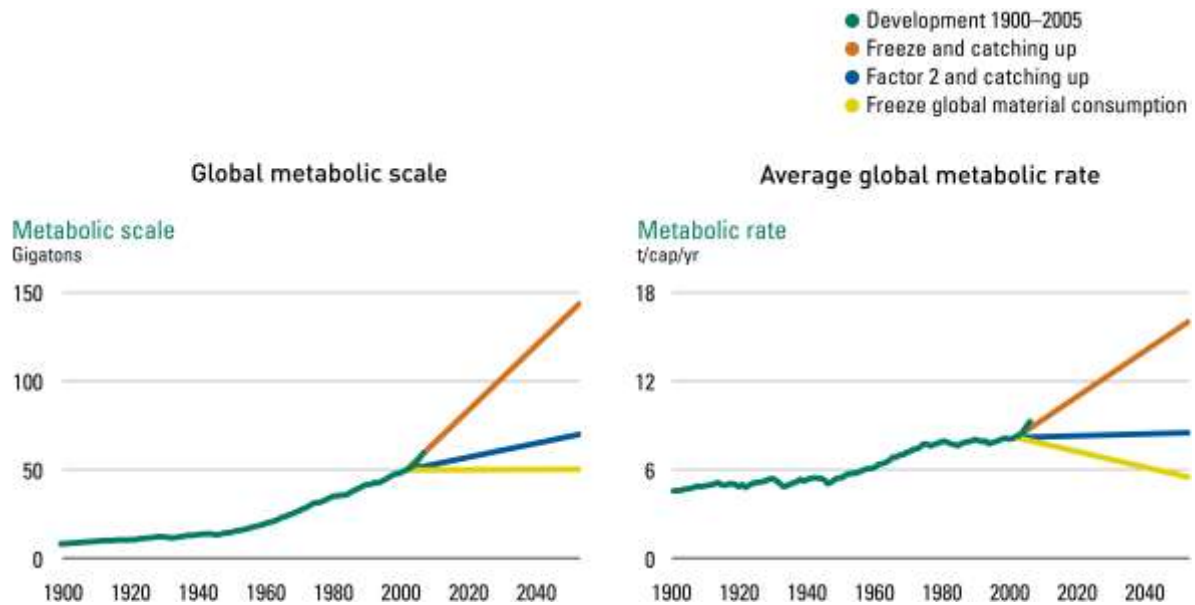


Figure 2.20: Global resource use under three different scenarios (Source: UNEP 2011a, 30)

The ongoing socio-ecological transitions in emerging economies in combination with relatively stable but quite high levels of resource consumption in the mature industrial countries reflect themselves as increasing pressure on the world’s resources, in the form of “the most extended and steepest boom of commodity prices ever” (World Bank 2009). With a short interruption by the economic crisis 2007/08, commodity prices keep rising since the beginning of the 21st century (Figure 2.21). This is of major importance, as the past SETs of the mature industrial countries have all happened in a global context of easily available fossil fuels and plenty of commodity frontiers for further exploitation (Bunker and Ciccantell, 2005; Bunker, 2003). But this global context has changed and will be quite different in the future.

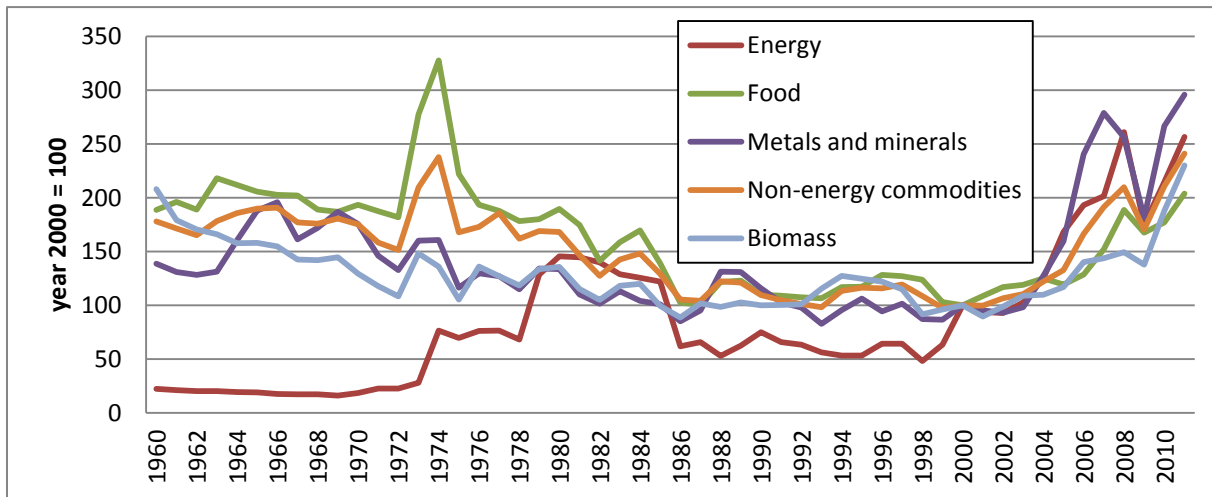


Figure 2.21: Global commodity prices in constant prices, year 2000 \$ (Source: WorldBank database Global Economic Monitor)

The WBGU's flagship report on the "World in Transition" came to similar conclusions: "The idea that all people should be able to enjoy a lifestyle that equals today's predominant lifestyle in the industrialised countries, characterised by the use of fossil energy carriers, cannot be realised. To avoid non-sustainable development paths, the developing and newly industrialising countries would have to leapfrog technological development stages. The industrial countries should therefore lead the way off current development paths to demonstrate that it is also possible to follow sustainable paths. A lifestyle must be found that is consistent with the guiding principle of global sustainable development. It must also allow the catch-up development of poorer countries, equally guided by the criteria of global sustainability, and allow for inclusion of the so far excluded 'bottom billion'." (WBGU 2011, 62).

This fundamentally changed global context and the need for systemic changes in policy and institutional settings have also been acknowledged by several major institutions regularly reporting on the state of the world and the world-economy.

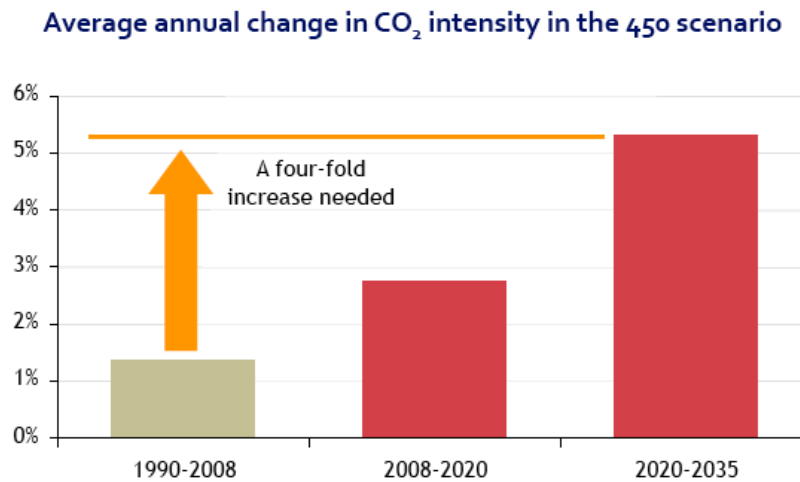
UNEP, for example, states in its recent report on the green economy: "Indeed, most economic development and growth strategies encouraged rapid accumulation of physical, financial and human capital, but at the expense of excessive depletion and degradation of natural capital, which includes our endowment of natural resources and ecosystems. By depleting the world's stock of natural wealth – often irreversibly – this pattern of development and growth has had detrimental impact on the well-being of current generations and presents tremendous risks and challenges for future generations. The recent multiple crises are

symptomatic of this pattern.” (UNEP 2011c, 1). In another report on the prospects for decoupling economic growth and resource use, UNEP notes that “Technological innovations have often led to greater resource consumption; however, innovations in resource extraction and use systems [...] will be required to enable decoupling to take place in different settings, with a diversity of approaches being applied. Economic innovations will also be essential, perhaps even leading to a substantially revised progress indicator that complements GDP with environmental and social concerns” (UNEP 2011a, XV).

The US National Intelligence Council, which conducts regular strategic risk studies, also recognizes these issues, and states that „With the emergence of rapid globalization, the risks to the international system have grown to the extent that formerly localized threats are no longer locally containable but are now potentially dangerous to global security and stability. At the beginning of the century, [...] a new generation of global challenges including climate change, energy security, food and water scarcity, international migration flows, and new technologies – are increasingly taking center stage” (NIC 2010, 4). They also explicitly recognize the fundamental challenges posed by increasing global demand for resources and fossil fuels and the importance of security of supply (NIC 2008, 41-57). “Unprecedented global economic growth – positive in so many other regards – will continue to put pressure on a number of highly strategic resources, including energy, food, and water, and demand is projected to outstrip easily available supplies over the next decade or so. For example, non-OPEC liquid hydrocarbon production [...] will not grow commensurate with demand. Oil and gas production of many traditional energy producers already is declining. Elsewhere – in China, India and Mexico – production has flattened. Countries capable of significantly expanding production will dwindle; oil and gas production will be concentrated in unstable areas. As a result of this and other factors, the world will be in the midst of a fundamental energy transition away from oil toward natural gas, coal and other alternatives (NIC 2008 vii). “[...] an energy transition, for example is inevitable: the only questions are when and how abruptly or smoothly such a transition occurs. An energy transition from one type of fuel (fossil fuels) to another (alternative) is an event that historically has only happened once a century at most with momentous consequences.” (NIC, 2008, xii)

The International Energy Agency has tried to model possible pathways for a decarbonisation of the energy system. In order to stay within the IPCC’s 2°C stabilization target to avoid catastrophic consequences of climate change, a fourfold increase of annual efficiency gains,

compared to observed gains from 1990-2008, would be necessary until 2035 (Figure 2.22 from IEA 2011). The size of this challenge is immense.



**Carbon intensity would have to fall at twice the rate of 1990-2008 in the period 2008-2020
& almost four times faster in 2020-2035**

Figure 2.22: Projected necessary improvements in carbon intensity of the global energy system to stay with the 2°C target (Source: IEA 2011)

On the European policy level, a fundamental recognition of these challenges has happened, as expressed in the opening remarks of the Roadmap to a Resource Efficient Europe, published in 2011. “Europe has enjoyed many decades of growth in wealth and wellbeing, based on intensive use of resources. But today it faces the dual challenge of stimulating the growth needed to provide jobs and well-being to its citizens, and of ensuring that the quality of this growth leads to a sustainable future. To tackle these challenges and turn them into opportunities our economy will require a **fundamental transformation** within a generation - in energy, industry, agriculture, fisheries and transport systems, and in producer and consumer behaviour. Preparing that transformation in a timely, predictable and controlled manner will allow us to further develop our wealth and well-being, whilst reducing the levels and impact of our resource use” (EC 2011, 2).

3. The linkages between socio-ecological transitions and labour

3.1 Introduction

Our point of departure, as outlined in Chapter 2, is the assumption of human society being – willingly or not, slowly or fast - in a transition away from the use of fossil fuels. We assume that the transition away from fossil fuels has as many implications for human labour as the transition towards fossil fuels has had.

To understand this better, we first delve more deeply into the previous historical energy transition and describe its consequences for human labour on three levels:

1. Qualitative change: critical capacities of human labour
2. Quantitative change: how much of collectively existing human lifetime is spent on labour
3. Change in the institutional form of labour: how is labour organized?

The final section of this chapter will make an effort at speculation: What could labour look like after the on-going socio-ecological transition is completed, or has come to a next stage? Most analyses of “green jobs” deal with a fairly close future, and mainly with the future of gainful employment.²⁰ We open up the time horizon (which also means keeping it somewhat unspecific) and ask ourselves: as the fossil-fuel based socio-ecological transition apparently induced such major societal changes, in work and life, what indications do we have for the changes we may expect from major societal transition away from fossil fuels?

3.2 How can human labour be characterized qualitatively from a socio-ecological perspective?

Human labour, by nature and socio-culturally, may be seen as equipped with three basic capacities:

1. physical power: Physical power is the capacity to alter physical objects through the use of force. This capacity relates to the notion of exergy which is the ability to perform work in a physical sense (see Ayres and Warr 2005), and it relates to the concept of “energy return on

²⁰ There are some exceptions to this, such as the project by the Hans Böckler Stiftung (2000), “Arbeit und Ökologie”. This project looked at a broad range of conceptions of “labour”, including household work and unpaid civil work. In some ways, we follow the pathway of this project, as it seems to relate well to the overall goals of NEUjobs.

energy investment” (EROI): you can look at the human body as a kind of machine that requires a certain amount of energy input (=food) to perform a certain amount of work (energy output). Physically speaking, the human body is not a very efficient machine as it needs much energy input just for living, for base metabolism, and can transform only a small amount of energy input into useful work, and only for a limited fraction of lifetime. While the basic metabolic rate (BMR) depends upon age and body mass and for example amounts to 6,2 MJ/day (for a 50 kg woman) and 9,6 MJ/day (for an 80kg man), corresponding to fluxes of about 70-110 Watt, heavy farm work or sports like day-long cross-country skiing double the daily energy demand; which in a reversed perspective means that hardly half of the energy input may translate into physical activity (see Smil 2008, p.127f). Thus the EROI of the human body is at best 0,5 (two units of energy input for 1 unit of output). Another limitation is the relatively small “installed power” of the human body – even well trained young adults cannot sustain fluxes beyond 150-170 Watt.

2. Rationality / knowledge: This represents the intellectual capacity to correctly anticipate the effect own actions have and to plan them deliberately. This capacity relates to information processing and learning from experience as well as from communication with others. While the human brain in adults is responsible for about one sixth of the basic metabolic rate, brain work is energetically speaking light work – even intensive intellectual activity only marginally raises the brain’s metabolic demand (Smil 2008, p.128). But more than with physical power, the perspective upon the individual is too narrow: rationality and knowledge should be looked upon as social properties, as being built up and maintained collectively, with individuals just having a certain share in this collective property. And of course this build-up and maintenance of a stock of knowledge and information processing generates a certain energy demand on the social system level.

3. empathy: Empathy is the capacity to emotionally anticipate und mirror the feelings of other living beings. While modern brain research has demonstrated it to be an innate capacity of primates to sense the feelings of others and “understand” (mirror) the intentions guiding activities of others (Rizzolatti 2006), this natural capacity should be expected to be strongly influenced by cultural features on the social system level. It should be looked upon not as an intellectual, but as an emotional capacity, crucial for human labour that involves and functionally relies upon communication and caring for the needs of people (or animals). Empathy as an emotional capacity rooted in certain neuronal equipment must not be

equated with a value orientation of altruism; the ability to mirror the feelings of others may just as well be used to manipulate or harm them more skilfully.

When analysing the linkages between these qualitative features of human labour, socio-metabolic regimes and transitions between them, one has to keep in mind the following three dimensions: each capacity can be, under the given circumstances,

- **functionally** (economically, technologically) more or less relevant for work performance
- **socially** (culturally) more or less valued and enhanced (investment in education) or suppressed, and finally
- **technologically** more or less supported and enhanced, or it may even be substituted by technology.

3.3 How can human labour be characterized quantitatively from a socio-ecological perspective?

Anthropologically speaking, human labour is an element of human time use in a social (distributional) context. As humans reproduce their lives in social groups, they cooperate in various forms of “division of labour”. It makes sense, in a wide perspective, to regard all those elements of time use as “labour” that are subject to such division and therefore constitute social interdependencies. While traditional time use research (Gershuny 2000) deals with time use on a descriptive and individual level only, a socio-ecological analysis places the traditional time-use categories in a functional context of system reproduction. Human time is looked upon as a key “natural resource” social systems make use of.

The main systemic distinctions should apply to very different historical or functional types of social systems and allow for comparisons between them (Ringhofer 2010). There needs to be time use for...

1. **The reproduction of the self:** Core feature of this class of activities is that they cannot be delegated to others (such as sleeping, eating, resting, learning, having fun...). In all types of society, this requires about 50% of human time (much more with children & elderly). If people for extended periods are allowed less than 50% of their time for self-reproduction, health impairments are likely to ensue. Excess time for self-reproduction (for rest, for education, for entertainment...) may be considered a social privilege. This

class of activities cannot be subject to a division of labour, and thus cannot be considered “labour”.

2. **The reproduction of the household / family:** These activities also deal with personal reproduction but in an inter-subjective mode. There are delegable and in many societies define a female role compartment (child bearing and rearing, food preparation, daily chores...). This clearly can be considered “labour”.
3. **The reproduction of the community:** participation in “public affairs” on various scale levels beyond the family, such as shared infrastructure work, collective decision making, voting, participation in religious and public ceremonies or military service... In most societies, such activities to some degree are considered social duties (sometimes gendered), but the amount of time required under this label is highly variable (Ringhofer 2010). This class of activities is a mixed bag in terms of labour: As far as it contains general obligations that are not subject to any division and interdependency (such as attending mass on Sundays), it should not be considered labour. On the other hand, serving as civil fireman has many labour-like features.
4. **The reproduction of the economy:** food procurement and income generation on the market. For a subsistence economy, it is often difficult to draw a distinction to family and community reproduction, while participation in a market of paid labour constitutes a very distinct pattern. In modern societies, of course, engaging in gainful employment constitutes the core of “labour”.

What share of a population’s time is devoted to each function varies strongly between socio-ecological regimes. It is also related to demographic patterns. How the activities are distributed among subgroups of the population by gender, age and status is highly variable. The higher the status of a group, the more time for self-reproduction (type 1) it will be entitled to. Time use of the types 2 and 4 may be considered as „labour“, with the somewhat diffuse type 3 sometimes counting as labour and sometimes not..

For the individual, the question is how much work it needs to do to survive and to reproduce – this defines a minimum of activities of type 2 and 4. Under favourable environmental and social conditions, this may be very little (see Sahlins 1972; Ringhofer 2010). Under unfavourable environmental and social conditions, this may be more than the individual can afford for a longer stretch of time, so it will not reproduce and not be able to

survive.²¹ For the social community, demand for labour can best be seen as an economic relation, the relation between the benefit the community has (i.e. the marginal return upon additional labour) and the cost of this additional labour. In family and community relations, an additional potential labourer (an additional child, for example, or a second wife) may be sustained although the benefit of this labour is lower than the costs.²² In strictly economic relations, additional labour will not be employed if benefits don't surpass costs. What determines both variables, the benefits to be gained by additional labour, and the cost of it, strongly depends on the socio-ecological regime (table 1).

As known from cultural anthropology (Sahlins 1972; Gowdy 1998), the hunting & gathering regime requires the least amount of human labour. With the transition to the agrarian regime, the amount of labour increases, and increases even more with the intensification of traditional agriculture (see table 3.1, Boserup 1981; Ringhofer 2010). The transition to the industrial regime at first may have even further boosted labour time (see Germany and Japan 1870 in table 3.1), but then provides relief.

²¹ Young adult slaves working in the mines of ancient Rome had an average life expectancy of no more than 2-3 years (Scheidel 2011).

²² Under tight ecological conditions though, children or sick people may be sent away (such as children age 10-12 from alpine villages in the past centuries) or seek a ritual death (eg. traditional Japan).

	Work in the economy	Household & family work
Trinket (hunters & gatherers)	0.8	2.1
Campo Bello (swidden agriculture)	2.5	2.1
Nalang (permanent farming, traditional)	3.5	2.1
Japan 1870 (traditional agriculture, beginning industrialization)	4.4	
Germany 1870 (trad. agriculture, cities industrialized)	3.3	
Japan 2000 (industrialized)	2.5	
Germany 2000 (industrialized)	1.9	

Table 3.1: Working hours by socio-metabolic regime by number of hours for average inhabitant and average day of the year (Sources: Fischer-Kowalski et al. 2011 (for Trinket, Campo Bello and Nalang), Maddison 2001 (for Japan), Clearingstelle Verkehr 2012 (for Germany 2001/02)²³)

Another key quantitative relation concerns the degree to which the population of a social system is consumed by food production. This is not so easy to estimate. The most encompassing indicator would be the **proportion of the population's lifetime** (in a particular year, for example) **spent on food production** and/or agriculture, respectively. In Japan in 1870, if we assume all the labour time given for "work" in table 3.1 above were for food production only, it would have been 18%, or 37% of the available work time (as roughly half of the lifetime hours need to be spent on the reproduction of the person, such as sleeping and eating, growing up from birth through childhood, resting, being sick and recovering from it...). On top of this there would be household work, again indispensable for personal reproduction, of another 17%.- Thus 54% of all available lifetime would have been consumed by primary reproduction (food production, food preparation, child bearing and rearing...). Unfortunately, this indicator is rarely available. Another potential indicator is the **proportion of the population that does not make its living on food production**. This indicator may be approximated by estimates for the **proportion of urban (as opposed to rural) population** as we attempt below. Another approach would be to use estimates of the proportion of

²³ these data are based on a population sample age 15-65, so both types of labour are slightly overestimated

agricultural produce that can be taken away from the producers **by tithes and taxes**. This would allow a minimum estimate of how many people can live from the agricultural surplus. If each farming family pays 10% tithes and taxes, we may assume at least one non-farming family to sustain itself on 10 farming families – or, if we assume a more luxurious life for them, maybe only one non-farming per 20 farming families. Such information on tithes and taxes does exist for many agricultural systems and has been analysed by historians (e.g. Kulke & Rothermund 2008 for India across history).

3.4 How can the institutional form of labour be characterized?

Labour can be organized ...

- as **family work** within personally interdependent **household systems**: mutuality of obligations (subsistence agriculture, hunters & gatherers, household work in most regimes)
- as **slavery** (master owns the labourer, has to take care of his/her reproduction or, if cheaper, buy a new one)
- as other kinds of collective, often **compulsory services** (military, prisoners camps, cloisters ...)
- within **manorial systems** (family gets land from lord of the manor, owes a share of its produce as taxes and/or compulsory labour in return)
- as **self-employed** in own firm/enterprise, household based but selling produce on markets
- as **wage labour** (personally free to sell a certain quantity of time on a labour market)

These institutional forms offer very different balances of self-determination / dependency, security of self-reproduction, and societal chances for learning & innovation.

Ultimately, in every pre-industrial social system, the amount of available labour depends on the food base of this system, usually the land (Sieferle et al. 2006). And as every labourer must use most of the resources he can generate by his labour power for just sustaining himself and his family, any effort from the part of leaders to have more labour power (and more riches) under control will ultimately lead to efforts at extending the territory. This, in turn, requires military power, again based on human and animal labour, and thus may easily become self-defeating. A partial exception from this rule is labour in the form of slaves. The

social system that purchases (or captures) adult slaves and uses them for labour saves on a very costly part, namely on the mother's investment in child bearing and raising the child to adulthood. Thus if a system uses slaves, it can afford, at the same land/food level, just for this reason maybe one fifth more labour power than when it uses farmers or free labourers.

3.5 A brief description of socio-metabolic regimes

Based upon distinctions made by Sieferle (and others), we discuss the following sociometabolic regimes:

1. **The agrarian regime.** It is based upon active (as opposed to passive, as with hunters & gatherers) solar energy utilization. The active element consists in deliberately colonizing terrestrial ecosystems, trying to concentrate solar energy conversion in plants useful for human reproduction (as food and feed). Practically all energy depends on land use and the availability of land (in some cases also fishing grounds). This allows a lifestyle at an energy consumption level of up to 40 GJ/person (measured in DEC units)²⁴ and year and requires very much human labour (about 80%-100% of the labour power of a population).
2. **The coal-based industrial regime.** Key feature of this regime is its ability to gain substantial amounts of additional energy from fossil sources²⁵. This additional energy is technologically translated into heat (for cooking and housing in urban centres) and later into mechanical power such as the steam engine, railways and steamships, and steel production, thus creating a new dimension of production, transportation and capital investment. The typical energy level at this stage is at 50-150 GJ/cap*a, and the generation of mechanical power has at least partially become independent from humans and animals, thus loosening the link to land as the key supply base.
3. **The oil based industrial regime II.** This uses, on top of and in substitution of coal, petroleum, technologically translated into car based mobility, and later aeroplanes. Electricity provides a universally applicable and locally available form of energy; electric motors allow for the mechanization of a wide variety of decentralized technical processes. Petroleum is also key to the industrialization of agriculture ("green

²⁴ DEC, domestic energy consumption, includes – beyond the technical or "commercial" energy counted as total primary energy supply (TPES) – also the food and feed energy consumed annually. (Haberl 2001)

²⁵ just to give an impression: already at the turn to the 20th century, UK had as much energy from coal at its disposal as it could have gained from using wood from a territory 13 times the actual size of the UK (Sieferle 2001)

revolution”), providing tractors, mineral fertilizers and pesticides, and creating the opportunity to substantially raise both land and labour productivity.

Since the early 1970s we can observe structural changes in the highly developed industrial countries that may signal the onset of a new socio-metabolic regime. While new energy sources play only a minor role²⁶, there are technological changes that (would) allow a partial decoupling from high energy demand: Information and communication technologies. Culturally, there is a new awareness of the “limits to growth” (Meadows et al. 1972), many highly developed economies shift from manufacture to services, and their material and energy use stagnates, while income keeps rising. This change in trends is so marked that it even dominates the global trends of socio-economic metabolism (figure 3.1).²⁷ The potential of this new situation has not yet fully unfolded, and politically this period was dominated by (partly futile) efforts to maintain the status quo, the high growth rates of the previous phase, be it at the expense of debts and speculative profits.²⁸

²⁶ This refers in particular to renewables: they seem not to really take off. But also nuclear energy that had been attracting so many hopes in the previous decades plays a dominant role only in a few countries (such as Japan and France, for example), and its further expansion is impeded by a number of severe accidents and an unforeseen explosion of costs.

²⁷ It is important to look at the global picture: To a certain degree, Europe, Japan and other OECD countries had been outsourcing their industrial production and manufacturing processes to developing countries and sustaining their continuing high consumption levels of industrial products from imports. Global data though show a worldwide decline in the growth rates of energy and material consumption (figure 3.1) for this period – so there cannot just have been a geographical shift.

²⁸ From the early 1970s onward, state debts begin to rise, although no particular social welfare gains above the achievements of the previous decades can be observed (see Reinhard & Rogoff 2010)

We feel a certain temptation to interpret this developmental phase in industrial countries as the onset of a next socio-ecological transition. In the literature, some terms are used that signify a change (such as “postindustrial”, or “postfordism”), but rarely this change is understood as start of another “great transformation” (Polanyi 1944). During the same period, a number of developing countries turn into “emerging economies” and choose the same materially and energetically intensive fossil fuels based pathway as the “old” industrial economies had (see for example the recent report on Asia and the Pacific by UNEP 2011c). On the global level this dominates the picture from the year 2000 onward also quantitatively: while the “old” industrial economies continue their stagnating course (and will suffer strongly from the aftermath of the financial crisis from 2008 onwards, beyond the scope of the data presented in in figure 3.1), the overall resource and energy consumption turns sharply upward (figure 3.1).

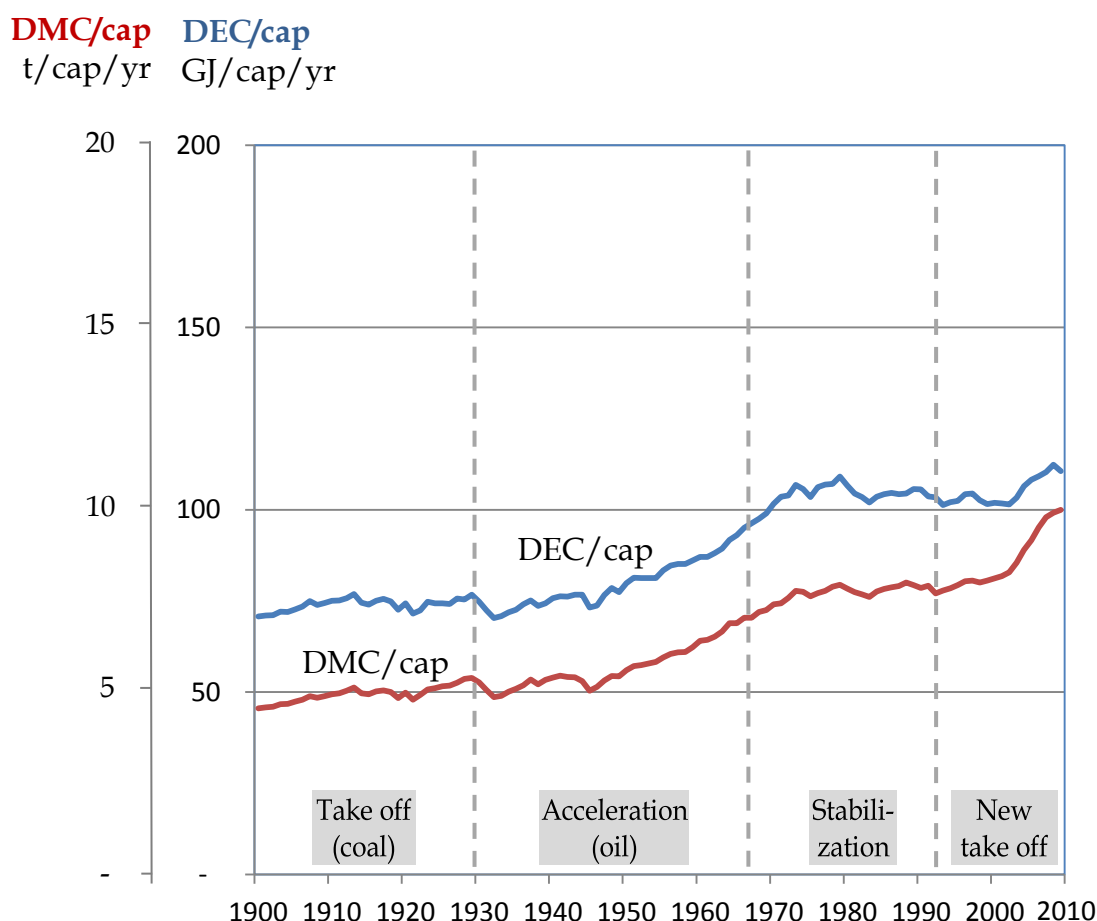


Figure 3.1: Phases of global per capita materials and energy use during the 20th century (Source: after Krausmann et al., 2009).

The numbers represent the average amount of resources/energy required to sustain one person for a year (metabolic rate).

DEC= Domestic Energy Consumption (commercial energy plus food and feed);
DMC=Domestic Material Consumption. This encompasses the total amount of biomass, fossil fuels, industrial minerals and metals, and construction minerals extracted and used globally.

3.6 Labour in the agrarian regime

Qualitative features

Qualitatively, the **agrarian regime** relies mainly on the **physical power** (and physical endurance) aspect of human labour. This applies to the rural population (constituting the very large majority), and also for example to slave labour in mines and infrastructure building (if we think of the Roman Empire). There is little societal effort to improve the skills and knowledge base of those 90% - 95% of the population in agricultural labour – as long as they feed themselves and deliver their tithes and taxes, they are left to themselves to organize their work. With fellachs in ancient Egypt, with the lower castes in India or with feudal serfs in Europe as well as with black slaves the Southern states of America, no effort is made at spreading literacy or practical knowledge concerning work in agriculture²⁹. **Education, in the sense of societal investment in the skills and the knowledge capacity of physical labour, is largely absent.** This investment remains reserved to a small minority of privileged usually male urban elites liberated from the need to work for their subsistence, and largely unconnected to what may be considered “useful work” (Sohn-Rethel 1971). Religious castes and organisations contribute to the education of ideological elites³⁰, and to the religious indoctrination of children (Sunday schools, qu’ran schools...) but do not convey functionally useful knowledge to those whose labour sustains society. Whatever great civilizational gains were achieved, they are rarely connected to the mass of human labour. The social tensions created by this highly unequal distribution of knowledge (be it even without any relation to practical application) in Europe reflected themselves in the wide-

²⁹ Some exceptions exist like the Roman Empire’s writers on agricultural technology, transmitted at least to an intermediate stratum of administrators of large estates.

³⁰ This certainly holds for the universities founded in Europe from the late 14th century onward. Here also a counter-argument: monasteries and religious communities in Europe (and probably similarly in the rest of the world) sometimes played an important role in systematic improvements of agriculture through experimentation and learning. But this does not mean that they transferred the control of such knowledge to their inferiors, let alone spread it among regional peasant populations.

spread religious conflict over the Bible, and the right of everyone to read it by oneself, from the 14th to the 16th century, and in the efforts to maintain knowledge monopolies as reflected in the burning of Giordano Bruno in 1600.

Technological enhancement and substitution of human physical power is mainly sought in animal power: buffaloes, oxen and later horses, in other regions elephants and camels, are used for traction of ploughs, water pumps and carriages, or donkeys for carrying burdens. This technological solution draws on the human labour capacity in **empathy**, since educating and guiding working animals requires a certain understanding and concern for their needs and feelings. Animals, nevertheless, may be useful or even indispensable for having a higher energy density than humans (details in Smil 2008, pp.174), but do not quantitatively substitute for their physical labour (as this is still required for working with and feeding those animals). In general, agrarian systems are marked by a substantial degree of public cruelty, and by a cultural emphasis of heroism and the use of force. Thus it should not be expected that the evolution of empathy receives much social enhancement.

Quantitative features

Quantitatively, it is always the question how many people can be sustained on a certain piece of land, and on top of this, how many additional people not working the land (landlords, urban citizens, soldiers...) can be subsidized. As Boserup (1981) has shown, there is a tendency to develop techniques that allow more people to live on a piece of land, by intensifying land use at the expense of investing additional labour. Thus the labour burden on the population working the land is rising, creating an incentive to having more children sharing in the workload. If population pressure on the land is reduced by, for example, labour opportunities in urban centres, agricultural labour productivity may rise again and allow for increasing surplus production that then allows feeding the urban population. Nevertheless, working hours in mature agrarian systems tend to be very high (Clark and Haswell 1967, Fischer-Kowalski et al. 2011, Fischer-Kowalski 2011). The overwhelming majority of the population (including children and elderly) is occupied with food production, most of their available lifetime. This relates to the relatively low energy return upon investment (EROI) of agriculture (depending on land productivity, it lies somewhere between 25:1 and 10:1) and the focus on humans as main source of mechanical power. The proportion of the population that can be sustained from the surplus of agricultural labour, even in advanced agrarian systems, ranges in the order of magnitude of 5%.

	Japan	China	Western Europe		England	France	Italy
1000	n.a.	3,0	0,0	Ca. 1800			
1500	2,9	3,8	6,1	Capital city	12%	2%	1%
1820	12,3	3,8	12,3	Next big city	1%	0%	3%
1890	16,0	4,4	31,0	Ca. 1850			
				Capital city	14%	3%	1%
				Next big city	2%	1%	2%

Source: Maddison 2001, p.40

Computed from www.populstat.info

Table 3.2: Rates of urban population worldwide across history

As becomes apparent in table 3.2, the proportion of urban population is rising in the course of history, also under agrarian regime conditions, but remains very low until the advent of the use of coal.

Institutional form of labour

Labour in agriculture (> 90%): In peripheral or unproductive regions (such as mountainous areas, marshes, thinly populated arid regions), agricultural or herdsman labour is usually organized as household based family labour, largely subsistence oriented, according to family power structures.

In more productive regions, labour is organized in some form of manorial systems with bonded serfs or slaves that owe a defined proportion of their produce in the form of *naturalia*, labour or money to the landlord.

Labour outside agriculture (< 10%) can be organized as slave and compulsory labour (for example in mining or construction), or as household based self-employment, for example in crafts & trades, or transportation. The „atomization of production was the rule...“ (Christ 1984).

Another common and important form of „labour“(?) is **military service**. It may be considered labour in the sense of providing food, animals and treasures by looting, and by protecting the own population from looting. But it cannot be considered labour in the sense of producing resources; it does so only by re-distribution.

3.7 Labour in the coal based industrial regime

Qualitative features

The **coal based industrial regime** at the onset mainly enhances and substitutes for human **physical power** through steam engines driving water pumps (in mines) and weaving looms in manufacture³¹. For agriculture there was only an indirect impact: by allowing (and in part: forcing, see (Wrigley 1998; 2010) for the UK) surplus rural population to migrate to urban centres and **making their living on wage labour in manufacture**. Later railways facilitated transporting coal and food over large distances into those urban centres, thus allowing them to grow and at the same time stimulating rural surplus production. In its impact upon manufacture (so-called proto-industry) and later industrial labour, the impact of steam engines was not to improve the skill component in human labour, but rather stupefying labour. The key capacity of human labour in agriculture as well as in urban wage labour remains **physical power and endurance**. Small skill segments, though, evolve further: in urban craftsmanship and engineering, in trade and finance, in the military and among civil servants.

During this regime most countries started to introduce **publicly financed compulsory schooling for children** (also or even particularly for the lower classes in urban centres). Often still under the supervision of the clergy, children were besides religious beliefs also expected to learn reading, writing and simple forms of algebra. As Gellner (1981) plausibly argues, this had mainly to do with the functionalities of the modern national state and the requirements of its military, and very little meaning for “qualifying labour”. On the other hand, it created a need for teachers as maybe the first labourers mainly qualified by formal education.

With **empathy**, one can observe an increasing cultural differentiation by gender: while men, in their work and beyond, are supposed to be tough and contain their emotions, females are supposed to be sympathetic and emotional. Empathy, one might say, becomes a female virtue, but a virtue after all (Elias 1939; Badinter 1980).

³¹ The first and – in the UK – for a long time most important impact of coal was to substitute for wood in heating and cooking in emerging urban centres that could not have grown in size without (Krausmann and Schandl, 2006).

Quantitative features

Quantitatively, the unfolding of the coal based industrial regime multiplies the demand for labour. Although industrial labour is mainly the exertion of physical power, and so much additional physical power is brought into the economy from coal driven steam engines, the demand for human labour is soaring so much that even the rapid population growth (“first demographic transition”) can be absorbed. For the industrial workforce, it is only humanitarian legal efforts that gradually achieve a reduction of daily working hours and a ban on child labour. Industrial labour is cheap, and the profits to be gained from it by far surpass the surplus to be gained from land ownership. In this phase, there is clearly a positive relation between energy input into the economy and the number of labour hours: more energy does not substitute, but facilitates the use of additional human labour (see figure 3.2).

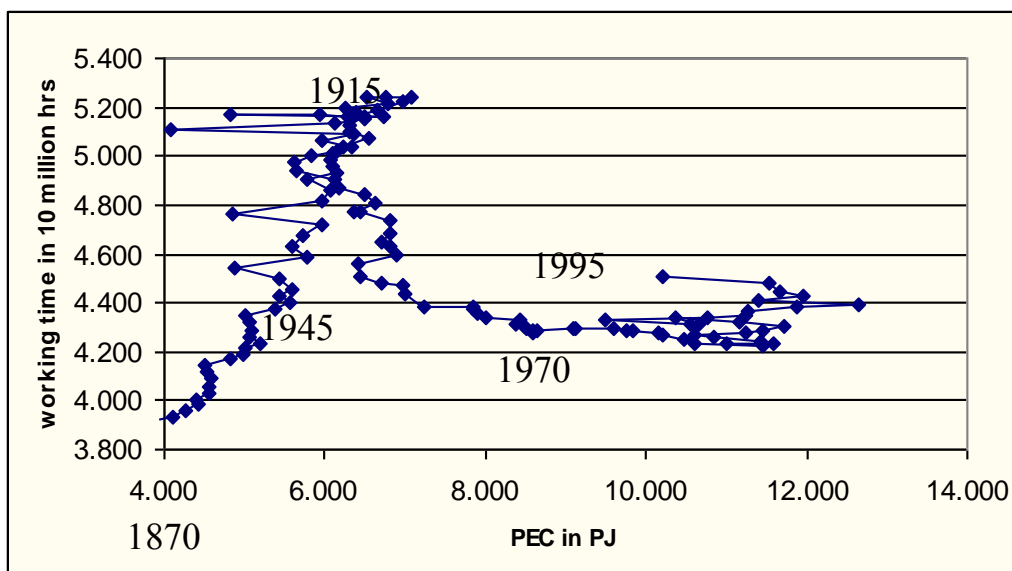


Figure 3.2: Primary energy consumption and working hours in the UK, 1870-2000 (Source: after Schandl and Schulz 2002; Krausmann et al 2003)

Thus, for the United Kingdom, we can see a very strong co-evolution of energy use and overall working hours in the economy from 1870 to the onset of the First World War. Afterwards, working hours decline while energy use keeps rising, as we will discuss in our next paragraph. Historians of time use (Voth 2000) even documented that in the early phase of industrialization in the UK (18th century), the weekly working hours of urban labourers were rising.

Institutional form of labour

The most spectacular change in the institutional form of labour is the **rise of free wage labour**. Free wage labour, a very minoritarian form at first, increases to become the most dominant form. Gradually, often by revolutions, serfdom and slavery are abolished.

In contrast to the landed aristocracy of the agrarian regime, industrialists see themselves as hard-working, responsible for the labour process, and drivers of technical innovation. Capitalists do not see themselves as a leisure class, but feel obliged to frugality and work ethics (Weber 1920).

During this phase, the separation of a sphere of production and gainful employment from the sphere of reproduction as a cosy and secluded home wisely governed by a housewife (who is not seen as “working”, but as exercising love and care) becomes an urban middle class model that gradually spreads to other social strata. (Bolognese-Leuchtenmüller and Mitterauer 1993).

3.8 Labour in the oil based industrial regime (Europe: late 1940s to early 1970s)

Qualitative aspects of human labour

Liquid fossil fuels allow for the **substitution of the physical power dimension of human labour by decentralized energy services**. Key technologies are the internal combustion engine used for cars and small multi-purpose electro-motors linked to electricity grids. Liquid fossil fuels used for tractors, and in chemical conversion for mineral fertilizers and pesticides, also substitute for a large part of physical human and animal labour in agriculture. In effect, physical strength and prowess lose much of their economic and in consequence cultural value.

Instead, the **knowledge dimension of human labour** becomes much more important: There is unprecedented growth in public education and knowledge production. This is the “golden age” for expanding the public education system, propagating equal opportunities, and building up a skilled workforce with capacities in information and knowledge management rather than physical power and endurance. Knowledge production, information processing and communication become major economic activities. For the first time in history, in that broad generality, knowledge production and learning become detached from being class privileges and ideological bastions, but evolve to become secular and rational, and

functionally related to roles in the labour market.³² In 1973, Daniel Bell published with *The Coming of Post-Industrial Society* a vision of a knowledge based service society that would have overcome both the farm's and the factory's hardships.³³

As far as **empathy** is concerned, the genderized picture predominates: Toughness and rationality for men, empathy and emotionality for women. Women as loving housewives, taking care of husband and children, become a majority model of middle class life.

Quantitative features

This "substitution" effect of mechanical energy for human labour can be clearly seen in figure 3.2 for the UK after the World Economic Crisis: Primary energy consumption in the economy rises, but overall labour hours decline; energy input per labour hour is no more stagnant, but rises rapidly. Even more clearly this sudden structural change can be seen in figure 3.2: From an overall primary energy input of roughly 7000 PJ onward (a value that is reached in the UK around 1920, and then after the crisis, in 1940), the further increase in energy input is associated with a decline in labour hours: mechanical energy substitutes for labour. From then on, up to the early 1970s, there is a steady increase of energy input into the economy, and with the increase in energy working hours decline. This is exactly the "golden age" of building up the welfare state, boosting private consumption, and steady increases in wage levels. It is also the "golden age" when the consequences of expanding the education system becomes statistically visible in the rapid increase of "white collar labour"³⁴ over "blue collar labour" and the near disappearance of agricultural labour.

³² It would be a promising exercise to document this in the OECD reports on education from the early 1960s onward. This trend was often criticised by more traditional, humanistic educational professionals. Interesting, though, is that the previous tension between religious/denominational versus public/secular education that had blocked educational reforms in so many countries for such a long time, gradually faded away.

³³ In politics, the term knowledge society boomed much later (and is now, for example, part of the EU's future perspectives).

³⁴ „White collar labour“ vs. „blue collar labour“ characterizes this distinction better than the more common distinction between industrial production and services, although these distinctions of course overlap. See also Peter Drucker, „, who coined the notions „Die Angestelltengesellschaft“ (1953), „Wissens- und Kopfarbeiter“ (1953) and also „Wissensgesellschaft“ (1969).

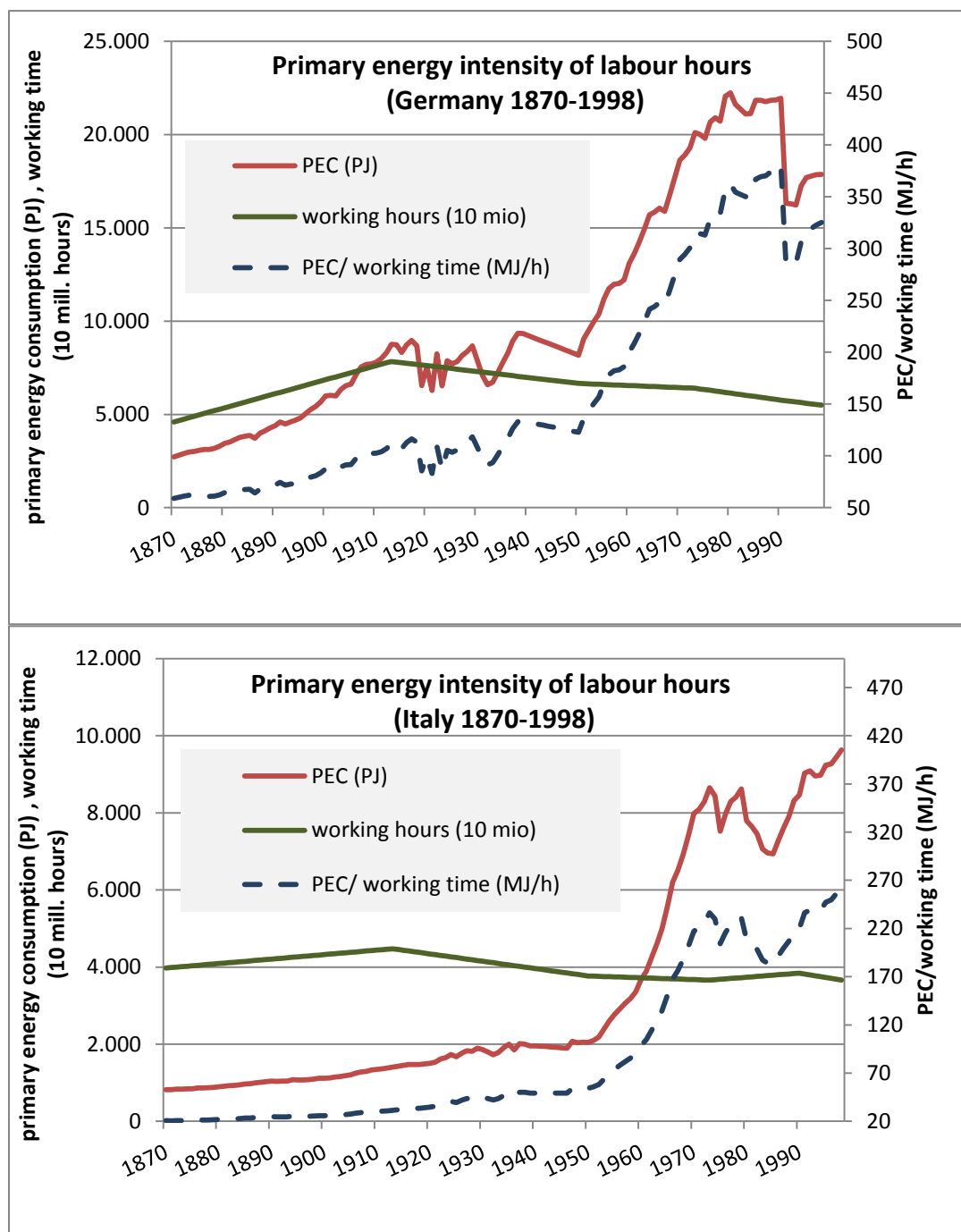


Figure 3.3: Energy consumption, working hours and energy intensity of working hours for Germany and Italy (Sources: Maddison 2001; 2008, Cleveland 2011, SEC- Database 2011)

The same message as Figure 3.2 has illustrated for the UK, Figure 3.3 demonstrates for Germany and Italy: With the implementation of the “oil regime” after the world wars, human labour hours in the economy completely dissociate from energy input. While labour hours show a slight decline, energy use soars and so does the energy intensity per labour

hour. This very same pattern can be shown for all European countries. An important part in the decline of labour hours plays the decline of employment in agriculture: there the working hours per employee had been particularly high, relative to all other economic sectors.

Somewhat similar changes occur in the households: electric equipment (washing machines, hoovers, mixers...) substitutes for physical effort from the part of the housekeepers, and raises the intellectual demand to handle those machines. As has been demonstrated in a number of studies, though, the overall impact is not to reduce household work, as purchasing and servicing this equipment, in combination with larger homes and higher standards of order and cleanliness are time consuming activities. In combination with the gradual disappearance of servants, the household burden upon middle class women tends to rather increase (see also table 3.1).

Institutional form of labour

In this phase, wage labour becomes by far the most dominant form of labour. Self-employment both in agriculture and in other sectors declines while employed labour rises. The overall participation rates in gainful employment remain largely constant. Within wage labour, there is a shift from “blue collar” to “white collar” labour: From the end of the Second World War to the early 1970s, unemployment rates remain very low.

3.9 Labour in the transition phase away from fossil fuels (early 1970s onward)

Qualitative features of labour

One might draw the analogy: as technological development plus increasing fossil fuel use had substituted internal combustion and electric motors for much of human physical work, now information and communication technology is **substituting for knowledge work**. Substituting for knowledge work is inherently less energy intensive than substituting for physical work, even if it is not optimized in this direction. Nevertheless, knowledge production and knowledge handling remain key features of human work.

Coinciding with the first world oil crisis, structural change in the relation between energy and labour becomes apparent: the trend of steeply increasing primary energy input is over, and gives way, after some sharp fluctuations, to a more stationary energy consumption,

both overall and per working hour (see figures 3.2 and 3.3). There is no discernible correlation between energy use and working time any more.³⁵

The reduction of physical work in Europe was of course also greatly enhanced by the externalization of industrial production to the world's periphery, where emerging economies with very low labour costs were prepared to produce the steadily increasing amount of industrial products that Europe and other rich regions of the world wished to consume. Studies of carbon emissions embodied in trade (Hertwich and Peters 2009) have shown, for example, that the apparent domestic growth reduction in fossil fuel based energy was – at least to a certain degree - compensated for by rising fossil fuel combustion elsewhere.

Intellectual educational standards in the labour force keep rising, as does school and university enrolment, and qualified white collar work increases while industrial blue collar work continues to decline.

There are indications that – connected to the rising importance of marketing, services and communication processes – the capacity for **empathy** is gradually losing its exclusive female label and becoming a more important qualification for work generally.

Quantitative features and institutional form

In Europe, average annual working hours per inhabitant decline only very little in the early 1970s, much less than before, but working time per employee continues to decline. This is a symptom of increasing part time work (particularly by females), unemployment and rising “flexibility”. While Japan shows trends similar to Europe, the USA are increasing the working time per inhabitant, with stagnating numbers per employee. More generally, one might say that there are signs of erosion of traditional well-established patterns of employment, and rising insecurity (Figure 3.4), while no clear-cut new pattern has established itself. The family pattern that had been introduced in the course of the industrial transformation, and had seen its climax in the late 1960s, namely early marriage by a large majority, and long phases of female economic dependency upon males' income, gradually dissolved: marriage occurs less frequently, and largely ceased to be a reliable and accepted economic alternative to gainful employment, not even for mothers of children. In parallel, the household division of labour slowly and gradually became less genderized.

³⁵ For the same period, Ayres observed a loosening of the so far very tight ties between exergy and economic output (Ayres and Warr 2005). He interprets this as an effect of the technology turn towards ICT.

Unemployment remains at a higher level than in the period before, and the main countermeasures considered are boosting economic growth and keeping immigration at bay.

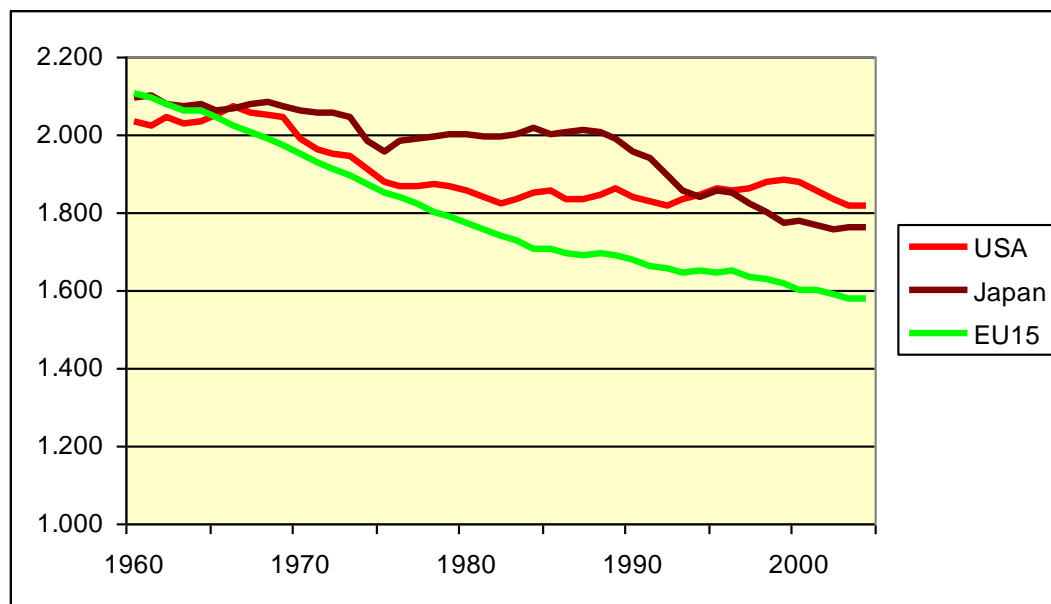


Figure 3.4: Annual working hours per employee (Source: OECD, Groningen dbe)

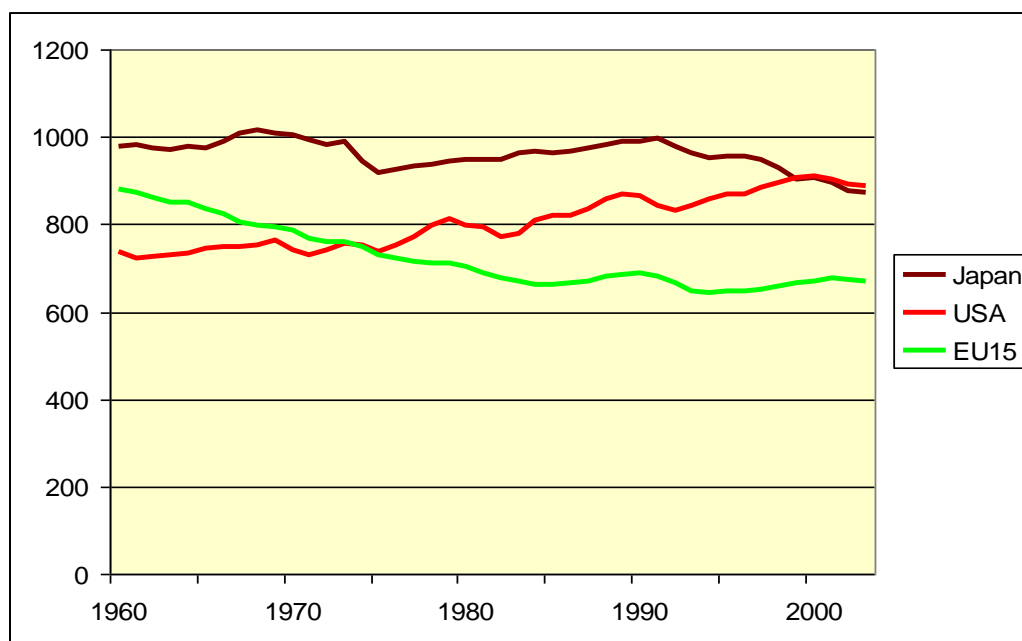


Figure 3.5: Annual working hours per inhabitant (Source: OECD Groningen dbe, own calculations)

3.9 Resume and outlook: Indications of and latent causes for major changes in labour as a consequence of an ongoing socio-ecological transition?

In the introduction to this chapter, we justified the view back into history by the claim that a next socio-ecological transition away from fossil fuels might in the long run have as massive an impact on the organisation of human labour as the socio-ecological transition towards fossil fuels had had.

The following figures in a very crude way attempt to illustrate some aspects of our storyline, and make an – admittedly highly speculative – effort at incorporating the elements of structural change we can anticipate for SET into our imagery of the future of work.

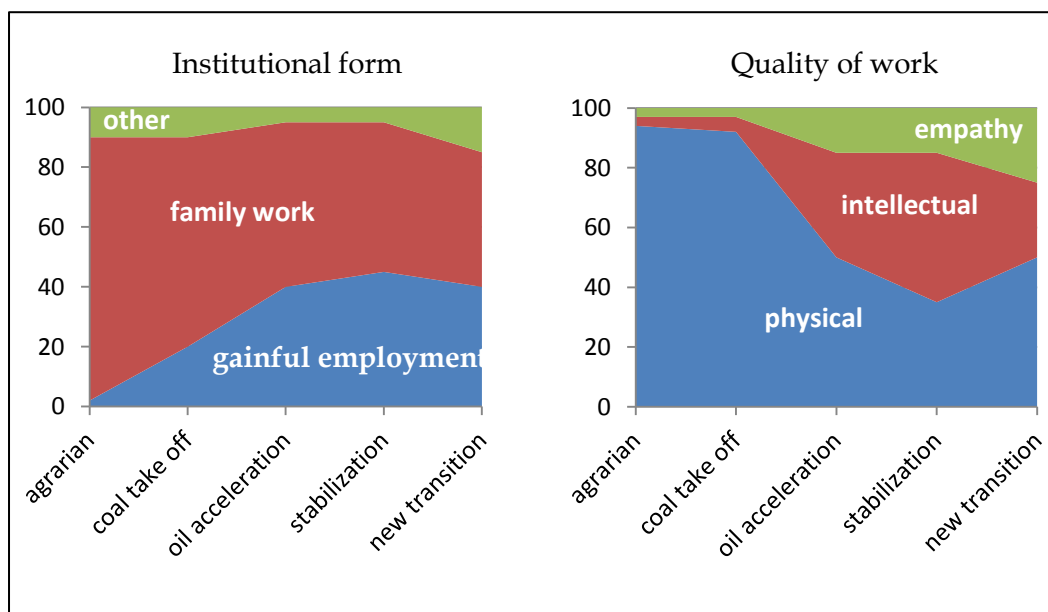


Figure 3.6: Variation of quality of work and its institutional form by socio-ecological regimes (work including market oriented employment, non-market subsistence work incl. household & non-market community work; Europe only)

Structural change towards a post-SET condition in Europe (away from un-sustainability) would encompass, from a socio-ecological perspective:

- an energy shift away from fossil fuel use towards renewables
- a production and consumption shift away from energy- and materials-intensive products towards services enhancing human resources & capacities
- an institutional shift towards low-vulnerability, low-maintenance infrastructures
- lowering energy consumption (efficiency increases, saving...)

- lowering use of (virgin) raw materials (efficiency increases, recycling, reduced consumption, avoiding waste, waste mining...)
- probably: European self-sufficiency in biomass and water.

Why can we assume that these structural changes might in consequence lead to the changes of work we picture in Figure 3.6?

In the left part of the figure, we project³⁶ that the proportion of physical work, after a long period of decline, might rise again. This follows from the assumption that both rising costs of energy and the declining energy return upon energy investment (EROI) already now observed for fossil fuels (Hall 2010) and to be expected for renewable energy sources will lead to a reduced substitution of human labour by mechanical energy, and may be an increasing use of very intelligent but mechanical tools and devices. The existing “green jobs” reports (such as UNEP et al. 2008, or the European Strategy Agenda 2020) do not elaborate on their quality; a recent study for the USA (Mattera et al. 2009) and for Austria (Leitner et al. 2012) identify forestry and agriculture³⁷, the construction industry, waste management and trade and transport as main sectors of new “green jobs”. Beyond the more narrow assumptions related to the shorter time horizon of these studies, we also refer to the increasing frequency of climate extreme events as a source of additional physical labour, be it in the form of gainful employment, as non-market civil services or as family labour in coping with such events. This therefore also reflects itself in the right side of Figure 3.6 as a possible increase of non-market forms of labour (family and “other”) at the expense of the proportion of gainful employment.

Another consideration that entered the above figures is a continuing process of substitution of (particularly medium qualified) intellectual or knowledge work by ICT, and eventually – facilitated by the use of ICT – its global outsourcing to lower income countries. The only services that are very difficult to substitute by ICT and almost impossible to outsource to other countries are activities that involve face-to-face contact with the resident population: various form of caretaking. In view of an aging and culturally increasingly heterogeneous

³⁶ It should be noted that the numerical values in Figure 3.6 are more or less fiction. The reference frame of 100% refers to the total of human working hours outlined in the time budget approach explained in the introduction to this chapter. For these working hours no reasonable statistics exist that would allow for a quantitative historical comparison of the quality and institutional form of labour as we attempt in Figure 3.6. These numbers are therefore only to be takes as illustrative.

³⁷ There are also other arguments why the decline of agricultural labour in Europe may be reversed in the future, for example in consequence of a health-oriented increase of organic farming, decentralized energy generation, and higher cost of fossil fuel based (labour saving) supplies..

and demanding population we therefore above assume an increase in the type of work that is based upon empathy (at the expense of medium qualified intellectual work), and both in the institutional form of gainful employment and as civil services.

Already now there are new framework conditions that may have a long lasting structural impact upon work beyond the features described above: After many decades of decline, there now (since about the year 2000) is a sharp rise of prices of all raw materials (commodities). While some believe this to be a transitional phenomenon due to lagging investments, we see many indications of approaching conditions of scarcity. If this should be the case, and commodity prices (including energy) continue to be high or even rise further, this could have a substantial impact on business strategies. There could be a shift in the dominant mode of cost reduction from labour to resources. In this case, not the increase of labour productivity would be the key measure, but the saving of resources, possibly at the expense of more labour. Macroeconomically, this would mean that there is a shift in relative prices between material goods and human labour, and consequently a decline in demand for material goods and increasing demand for human labour. As far as macroeconomic growth depends on rising labour productivity, it would be impaired. Increasing the share of work in caretaking, as assumed above, would have an impact in the same direction, as with caretaking labour productivity cannot be much enhanced. In effect, the purchasing power of workers would be reduced, and distributional conflicts about wages become more frequent.

Finally, our societies may become less energy intensive. If the world seeks to avoid dangerous climate change (i.e. a rise in average temperature beyond two degrees), most simulations assume a global decline in primary energy use, in the order of magnitude of 1% annually (see for example WBGU 2011). If this assumption were to be realized globally, the required decline in primary energy use for Europe would need to be much steeper. Part of this decline can be realized by avoiding losses³⁸, but more expensive energy might more generally lead to lower use. Could our societies slow down again?

³⁸ With coal powered electricity generation, for example, a high proportion of the primary energy contained in coal is lost as waste heat. In the case of photovoltaics or windpower, this kind of loss does not occur. Another major case can be made for improving insulation of buildings.

4. Global scenarios and key assumptions

4.1 Introducing global scenarios

The historical socio-ecological transitions, such as the fossil fuel based industrialization of Europe and beyond, led to a new type of society with unprecedented levels of natural resource extractions and energy and material consumption for approximately 15% of the world population, with equally unprecedented scientific and technical knowledge and with democracy. However, this transition is not only historical but still ongoing, as 60% of the world's population in the emerging economies are in a take-off or an acceleration phase towards a fossil fuels based system (see chapter 2). Also a next socio-ecological transition away from fossil fuels can be expected to have similar far-reaching implications as this still ongoing transition into fossil fuels, not only for production and consumption patterns, but also for many other features of society.

There is ample evidence provided by global change research that human activity caused and causes major changes in the functioning of natural systems on every spatial scale, from local to global, and is transforming the earth system at an increasing pace (IPCC 2007, Karl and Trenberth 2003, Rockström et al. 2009, Schellnhuber 1999, UNEP 2007, Turner et al. 1990, Vörösmarty et al. 2004, WBGU 2011). Such changes are now being accelerated by the on-going process of industrialization in the very populous emerging economies. Thus, imagining 2025 or even more so 2050, the further expansive continuation of the industrial socio-metabolic regime for a majority of the world seems biophysically not feasible and threatens to further erode humanity's natural base. It is very hard to know how fast this will happen, and this is subject to debate. It is not so hard to know that some of this will happen, such as an exhaustion of cheap fossil fuels and a number of other natural resources, and – to say the least – an increasing volatility of the climate system. More so, we can even see it already happening. This is what we sketch as “global megatrends in natural conditions”, the biophysical part of the on-going socio-ecological transitions (SET). Still, these changes occur in response to, or as a consequence of, the continuing socio-ecological transition towards fossil fuel based industrial societies and inevitably – sooner or later – will impose a new socio-ecological transition away from fossil fuels on societies. Under the “global megatrends in natural conditions” we subsume energy transitions (into and away from fossil fuels), rising challenges to resource security and increasing climate change impacts. We can also see elements of the social part of the socio-ecological transition happening, which are related to

social and technical achievements generated by the last transition, as what we term global “societal megatrends”. The three most important elements of the global SET we identify as the continuation of the global demographic transition, the on-going shifts in the economic and political centres of gravity worldwide, and the growing use of information and communication technologies plus the related new forms of knowledge sharing. These megatrends, so we argue, fundamentally reshape the global framework conditions for Europe. As stated above, it is an open question how fast and how radical these megatrends will evolve. Therefore we will distinguish, for each megatrend, based on existing literature, between “friendly” and “tough” variants by 2025 and by 2050, and use these as global framework scenarios for the European option space.

Figure 4.1 pictures the European option space in this (dynamic) global framework. In the centre of the picture, there is the socio-economic reproduction of the European population at a certain level of welfare. The population is subject to demographic change (depending on global and internal conditions). Its reproduction, depending on the mode of production and consumption, requires the use of natural resources the supply of which is subject to global (and internal) conditions. It also requires a certain amount and quality of human labour, again depending on global and internal conditions. At the top of the picture, there is the European policy process, political, economic and technical response strategies in a changing world shaped by the ongoing as well as the beginning next socio-ecological transitions.

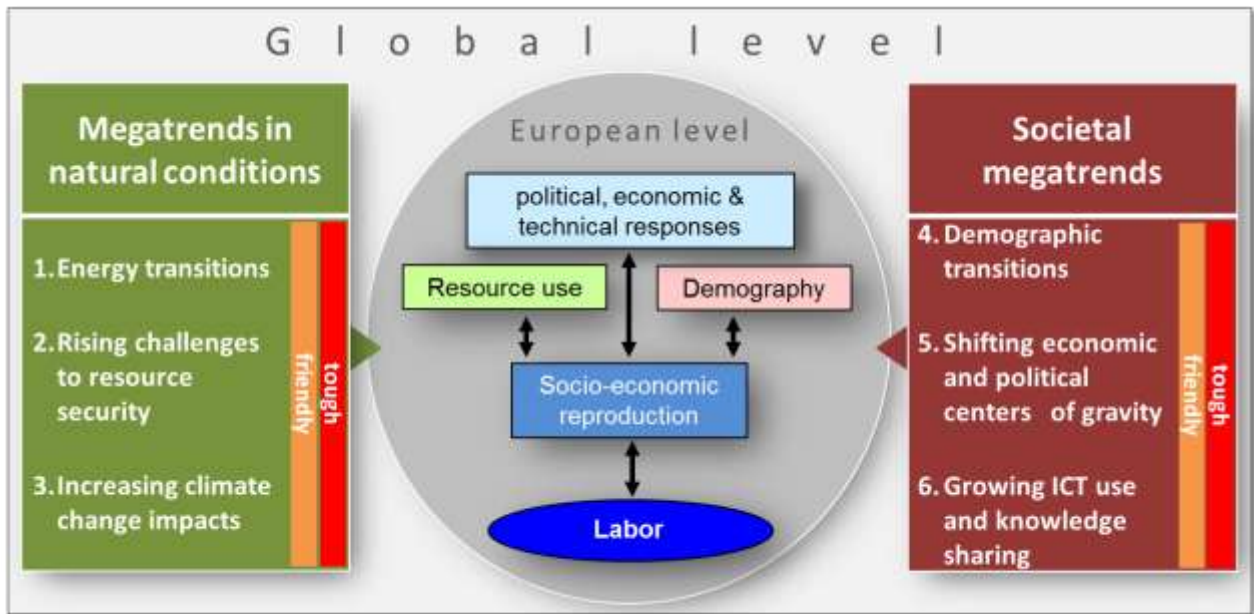


Figure 4.1: The socio-economic reproduction of Europe in a global context shaped by the ongoing socio-ecological transitions

This chapter will provide global scenarios and key assumptions based on an extensive review of literature that guided our choice of relevant global megatrends. We make an effort at simplifying and aggregating these choices to generate two variants of a global future world, a “friendly” and a “tough” one. This, of course, is relatively arbitrary, as well as our efforts to describe each megatrend separately (see appendices A and B). But the goal of this exercise is to find those key assumptions necessary for formal modelling as well as for creating self-consistent story lines of two possible futures. These possible futures map out the the range of the possible global conditions for 2025 and 2050. For defining “friendly” and “tough” we seek to distinguish between a slow rate of change that is less challenging for Europe, and a more radical or rapid version.

Friendly: A friendly future includes rather moderate changes which are less challenging for European policy making. It focuses on incremental global changes in the lower ranges of change found in the literature.

Tough: Our sketch of a tough global future is based on still quite likely but rather severe changes which would be highly challenging for European policy making, using the higher ranges of change found in literature, including possible abrupt changes.

We try to choose the cutting point between “friendly” and “tough” in a way that each has a similar likelihood. As in many areas quantification of trends is difficult and there are no broadly accepted and reliable likelihood estimates, we need to base these choices on our own expert judgement, and we are awaiting reviewers to comment and improve on them.

In the following paragraphs of this chapter, we will explain the research strategy that guided our literature review and summarize our major findings.

Finally, in chapter 5, we sketch out three European policy strategies which respond to the global and internal challenges.

4.2 Overview on global megatrends

In the following paragraphs and in table 4.1 we summarize the outcomes of our literature review (see in full in appendices A and B). The literature review was organized according to the six areas we had identified as directly related to past, ongoing and future socio-ecological transitions (see Figure 4.1). In each area, we screened the latest global forecasts or scenario analyses from international organizations (such as World Bank, UN, UNDP, UNEP, FAO, IMF, IEA, OECD and others) and complemented them where appropriate with similar efforts from international NGOs. On top of this, we made an effort to capture relevant journal articles or books that deal with socio-ecological transitions in one of these fields. European project reports were included as far as they dealt with these global issues.

The literature we thus collected is vast and highly heterogeneous. Economic literature was not covered as much as other fields, as economic forecasts tend to extend over a much shorter timespan than the one we are dealing with. Besides, our focus was more strongly on SET described as a biophysical process. Nevertheless, all recent World Bank or OECD reports dealing with the issues at hand were screened. Political science literature also tends to have a different format in dealing with the future: there you hardly find any quantitative estimates, but rather verbal analyses of ongoing trends. More natural science oriented assessments (as for resources, climate or demography) in many cases offered the most appropriate format: they tend to cover a longer time period and offer quantitative descriptions, often with estimates of uncertainty attached.

The extensive description of the results of this literature review is to be found in the appendices A (natural conditions) and B (societal conditions). Each field is structured in the following way:

- an introduction explaining the research question and selection process
- a description of the key literature used
- a usually longer substantial chapter on the "key issues" addressed in this field. This reflects our efforts to capture the intellectual structure from the part of experts in this field.
- Finally, we draw our conclusions from the literature and summarize the "key assumptions" to characterize the global megatrends in a "friendly" and in a "tough" variant. We also tried specifications of these variants for 2025 and 2050 respectively, but this was not always possible.

In the following paragraph we give a short resumé for each of the megatrends.



4.2.1 Megatrends in natural conditions – resumé from literature review in Appendix A

1. Energy transition (See Appendix A-1)

While fossil fuels enabled and still enable the transition away from agrarian regimes, high demand in mature economies as well as rising demand in emerging economies sooner or later will be faced by peak oil, peak gas and peak coal. Various studies for peak oil identify the peak between 2008 and 2037. This will fundamentally change the context for the ongoing fossil fuelled socio-ecological transitions as well as for the next transition towards renewable energy sources.

In addition to future supply restrictions, climate change prompts global political responses demanding mitigation policies that favour renewable energy sources and an overall reduction in fossil fuel consumption. Whether through climate mitigation policies or physical limits, a next energy transition is therefore inevitable and at least the take-off phase of such a new transition will be visible during the coming decades.

The transition away from fossil fuels will be accompanied by increasing and more volatile energy prices as well as by higher energy investments to get the same amount of final energy supply, whether for renewables or from the remaining fossil fuel deposits (declining EROI).

While carbon capture and storage technologies (CCS) are seen as a glimmer of hope to mitigate these challenges, the feasibility of large scale roll-out is under question and cannot safely be assumed in global scenarios. Finally, the bio-fuel demand of environmentally oriented scenarios conflicts with food production unless there is a major technological breakthrough.

2. Rising challenges to resource security (See appendix A-2)

Enabled by increasing energy use, material consumption has been increased tremendously in mature industrial countries and is currently stabilizing at very high levels. As with energy, the overall global material demand will rise further, due to rising fast growth in emerging economies. Overall rising global demand will be faced by deteriorating quality and declining quantity of supply.

For the EU, several raw materials are considered critical since they possess both high economic importance and high supply risks. Some of these critical raw materials are not produced within the EU but are metals essential for high technology and “green” applications (future sustainable technologies, “green” technologies).

In the case of rare earths and phosphorus the situation is further tightened by a high dependence on a few mining countries (special role of China and Morocco).

While global demand for many metals is increasing rapidly, ore grades are declining in all major mining countries. This leads to a shift from 'easy and cheap' to more 'complex and expensive' processing.

Phosphorus, critical for future food security, is expected to peak in the coming decades. The EU is a net importer of phosphorus in feed, feedstock and fertilizer.

Intensified global competition for resources will lead to further price increases and could contribute to price shocks.

3. Increasing climate change impacts (See Appendix A-3)

Climate change is a product of the former transition from biomass-based to fossil fuel-based energy systems in the now mature industrial economies. Past emissions already determine severe changes due to a strong time lag in the climate system between cause (emissions) and effect (warming). GHG emissions of the next decade will significantly determine the extent of future climate change and the risk of triggering irreversible damages to global ecosystems and their consequences for humankind.

- Continued marked increases in hot extremes and decreases in cold extremes are expected in most areas of the globe.
- Change in precipitation amounts and distribution: further increases in (very) heavy precipitation (*increasing risks of floods*) and increases in drought.
- Greatly increased risk of tropical cyclones to regions already endangered by hurricanes. Area at risk could expand towards the poles
- Accelerating trend of melting mountain glaciers and accompanying changes in water availability
- Sea level rise will amount to 1m by the end of this century, just from the impact of past warming
- Changes in water resources will be the most visible impact: severe implications for food production and food security

If industrialised countries continue to maintain their levels of energy consumption and/or emerging countries increase their fossil fuel use to the level of mature countries (as is currently the case), this will greatly increase the risk of catastrophic climate change.

Therefore in the long run the severity of impacts highly depends on both mitigation effective at the global level and adaptive capacities.

- Unabated climate change will cause large-scale changes in the Earth System, which would have severe consequences
- Europe: Mediterranean countries will be hit hardest (*temperature increases, draughts, water scarcity, occasional flash floods and more forest fires - loss of agricultural yields – with impacts on agriculture and tourism, impacts on health*). “Hot spots” will be Greece, Portugal and Spain
- Sea level rise is regarded as the greatest threat in the long term.
- Climate change, regarded as a threat multiplier of existing environmental and social problems, is increasingly perceived as international security risk
- Possible global agreements on a post-Kyoto climate change mitigation framework will act as an additional driver for the inevitable next energy transition.

4.2.2 Societal Megatrends – resumé from literature review in Appendix A

1. Population dynamics (See appendix B-1)

In mature industrial economies the past demographic transition was, via the increased availability of food, shelter and societal capacities to absorb a growing labour force, closely linked to the “historical” SET. This demographic transition is now largely completed and led to a stagnating (or even declining) and an ageing population. In emerging economies, present population growth goes hand in hand with growth in the use of fossil fuels and other resources, following a similar pattern – but fortunately not as steep as the one observed in the past of today’s mature industrial countries. Global population size and structure is a crucial factor for environmental concerns, since environmental impacts are closely related to population size and affluence. The observed slow-down of global population growth will probably lead to a stabilization of world population within this century, but at challengingly high levels. Increasing short term migration and relocation movements due to climate change impacts in Europe need to be considered.

2. Shifting economic and political centres of gravity (See appendix B-2)

So far, the fifth of the world population concentrated in industrial countries could strongly dominate the rest of the world. The transition of emerging economies into a fossil-based energy system has allowed for an economic development that increasingly makes them



equal partners, if not dominant players of the future. All forecasts assume much lower growth rates for the mature economies than for emerging economies, and so they will continue to increase their share in the world economy. Equally, political science expects a shift of the political centres of gravity away from mature towards emerging economies. At the same time, global economic and political interconnectedness through trade, global production chains, international investments and media communication is steadily increasing. The next energy transition away from fossil fuels, issues of resource security, increasing climate change impacts and higher volatility of commodity prices will be important challenges for the international collaboration. It remains an open question whether international relations will become more collaborative or more confrontational in the face of the challenges ahead.

3. Growing ICT use and knowledge sharing (See appendix B-3)

This latest class of new technologies does not substitute - as most technologies before - for physical labour, but it enhances and substitutes for intellectual labour and communication. It could provide crucial enabling tools for a next SET: enabling the handling of complex systems, speeding up a process of knowledge sharing worldwide and across all areas, and creating a cheap communications space for the development of new worldviews and lifestyles.

But ICT tools are ambivalent: analysing and managing complex systems can be democratic or dictatorial. Transparency helps enlightenment and surveillance, and social media may foster social innovation and mass hysteria.

4.3 Key assumptions for the year 2025

	Friendly	tough
Energy transition		
Demand	Roughly at today's levels ³⁹ (ER 2010, EREC/Greenpeace Energy [R]evolution Scenarios)	Increases by up to 40% ^{40, 41} (EIA 2011, EIA High Oil Price Case)
Supply	<p>Oil: Can keep up with demand due to new discoveries of conventional and unconventional oil, increased recovery rates</p> <p>Nuclear energy stagnating</p> <p>Biofuels: Progress in second generation biofuels lessens conflicts over land for food production</p>	<p>Oil: Shortages due to peak oil (in 2008 or even earlier) and delayed investment in new production (Alekt et al. 2010)</p> <p>Nuclear energy slowly phasing out due to increased risks</p> <p>Biofuels: no progress in second generation biofuels, first generation biofuels require substantial share of agricultural land competing with food production over land</p>
Prices	<p>Oil price at around USD100 (WEO 2011, IEA 450 Scenario)</p> <p>Due to improved price finding mechanisms and management of stocks reduced oil price volatility</p> <p>CO₂ price of around USD70 (estimation based on WEO, IEA 450 Scenario)</p>	<p>Oil price approaching USD200 (EIA 2011, EIA High Oil Price Case)</p> <p>Oil price volatility remains high and negatively affects investment and economic activity</p> <p>No or low CO₂ price of USD35</p>
EROI⁴²	of global oil and gas production decreases to 20:1 (Gagnon et al. 2009)	of global oil and gas production decreases to 10:1 (Gagnon et al. 2009)
CCS⁴³	very limited in scale	failing

³⁹ Share of fossil fuels drops to 70% (estimation based on IEA 450 Scenario, see appendix A.1)

⁴⁰ Share of fossil fuels remains at 80% (see IEA New Policies Scenario, EIA scenarios and industry scenarios, see appendix A.1)

⁴¹ Share of biomass constant at about 10% (IEA New Policies Scenario, see appendix A.1)

⁴² Energy return on investment

⁴³ Carbon capture and storage

Resource security		
Demand	<p>Critical metals: +20 % increase of total demand over 2007 (<i>Buchert et al. 2009</i>)</p> <p>Rare Earth Elements (REE): +120% increase over 2007⁴⁴</p> <p>Phosphorus: +10% increase over 2000⁴⁵ (<i>Van Vuuren et al. 2010</i>)</p> <p>Food:</p> <p>Moderate demand growth due to low population growth (low fertility variant) and dietary changes towards less meat in mature economies</p>	<p>Critical metals: +50% compared to 2007 (<i>Buchert et al. 2009</i>)</p> <p>Rare Earth Elements (REE): +370% increase over 2007⁴⁶ (<i>Schüler et al. 2011</i>) and criticality of some REE severe</p> <p>Phosphorus: +60% increase over 2000⁴⁷ (<i>Van Vuuren et al. 2010</i>)</p> <p>Food:</p> <p>High demand growth due to high population growth (high fertility variant) and dietary changes of emerging economies towards the level and diet of today's mature economies</p>
Supply	<p>Critical metals: supply steadied by efficient recycling systems and high recovery rates, relevant substitutions are realised, no further export restriction from producing countries, new mining projects, new discoveries</p> <p>Bulk metals: declining ore grades (<i>Giurco et al., 2010</i>) leading to slow but steady price increases</p> <p>Phosphorus: Peak 2030 (<i>Cordell et al., 2010, Rosemarin 2010, Zittel 2010</i>)</p> <p>Food:</p> <p>Progress towards key food security and environmental sustainability goals (<i>Foley et al. 2011</i>)</p>	<p>Critical metals: severe supply shortages due to low recycling rates, low/unknown substitutability, > 90% share of global mining within few countries and further export restrictions</p> <p>Bulk metals: declining ore grades (<i>Giurco et al. 2010</i>) leading to significant price increases</p> <p>Phosphorus: Peak 2020 (<i>Zittel 2010, lower range of estimate</i>)</p> <p>Food:</p> <p>Food security situation problematic, environmental impacts large</p>
Prices	Phosphorus: Steady price increases, no price shocks	Phosphorus: Sharp price increases and price shocks, high volatility
	Food prices increase steadily and volatility is under control (<i>World Bank and IMF 2011</i>)	Food price volatility high, supply cannot keep up with demand

⁴⁴ REE: annual growth rate of 4.5% based on literature equals +120%

⁴⁵ Phosphorus: 44,5 Mt P₂O₅ in 2000 and 49 Mt P₂O₅ in 2030

⁴⁶ REE 9.0% per year based on literature equals +370% and criticality of some REE more severe than projected

⁴⁷ Phosphorus: 44,5 Mt P₂O₅ in 2000 and 78 Mt P₂O₅ in 2030

Climate change impacts		
Temperature	Temperature rise +0.4 °C (compared to 2005)	Temperature rise +0.6 °C (compared to 2005)
Weather extremes	Increases in precipitation extremes: 5 % per °C of warming, and other weather extremes: heat waves, droughts....	Increases in precipitation extremes: 10 % per °C of warming, and other weather extremes: heat waves, droughts...
Glaciers, ice sheet, sea level rise	Accelerating trend: melting of glaciers, Arctic sea ice decline, sea level rise faster than in the 20 th c. (> 3.4mm/yr)	Accelerating trend: melting of glaciers, Arctic sea ice decline, sea level rise (much) faster than in the 20 th c. (>> 3.4mm/yr)
Population dynamics		
Population	7.6 billions in 2025 8.1 billions in 2050 (UNPD 2011, low fertility variant)	8.3 billions in 2025 10.6 billions in 2050 (UNPD 2011, high fertility variant)
Ageing	Age group 65+ has an increasing share of world population. Highest percentages in mature industrial economies starting from 20% in 2010 to 26% in 2025 and to 33% in 2050 (UNPD, 2011) ⁴⁸ .	
Migration	Stagnating net migration into Europe at less than 1 million per year (UNPD 2011).	Net migration less than 1 million per year, but with higher migration pressure due to climate change impacts; contributing to a polarisation in European societies
Displacements	Risk of floods and droughts leading to short term migration and relocation movements within Europe. For 2050 inland migration from Europe's low laying coasts (e.g. Netherlands: 5.000 persons) (IPCC 2007; Mc Leman and Hunter 2011).	High risk of floods and droughts leading to short term migration and relocation movements within Europe. For 2050 inland migration from Europe's low laying coasts (e.g. Netherlands: 50.000 persons) (IPCC 2007; Mc Leman and Hunter 2011).

⁴⁸ The difference re age group 65+ between low and high fertility variant is very low in mature industrial economies due to the small differences between the variants in these countries

Shifting Economic and Political Centres of Gravity		
Economic shift	<p>Mature industrial economies' share in world GDP declines from 50% in 2011 to 45% in 2025</p> <p>EU15 declines from 18% to 15%</p> <p>Emerging economies' share in world GDP increases from 30% to 37%</p> <p>China increases from 16% to 20%</p> <p>India increases from 6% to 8%</p> <p><i>(own calculations⁴⁹ based on The Conference Board 2012, base scenario)</i></p>	<p>Mature industrial economies' share in world GDP declines from 50% in 2011 to 40% in 2025</p> <p>EU15 declines from 18% to 13%</p> <p>Emerging economies' share in world GDP increases from 30% to 43%</p> <p>China increases from 16% to 25%</p> <p>India increases from 6% to 9%</p> <p><i>(own calculations⁵⁰ based on The Conference Board 2012, pessimistic for mature and optimistic scenario for emerging)</i></p>
Growth	<p>Annual GDP growth rates 2012-2025:</p> <p>Mature economies: 1,9% for 2012-2016 and 1,9% for 2017-2025</p> <p>EU15: 1,5% for 2012-2016 and 1,7% for 2017-2025</p> <p>Emerging: 6,0% for 2012-2016 and 3,4% for 2017-2025</p> <p><i>(own calculation based on The Conference Board 2012, base scenario)</i></p>	<p>Annual GDP growth rates 2012-2025:</p> <p>Mature economies: 1,1% for 2012-2016 and 1,3% for 2017-2025</p> <p>EU15: 0,4% for 2012-2016) and 1,0% for 2017-2025</p> <p>Emerging: 7,9% for 2012-2016 and 4,6% for 2017-2025</p> <p><i>(own calculation based on The Conference Board 2012, pessimistic for mature and optimistic scenario for emerging)</i></p>
Volatility	<p>no upward or downward trend in commodity price volatility over time compared to recent decades <i>(Calvo-Gonzales et al. 2010)</i></p> <p>Food and agricultural prices: Lessons learnt from previous periods of high volatility lead to successful implementation of measures to reduce price volatility and to better deal with consequences <i>(FAO et al. 2011)</i></p> <p>Oil price: due to improved price finding mechanisms and management of stocks reduced oil price volatility</p>	<p>Continued uptick in price volatility in a number of commodities</p> <p>Food and agricultural prices: Higher and more volatile agricultural commodity prices persist, largely due to continuing uncertainty on the supply side, against projected rising demand <i>(FAO et al. 2011)</i></p> <p>Oil price: volatility remains high and negatively affects investment and economic activity</p>

⁴⁹ Friendly assumes slow but steady growth in Europe that allows for adequate responses to challenges ahead and relatively moderate growth in emerging countries so that demand for resources grows moderate as well (meaning less challenging to European resource security).

⁵⁰ Tough assumes very low growth rates for Europe that challenge stability (financially and politically through high unemployment rates and polarization in society) and quite high growth rates in emerging economies due to growing domestic markets and increasing trade between emerging economies themselves and with developing countries. These assumptions require further considerations for a consistent scenario in a next phase of scenario development.

Inter-national relations	<p>Shift in political power from mature to emerging economies due to increased economic importance (see economic shift) leads to reformed cooperative international relations</p> <p>Common challenges dealt by weak international cooperation</p> <p>Little reform of existing international institutions</p> <p>Summit diplomacy</p> <p><i>(see NIC and EUISS 2010, Scenario I: "Barely Keeping Afloat" and Scenario III: "Concert of Europe Redux")</i></p>	<p>Shift in political power from mature to emerging economies due to increased economic importance (see economic shift) leads to confrontational international relations</p> <p>Resolving common challenges dominated by self-interested actors</p> <p>Attempts to resolve challenges by military, economic and resource/energy competition</p> <p>Increased military conflicts and armament</p> <p><i>(see NIC and EUISS 2010, Scenario II: "Fragmentation" and Scenario IV: "Gaming Reality: Conflict Trumps Cooperation")</i></p>
ICT use and knowledge sharing		
Societal Level	<p>Open governance: increased transparency, participatory policy intelligence</p> <p>Improved management of complex systems (smart grids, modelling global dynamics, smart energy production and consumption)</p> <p>Information and knowledge sharing: open collaboration, learning management systems, civil services</p>	<p>Governance by surveillance: use of ICT tools for increasing control over population, low openness and transparency, low integration and participation</p> <p>Increased management of complex systems by ICT solutions leads to dependency on highly vulnerable systems</p> <p>Information and knowledge denial: high and successful efforts in securing information monopolies</p>
Individual Level	<p>Protection of privacy</p> <p>Ambient intelligence/ ubiquitous computing supports daily living</p> <p>Social inclusion (right to internet and digital inclusion)</p> <p>New literacy (technology literacy, customized information services, personalized education)</p>	<p>Surveillance: disclosure of personal information, threat of social pressure)</p> <p>Ambient intelligence/ ubiquitous computing creates dependency and better enables surveillance</p> <p>Social exclusion (limited access and digital divide)</p> <p>New illiteracy (financial dependence, fragmentation of education)</p>

Table 4.1: Summary of global megatrends according to literature review (more elaborate see annexes)

5. European response strategies

Considering the ongoing socio-ecological transitions and their global consequences (see chapter 2 and appendices A and B), Europe has to be prepared for a world more complex and challenging than during the last decades. Europe therefore must make its choices on how to adapt to higher energy, food and resource prices, more frequent weather extreme events challenging existing infrastructures, and possibly more international tensions over resources and mobility. Moreover, price increases will hit low-income people most and further increase distributional tensions within Europe. On the other hand, Europe's population is better educated than ever before, ICT-technologies offer completely novel opportunities for democratic knowledge sharing and for the smart regulation of complex systems and Europe's huge wealth allows for the investment in new infrastructures that will make Europeans less vulnerable to climate events, energy shortages and resource price booms if implemented properly.

Politically, rather than passively settling with more unfavourable conditions, there is the chance of playing a pro-active role in moulding the unfolding of the next socio-ecological transitions of the mature industrial economies into a more sustainable future. Will Europe be able to create conditions under which climate change can be kept within acceptable limits, market economies become less dependent upon rising energy and materials inputs, maybe less dependent on growth altogether, and actively seek their margins in (input) cost reductions? Will Europe find ways to handle the distributional tensions that inevitably accompany low-growth and rising-prices in a peaceful and socially fair way? These are challenges that call for broad political visions that gradually need to emerge and be defended by authentic and plausible policy action and communication communication (see the term “new social contract” in WBGU 2011). The current financial crisis - not unlike what we have seen with the oil crisis in the early 1970s that also had been preceded by a broad movement promoting cultural change - could provide a turning point for such a development. The current European policy priority of financial stability could be a first step in this direction.

We now sketch three strategies on the European level, which in different ways attempt to cope with the changing global context of ongoing socio-ecological transitions. Two of these scenarios are also actively trying to shape the beginnings of the next socio-ecological transition away from fossil fuels. Finally, we propose a framework under which the chances

for of these three scenarios in the two different futures (tough and friendly) can be evaluated and discussed.

Strategy 1: No policy change

The first strategy assumes “**no policy change**”, where no additional policies are implemented to achieve sustainability or even to face the next socio-ecological transition. European policies are thought to generally remain in a business-as-usual mode and the overall aim is to defend the existing mode of production and consumption as well as the vested business interests related to these consumption patterns, while trying to re-establish previously more favourable conditions on the international level.

No policy change	
Aim:	No additional policy with reference to SET Defending the status quo in terms of level of resource consumption without major changes in distribution
Means:	<ul style="list-style-type: none"> • Despite increasing global challenges European policy responses remain in a business-as-usual mode. • Existing sustainability policies are only partially implemented. • No additional measures are successfully implemented. • Halting of European political integration impedes any coherent common measures to address the global challenges outlined above. • Current level of production & consumption defended.
Unattended:	Impact of global megatrends increasingly undermines the welfare of Europeans in the future. Lack of shared political vision to prepare people for upcoming changes and to win voters support. This further undermines national democratic systems and the common European vision and may stimulate scapegoating (foreigners, politicians...).

Table 5.1: No policy change

Strategy 2: Ecological modernization and eco-efficiency

In this second strategy Europe attempts to actively deal with the challenges outlined in this report by achieving eco-efficient production systems through market-based instruments and the “internalization of externalities”. Via increased eco-efficiency in Europe levels of energy and resource consumption are stabilized or even decreased, while efforts continue to secure growth in income (ie. relative or even absolute decoupling).

Ecological modernization and eco-efficiency	
Aim:	Eco-efficient production reached through market-based instruments
Means:	<ul style="list-style-type: none"> • Concerted policy action mainly based on supply-side market based instruments (i.e. „getting the prices right“) • Climate: Full use of EU-Emission Trading System • Support for investments into renewable energy sources • Ecological tax reform reflecting energy and material intensity of products • Removing subsidies that promote wasteful use of energy and material • Setting quantitative targets for eco-efficiency, both on product and on national levels • Using ICT capacity for resource-optimized dealing with complex systems (e.g. smart grid, sustainable mobility satisfying present mobility needs) • Informed rational consumers are to choose
Unattended:	<ul style="list-style-type: none"> • Rebound effects • Distributional issues within Europe and internationally (unequal access to resources)

Table 5.2: Ecological modernization and eco-efficiency

Strategy 3: Sustainability transformation

In the “**sustainability transformation**” strategy substantial structural change is being envisioned and pursued. Goals are set out to achieve a **smart, lean and fair societal metabolism** with the goal of optimizing European welfare. Thus this strategy recognizes that there is bound to be a next socio-ecological transition and pro-actively tries to shape the take-off into it, while at the same time taking action to deal with the fundamentally changing global conditions. This includes the recognition that a significant reduction in fossil fuels use is necessary and will have far reaching social and economic consequences. Therefore it includes a reconsideration of societal goals based on a thorough informed public debate and entails changes in consumption (patterns and levels) with a fundamental structural change in the economy.

Sustainability transformation	
Aim:	<p>Smart, lean and fair societal metabolism optimizing human welfare</p> <p>Efforts to stay within “a safe operating space for humanity” globally</p> <p>Taking into account European and global social justice</p>
Means:	<p>Beyond ecological modernization, consumption is restructured and reduced. It is taken care to maintain conditions of social justice.</p> <p>Smart: Measures as taken in the ecological modernization scenario</p> <p>Lean:</p> <ul style="list-style-type: none"> • Diet change towards less meat/more vegetarian food to substantially reduce biomass metabolism and agricultural land use • Major investment in R&D to re-design strategic products for using less energy in production and use, less rare metals and earths, and for longevity • A no-net-growth in built infrastructure with a focus on energy saving settlement patterns • Use of ICT’s ability to better understand and control complex systems (as in ecological modernization scenario, but additionally using ICTs capacity to shift consumption to less resource intensive forms e.g. virtual communication instead of traveling • A decisive ecological tax reform (ETR) that is based on RME (to include products’ embedded energy for imports) and aims at shifting taxes from labour to resources. This includes a property tax and a

	<p>financial transaction tax</p> <ul style="list-style-type: none"> • Pay-off of productivity gains in working hour reduction instead of income <p>These measures should lead to</p> <ul style="list-style-type: none"> • reduced societal metabolism and therefore transport demand • a decoupling of labour from energy productivity • the avoidance of rebound effects • a contribution to stay within a „safe operating space of the earth systems“, both through own resources use savings and through acting as a sustainability model for others ("contraction and convergence") <p>Fair:</p> <p>Europe strives for a more equal welfare distribution in Europe as well as internationally.</p> <ul style="list-style-type: none"> • new definitions of work and time use priorities that better comply with age and gender differences and allow for improved work-life balances. • property tax for financing shifts • securing social inclusiveness economically and socially
Unattended:	<p>Economic activity and competition is not seen as a goal in itself, but only as a means for human welfare.</p> <p>Preconditions necessary to enable such a fundamental transformation</p>

Table 5.3: Sustainability transformation

A framework for the evaluation of the European response strategies in a friendly and a tough global future world

The potential success of these response strategies depends to a large extent on the global conditions as described in the previous chapter (also see appendices A and B for longer discussions). Speaking in terms of game theory, we, the authors of this report, have openly speculated about the relative pay-offs of each response strategy, depending on how the global megatrends might evolve. The general framework we have created for this exercise allows for straight forward evaluation and visualization of results for each scenario for a number of indicators of interest (environmental, social, economic). Thus we want to facilitate discussion and reflection on the three strategies and the promises and pitfalls they hold under different global future conditions (Figure 5.1).

As we have tried to demonstrate in chapter 2, we do not think business-as-usual strategies will be able to cope with the global conditions to be expected. Accordingly, we feel the "no policy change" strategy will most likely have negative pay offs under both global scenario conditions, due to its insistence on the stabilization of the status quo, thereby impeding the necessary social and economic adjustments and structural changes.

For the ecological modernization strategy, in contrast, we expect outcomes to be the most satisfactory under conditions of a "friendly world", but for this strategy to fail under conditions of a "tough world". This assessment is mainly based on the judgment that market-based strategies work best under relatively stable and smooth conditions because the expectations of economic actors can adjust properly and implement investment activities accordingly. Structural change can be induced with relatively minimal distortions and negative side-effects. The open questions are how large the negative feedbacks of the unattended aspects of this strategy will be (see discussion of the strategy) and if the adjustments can happen fast enough.

The sustainability transformation strategy we expect to have positive outcomes under both future conditions, but to be most valuable in a "tough world", because it provides the vision and coherence socially required to overcome the hardships and challenges in a world shaped by ongoing and future SETs. In our judgment, this strategy is better suited to deal with international volatility and supply shocks by focusing on inter-European activities and adaptation, thereby inducing changes towards a resilient and sustainable socio-metabolic regime with a focus on societal welfare rather than on increasing economic activity. This also

includes numerous technical and social innovations, thereby strengthening the role of Europe as a leader in promoting and implementing sustainable development. .

These evaluations are obviously informed speculations of the authors of this report and mainly meant as an open invitation for the project consortium and all interested stakeholders to discuss and evaluate the various outcomes of different work packages in NEUJOBS under a common framework. This could foster comparability and coherence of joint efforts. In turn this would facilitate an inter- and transdisciplinary reflection and discussion of the results hopefully contributing to an improved understanding and policy relevant conclusions.

Response scenario	Global scenario Rate of change induced by response strategy	Friendly world gradual change	Tough world rapid change
no policy change	Low	-	- -
Ecological Modernization	medium	++	-
Sustainability Transformation	High	+	++

Figure 5.4: Speculative game-theoretical pay offs of three European response strategies under two global conditions

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Appendix A: Global Megatrends in natural conditions

A1. Energy transitions

- Growth in global energy demand mainly driven by population and economic growth in emerging economies
- Decreasing dependence on fossil fuels, but not sufficient to halt and reverse ecosystem degradation
- Varying opinions on peak-oil: suggested timing between 2008 to 2037
- Oil production becomes inelastic, leading to higher prices and increased oil price volatility
- Most likely the energy return on investment of the energy mix will decrease
- Feasibility of large scale roll-out of carbon capture and storage technology is under question
- Bio-fuel demand of environmentally oriented scenarios conflict with food production unless there is a major technological breakthrough
- No major expansion of nuclear foreseen

A1.1 Introduction

Global warming, biodiversity loss, desertification and more generally a growing trend towards ecosystem degradation are all evidence of the rapidly rising pressures of societies on the environment. In addition, many natural resources required to maintain and expand economic activities – such as certain types of non-renewable energy sources, minerals, clean water and arable land – are already becoming scarce due to overuse and may severely increase in price thus jeopardising future economic development if no alternative resources can be found.

The use of energy is one of the key societal activities responsible for these trends. On the one hand, world primary energy demand remains highly dependent on fossil fuels⁵¹ (81% in 2009, IEA, 2011). On the other hand, energy related emissions⁵² still account for three quarters of global greenhouse gas (GHG) emissions (75% in 2005, WRI, 2011). Curbing global warming, one of the key motivations for advancing towards a green economy, will thus require substantial changes in energy systems around the world. In fact, the European Union (EU) aspires to achieve a legally binding comprehensive global agreement that makes it

⁵¹ Coal, oil and gas

⁵² Energy related emission refer to emissions from electricity, heat, manufacturing, construction, transport, other fuel combustion and fugitive emissions (WRI, 2011).

possible to reduce GHG emission globally by 50% in 2050 compared to 1990, translating into a reduction by the EU of the order of 80-95% by 2050 compared to 1990, as was confirmed by the European Council on 4 February 2011.

Against this background, this chapter first outlines several global scenarios in sub-chapter A1.2 to give an indication of potential future developments in the global energy consumption as developed by prominent international institutions. Where possible business-as-usual scenarios are compared with the “greenest” scenarios, i.e. with those that come closest to a global socio-ecological transition away from fossil fuels, to provide the range of possible futures envisaged by these institutions.⁵³ Chapter A1.3 discusses some key issues related to the scenarios, including resource availability (e.g. peak oil), price volatility, energy return on investment (EROI), the role of carbon capture and storage technologies in reducing CO₂ emissions, and potential conflicts between the production of biofuels and a green economy.

Finally, key assumptions resulting from the analyses in Chapters A1.2 and A1.3 will be used to describe possible global trends (megatrends) that could characterise the world in 2025 and 2050 in a “friendly” scenario, i.e. one where only moderate challenges for EU policy making can be expected, and in a “tough” scenario, i.e. one where severe changes are expected with substantial impacts on Europe.

⁵³ With changes in society’s energy system being at the core of socio-ecological transitions defined by the phasing out of fossil fuels on the global scale in favour of low-carbon and renewable energy sources (see also Fischer-Kowalski and Haas, 2011).

A1.2 Global Energy Scenarios

While energy scenarios are not designed to reflect realistic images of future developments, they are useful for policymakers and enterprises to test the sustainability and coherence of different policy options and to address potential future challenges by developing appropriate strategies. This chapter presents five sets of global energy scenarios provided by the International Energy Agency (IEA), the US Energy Information Administration (EIA), Greenpeace (in collaboration with the European Renewable Energy Council – EREC), the French Centre National de Recherche Scientifique (CNRS) and its partner institutions (based on the POLES model), and three large international oil companies (BP, ExxonMobil, Shell). Given that scenarios often reflect the views and interests of the institutions developing them, the selection of the sets of scenarios presented in this paper aims at achieving a balance between international and national governmental institutions, scientific institutions, business and NGOs.

The scenarios will be analysed based on whether their projections include elements of a socio-ecological transition away from fossil fuels. Underlying this analysis is a definition of the key drivers of a sustainability transition in the energy sector:

- Global energy demand development
- Share of renewable energy sources (RES) in the energy mix
- GHG (or CO₂) emissions reductions
- Resource availability (e.g. peak oil)
- Fossil fuel (or oil) price developments (i.e. price level and volatility)
- Energy Return on Investment (EROI)
- The role of carbon capture and storage (CCS)
- Indications of conflicts between the production of agrofuels and food security

Since not all of these indicators are mentioned or described in the scenarios presented, they will further be developed in Chapter 3.

World Energy Outlook 2011⁵⁴

The International Energy Agency's World Energy Outlook 2011 (WEO 2011) is based on the World Energy Model (WEM), which has been designed to analyse global energy prospects, CO₂ emissions from fuel combustion, effects of policy actions and technological

⁵⁴ Source of this subchapter: IEA (2011)

changes, and investment in the energy sector. The WEO 2011 is based on 2009 data (the model's dataset covers the period from 1971 to 2009) and provides regional and sectoral energy projections up to 2035. The model consists of six main modules, including final energy demand (with sub-models covering residential, services, agriculture, industry, transport, non-energy use), power generation and heat, refinery/petrochemicals and other transformations, fossil-fuel supply, CO₂ emissions, and investment.

Three different scenarios have been calculated for the WEO 2011, including the Current Policies Scenario, the New Policies Scenario and the 450 Scenario. The Current Policies Scenarios pictures global energy trends taking into consideration only policies already formally adopted or implemented by mid-2011. Beyond that, the New Policies Scenario also includes broad policy commitments and plans announced (but not yet implemented) by countries around the world to address energy security concerns, climate change, local pollution and other energy-related challenges. Finally, the 450 Scenario sets out a pathway consistent with a 50% chance of limiting global warming to 2 degrees Celsius compared to pre-industrial levels. This requires limiting the concentration of GHG in the atmosphere to 450 parts per million of CO₂ equivalent (450 ppm CO₂e). The results presented in this sub-chapter will focus on the New Policies Scenario and the 450 Scenario, as these are considered most relevant for the transition studies conducted within the NEUJOBS project. To provide for best usability in for the modelling exercise in Work Package 1 of NEUJOBS, results will report data for 2025 where possible (and for 2020 or 2035 in other cases).

Apart from the policy assumptions presented above, the scenarios are also based on a number of non-policy assumptions, including economic growth, population growth, energy prices, CO₂ prices, and technology. **World GDP is assumed to grow by 3.6% annually**⁵⁵ between 2009 and 2035 in all three scenarios, although the IEA (2011) notes that the energy system transformation in the 450 Scenario and the higher energy prices in the Current Policies Scenario could reduce GDP growth in reality, at least temporarily. Historically, economic growth and energy demand are closely linked, however, this link weakens as economies develop. **Income elasticity of energy is thus expected to decline** as large emerging economies mature (IEA, 2011).⁵⁶

⁵⁵ Calculated in year-2010 dollars at constant purchasing power parity. OECD: 2.2%, non-OECD: 4.9%.

⁵⁶ The main reason for this is the change in the structure of economic output and the reduction of income-driven increases in demand due to energy efficiency and saturation effects (IEA, 2011).

Another key driver for energy demand is population growth. In the WEO scenarios, world population is expected to increase from 6.8 billion in 2009 to around **8.6 billion people in 2035**, mainly driven by developments in Asia and Africa.

In the New Policies Scenario, the international oil price⁵⁷ is expected to increase steadily to USD109⁵⁸/barrel in 2020 and to **USD120/barrel in 2035**. In the 450 Scenario, lower demand for oil causes the oil price to level off at **USD97/barrel in 2015** and to remain at that level until 2035.

As regards CO₂ prices, the New Policy Scenario assumes that they will increase to a maximum of USD30 by 2020, USD40 by 2030 and **USD45/tonne of CO₂ by 2035**. In the 450 Scenario, prices are higher reaching a maximum of USD45 by 2020, USD95 by 2030 and **USD120/tonne of CO₂ by 2035**.

No completely new technologies are assumed to be deployed in the three scenarios, technology development and deployment varies between them and is highest in the 450 Scenario (e.g. with respect to CCS, advanced biofuels, hydrogen fuel cells etc.) due to government support in the form of economic instruments, regulatory measures and direct investment.

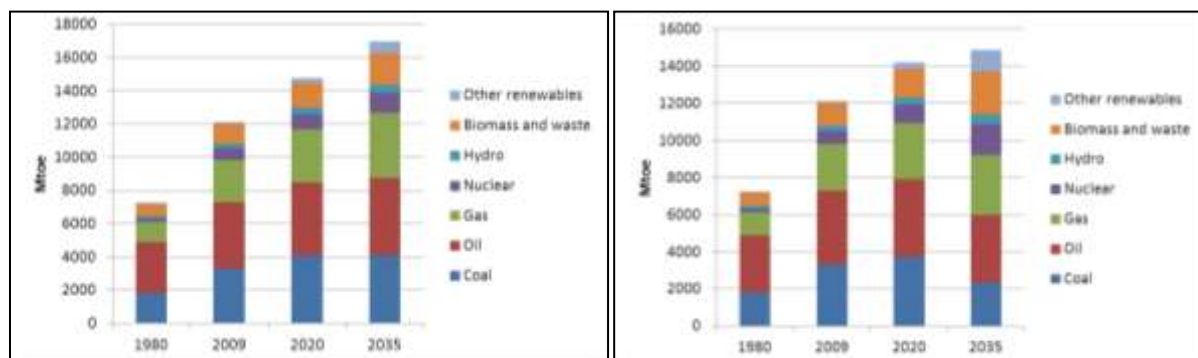
Turning towards the results of the scenarios, Figure A1.1 shows that global primary energy demand is expected to increase in both the New Policies Scenario and the 450 Scenario. In 2009, global primary energy demand was at 12,132 Mtoe with a 81% fossil fuel share. In the New Policies Scenario **demand increases by 40% to 16,961 Mtoe in 2035 with the share of fossil fuels decreasing marginally to 80%**. Data reported for 2025 shows that demand will be at 15,469 Mtoe, with a fossil share of 78%. 90% of the demand increase until 2035 is caused by non-OECD countries. The IEA (2011) claims that such an expansion of demand is possible. For example, oil production would need to increase from 87mb/d in 2010 to 99mb/d in 2035. Demand can be satisfied despite a slight reduction in conventional crude oil production due to increasing production of natural gas liquids, unconventional sources, light tight oil and biofuels.

In the 450 Scenario, the situation is slightly different with global energy demand only increasing by **23% to 14,870 Mtoe in 2035**. Most of this increase is covered by low-carbon energy sources causing the **share of fossil fuels in the energy mix to decrease to 62%**. It can thus be argued that neither the development of energy demand nor the penetration of

⁵⁷ Can be used as reference for all other related fuel prices.

⁵⁸ All USD figures in year-2010 USD

renewable energy sources show signs of a socio-ecological transition away from fossil fuels. However, optimistic assumptions about the deployment of nuclear power and of carbon capture and storage (CCS) technologies for coal and gas help to achieve GHG emissions reductions in line with the 2 degrees target.



Source: IEA, 2011

Figure A1.1: World primary energy demand by fuel in the New Policies Scenario (left) and in the 450 Scenario (right)

Biomass plays an important role in both scenarios. In the New Policies Scenario its share in the global energy mix remains more or less stable at slightly above 10% until 2035, but demand for biomass (including waste) is expected to increase by 32% until 2025 and by 55% until 2035 (compared to 2009). In the 450 Scenario, the share of biomass in energy demand rises to 16% in 2035. The share of biofuels in transport, still at 2.3% in 2009, increases to more than 13% by 2035 in this scenario.

As regards the deployment of **carbon capture and storage technologies**, it is estimated that 18% of the CO₂ emissions reductions required to move from the New Policies Scenario to the more sustainable 450 scenario can be achieved by CCS, with large-scale deployment starting only after 2020. It is quite obvious that delayed action on CCS or the potential failure of the technology will put additional pressures on renewable energy sources (RES) if GHG emissions reduction targets are to be met.

To conclude, the New Policies Scenario fails to depict a global sustainability transition in the EU despite of the fact that it shows **relative decoupling** between economic growth (3.6% p.a. between 2009 and 2035) and CO₂ emissions (0.9% p.a.). The 450 Scenario, on the other hand, pictures a world that differs substantially from today and contains some elements of a sustainability transition, including **absolute decoupling** between economic

growth (3.6% p.a.) and CO₂ emissions (-1.1% p.a.) leading to a reduction of CO₂ emissions to some 3% above 1990 levels by 2035. However, it still projects a 62% share of fossil fuels in global primary energy demand in 2035, its assumptions about the deployment of CCS are optimistic and the extent to which nuclear will remain part of the global energy mix (11.2% of demand by 2035, up from 5.6% in 2009) is not clear after the Fukushima accident and possible future incidents.

International Energy Outlook 2011⁵⁹

The US Energy Information Administration's (EIA) International Energy Outlook (IEO) (EIA 2011) is based on EIA's World Energy Projections Plus (WEPS+) model providing projections for 16 regions or countries of the world until 2035. The WEPS+ platform consists of several models, including end-use demand models (residential, commercial, industrial and transport), transformation models (power generation and district heat), supply models (petroleum, natural gas and coal) and a refinery model. The main model in the WEPS+ system monitors the convergence of consumption and prices to an equilibrium solution and projects energy-related CO₂ emissions at the regional level.

The IEO 2011 presents five scenarios (referred to as "cases"). The focus of the analysis is on the Reference Case, which is based on existing policies and laws, and thus does not take into account submitted emissions reduction goals under the UNFCCC. The Reference Case is accompanied by four cases, which show the impact of changes in the oil price, in the share of available conventional oil (based on OPEC production), and in GDP growth rates. For the purpose of this paper, only the High Oil Price Case and the Low Oil Price Case will be presented.

All cases assume that the **global population** will increase from 6.7 billion in 2008 to **7.9 billion in 2025** and to 8.5 billion in 2035. Assumptions on economic growth and the price of oil, however, differ significantly. In the Reference Case, **the global economy is assumed to grow on average by 3.4% annually between 2008 and 2035**.⁶⁰ In the High Oil Price Case, the average annual GDP growth rate is increased to 4%,⁶¹ whereas it is decreased to 2.8%⁶² in the Low Oil Price Case. Different assumptions about economic growth are also reflected in differing assumptions about the oil price development. In the Reference Case, the oil price increases from an average level of USD100 in 2011 to **USD118/barrel in 2025** and USD125 in

⁵⁹ Source of this subchapter: EIA (2011)

⁶⁰ Calculated in year-2005 dollars at constant purchasing power parity. OECD: 2.1%, non-OECD: 4.6%.

⁶¹ OECD: 2.1%, non-OECD: 5.5%.

⁶² OECD: 2.1%, non-OECD: 3.6%.

2035.⁶³ The High Oil Price Case is characterised by higher economic growth in non-OECD countries and thus also higher global demand for liquid fuels. At the same time OPEC countries reduce production substantially and non-OPEC countries restrict access to, or increases taxes on, production from prospective areas. Increasing demand and decreasing supply cause oil prices to increase to **USD 186/barrel in 2025** and to reach USD200 by 2035. In the Low Oil Price Case the situation is reversed. Lower economic growth in non-OECD countries causes demand for liquid fuels to decrease while both OPEC and non-OPEC countries expand output. This results in the oil price to decrease to **USD51/barrel in 2025** and to USD50 in 2035.

It seems that climate policy does not play a pronounced role in the IEO2011 analysis and there are **no scenarios with stronger climate policies and no indications of a (national/regional/global) CO₂ price** anywhere in the document, although it is stated that the effects of carbon prices can be analysed by WPES+.

Figure A1.2 shows the development of world total energy consumption by fuel for the three cases presented above. **Energy demand** grows fastest in the High Oil Price Case (2008-2025: 38%, 2008-2035: 69%) mainly driven by non-OECD economic growth. In the Reference Case, the expansion of global energy demand is limited to **33% until 2025 and 52% until 2035**. The lowest growth rates are observed in the Low Oil Price Case, where energy demand grows by 31% until 2025 and 41% by 2035.

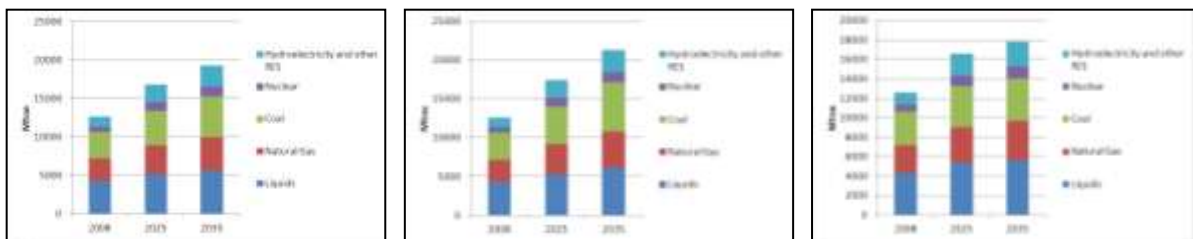


Figure A1.2 World total energy consumption by fuel in the IEO2011's Reference Case (left), High Oil Price Case (center) and Low Oil Price Case (right) (Source: EIA, 2011 and own calculations⁶⁴)

⁶³ Prices in year-2009 dollars.

⁶⁴ Conversion rate of 0.025 applied to convert trillion British thermal units to million tonnes oil equivalent.

It is interesting to note that the **share of fossil fuels remains more or less constant** over the time period under consideration **at around 80%** in all the three cases. Non-OPEC countries account for 57% of the increase in liquids production and 35% of the increase if covered by unconventional fuels. IEO 2011 thus sees no supply shortfalls based on resource availability “below-ground”. However, it does recognise “above-ground” factors,⁶⁵ which might limit the production of economically competitive conventional fuels.

Renewables reach the highest share (14.3%) in the Low Oil Price Case, however, this level is almost similar to the Reference Case (14.2%). The IEO 2011 does not include ethanol and biodiesel in its category “hydroelectricity and other RES” (these are included in the category “liquids”), however, it is assumed that these will not considerably increase the share of renewables in energy consumption and will continue to make a rather modest contribution to the overall level of liquids, which remain dominated by petroleum and petroleum-derived fuels. The only direct reference to biofuels in IEO 2011 is in regard to Brazil where biofuels production in the Reference Case is projected to triple from 0.5 million barrels in 2008 to some 1.7 million barrels in 2035.

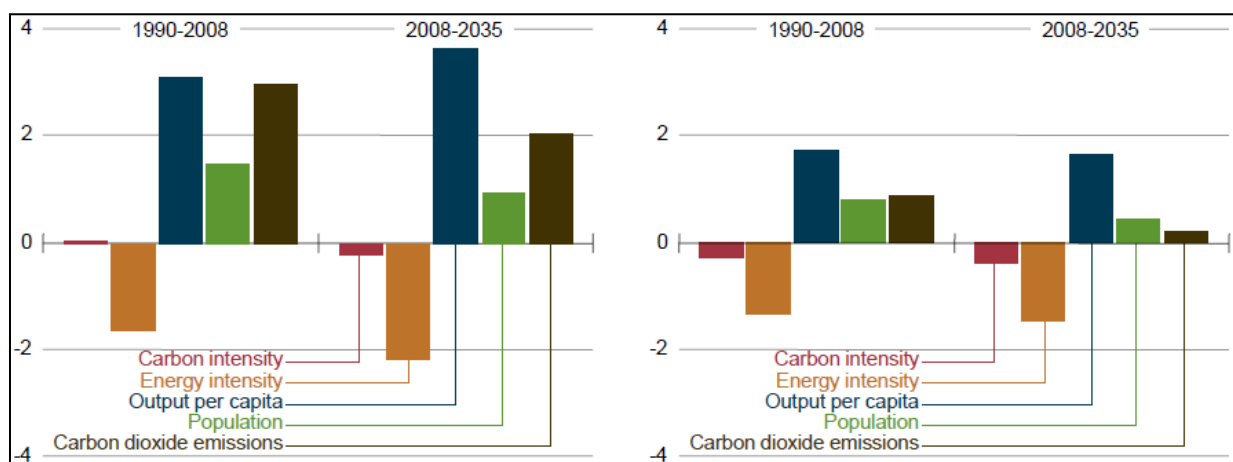


Figure A1.3 Average annual changes in Kaya decomposition components of non-OECD (left) and OECD (right) carbon dioxide emissions growth (in percent per year) (Source: EIA, 2011)

⁶⁵ The IEO 2011 refers to “above-ground” factors as “non-geological factors that could affect supply, including but not limited to government policies that limit access to resources; conflict; terrorist activity; lack of technological advances or access to technology; price constraints on economic development of resources; labour shortages; materials shortages; environmental protection actions; and short- and long-term geopolitical considerations” (EIA 2011: 30).

As regards the development of energy-related CO₂ emissions, IEO 2011 takes the so-called “Kaya decomposition” approach, which recognises that CO₂ emissions are the product of four factors: (1) carbon intensity of energy supply, (2) energy intensity of economic activity, (3) economic output per capita, and (4) population. Figure 3 shows the historic and projected development of these four factors and of CO₂ emissions for non-OECD countries (left) and for OECD countries (right). On the global level, energy-related **CO₂ emissions are projected to increase in the Reference Case by 26% until 2025 and by 43% until 2035** (compared to 2008), equivalent to an average annual growth rate of 1.3% between 2008 and 2035. Although this development reflects **relative decoupling** of CO₂ emissions from economic growth, it does not adequately consider the need of a new socio-ecological transition away from fossil fuels. On the positive side, energy intensity of economic activity (2) is projected to decrease considerably (-1.8% annually), while carbon intensity of energy supply remains more or less constant (-0.2% annually). However, these benefits are more than outweighed increasing income per person (+2.5% annually) and population growth (+0.9% annually between 2008 and 2035), which cause global CO₂ emissions to increase considerably. In the High Oil Price Case, global CO₂ emissions increase by 32% until 2025 and by 63% until 2035 (compared to 2008). In the Low Oil Price Case, emissions increases are lower with 24% until 2025 and 30% until 2035 (compared to 2008). The role of CCS in these developments remains unclear in the IEO 2011 report.

It is quite clear from this analysis, that none of the cases presented in the IEO 2011 reflect a socio-ecological transition. The different cases merely reflect the direct link between economic growth, energy consumption and CO₂ emissions. Climate policy and more general attempts to making the global socioeconomic system any “greener” are not analysed in the report.

Energy [R]evolution – A Sustainable World Energy Outlook⁶⁶

The third edition of the global Energy [R]evolution scenarios (ER) was published by the European Renewable Energy Council (EREC) and by Greenpeace International (EREC/Greenpeace International 2010). The scenarios, were jointly commissioned from the Institute of Technical Thermodynamics of the German Aerospace Center (DLR). The supply scenarios were calculated using the MESAP/PlaNet simulation model. Energy demand projections were developed by Ecofys (for industry, transport and “other” consumers – which include households and services). Also incorporated in the analysis was a study on

⁶⁶ Source of this subchapter: EREC/Greenpeace (2010)



options to reduce CO₂ emissions from Light Duty Vehicles (LDVs) by the Institute of Vehicle Concepts in Stuttgart, Germany. Finally, the potential for sustainable bio energy has been assessed by the German Biomass Research Centre.

ER 2010 presents three scenarios. The ER 2010 Reference Scenario is based on the Reference Scenario of the IEA's World Energy Outlook 2009 but extrapolates the projections beyond 2030 until 2050. Similar to the Current Policies Scenario presented in WEO 2011, the ER 2010 Reference Scenario only takes into account policies that have formally been adopted or implemented by mid-2009. Based on the conviction that the most catastrophic impacts of climate change can only be avoided if global temperature increase is kept as far below 2 degrees Celsius as possible, ER 2010 presents two scenarios that drastically reduce GHG emissions. The Energy [R]evolution Scenario aims to show a pathway of how global CO₂ emissions can be reduced in 2050 by 50% (compared to 1990 levels) while **phasing-out nuclear energy** (by 2050). The Advanced Energy [R]evolution Scenario goes even further by aiming to reduce global CO₂ emissions by more than 80% by 2050 (compared to 1990 levels).

Basic assumptions regarding population growth, GDP growth, oil price and carbon price are equal for all three scenarios. The global population is expected to increase from 6.7 billion in 2007 to **9.2 billion in 2050**. Global GDP is expected to increase on average by **3.4% annually** between 2007 and 2050. The oil price is assumed to increase to **USD140/barrel in 2025** and to USD150 in 2050.⁶⁷ Non-Annex B countries introduce a carbon price as of 2020 and the (then) global carbon price increases from **USD20 in 2020** to USD50 in 2050.

It is interesting to note that **CCS does not play a role** in the two sustainability scenarios due to the fact that "overall costs of CCS could [...] serve as a major barrier to its deployment" (ER 2010: 53). Similarly, ER 2010 takes a precautionary approach to biofuels, reflecting sustainability concerns. As a result, ER 2010 restricts the use of feedstocks to a limited amount of forest and agricultural residues and **does not include biofuels from energy crops**.

The results of the scenario analysis are presented in Figure A1.4. The report stipulates that global energy demand is a function of population development, economic development and energy intensity (i.e. energy per unit of GDP). Given that population growth and economic growth are fixed in all three scenarios, energy intensity needs to decline considerably. This is assumed in all three scenarios. In the Reference Case, energy intensity declines by 56% between 2007 and 2050. In the Energy [R]evolution Scenario it declines by

⁶⁷ Expressed in year-2008 dollars.

73%. In addition, energy intensity of the transport sector declines by another 17% in the Advanced Energy [R]evolution Scenario. As a result, it is clear to see that energy efficiency is projected to play the largest role in curbing energy demand. As opposed to the Reference Scenario, efficiency measures cause energy demand to be about 10% lower by 2020 both sustainability scenarios. By 2050, efficiency reduces demand by about 41% in the sustainability scenarios compared to the Reference Scenario.

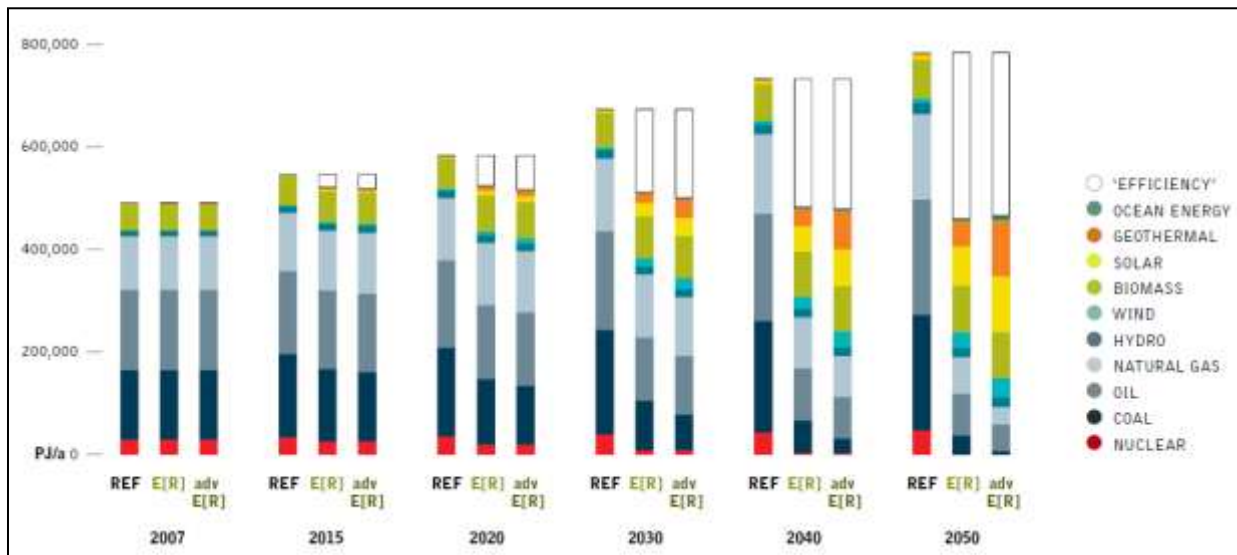


Figure A1.4: Global primary energy demand by source under the three ER 2010 scenarios (Source: ER 2010)

Note: REF = Reference Scenario, E[R] = Energy [R]evolution Scenario, adv E[R] = Advanced Energy [R]evolution Scenario

Similarly, the share of fossil fuels is considerably reduced. While in 2020 still at 75% and 73% in the Energy [R]evolution Scenario and the Advanced Energy [R]evolution Scenario, respectively, the **share of fossil fuels is reduced by 2050 to 42% in the Energy [R]evolution Scenario and to 20% in the Advanced Energy [R]evolution Scenario**. Taking into account the nuclear phase-out by 2050, this means that 58% and 80% of energy demand is projected to be covered by renewables in the two scenarios, respectively.

Reduced demand for primary energy and an increasing share of various types of RES have a positive effect on global CO₂ emissions. While in the Reference Scenario CO₂ emissions would be 61% above 2007 levels (and 111% above 1990 levels) by 2050, they would be **63% below 2007 levels (and 51% below 1990 levels)** in the Energy [R]evolution Scenario.

In the Advanced Energy [R]evolution Scenario, **CO₂ emissions would be reduced by 88% in 2050 compared to 2007 and by 84% compared to 1990.**

The ER 2010 scenarios depict a far reaching change in the global energy system towards sustainability, with **strong absolute decoupling** of economic growth and energy demand/CO₂ emissions. They show pathways of how a socio-ecological transition can be achieved by applying strict sustainability criteria. Although the ambitiousness of the two E[R] scenarios might put their achievability into question, they can nevertheless be used for the defining what a sustainability transition could look like.

The POLES Model⁶⁸

The POLES model (Perspective Outlook on Long-Term Energy Systems) is an econometric, partial-equilibrium world model originally developed in the early 1990s by the Centre National de Recherche Scientifique (CNRS) and now by a joint consortium, which includes the University of Grenoble, Enerdata and the Institute for Prospective Technological Studies (JRC-IPTS, Seville). POLES energy projections are carried out on three levels: demand models determine final demand of electricity, oil products etc.; the transformation modules assess electricity production and its related primary energy demand; and primary supply modules assess fossil fuel production and related transformation. The POLES model provides for projections of energy demand and supply, international energy prices, simulation of technology development for new energy technologies (exogenous or endogenous), and simulations of CO₂ abatement policies (through taxes or quota mechanisms).

The availability of oil and gas is constrained in the POLES model, which takes into account resources for about 20 producing countries. The structure of the oil and gas module, with an "oil discovery process model" allows reproducing peak oil features, according to the hypotheses adopted and to the scenario dependent demand profiles (which also allows for "peak demand" cases). There are no resource constraints for coal.

Within the framework of the SECURE project,⁶⁹ a family of scenarios has been developed between 2008 and 2010 using the POLES model in order to illustrate the

⁶⁸ Source of this subchapter: Unpublished dataset produced in the context of the SECURE project

⁶⁹ The SECURE project (Security of Energy Considering its Uncertainty, Risk and Economic implications; see also www.secure-ec.eu) analysed the risks associated with the supply of various energy sources in the EU in order to come up with concrete policy proposals for their mitigation. It was funded by the European Commission under the Seventh Framework Programme. A key conclusion of the project was that security of supply and climate change cannot be considered separately and that there are clear synergies between strong climate action and energy security policies.

interactions between climate change policies and energy security issues until the year 2050. The first is the Baseline Case, which serves as a hypothetical benchmark projecting a counterfactual development in the absence of climate policy, both on the EU and international levels. A second scenario, the Muddling Through (MT) Scenario, describes the consequences of non-coordinated, low profile climate policies. The Muddling Through & Europe Plus Scenario (MT E+) represents the same setting but with some leadership from Europe. Fourth, the Europe Alone Scenario (EA) represents a case where only the EU commits to strong targets that are broadly in line with limiting global warming to 2 degrees Celsius above pre-industrial levels.⁷⁰ Finally, the Global Regime Scenario (GR) explores a new world energy system under a strong international climate change agreement consistent with the 2 degrees target (SECURE, 2010).

This sub-chapter will focus on the results of the Europe Alone (EA) and Global Regime (GR) Scenarios, which represent the most ambitious EU and international responses to climate change. In both cases, global population is assumed to increase from 6.9 billion in 2010 to **9.2 billion in 2050**. Also, global economic growth is assumed to be equal in the two scenarios with an annual average of just below **2.8% between 2010 and 2050**.

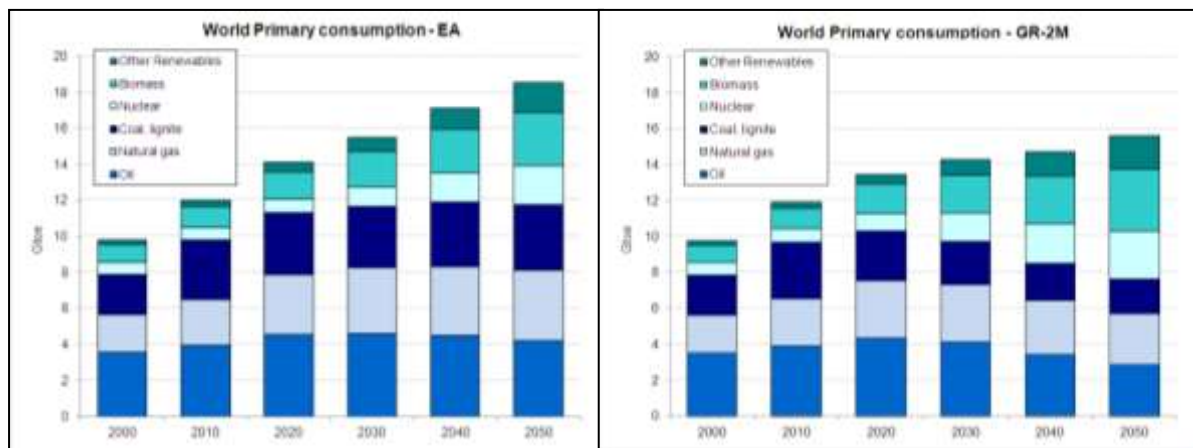


Figure A1.5: World primary energy consumption in the Europe Alone Scenario (left) and in the Global Regime Scenario (right)(Source: POLES model)

⁷⁰ Of course the EU is not in a position to limit climate change all by itself, but in the EA scenario the EU shows leadership in the aspiration that other industrialised and emerging economies will eventually follow suit.

In the **Europe Alone Scenario (EA)**, it is assumed that an internationally binding agreement on climate change has not been reached. Yet, the EU does not abandon its energy and climate change ambitions. European member states not only stick to the 20-20-20 targets by 2020 as agreed in the 2008 Energy and Climate Change Package, but they decide to go further, cutting their GHG emissions by 60% by 2050 compared to 1990. A key driver for decarbonisation is an ever increasing carbon price in Europe, which reaches **EUR180/tCO₂ in 2050**. In the rest of the world, a shadow carbon price of EUR30/tCO₂ in 2050 is not high enough to induce substantial changes in the global energy system. At the same time the international oil price is projected to develop towards USD74/barrel in 2020 and increases to **USD117/barrel in 2050**.⁷¹

Although there are considerable changes in the EU energy system (with the share of fossil fuels in the energy mix declining to well below 50%) the global benefits of the EU advancing alone are clearly very limited.⁷²

Figure A1.5 (left panel) shows that global **primary energy consumption** in the EA Scenario is projected to **increase by 53% between 2010 and 2050**. The **share of fossil fuels** in the global energy mix, however, might decrease to **64% by 2050**. Similarly, the **share of renewables** would increase from 12% in 2010 to almost **25% in 2050**, with biomass and wind contributing the most to this increase. In fact, the high reliance on biomass in this scenario raises doubts as to whether such quantities can be produced globally in a sustainable way.

Despite these positive developments, **global CO₂ emissions** are projected to increase to **57% above 1990 levels** (or 11% above 2010 levels). Although this reflects **relative decoupling** between economic growth and CO₂ emissions, this development is clearly not in line with the 2 degrees target. In fact, the Europe Alone Scenario would lead to an average global temperature increase of 3-4 degrees Celsius. Global CO₂ emissions would be even higher without the deployment of CCS technologies, which only play a marginal role in 2020 but help to reduce global CO₂ emission by roughly 5% in 2050.

The **Global Regime Scenario (GR)** assumes a binding international agreement aimed at reducing global GHG emissions by 50% by 2050 compared to 1990 levels in line with the 2 degrees target. The commitment of major energy consuming countries - China, the US, India - to cut GHG emissions gives a further incentive to the European Union to pursue its climate policy objectives of reducing EU GHG emissions by almost 80% until 2050 compared

⁷¹ Expressed in year-2005 dollars.

⁷² For the EU, however, there are considerable benefits in terms of security of energy supplies, reduced import dependence, reduced pollution, technological leadership, job creation etc.

to 1990. Decarbonisation in this scenario is driven by considerably higher carbon prices than in the Europe Alone scenario, reaching **392EUR/tCO₂ in Annex I countries** and **257EUR/tCO₂ in non-Annex I countries** by 2050. Reduced demand for oil (products) reduced the international oil price to some USD70/barrel in 2020 and to **USD71/barrel in 2050**.

Two additional elements compose the strategy to achieve a low carbon global economy: improved energy efficiency and the increasing penetration of renewables in the global energy mix. The former reduces the **increase in global energy demand to 29% between 2010 and 2050** (see Figure A1.5, right panel). In addition, the **share of renewables in primary energy consumption increases to almost 34% in 2050**. The share of biomass alone increases to almost 22% of primary energy consumption, raising concerns about the sustainability of agrofuels production and of competition with food and other agricultural products. Together with nuclear, the share of low carbon technologies in the energy mix increases to some 51% by 2050. The **share of fossil fuels, on the other hand, is reduced to 49%**.

The 50% reduction of global GHG emission by 2050 (compared to 1990) is achieved with a **high rate of deployment of CCS technologies**. In fact, in addition to the 11.8 Gt of CO₂ emissions projected for 2050, some 9.8 Gt of CO₂ are projected to be sequestered. Although the POLES model takes into account storage potentials depending on related costs, it does not incorporate social acceptability constraints.

The Global Regime Scenario is clearly the scenario that projects a future development of the global and EU energy system that comes closest to a socio-ecological transition away from fossil fuels. Although there remain some open questions as to the feasibility of increasing the share of biomass and CCS to such elevated levels as projected in this scenario, it does give an impression of what the world could look like under strong environmental constraints.

Industry Outlooks⁷³

This sub-section gives a brief overview about the key results of the global energy outlooks of three large international oil/energy companies: BP, ExxonMobil and Shell.

BP published its **“BP Energy Outlook 2030”** (BPEO 2030) in January 2011. It is neither an attempt to extrapolate a business-as-usual scenario nor to model a policy target. What BP aimed to do is to provide a likely path of global energy markets to 2030, based on internal and external consultations. The Base Case is complemented by a Policy Case, which assesses

⁷³ Sources of this subchapter: BP (2011), ExxonMobil (2011), Shell (2008)

the impacts of possible policy changes on energy production and consumption. The publication only includes key raw data, which does not allow for a scientifically accurate account of the population growth (about **0.9% annually between 2010 and 2030**) and GDP growth assumptions (about **3.7% annually**). Neither does the publication report any data on oil price or carbon price developments. However, some key conclusions can still be drawn.

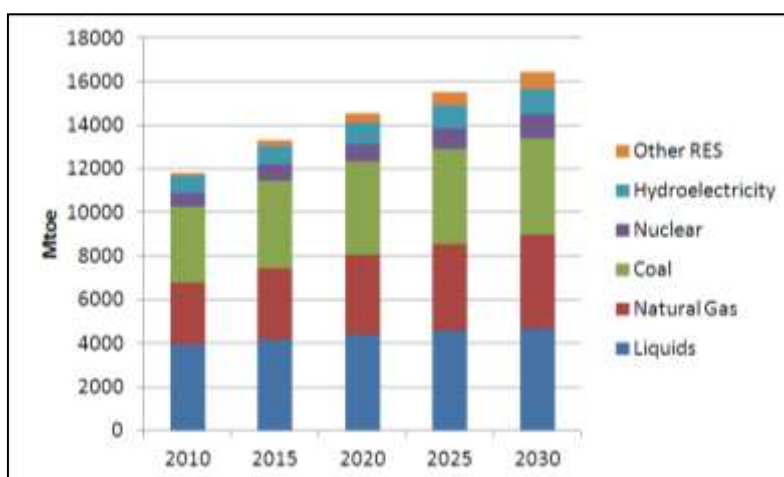


Figure A1.6: Global primary energy consumption by source in the Base Case of the BP Energy Outlook 2030 (Source: BP 2011)

Figure A1.6 shows that **global primary energy consumption** in the Base Case is projected to **increase by 39% between 2010 and 2030**. Non-OECD countries account for 93% of this growth. The fuel mix changes relatively slowly due to long asset lifetimes, and the **share of fossil fuel in the energy mix only declines to 82% in 2050** (down from 87% in 2010). In absolute terms, demand for liquids (oil, biofuels, and other liquids) is projected to increase by 15 mb/d to more than 102 mb/d by 2030. Non-OPEC biofuels will play a large role in covering this increment, as will conventional crude oil from Iraq and Saudi Arabia, as well as OPEC natural gas liquids (NGLs).

In this outlook, **RES can only capture a share of 12% in 2050**. However, the actual share of RES is likely to be higher, since biofuels are included in the category “liquids” and are projected to contribute 9% to transport fuels in 2050 (up from 3% in 2010).

The BPEO 2011 also finds that energy intensity is declining steadily in most countries and globally and will continue to do so until 2030. Moreover, **energy intensity is likely to converge across countries**, mainly due to trade in energy, common technologies and converging consumption patterns.

However, despite improvements in energy intensity, global CO₂ emissions from energy use are projected to increase. Even in the Policy Case, global emissions would peak just after 2020 and would still be 21% above 2005 levels in 2030. This means that the 2 degrees target would be missed by a wide margin.

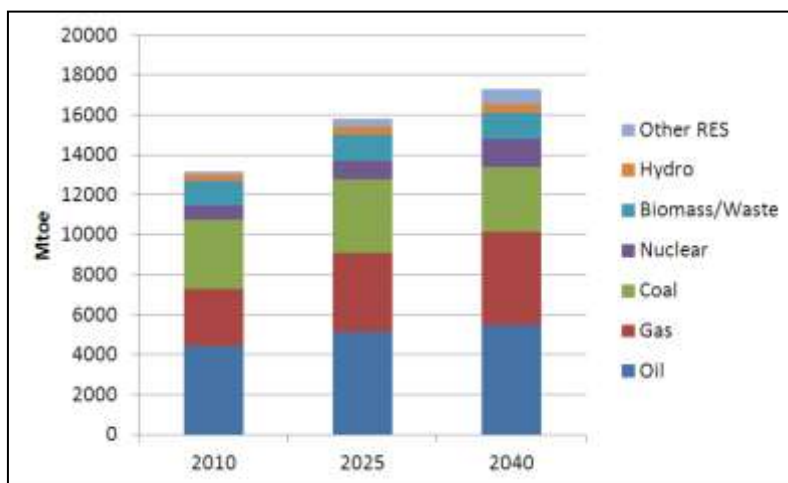


Figure A1.7: Global primary energy demand by source in ExxonMobil's 2012 Outlook for Energy (Source: ExxonMobil, 2011 and own calculations⁷⁴)

ExxonMobil's "2012 The Outlook for Energy: A View to 2040" provides a view of the world's energy future based on the assumption that by 2040 there will be nearly 9 billion people living on the planet. In addition, **global economic output is expected to increase on average by 2.9% annually between 2010 and 2040.**⁷⁵ These will be the main drivers behind the **expansion of global primary energy demand by 32% between 2010 and 2040** (see Figure A1.7). Similar to the BPEO 2011, the fossil share is expected to remain high with 77% in 2040 and **no resource shortages are expected**. As a result, the **share of renewables will remain rather limited at 15%** (all sources included).

As regards global energy related CO₂ emissions, ExxonMobil expects them to grow slowly until 2030 and to level off thereafter. However, this still means that **by 2040 CO₂ emission would be almost 68% above their 1990 levels** (or 16% above their 2010 levels), despite growing energy efficiency improvements and an (albeit marginally) increased share of low-carbon fuels in the energy mix.

⁷⁴ Conversion British thermal units to million tones oil equivalent

⁷⁵ OECD 2.1%, non-OECD 4.4%.

Finally, a brief look at the two “**Shell Energy Scenarios to 2050**” published in 2008, which are called “Scramble” and “Blueprints”. These two (rather extreme) scenarios are used by Shell to identify emerging challenges and to foster adaptability to change. They are therefore essential to help review and assess the company’s strategy.

Scramble reflects a world where national governments prioritise security of supply and bilateral deals between energy producers and consumers to the detriment of climate change and multilateralism. It is a world in which major resource holders have a strong market and political position and where resource prices are generally strong. As a result, countries resort to widely available and cheap coal resources (with negative consequences on CO₂ emissions), but also to biofuels and renewable energy (as coal hits constraints) to satisfy **growing energy demand (+66% between 2010 and 2050)**. As shown in Figure A1.8 (left panel), this leads to a 30% share of coal and to a 15% share of biomass in the energy mix by 2050, raising substantial sustainability concerns (although it should be noted that second generation biofuels would make up more than one third of global biomass based energy production). Yet, the **share of fossil fuels would decrease to 58% by 2050**, mainly due to the fact that renewables will cover most of the energy demand increase after 2020. Accordingly, the **share of RES in the global energy mix will increase to 37% by 2050**. Although there will be a global carbon trading system in place after 2020, it is clear that the world fails to achieve the 2 degrees target.

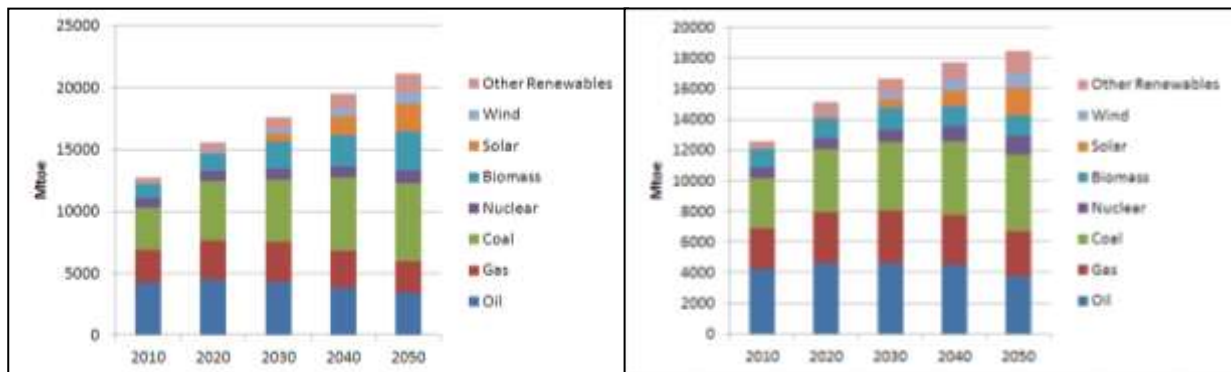


Figure A1.8: Global primary energy by source in Shell’s Scramble Scenario (left) and in the Blueprints Scenario (right) (Source: Shell 2008 and own calculations⁷⁶)

⁷⁶ Conversion of Exajoules to million tones oil equivalent.

The **Blueprints Scenario**, by contrast, is characterised by a higher degree of cooperation building on common interests related to the security of supply, the environment, and entrepreneurial opportunities. Shell notes that consumers and investors increasingly realise the benefits of changes in the global energy system, which causes the global economy to shift towards a less resource intensive path. It is stressed that global multilateral companies benefit from clear, harmonised policies as a way of avoiding inefficiencies and uncertainties of uncoordinated action as outlined in the Scrambles Scenario. In addition, increased oil production has a dampening effect on prices. Without mentioning concrete figures, Shell also foresees the introduction of “meaningful” CO₂ pricing aimed at stimulating energy efficiency, electrification of the energy system, and more generally reduced demand for conventional hydrocarbons.

Although this sounds like a major move away from **fossil fuels**, their **share will still be at 63% in 2050. RES will contribute 30%** to the global energy mix, less than in the Scrambles Scenario. However, CO₂ emission are likely to be considerably lower than in the Scrambles Scenario with an increasing share of nuclear power and with decreasing demand for coal and a high rate of CCS deployment.

Unfortunately, Shell is quite restrictive with exact data regarding assumptions and results, but from the data that has been made available it is very clear, that the company does not include a major shift away from fossil fuels in either of its two scenarios.

The conclusion from this sub-section on industry forecasts is that they all expect considerable increases in global energy demand, which will need to be satisfied with high levels of fossil fuels in the energy mix. It is clear to see that there is no intention to model a deliberate phasing out of fossil fuels. Also, there is a tendency to limit transparency of the data behind the outlooks/scenarios, which makes it hard to evaluate many of the statements made.

A1.3 Key issues

This section analyses five key issues that are of high relevance when assessing the future of the global energy system. Apart from demand developments, which have been described in the previous chapter, these include the extraction limitations of exhaustible (fossil) resources, variability of the oil price, the availability of CCS as a technology to decarbonise the use of (mainly) coal, reductions in the Energy Return on Investment (EROI), and potential conflicts between biomass production and food security.

Peak Oil

An important aspect to consider when looking at energy scenarios is the availability of exhaustible fossil (and other) fuels. As regards oil, data regarding existing reserves is characterised by a high degree of uncertainty (both for proved reserves and even more so for unproved reserves). A well-known and often cited source of data for proved oil reserves and global oil production is the BP Statistical Review of World Energy. In its edition of June 2011, it puts global proved oil reserves in relation to current levels of oil production and concludes that world proved oil reserves in 2010 were sufficient to meet 46.2 years of global production (at 2010 levels). This so-called “reserves-to-production ratio” (R/P ratio) has remained more or less constant at above 40 years over the last 25 years (see Figure A1.9). Similar data is available for gas and coal, where current R/P ratios are estimated at 58.6 and 118 years, respectively (BP, 2011).

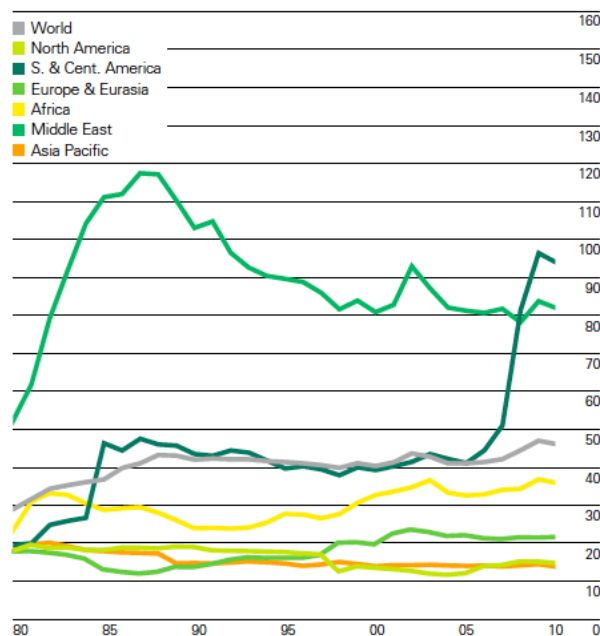


Figure A1.9: Historical reserves-to-production ratios for oil by region and worldwide (Source: BP 2011)

And yet, there are signs that the era of “easy and cheap oil” is over. On the one hand, this is due to the fact that many of the giant fields, each producing more than 100 thousand barrels per day, are ageing and their resources are depleting. The consequent loss in production is partly offset by newly discovered oil fields whose size is decreasing. On the other hand, there still seems to be plenty of oil in the ground but the problem is how to recover it. Today’s average global recovery rate is only about 35%, which means that 65% of the world’s discovered oil is left in the ground. Although new technologies and exploration

techniques may be able to increase recovery rates and can make unconventional oil (such as tar sands, extra heavy oil and oil shale) become conventional, it is likely that extraction costs will increase.

This is what the peak oil debate is about. On the one hand, there are the pessimists who argue that global oil production has already peaked (see Table A1.1). In a recent article Murray and King (2012), for example, claim that “the true volume of proven global reserves is clouded by secrecy; forecasts by state oil companies are not audited and seem to be exaggerated” (Murray and King, 2012: 434). As a result they propose to look at actual production rates instead of proved reserves and conclude that “even while reserves are apparently increasing, the percentage available for production is going down” (*ibid.*). Their argument is founded on the fact that conventional crude oil production has not risen since 2005, despite increasing demand. According to them, oil supply seems to be “capped” at around 75 mb/d and is thus not able to respond to price increases anymore, leading to increases in price volatility (see next section).

On the other hand, there are the “optimists” who believe that unconventional oil sources would be able to offset the decline in conventional oil sources meeting the future increase in oil demand. To the latter, the oil peak will not be visible before 2035, and even beyond then there will be the possibility to substitute oil products with other products such as natural gas liquids (NGLs). For example, the IEA in its WEO2011 New Policies Scenario, excludes the possibility of peak oil before 2035, forecasting a significant increase in the production of unconventional oil (expected to be more than four times larger) and natural gas liquids (almost doubling). Crude oil production is instead expected to reach a plateau of around 69 mb/d and then decline to 67 mb/d (IEA, 2011).

Furthermore, these two views are divided on whether the decline in global oil production will be preceded by a peak or a plateau. The optimists generally think that before a peak the world will experience an “undulating” plateau. Such a multi-year rollover period followed by a multi-year roll-down periods would correlate with relatively moderate economic distress. The pessimists are divided between those who talk about a “pumping plateau” and those who expect a sharp decline after the peak. In fact, the depletion rate is extremely important for the prediction of the consequences of peak oil. While decline rates are generally expected to be in the 2-3% range, a relatively monotonic, terminal 3-5% annual rate of decline of world oil production would have devastating economic consequences (Hirsch, 2008).

Assuming that a peak is inevitable, it is difficult to tell which view is correct because of different methodologies, data, definitions and assumptions. There seems to be agreement, however, that the times of easy and cheap oil are over and that sooner or later the world will run out of oil. Yet peak oil may become irrelevant the moment the world engages in aggressive climate change policies.

Table A1.1: Examples of different views in the literature on peak oil

Author	Methodology	Peak Date
Alekett et al. (2010)	Bottom-up Analysis , based on the predicted production of all new wells/fields that have been announced subtracted by the expected depletion rates of the presently producing fields	Already happened in 2008
Koppelaar (2006)	Bottom-up Analysis	Before 2015 (Uncertain situation beyond 2010)
Laherrere (2003)	Fitting of a Bell Curve , adjusted to represent a total final production, expected to equal the ultimately recoverable reserves (URR)	Before 2020
UKERC (2009; p.199)		Likely before 2030 high risk before 2020
CERA (2009) ⁷⁷		Before 2030
EIA 2010	For projections before 2015 : Bottom up Analysis considering also country specific geopolitical situations; 2015 onward : based on the assessment of resource availability and the resulting economic viability of production.	Before 2035
Hallock et al. (2004)	Curve fitting model	Before 2037
IEA 2011	Bottom-up Analysis	After 2035

Source: De Almeida and Silva (2009), IEA (2011), EIA (2011), Alekett et al. (2010) and UKERC (2009)

⁷⁷ As quoted in Hirsch (2008)

Oil price variability

In the past year, oil prices have been exceptionally volatile, reaching a record high of USD145/barrel in July 2008 followed by a decrease to some USD30 in December of the same year (see EIA, 2011). More recently, prices have recovered in the aftermath of the financial crisis of 2008 and as a result of political instability in some producer countries to reach levels of over USD100 by spring 2012 (see Figure A1.10). However, the reasons for such swings in oil prices are very complex. In the short-term, the rigidity of demand and supply has been identified as the root cause (“bilateral price rigidity”) (see also Luciani, 2010).

On the supply side, only a very limited amount of the extracted oil is actually traded on the oil market. Similarly, demand for oil is highly inelastic to price changes, especially in the short-term. Production can simply not be modified quickly, as capacity increases tend to take place in large increments – typically for heavy industries where scale considerations are important. In fact, only some OPEC countries, notably Saudi Arabia and the other Arab Gulf producers make large-scale investments to create capacity and to be used for stand-by. This behaviour is integral to counteract the structural instability of prices (see CEPS Task Force on Energy Commodities, 2011).

On top of supply rigidities, demand is equally rigid as oil satisfies essential needs with considerable lead time (transport, heating with low price elasticity), taxation often isolates consumers from immediate impact, energy expenditure is often a small part of overall expenditure in OECD countries while often subsidised in developing countries, and demand is often influenced by macro trends such as income or weather. Given the high dependence on oil products, these fundamentals are unlikely to change and existing supply and demand will seriously react only if prices reach very high or very low levels.

However, the oil price is not just determined by trade in real (“wet”) oil barrels, but to a much larger and increasing extent by trade in future paper contracts and their multiple derivatives (i.e. “paper” barrels). The financial fundamentals of oil “go beyond the petroleum market alone and contribute to the operation of financial markets as a whole, where different types of assets, including oil, are constantly competing with each other” (Chevalier, 2010).

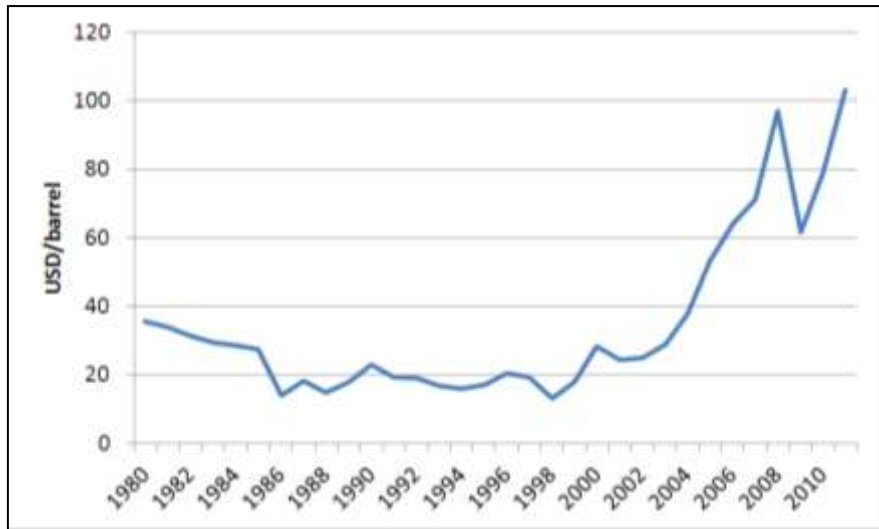


Figure A1.10: Crude Oil (petroleum), Simple average of three spot prices (APSP); Dated Brent, West Texas Intermediate, and the Dubai Fateh (1980-2011) (Source: IMF, World Economic Outlook Database, September 2011)

Whether the increase in price volatility is mainly caused by changes in the physical fundamentals (e.g. financial crisis of 2007/08, increasing demand from emerging economies, fears of peak oil, etc.) or by changes in the financial fundamentals (increase in “paper” trade and other recent market developments) is subject to discussion. However, Chevalier (2010) concludes that speculation has amplified the natural volatility of prices and that “it cannot be excluded that such movements occur again in the years to come” (Chevalier, 2010). Similarly, it is likely that the physical fundamentals (mainly relating to under-investment in new production capacities) will play an increasing role in price rises by the end of the decade, adding to increasing volatility. In fact, this is comparable to a vicious circle, because price volatility and unpredictability increases uncertainty about the expected future revenue stream of investors and thus disincentivises investments in production capacities. Lower investments, however, increase price volatility as production becomes less able to counterbalance changes in demand.

There are numerous ideas to address price volatility, including for example encouraging vertical integration of the industry, more long term pricing at downstream/retail level, oil storage capacity, offer of demand security through take or pay contracts, or an internationally agreed price collar. It is, however, unclear, what the impact of such changes on oil pricing would be (see CEPS Task Force on Energy Commodities, 2011).

Carbon Capture and Storage

Some of the projections presented in Chapter A1.2 are quite optimistic about the deployment of Carbon Capture and Storage (CCS), which is regarded as a technology for decarbonising, in particular, the use of coal and also of gas. The IEA (2011) still considers CCS to be the main tool for tackling climate change, together with increased energy efficiency and a higher share of low-carbon energy sources in the energy mix. In addition, it has been argued that CCS holds “the potential to function as an ‘energy bridge’ between the use of fossil fuels and a future renewable-based, largely carbon-free energy system” (Herold et al., 2010: 1). As a result, it is claimed that the large-scale deployment of CCS technologies reduces the urgency to phase out fossil fuels, particularly coal.

According to the IEA (2011c), CCS in industrial applications can reduce global CO₂ emissions by up to 4Gt annually by 2050, accounting for about 9% of the global reductions needed to halve energy-related CO₂ emissions by 2050. Achieving this will require 20% to 40% of all industrial and fuel transformation plants to be equipped with CCS by 2050.

The Global CCS Institute Survey (2010) identifies 80 currently active or planned large-scale, fully integrated projects worldwide, nine of which are currently in operation. These projects are located primarily in developed countries, with the majority in United States (32) and in the European Union (21). According to the IEA (2010b), the implementation of around 200 projects is needed before 2020, in order to mitigate GHGs emissions.

However, CCS technologies have not been proven on a commercial scale, and several factors, including investment and operation costs, efficiency losses and (publicly acceptable) storage potential raise doubts about the possibility and timing of its future deployment.

A key issue is costs. Both investment and operating costs are generally higher for CCS equipped plants than for standard plants, driving up the costs of electricity production. Cost differentials appear to be in the range of 30-70% for investment costs and 25-75% for operating costs. Current carbon prices, however, are insufficient to incentivise these investments (IEA, 2010). According to Hirschhausen et al. (2010) the carbon price needs to increase to some EUR55 by 2050 for CCS to be competitive with available technologies. Lower carbon prices will suffice only if costs of CCS can be reduced. The IPCC (2005), for example, expects cost of CCS to be reduced by 20-30% over the next decade. In addition, large upfront investments are required for building a network of CO₂ pipelines. Apart from regulatory issues regarding the transport of CO₂ there remains a high level of uncertainty about the size and configuration of the transport network, which results from uncertainty

about future policies and the suitability of geological formations to store the captured CO₂ (Hirschhausen et al., 2010).

Another issue is the reduced energy efficiency of CCS equipped plants. According to the IPCC (2005) a power plant equipped with CCS would need roughly 10-40% more energy than a plant of equivalent output without CCS. The deployment of currently available capture technologies will thus reduce energy efficiency. Hirschhausen et al. (2010) estimate a maximum loss of 25% of thermal efficiency for post-combustion and a minimum of 8-10% efficiency reduction for oxyfuel combustion, whilst the IEA (2011b) presents even higher figures (e.g. up to 23% for oxyfuel combustion and 20% for pre-combustion).

Finally, and maybe most importantly, the EU CO₂ storage potential seems to be less than previously expected and corresponding estimates have been revised downwards (Gerling et al., 2010 and Höller, 2010). Even those sites that are still under consideration for storage (mainly saline aquifers, coal seams and fossil fuel reservoirs) are prone to leakage to a varying extent (ranging from no leakage to very high rates of leakage). Another drawback to large-scale storage is public opposition to on-shore storage, which can further reduce storage potentials with negative impacts on transport and storage costs (Hirschhausen et al., 2010).

All these factors put the feasibility of a large-scale roll-out of CCS technologies into question and raise the uncertainty about the future of coal as the most carbon intensive fossil fuel in the global energy mix. It is thus much more likely that the increasing share of coal in the global energy mix will be challenged by climate change concerns rather than be resource scarcity, if CCS will not be deployed (on time).

Energy Return on Investment

Energy Return on Investment (EROI) is defined as “the ratio of how much energy is gained from an energy production process compared to how much of that energy (or its equivalent from other sources) is required to extract, grow, etc. a new unit of the energy in question” (Murphy&Hall, 2010: 102). More precisely, Gupta&Hall (2011: 1797) define it as

$$\text{EROI} = \frac{\text{Energy returned to society}}{\text{Energy required to get that energy}}$$

It follows that as the ratio approaches 1:1 the production of the respective fuel is no longer useful to society.

Although the scientific basis on past and future developments of EROI is still rather weak, there seems to be evidence for a historical trend of declining average EROIs of fossil



fuels. Data from the US suggests that the EROI of oil and gas production declined steadily since 1930, when it was about 100:1, to around 30:1 in the 1950s and 20:1 in the 1970s. In the mid 2000s it was in the range of 11-18:1 (Cleveland C.J., 2005) (see Figure A1.11).

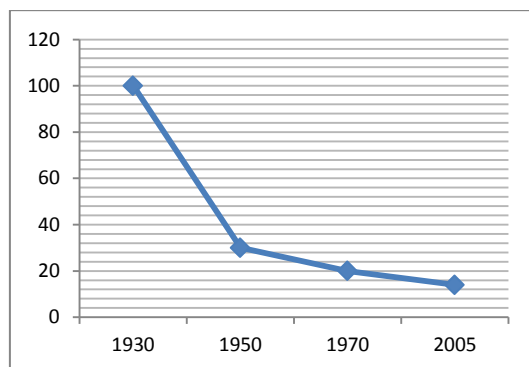


Figure A1.11: Historical Trend of EROI of Oil and Gas Production in the US (US Data from different sources, as presented by Cleveland C.J., 2005)

Average global EROIs still suggest better energy returns, not least due to the fact that US production has already achieved a high grade of maturity. The global EROI of oil and gas production, for example, increased from approximately 26:1 in 1992 to 35:1 in 1999 and declined thereafter to 18:1 by 2006⁷⁸ (Gagnon et al., 2009).

⁷⁸ Gagnon et al. (2009) expect the EROI of oil to be somewhat lower than the aggregate figure, and that of conventional natural gas to be higher.

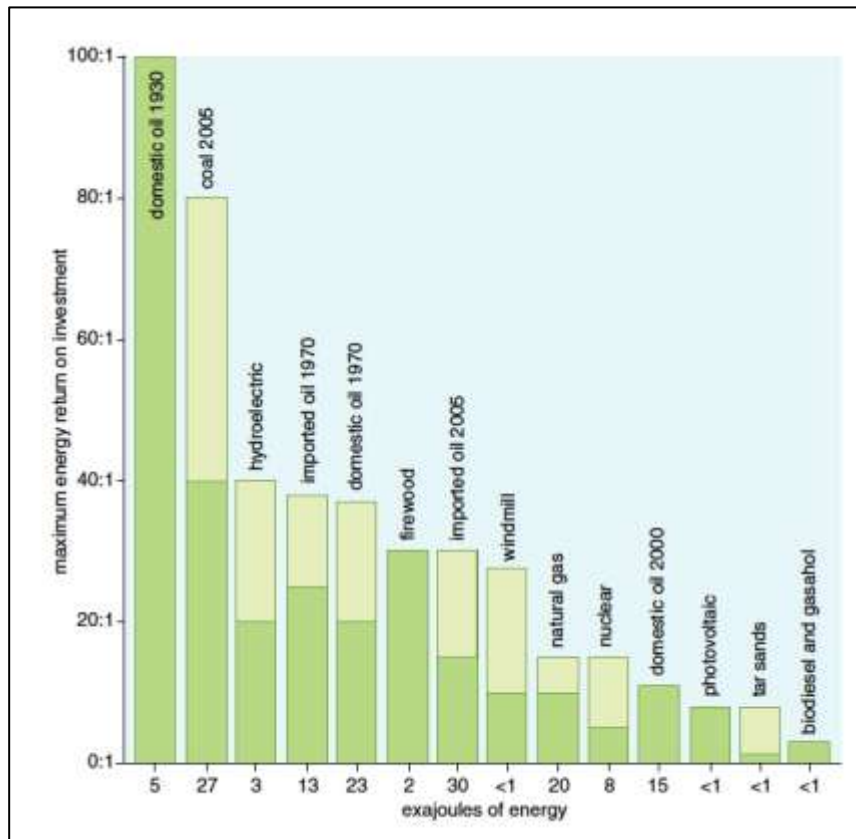


Figure A1.12: EROIs of different US energy sources (Source: Hall and Day 2009) Note: Data for the US; lighter colour indicates range of EROI depending on conditions

A comparison of current EROIs of different (US) energy sources (see Figure A1.12) reveals that there is still a large energy surplus from fossil fuels.

With a ratio of 80:1, coal is the fossil fuel with the highest return (Murphy&Hall, 2010). As noted above, the EROI of domestic US oil has dramatically declined and is now at about 18:1 (Hall et al., 2009b). Except for Hydropower, all other RES have low EROIs ranging between <1-18:1. RES with high EROIs include hydropower (>100:1), wind (18:1) and wave/tidal (15:1). Photovoltaic (PV), nuclear and biofuels, on the other hand, are characterised by low average EROIs. It is also interesting to note that the unconventional oil sources (e.g. bitumen from tar sands, oil shale, ethanol, biodiesel etc.) all have very low EROIs (biodiesel 2:1, ethanol 1.2-1.4:1, shale oil close to 1:1), which means that as the world increasingly resorts to unconventional sources in the future, it will require more energy to maintain production levels.

Predictions about future developments of EROIs are difficult, and depend amongst others on discoveries of new resources as well as on the development of production

technologies. However, most major fuels, including especially liquid fuels, will most likely experience declining EROIs resulting from an intensification of production efforts as more unconventional and remote sources are tapped (Hall et al., 2009b).

Limitations to biomass expansion

Increasing the share of biomass and in particular biofuels raises several sustainability concerns.

Land attributed to the cultivation of fuel crops displaces the cultures of food crops, with possible negative effects on staple food prices, causing social unrest such as the 2007 ‘tortilla rallies’ in Mexico in protest against the rising prices of corn (BBC, 2007). According to a working paper published by the World Bank (Mitchell, 2008), three quarters of the 140% price increase in food prices from January 2002 to February 2008 were caused by the expansion of biofuels cultivation and indirect impacts thereof. Between 2000 and 2009, for example, the global output of bioethanol quadrupled and production of biodiesel increased tenfold – a trend which was largely driven, at least in OECD countries, by government support policies (FAO et al., 2011). The 2011 inter-agency (FAO, IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF) report to the G20 states that:

„During the 2007-2009 period biofuels accounted for a significant share of global use of several crops – 20% for sugar cane, 9% for vegetable oil and coarse grains and 4% for sugar beet. Projections encompass a broad range of possible effects but all suggest that biofuel production will exert considerable upward pressure on prices in the future. For example, according to one study international prices for wheat, coarse grains, oilseeds and vegetable oil could be increased by 8%, 13%, 7% and 35% respectively. Moreover, as long as governments impose mandates (obligations to blend fixed proportions of biofuels with fossil fuels, or binding targets for shares of biofuels in energy use), biofuel production will aggravate the price inelasticity of demand that contributes to volatility in agricultural prices.“

In addition, the report highlights the increased correlation of agricultural commodity prices with oil prices, partly due, amongst other factors, to higher demand for the crops (sugar, maize and vegetable oils) used in biofuels production. As a result high and volatile oil prices could further contribute to higher and more volatile agricultural prices.

The lifecycle of biofuels production also needs to be taken into account, not only in terms of the resources needed for their cultivation (such as fuel for agricultural machinery), but also in terms of environmental pressure on land and water. Increasing biofuels production may decrease freshwater availability for alternative uses. Similarly, land use changes associated with increasing production may speed up the destruction of natural habitats and lead to large amounts of carbon actually being released from sinks (natural areas that absorb and store CO₂), depending on what land is substituted (Behrens, 2008). Studies on CO₂ emissions linked to biofuels production range from cautious to negative. According to a study from the University of Minnesota, converting rainforests, peatlands, savannas or grassland to produce crops for fuel could release annually 17 to 420 times more CO₂ than the GHG reductions obtained by replacing fossil fuels by these biofuels (Fargione et al., 2008). However, biofuels made from waste biomass or from biomass grown on degraded or abandoned agricultural land would not cause carbon release from sinks, and would result in sustainable GHG reductions (Fargione et al., 2008).

The UNEP International Resource Panel report on biofuels in the agricultural sector (2009) analyses the potential GHG emissions from different crops, showing large variations depending on farming practices and location. For some of the most common sources of biofuels, such as maize and palm oil, there is a risk of a negative CO₂ emissions balance. Other sources of biofuels show potential for CO₂ emissions reductions, such as wood and forestry residues and sugar cane. Despite positive evaluations for some crops, the report globally pictures rather negative impacts on the general environment (e.g. water resources, desertification, deforestation, etc.).

However, pressures on agricultural land, food prices and the environment should decrease with the eventual entry in the market of second generation, non-crop based biofuels. According to the OECD-FAO Agricultural Outlook 2011-2020, this is not expected to happen before 2020. In the medium term, agricultural biofuel and food crops will continue to compete for resources, with the above-mentioned impacts on food market prices. The projections for crop biofuels show rising production in all markets, partly driven by fossil fuel prices, but also by subsidies and regulations. The EU's Renewable Energy Directive is one of the driving forces of Europe's biofuel demand, domestic production increases and rising imports. The renewable energy directive stipulates a fuel mix from renewables of at least 10% by 2020, and while this is not necessarily meant to be by the means of food crop-derived biofuels, the absence of viable alternatives will likely cause the increasing use of

crop-based biodiesel and bioethanol. In Europe demand for biodiesel-like products is expected to increase by 70% until 2020, compared to the 2008-2010 period. Most of the increase will be covered by domestic production. The US shows a more modest increase in ethanol production, but a more rapidly increasing demand, thus rising imports (OECD-FAO, 2011).

By 2020 the OECD-FAO report considers that biofuels will continue to represent an important share of global cereal, sugar crops and vegetable oil global production: 12% of coarse grains, 16% vegetable oil and 33% sugar. These represent close to a 50% increases in each case compared to the 2008-2010 period.

In light of the above considerations, there are limits to the share that biofuels can have in the future energy mix. The IEA 450 Scenario (see Chapter A1.2) shows a share of biomass in global energy demand reaching 16% in 2035, with the share of biofuels in transport increasing to 13% (the current figure being lower than 2%). These considerable increases cannot be sustainably supported by today's agricultural crop-based first generation biofuels, and would only be achievable by the means of a major technological breakthrough for second generation, non-crop based biofuels that do not compete for agricultural land. Similarly, reducing currently existing inefficiencies in global food markets, e.g. by reducing the amount of food going to waste in OECD countries and emerging economies, can play a significant role in allowing for a higher penetration of biomass in the global energy mix.

In contrast, the IEA New Policies Scenario is less demanding and includes a more modest and more achievable contribution from the biofuels sector, representing approximately half the increase required by the 450 Scenario. The OECD-FAO (2011) already predicts a 50% increase in first generation biofuels from agricultural crops by 2020, together with the expansion of the production of biogas from organic waste. This, in combination with second generation biofuels progress, may allow the 2035 projection to be reached. It is important to note that the more sustainable second generation biofuels, and in particular the non-crop varieties, must have entered the market by 2020 and need to spread rapidly in order to avoid severe negative side-effects in terms of challenges to food security and aggravated biodiversity loss.

A1.4 Key assumptions

This chapter shows that the global energy system will undergo considerable changes in the coming decades as emerging economies drive demand growth and as the share of low-carbon technologies increases in the global energy mix. Many factors are responsible for increasing global energy demand, with population increase and economic growth being the key drivers. The scenarios analysed in this paper indicate a shift away from fossil fuels, which increases with the ambitiousness of global GHG emissions mitigation efforts. However, only those scenarios that reflect the most ambitious climate policies aimed at limiting global warming to 2 degrees Celsius above pre-industrial levels, show signs of a socio-ecological transition away from fossil fuels of the scale required to halt and potentially reverse ongoing ecosystem degradation. But even some of those scenarios must be handled with care as they often rely on high shares of nuclear, CCS or biomass, all of which have drawbacks in terms of their potential contribution greening the global economy.

In addition, there are concerns about the availability of (exhaustible) fossil fuels, foremost in terms of oil. Rising oil prices and increasing oil price volatility are likely to result from increasingly inelastic production patterns.

It is clear that different scenarios project different futures for the global energy sector, depending on the assumptions, targets and interests they are based on. This variety of outlooks allows for a differentiation of possible futures into an aggregated “friendly” scenario, i.e. one where only moderate challenges for EU policy making can be expected, and in an aggregated “tough” scenario, i.e. one where severe changes are expected with substantial impacts on Europe. Table A1.2 summarises the possible pathways both for the 2025 and the 2050 time horizons. The assumptions are based on the analysis in Chapters A1.2 and A1.3, partly complemented by the expert knowledge of the authors.

Table A1.2: Suggested assumptions for “friendly” and “tough” scenarios based on results of Chapter A1.2 and A1.3

	friendly	tough
2025	Energy demand roughly at today's levels (see EREC/Greenpeace Energy [R]evolution Scenarios)	Energy demand increases by up to 40% (see EIA High Oil Price Case)
	Share of fossil fuels drops to 70% (estimation based on IEA 450 Scenario)	Share of fossil fuels remains at 80% (see IEA New Policies Scenario, EIA scenarios and industry scenarios)
	Oil supply can keep up with demand due to new discoveries of conventional and unconventional oil, increased recovery rates	Oil shortages due to peak oil (in 2008 or even earlier) and delayed investment in new production (see Alekett et al., 2010)
	EROI of global oil and gas production decreases to 20:1 (see Gagnon et al., 2009)	EROI of global oil and gas production decreases to 10:1 (see Gagnon et al., 2009)
	Oil price at around USD100 (see IEA 450 Scenario)	Oil price approaching USD200 (see EIA High Oil Price Case)
	Reduction of oil price volatility due to improved price finding mechanisms and management of stocks	Oil price volatility remains high and negatively affects investment and economic activity
	Share of coal (hard coal and lignite) in global primary energy demand decreases to about 18% due to carbon constraints (see EREC/Greenpeace Advanced Energy [R]evolution Scenario)	Substantial growth in cheap and widely available coal (up to 30%) (see Shell Scramble Scenario)
	CCS deployment starting after 2020 (see IEA 450 Scenario), but very limited in scale	CCS still in demonstration phase
	Share of biomass in global primary energy demand increases to about 15% (representing an absolute increase of over 50% from today's levels) (see EREC/Greenpeace Advanced Energy [R]evolution Scenario).	Over 30% growth in biomass production (incl. waste), but constant share in global energy mix at 10% (IEA New Policies Scenario)
	Nuclear energy stagnating. Phase-out by Germany and other industrialised countries is only partly offset by new built plants in China and other emerging economies. Decreasing share in global electricity production.	Early phase-out of nuclear reactors in Europe and limited expansion in emerging economies leads to a drastic reduction of global nuclear generation capacity.
	CO ₂ price of around USD70 (estimation based on IEA 450 Scenario)	No or low CO ₂ price of USD35

	friendly	tough
2050	Energy demand declines by 5-10% (<i>see EREC/Greenpeace Energy [R]evolution Scenarios</i>)	Energy demand increases by 80% or more (<i>estimation based on EIA High Oil Price Case</i>)
	Share of fossils below 40% (<i>see EREC/Greenpeace Energy [R]evolution Scenarios</i>)	Share of fossil fuels stable after decreases to about 60% (<i>see POLES Europe Alone Scenario, both Shell scenarios</i>)
	Peak-oil before 2037 (<i>see Hallock et al., 2004</i>), but most likely irrelevant due to peak-demand	Oil production declining since 2008 (<i>see Alekett et al., 2010</i>)
	EROI of global oil and gas production further decreases compared the 2025 friendly (<i>see Gagnon et al., 2009</i>)	EROI of global oil and gas production further decreases compared the 2025 tough scenario (<i>see Gagnon et al., 2009</i>)
	Prices drop to below USD50 (<i>see EIA Low Oil Price Case</i>)	Oil price highly volatile and rising to over USD200 (<i>estimation based on EIA High Oil Price Case</i>)
	Volatility less relevant at low oil prices and possibly reduced further by policy measures	Depending on production decline after peak (worst case: 3-5% annually) much higher prices expected
	CCS deployment successfully phased-in after 2020, over 40% of global emissions sequestered by 2050 (<i>see POLES Global Regime Scenario</i>)	CCS technology efforts discontinued after demonstration proved unsuccessful
	Second generation biofuels allows for high share of biomass in global energy mix (22% according to <i>POLES Global Regime Scenario</i>)	Limited expansion of biomass production possible due to strong competition with food production
	Due to continued government support, global nuclear capacity remains roughly constant at 2025 levels, but total share in electricity production continues to decrease. Growing potentials for fusion reactors	Nuclear energy largely phased out, some remaining old plants with extended lifetimes still produce limited amounts of electricity
	Carbon price increases to up to EUR400/t CO ₂ in Annex I countries (<i>see POLES Global Regime Scenario</i>)	Shadow global CO ₂ price at EUR30/tCO ₂ (<i>see POLES Europe Alone Scenario</i>)

The two sets of scenarios follow a simple logic. Representing two different levels of global change, i.e. a favourable “friendly” case and a more challenging “tough” case, they only take those assumptions into account that fit into each of these cases. It is very important to note, that since these assumptions originate from a wide range of different scenarios they are not necessarily compatible with each other. Instead, they allow for a general view of how the world could look like if global developments lead to a “friendly” energy future or a “tough” one.

The “friendly” scenario describes a hypothetical world where resource consumption initially increases slightly and decreases as energy efficiency measures take effect on a large scale. Resource availability is no issue, first because peak oil is only expected towards the middle of the century, and second because demand for energy decreases and thus reduces pressure on fossil fuels extraction. This also reduces pressure on the oil price, which is considerable lower than in the “tough” scenario. In principle, the “friendly” scenario describes a world with global cooperation and joint targets, in which a broad range of technologies are employed to achieve ambitious GHG emissions reduction targets.

The “tough” scenario, on the other hand, is characterised by increasing demand for fossil fuels under limited supply conditions. This pushes the oil price upward, while enhancing oil price volatility. Technologies such as second-generation biofuels or CCS are either introduced very late in the future or fail altogether and are thus abandoned. This is clearly a world that does not reach a consensus on climate change policies and thus fails to reduce global warming to acceptable levels.

These assumptions can only serve as simplified guidelines due to the fact that the scenarios presented in Chapter A1.2 are much more complex, report on different variables and for different time horizons. However, they allow for setting two diverging hypothetical global frameworks the EU might be faced with.

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A2. Rising challenges to resource security

- For the EU several raw materials are considered critical since they possess both high economic importance and high supply risks
- Some of these critical raw materials, which are not produced within the EU, are metals essential for high technology and “green” applications (future sustainable technologies, “green” technologies).
- In the case of rare earths and phosphorus the situation is further tightened by a high level of concentration of the production in a few countries (special role of China and Morocco).
- While global demand for many metals is increasing rapidly, ore grades are declining in major mining countries. This leads to a shift from ‘easier and cheaper’ to more ‘complex and expensive’ processing.
- Phosphorus, critical for future food security, is expected to peak in the coming decades. The EU is a net importer of phosphorus in feed, feed stock and fertilizer. Western Europe is totally dependent on imports.
- Food security, in the light of steadily increasing global demand, is a major concern. This is due to land and water limitations, significant yield gaps, diet changes in emerging economies and rising competition with biofuels, all leading to increased prices and price volatility.
- Peak oil will directly affect the mineral industry.
- Intensified global competition for resources will lead to price increases and could contribute to price shocks (and armed conflicts over resources in the worst case).

A2.1 Introduction

In the light of growing global demand for raw materials the question of the security of supply is a challenge for Europe. High levels of consumption in Europe depend on raw material imports, which are increasingly under pressure as emerging economies aim at reserving their resource base for their exclusive use. In some cases, the situation is further compounded by a high level of concentration of the production in a few countries (European Commission, 2011). For many metals the global demand is increasing rapidly while declining ore grades are observed in the major mining countries. Furthermore new challenges are emerging in the field of the so-called critical raw materials or critical metals.

Those raw materials for which a threat to supply from abroad could involve harm to the national economy are defined as “critical raw materials” (European Commission, 2010). The

term refers to economic importance, import dependence, projected increasing demand, low substitutability, and recycling restrictions of respective raw materials (Buchert et al., 2009).⁷⁹ In many cases the discussions are linked with innovations and new technologies, often in the field of green technologies (e.g. electric vehicles, wind power etc.) (Schüler et al., 2011). Metals which are important for future sustainable technologies (eg. renewable energies, energy efficient technologies and cleaner technology innovation) and high technology are also classified as “green minor metals”, “high tech materials”, “speciality metals” or rare metals (Schüler et al., 2011).

Phosphorus (phosphate rock), a non-renewable resource, is expected to peak in the coming decades, which has not been widely recognized so far. However, security of phosphorus supply will play an essential role in feeding an increasing world population. As phosphorus will be critical for future food security, the Global Phosphorus Research Initiative (GPRI) recommends adding it to the list of 14 critical materials identified for the EU.⁸⁰

This chapter discusses non-energy minerals and metals which are considered as critical according to the definition above. Issues of global food security are also discussed. After the description of the selected key literature, it provides an overview on those materials, which are considered critical for the EU within the next decade and highlight the criticality of rare earths and the underestimated emerging supply shortages of phosphorus in more detail.

A2.2 Key literature

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

The report stems from the ad hoc Working Group on defining critical raw materials, a subgroup of the Raw Materials Supply Group, which was chaired by the Commission services and pursued within the framework of the EU Raw Materials Initiative. Major contributions were provided by Fraunhofer ISI and Bio Intelligence BIOIS. The aim of the report was to

⁷⁹ In some studies the term “strategic⁷⁹” is used instead of “critical”. The term refers to the importance of these materials for military use (European Commission, 2010, U.S. Geological Survey, 2002)).

⁸⁰ GPRI 2010

identify a list of critical raw materials at EU level⁸¹. Therefore the economic importance and supply risk for 41 minerals and metals were analyzed.

The methodology is based on a concept of relative criticality: Raw materials are considered critical if “the risks of supply shortage and their impacts on the economy are higher compared with most of the other raw materials” (p.5). To assess the specific supply risk the political-economic stability of the producing countries, the level of concentration of production, the potential for substitution, the recycling rate; and the so called environmental country risk were analysed. The latter refers to “the risks that measures might be taken by countries with weak environmental performance in order to protect the environment and, in doing so, endanger the supply of raw materials to the EU” (p. 5). The considered time horizon of the study was only 10 years, thus geological scarcity was not an issue for the definition of criticality. For methodological details refer to the annexes of the report.

The result of the analysis is a short list of 14 materials (including two material groups) which are regarded critical due to their high relative economic importance and high relative supply risk. The latter is mainly due to the fact that a high share of the worldwide production comes from only a few countries. This production concentration, in many cases, is compounded by low substitutability and low recycling rates⁸². (European Commission, 2010: summary p.5-10)

Critical Metals for Future Sustainable Technologies and their Recycling Potential (Buchert et al., 2009)

The study, commissioned by the United Nations Environment Programme, Division of Technology, Industry and Economics (UNEP DTIE) and United Nations University, was pursued by the Institute for Applied Ecology, Germany (Öko-Institut e.V.) and received the support of the European Commission, Directorate-General for the Environment. It is in line with UNEP's mission and vision on resource efficiency and sustainable consumption and production, which is one priority of UNEP's mid-term strategy. The results of this study were fed into the work of the International Resource Panel, the preparation of the 10-year framework of programs on SCP (Marrakech Process), and into the 2010/2011 cycle of the Commission on Sustainable Development. Thus the study finally contributes to the ultimate

⁸¹ For the criticality of materials at the level of European Member States (Austria, France, Germany and the UK) see the assessments which are referred to in Annex 8 of the Communication on the Raw Materials Initiative (European Commission, 2011)

⁸² The 'environmental country risk' metric did not have any influence on these results.

goal of stimulating sustainable innovation leading to decoupling of economic growth from environmental degradation (Buchert et al. 2009, p. I).

The focus of the study lies on 11 green minor metals (10 critical metals and 1 metal group (REE) which are crucial for cleaner technology innovation. This stands within the context of exploring future sustainable technologies (renewable energies and energy efficient technologies), which will make use of these metals (indium (In), germanium (Ge), tantalum (Ta), PGM [platinum group metals: ruthenium (Ru), platinum (Pt) and palladium (Pd)], and rare earth elements (REE). Other important metals, like titanium or magnesium (used for light weight applications) are not addressed here. The authors point out that this should be an issue for further research. The study aims at analysing in depth the global availability and expectations for the development of the metals under consideration (demand, supply and prices) as well as at exploring favourable framework conditions, proposed course of actions, policies, instruments, models etc. to predict and monitor the availability of critical metals and recycling systems. The approach focuses on a comprehensive analysis of the recycling potential of the selected metals and identification of gaps. (Buchert et al. 2009, p.I)

Methodological approach: the metals under investigation are classified according to the main topics of demand growth, supply risks as well as recycling restrictions. The different metals under investigation are prioritized according to defined (sub-)criteria⁸³. The results from the prioritization in terms of criticality are assessed according to three timelines: as critical in a short-term perspective (next 5 years), in a mid-term perspective (2020) or a long-term perspective (2050). Furthermore four major application clusters for the metals under consideration are identified: I. EEE Technologies, II. Photovoltaic Technologies, III. Battery Technologies and IV. Catalysts. For further details on the methodology see p.4ff. (Buchert et al., 2009: summary, p. I-VIII)

⁸³ Applied (sub)-criteria of the main topics:
 Demand growth: Rapid demand growth: > 50% increase of total demand until 2020, moderate demand growth > 20% increase of total demand until 2020; (compared to 2007).
 Supply risks: Regional concentration of mining (> 90% share of the global mining in the major three countries). Physical scarcity (reserves compared to annual demand). Temporary scarcity (time lag between production and demand). Structural or technical scarcity (metal is just a minor product in a coupled production and inefficiencies occur in the mining process, production and manufacturing).
 Recycling restrictions: High scale of dissipative applications. Physical/chemical limitations for recycling. Lack of suitable recycling technologies and/or recycling infrastructures and lack of price incentives for recycling.

The story of phosphorus: Global food security and food for thought (Cordell et al., 2009)

The paper was published in “Global Environmental Change”. It gives insights on historical trends, the current situation as well as on future projections and future options in the context of phosphorus scarcity and food production. It refers to the relevant literature in the field.

Abstract:

“Food production requires application of fertilizers containing phosphorus, nitrogen and potassium on agricultural fields in order to sustain crop yields. However modern agriculture is dependent on phosphorus derived from phosphate rock, which is a non-renewable resource and current global reserves may be depleted in 50–100 years. While phosphorus demand is projected to increase, the expected global peak in phosphorus production is predicted to occur around 2030. The exact timing of peak phosphorus production might be disputed, however it is widely acknowledged within the fertilizer industry that the quality of remaining phosphate rock is decreasing and production costs are increasing. Yet future access to phosphorus receives little or no international attention. This paper puts forward the case for including long-term phosphorus scarcity on the priority agenda for global food security. Opportunities for recovering phosphorus and reducing demand are also addressed together with institutional challenges.” (Cordell et al., 2009)

Phosphorus demand for the 1970–2100 period: A scenario analysis of resource depletion (van Vuuren et al., 2010)

Abstract:

“The phosphorus (P) cycle has been significantly altered by human activities. For this paper, we explored the sustainability of current P flows in terms of resource depletion and the ultimate fate of these flows. The analysis shows that rapid depletion of extractable phosphate rock is not very likely, in the near term. Under best estimates, depletion would be around 20–35%. In worst case scenarios, about 40–60% of the current resource base would be extracted by 2100. At the same time, production will concentrate in Asia, Africa and West Asia, and production costs will likely have increased. As there are no substitutes for phosphorus plant nutrients in agriculture, arguably even partial depletion of P resources may in the long run be relevant for the sustainability of agriculture. Consumption trends lead to large flows of phosphorus to surface water and a considerable build-up of phosphorus in agricultural soils in arable lands. This may allow a reduction in future P

fertiliser application rates in crop production. Results also indicate a global depletion of P pools in soils under grassland, which may be a threat to ruminant production.” (van Vuuren et al., 2010)

A2.3 Key issues

A2.3.1 Declining ore grades - declining quality

The global demand for many metals is increasing rapidly and most forecasts predict further growth (see chapter 2). At the same time declining ore grades in the major producing countries are observed. This indicates a shift from ‘easier and cheaper’ to more ‘complex and expensive’ processing – in social, environmental as well as economic terms. Furthermore, declining resource quality has led to declining productivity and the energy intensity of processing has subsequently risen – in the case of Australia’s production by 50% over the last decade. Consequently peak oil will directly affect the mineral industry (Giurco et al., 2010).

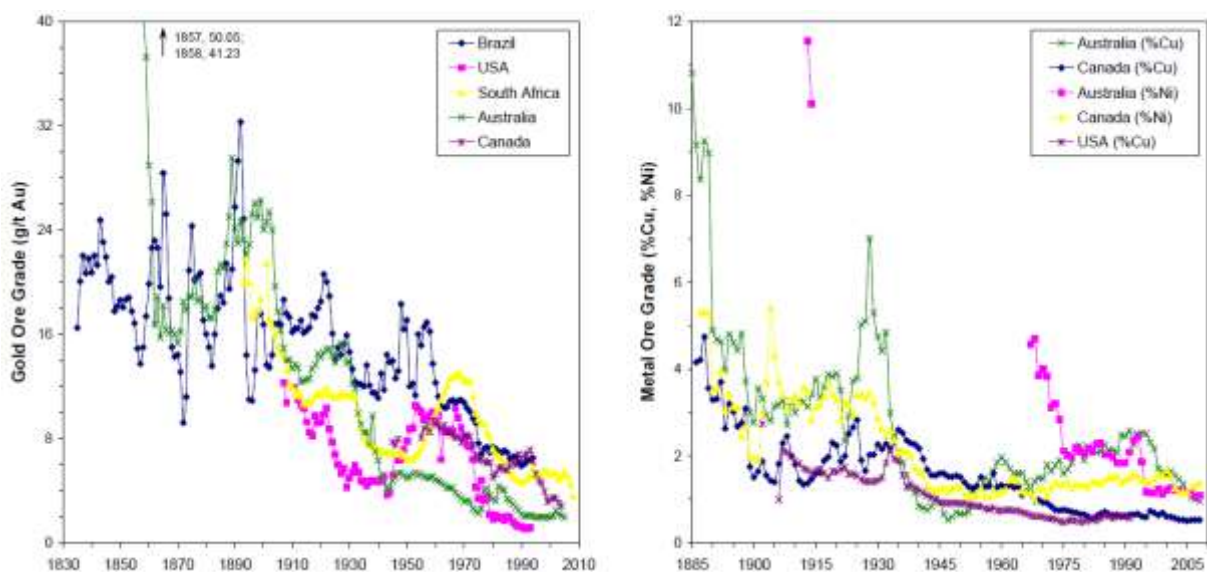


Figure A2.1: Declining ore grades in the major producing countries (Source: Giurco et al, 2010, p.28: based on Mudd 2010, 2009, 2007)

Similar as it is the case with peak oil, declining ore grades imply declining quality, which refers to the concentration of a particular metal or metals being mined, as well as the quality of the ore with respect to processing. As ore grades and/or quality decline, the energy requirements and pollution burdens increase substantially. Figure A2.1 shows historical

long-term trends of respective metals using the examples gold (left figure), copper and nickel ore grades (right figure) in Australia, Canada and the US (Giurco et al., 2010:p. 28).

A2.3.2 Critical raw materials for the EU

The EC commissioned the analysis of 41 materials (including 2 material groups) regarding criticality for Europe. Three sub-clusters of materials according to supply risk and economic importance were identified. Those raw materials falling within the sub-cluster which is characterized by high supply risk and significant economic importance are considered to be critical (see figure A2.2).⁸⁴ It comprises 14 raw materials, including the material groups Platinum Group Metals (PGM) and rare earths (or rare earth elements REE): see table A2.1.

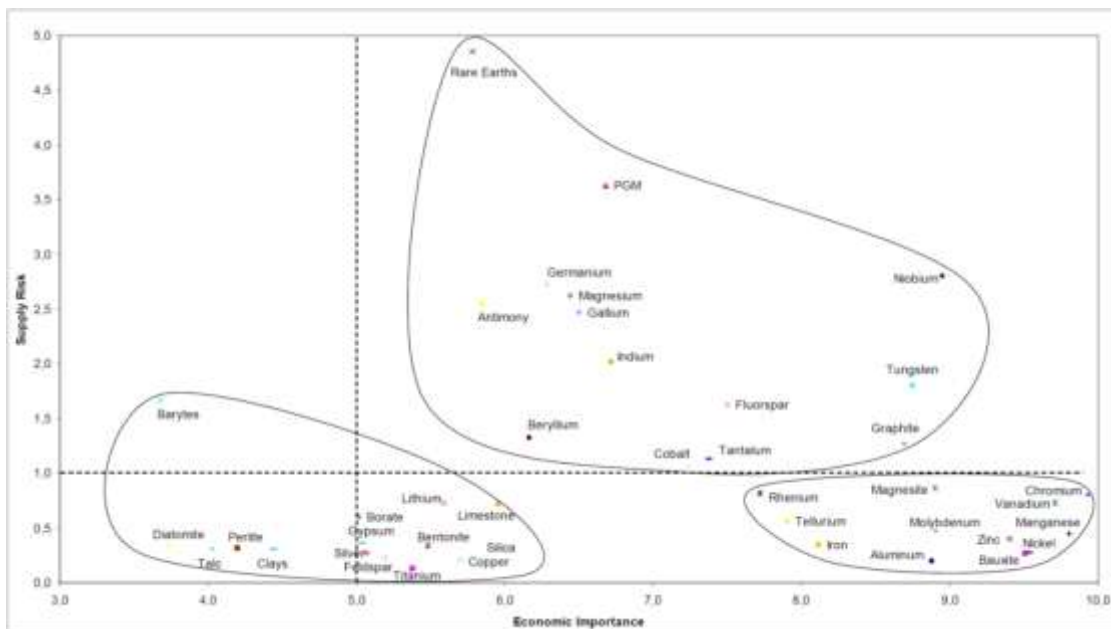


Figure A2.2: Sub-clusters of materials according to supply risk and economic importance

14 raw materials falling within the top right cluster are considered as critical for the EU due to high relative economic importance and high relative supply risk.

Source: (European Commission, 2010:p.34)

⁸⁴ The 'environmental country risk' metric (see the section: key literature) did not have any influence in these results. According to this assessment, rare earths were ranked as the raw materials with the highest environmental country risk among all 41 raw materials.

List of critical raw materials at EU level (in alphabetical order):

Antimony	Indium
Beryllium	Magnesium
Cobalt	Niobium
Fluorspar	PGMs (Platinum Group Metals) ¹
Gallium	Rare earths ²
Germanium	Tantalum
Graphite	Tungsten

¹ The Platinum Group Metals (PGMs) regroup platinum, palladium, iridium, rhodium, ruthenium and osmium.

² Rare earths include yttrium, scandium, and the so-called lanthanides (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium)

Table A2.1: List of critical raw materials at EU level (Source: European Commission 2010, 6)

High supply risk

The high supply risk of these materials is mainly due to the fact that they are allocated unevenly (see figure A2.3). A high share of the worldwide production comes from China⁸⁵, Russia⁸⁶ the Democratic Republic of Congo ⁸⁷ and Brazil⁸⁸. This production concentration is often compounded by low substitutability and low recycling rates (European Commission, 2010).

⁸⁵ antimony, fluorspar, gallium, germanium, graphite, indium, magnesium, rare earths, tungsten

⁸⁶ PGMs

⁸⁷ cobalt, tantalum

⁸⁸ niobium and tantalum

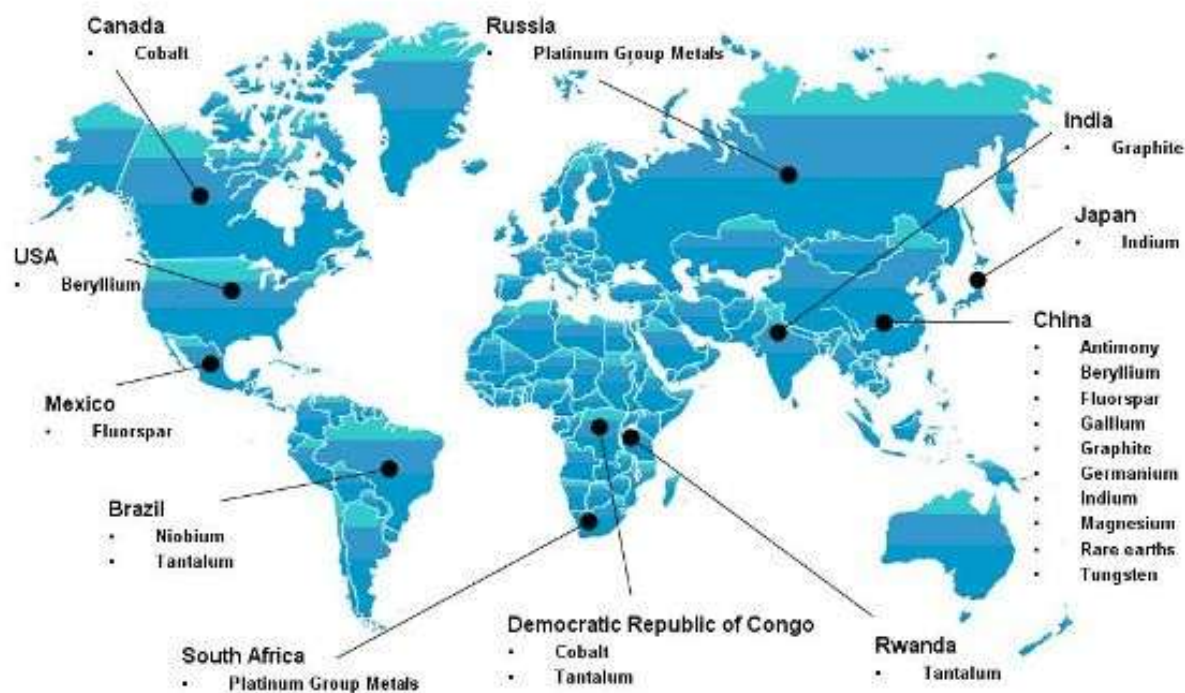


Figure A2.3: Production concentration of the 'critical' raw materials by source country (Source: http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm (accessed 4.11.2011))

The EU still has valuable deposits and much under-explored and unexplored geological potential. But these opportunities for securing material supplies (exploration and extraction) are limited, due to increasing land use competition. Furthermore it takes years between the discovery of deposits and the start of actual production (European Commission, 2010: p.12).

Economic importance - Importance for new and green technologies

“One of the most powerful forces influencing the economic importance of raw materials in the future is technological change. In many cases, their rapid diffusion can drastically increase the demand for certain raw materials” (European Commission, 2010). Thus, emerging technologies⁸⁹ will play a key role in forcing future raw materials demand and consequently will determine criticality and economic importance of specific raw materials. The demand is expected to evolve rapidly sometimes by 2030.

⁸⁹ Emerging technologies include ICT, traffic engineering, environmental technologies, medical engineering, and materials technologies (European Commission, 2010).

According to a study commissioned by the German Federal Ministry of Economics and Technology the share of global demand for raw materials from emerging technologies in 2030 will increase. The indicators range between 0.24 (compared to 0.09 for copper) and 3.97 (compared to 0.18 for gallium) (European Commission, 2010 cf. BGR 2010)⁹⁰.

The study, “Critical Metals for Future Sustainable Technologies and their Recycling Potential”, focuses on future sustainable technology⁹¹ which will make use of so called “green minor metals” on a global level (Buchert et al., 2009). 11 metals are identified as critical for future sustainable technologies and calculated according to the criteria demand growth, supply risks and recycling restrictions: **These metals comprise: indium (In), germanium (Ge), tantalum (Ta), PGM [platinum group metals, such as ruthenium (Ru), platinum (Pt) and palladium (Pd)], tellurium (Te), cobalt (Co), lithium (Li), gallium (Ga) and rare earths.**⁹² Except of lithium and tellurium the green minor metals are all regarded critical for the EU as described above. The results of the prioritization are assessed according to three different timelines. Based on these estimations the metals tellurium, indium and gallium are regarded most critical within the near future due to rapid demand growth and serious supply risk. Most of the metals (e.g. rare earths) are regarded to become critical by 2020 (see table A2.2).

⁹⁰ The global demand for raw materials from emerging technologies has been analysed in 2006 and projections for 2030 related to today’s total world production of the specific raw material: “The indicator measures the share of the demand resulting from driving emerging technologies in total today's demand of each raw material in 2006 and 2030.” (p: 7)

⁹¹ The term sustainable technologies refers to “an assumption of technologies, their use implicates positive environmental effects” (Buchert et al., 2009)

⁹² Other metals like titanium or magnesium (used for light weight applications) are not addressed by this study.

timeline	Metal
short-term (within next 5 years) + rapid demand growth + serious supply risks + moderate recycling restrictions	Tellurium Indium Gallium
mid-term (till 2020) + rapid demand growth and + serious recycling restrictions or: + moderate supply risks + moderate recycling restrictions	Rare earths Lithium Tantalum Palladium Platinum Ruthenium
long-term (till 2050) + moderate demand growth + moderate supply risks + moderate recycling restrictions	Germanium Cobalt

Table A2.2: Prioritization of 11 green minor metals regarding different timelines (Source: Buchert et al. 2009: p.IX)

In response to these results Schüler et al. state, that “within the REE group the availability of several elements could prove to be even more critical as the result of this report suggest” (Schüler et al., 2011).

Figure A2.4 shows four major application clusters of “green minor metals” (I) Electrical and electronics equipment (EEE) technologies, (II) photovoltaic technologies, (III) battery technologies and (IV) catalysts and the specific raw materials which are needed for application out of these sectors.

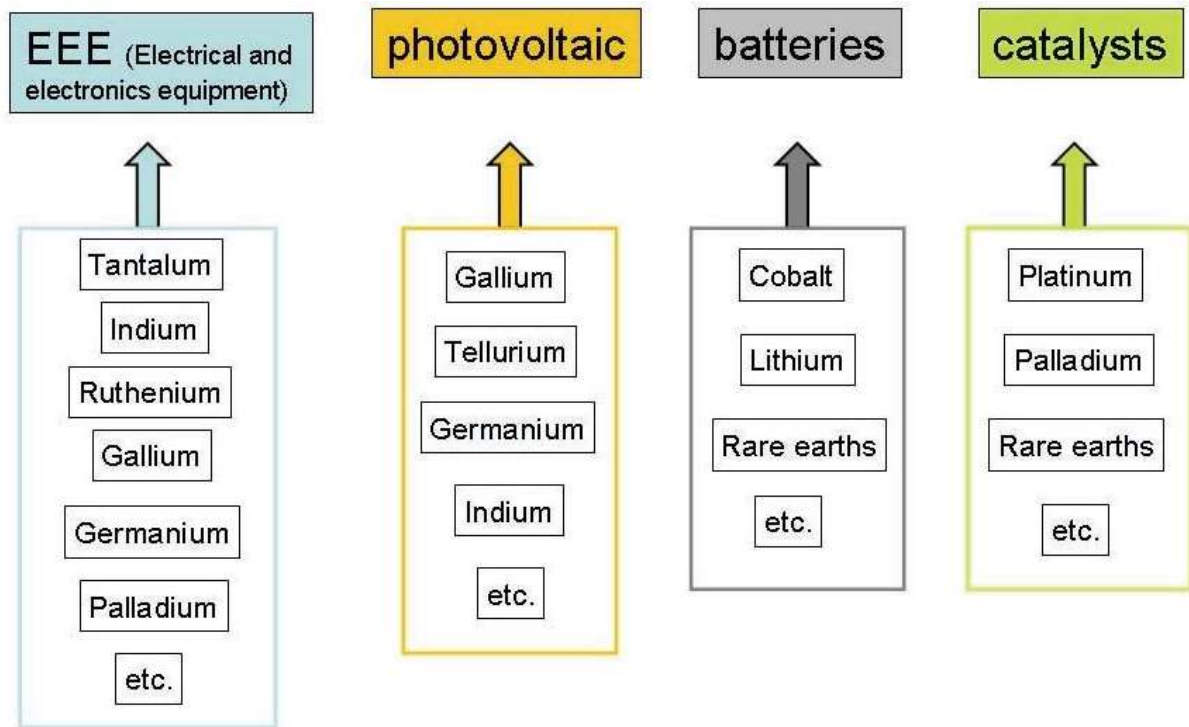


Figure A2.4: Application cluster and exemplary metals belonging to the particular cluster (Source: Buchert et al. 2009, p.IV)

Rare Earth Elements – critical resources for high technologies

Rare earth elements are not produced within the EU. Due to their high economic importance and high supply risk for the EU this material group is described in more detail.

Rare earth elements (REE) or rare earth metals⁹³ (short: rare earths) are – with few exceptions - relatively plentiful in the Earth's crust. "Rare" refers to their geochemical properties. They are typically found dispersed and not in economically exploitable forms. Consequently, most of the world's supply of REE comes from only a handful of sources (U.S.Geological Survey, 2002). The few economically exploitable deposits are known as rare earth minerals (a mineral which contains one or more REE as major metal constituents). According to the International Union of Pure and Applied Chemistry (IUPAC), rare earth elements or rare earth metals are a set of seventeen chemical elements (the 15 lanthanides and scandium and yttrium)⁹⁴: **lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm),**

⁹³ The name refers to the history of their recovery and is misleading: These elements are neither rare nor earths.

⁹⁴ Scandium and yttrium are considered rare earth elements since they tend to occur in the same ores as the lanthanides and exhibit similar chemical properties

samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), lutetium (Lu), yttrium (Y) and scandium (Sc).

Technological innovations resulted in many of hundreds applications using REE. They are essential for high technology and environmental applications which have increased dramatically in diversity and economic importance over the last decades (see figure A2.5). Many of these applications are highly specific in that substitutes are inferior or unknown. A relevant share of the increasing demand is caused by so-called “green technologies” which are designed to contribute to environmental protection (e.g. energy efficiency, renewable energy carriers or air pollution control). Due to their versatility and specificity REE have acquired a high level of technological, economic as well as environmental importance. It is widely assumed that this trend will continue. There are serious concerns that the demand of some REE⁹⁵ might exceed the present supply within a few years. (Schüler et al., 2011, U.S.Geological Survey, 2002)

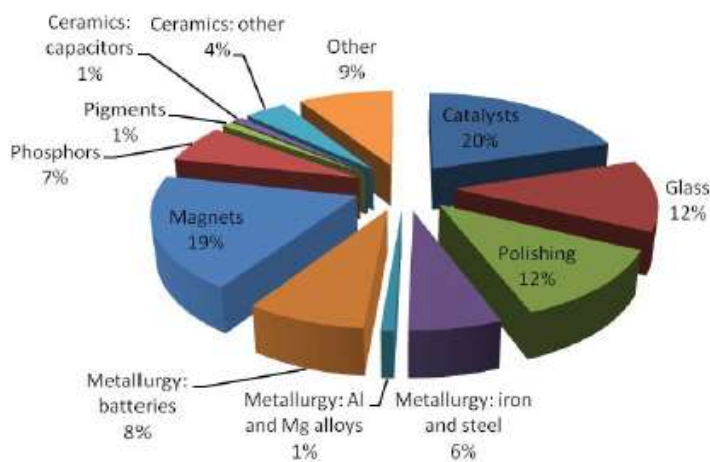


Figure A2.5: Economic importance of REE (Source: European Commission, 2011)

⁹⁵ REE such as neodymium, praseodymium, dysprosium, terbium, lanthanum, yttrium and europium

Global production and global reserves

Four periods of REE production can be distinguished. Whereas the US dominated the production between 1965 and about 1984, since the early 1990ths the Chinese period has begun (see figure A2.6). Today China accounts for more than 95% of world production (Schüler et al. 2011, 97% according to European Commission, 2010) and applied export restrictions and quota for rare earths recently.

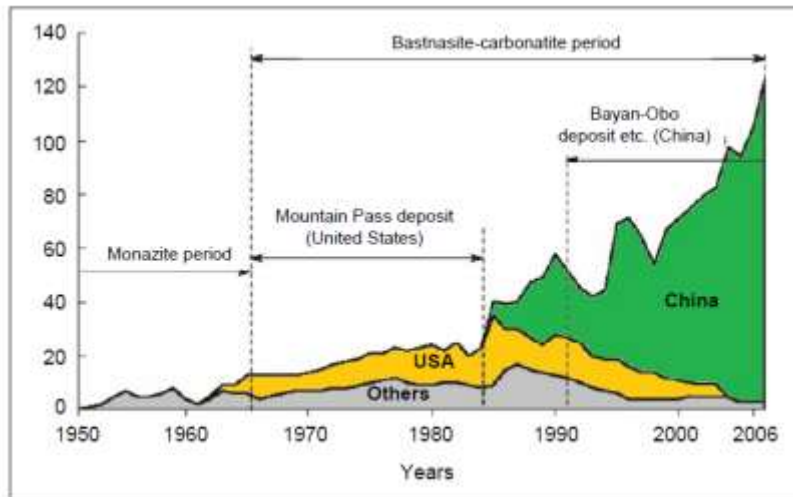


Figure A2.6: Global rare earths production 1950-2000 (Source: Schüler et al., 2011; cf Angerer et al. 2009 Production in [kt]).

The figure shows the steady increase in the REE production and the continuous increase of the Chinese market share, particularly since 2002, when the American mine was closed due to environmental problems and low Chinese prices.

China's share of global REE reserves is estimated at 38 %. Large deposits are also found in the US, Australia and states of the former Soviet Union (see figure A2.7).^{96,97} Concerning Europe there is only limited information on a few potential sites, and no extensive explorations of these critical metals are known (Schüler et al., 2011).⁹⁸

⁹⁶ Schüler et al. stress, that the definition of reserves, reserve base and resources are not internationally harmonised which makes it difficult to compare the different estimations (Schüler et al., 2011).

⁹⁷ However, this overall estimation is not relevant for the forecast of individual REE shortages

⁹⁸ Known deposits in amounting to approximately 500.000 t exist in Sweden, with further prospecting underway.

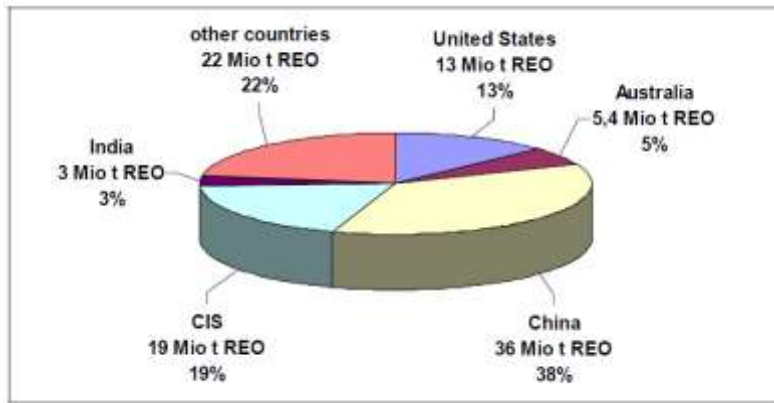


Figure A2.7: Global rare earth oxide reserves by country estimated by USGS (Source: Schöler et al., 2011 cf U.S.Geological Survey, 2002)

In 2007, approximately 14% of worldwide production (17.600 metric tons) was imported into the EU, 14% less than in the year before. The main source country was China, followed by Russia. As China is expected to require all of its production in the foreseeable future, several additional mining projects are currently underway in the United States, Canada, India, Australia and Malawi, the largest of which are in the US (Mountain Pass, CA) and Australia (Mt. Weld, Nolans)” (European Commission, 2010).

Comparing global supply - demand forecasts that show shortages in seven REE⁹⁹ at a high probability, Schöler et al. conclude: “Even if China imposes no export restrictions it is to be expected that the increasing demand up to 2014 can only be met if further mines in addition to the two planned mines in Australia and USA are opened” (p: I). After 2014 the negative balance might be attenuated, only if further mines start production, improvements in resource efficiency are implemented, relevant substitutions are realised and efficient recycling systems are implemented. A significant increase in rare earth prices reflect the high demand and the expected supply shortages, additionally triggered by Chinese export restrictions (ibid.). Remarkably, the authors argue that this price increase “is not only a burden [...]. It offers the chance to address the problem of today’s rare earth supply in more depth and to build up a sustainable rare earth economy in all relevant sectors” (ibid.p. I).

⁹⁹ Shortages will occur with a high degree of probability for terbium, dysprosium, praseodymium, lanthanum, yttrium and europium.

Figure A2.8 shows the price development for selected REE from 2001 to 2010. The steep increase at the end of the decade is explained by the increased global demand and the reduction of Chinese imports.

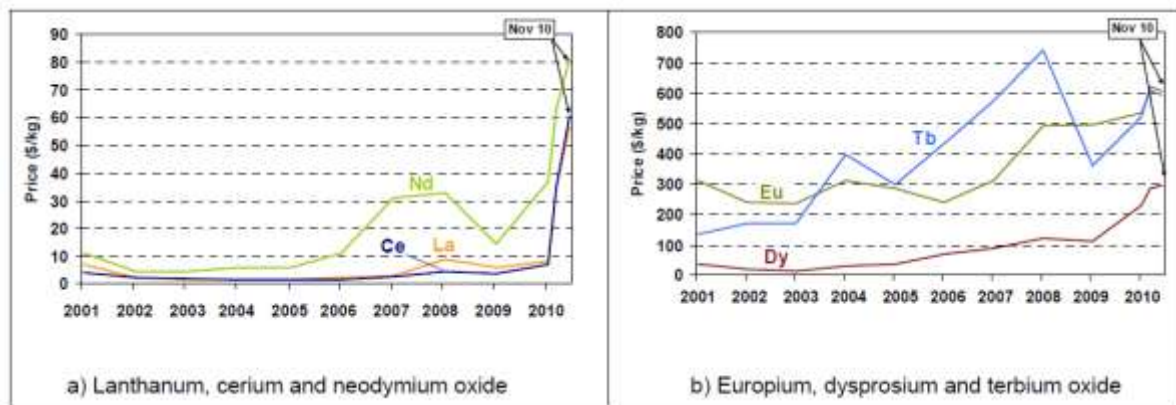


Figure A2.8: Price development for selected REE 2001-2010 (Source: Schüler et. al 2011: p. 39)

A2.3.3 Phosphorus – an emerging critical shortage of supply

Phosphorus is essential for all known forms of playing a major role in biological molecules (DNA and RNA)¹⁰⁰, biological metabolic processes (like energy transport) and as structural cell components (cellular membranes). Within specialized circles there is a growing awareness that phosphorus is not only a severe environmental pollution problem transgressing already the biophysical limits of the Earth-system (see the section on planetary boundaries in chapter 4.1.3) but also an emerging resource challenge (Vaccari 2011). “[...] acquiring enough phosphorus for feeding the world will be one of the great challenges for humanity in the future” (Cordell et al., 2009: p. 294).

Phosphorus is required as key ingredient in fertilizers to sustain high crop yields and has no substitute in food production. In a world of 9 billion people by 2050, securing sufficient phosphorus will be critical for future food security. The world’s main source - phosphate rock - is non-renewable (like oil) and is becoming increasingly scarce and expensive (Cordell

¹⁰⁰ DNA (deoxyribonucleic acid) carries the genetic information; RNA (ribonucleic acid) is a transcription of it. DNA and RNA are along with proteins the major macromolecules for all known forms of life (except of RNA viruses).

et al. 2011, GPRI 2010, van Vuuren et al., 2010). Recent price shocks¹⁰¹ give evidence of an increasing fertilizer demand exceeding supply which is explained due to an increasing demand of meat- and dairy based diets in emerging economies but also due to biofuel production.¹⁰² (Cordell et al., 2009) Vaccari 2009). The development of phosphate prices showed how volatile these prices can be (Rosemarin, 2010).

Phosphorus sources and use

Historically, crop production relied on natural levels of soil phosphorus and locally available organic matters. In the 20th century phosphate rock (inorganic phosphorus) was used extensively for food crops to keep up with increased food demand due to rapid population growth. The Green Revolution involved the application of chemical fertilizers (processed mineral fertilizers) and new agricultural practises which lead to an improved agricultural output (Cordell et al., 2009). Figure A2.9 shows the development of phosphorus fertilizer use for food production for the last two centuries.

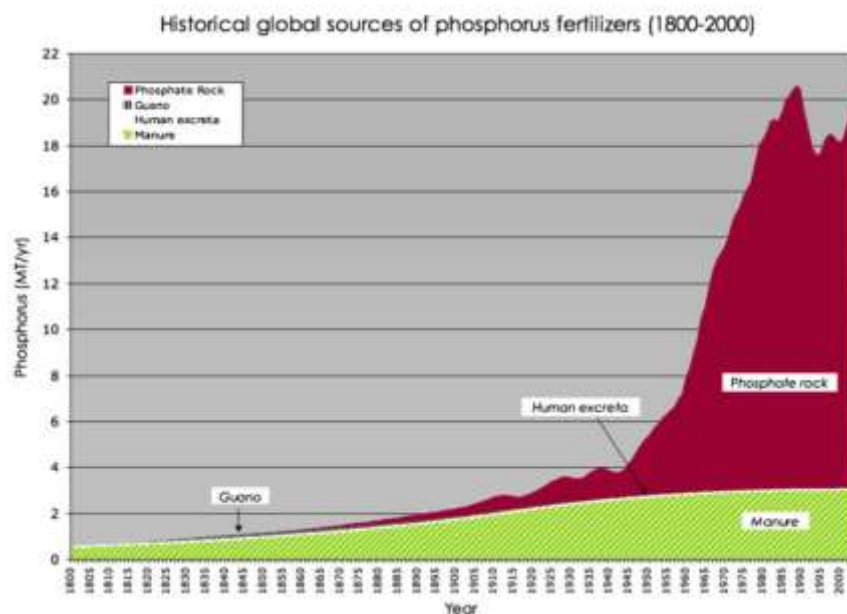


Figure A2.9: Historical global source of phosphorus fertilizers 1800-2000 (Source: Cordell et al. 2009: p. 292)

¹⁰¹ Severe concerns about oil scarcity and climate change has led to sharp increases in biofuel production. The biofuel industry competes with food production for grains and productive land and also for phosphorus fertilizers (Cordell 2009).

¹⁰² “The year 2007 was the first year a clear rise in phosphate rock demand could be attributed to ethanol production” (US Geological Survey 2007, pers. comm. cited in (Cordell et al., 2009).

According to the Global Phosphorus Research Initiative (GPRI) approximately 90% of global phosphate rock¹⁰³ is mined for agriculture purposes (fertilizers, feed and food additives, see figure A2.10).

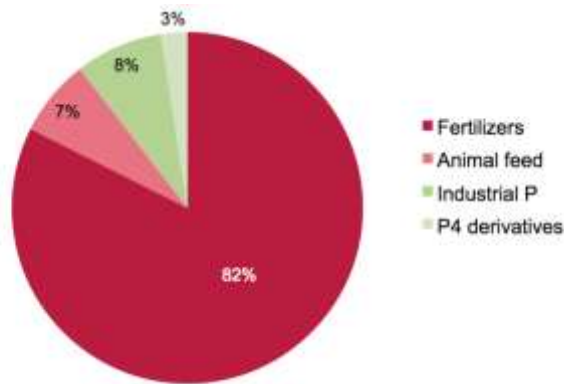


Figure A2.10: Breakdown of phosphate rock end uses (Source: Global Phosphorus Research Initiative GPRI 2010).

Increasing global demand

Production and use of phosphorus has been increasing consistently over the last few decades. This trend is driven by emerging and developing economies, where fertilizer use has been growing faster than in the industrialized world (Rosemarin 2010). According to the International Fertilizer Industry Association (IFA), in 2008, close to 53.5 million tonnes (Mt) of P₂O₅ (i.e. 175 Mt of phosphate concentrates, averaging 30.7% P₂O₅ content) was mined (Van Vuuren et al. 2010). It is expected that world production will further increase in the next decades, which will ultimately lead to depletion of high-grade phosphorus (van Vuuren et al., 2010).

“[...] acquiring enough phosphorus for feeding the world will be one of the great challenges for humanity in the future” (Cordell et al., 2009): The global demand for phosphorus is predicted to increase dramatically between 50 – 100% by 2050 with increased global demand for food and changing diets (Cordell et al., 2009) after (EFMA, 2000; Steen, 1998). This projected increase will be caused by developments in emerging and developing economies (population growth, changing diets) with 2/3 of this demand coming from Asia (FAO, 2007) where both absolute and per capita demand phosphate fertilizers is increasing (Cordell et al.,

¹⁰³ This equates 148 million tonnes of phosphate rock per (Gunther, 2005; Smil, 2001; Smil, 2000) cited in (Cordell et al., 2009).

2009). In Sub-Saharan Africa, where at least 30% of the population is undernourished, fertilizer application rates are extremely low and $\frac{3}{4}$ of agricultural soils are nutrient deficient, leading to declining yields (IFDC, 2006; Smaling et al., 2006; AGRA, 2008) cited in (Cordell et al., 2009). For Europe and North America the situation is quite different, though: After more than five decades of generous application of inorganic high-grade phosphorus (and nitrogen) fertilizers, soils in Europe and North America today have surpassed 'critical' phosphorus levels, thus only require light applications to replace what is lost in harvest. Today the demand for phosphorus in these regions has stabilized or is decreasing (EFMA, 2000; FAO, 2006) cited in (Cordell et al., 2009).

Supply risks: global phosphorus reserves, production and peak phosphorus

Phosphate rock reserves (high-grade ores) are concentrated in only few countries. They are in the control of mainly Morocco, which has a monopoly on Western Sahara's reserves, China, which is drastically reducing exports to secure domestic supply, and the US, which has less than 30 years of supplies (GPRI 2010). The future production will be concentrated on Morocco and China (Zittel, 2010). **The EU is a net importer of phosphorus in feed, feed stock and fertilizer. Western Europe is totally dependent on imports** (Rosemarin, 2004; Rosemarin, 2010).

It seems very likely that peak phosphorus will happen during the next few decades. Cordell et al. point out, that according to conservative analysis peak phosphorus could occur by 2033 (see figure A2.11: peak phosphorus curve). According to Zittel the time span lies between 2020 and 2030 (Zittel, 2010).¹⁰⁴

Although complete depletion is not likely to occur within the near future¹⁰⁵, undoubtedly the remaining potential reserves will be of lower quality or more costly to extract.

¹⁰⁴ It should be mentioned that the timeline of peak phosphorus is discussed. According to Déry and Anderson global phosphorus reserves peaked around 1989 (Déry and Anderson, 2007). Cordell argues, that it is likely that this [...] was not a true maximum production peak [...] instead a consequence of political factors such as the collapse of the Soviet Union[...] and decreased fertilizer demand from Western Europe and North America (Cordell et al., 2009).

¹⁰⁵ The timeline for the depletion of phosphate rock resources has been raised in several studies, with very contrasting results. Estimates vary regarding to when high-grade reserves (commercial phosphate reserves) will be depleted. Most authors note that depletion will occur within 50-100 years (see (van Vuuren et al., 2010), (Cordell et al., 2009), GPRI 2010). Van Vuuren et al. summarize that, "rapid depletion of extractable phosphate rock is not very likely, in the near term. Under best estimates, depletion would be around 20–35%. In worst case scenarios, about 40–60% of the current resource base would be extracted by 2100." (van Vuuren et al., 2010): p. 428)

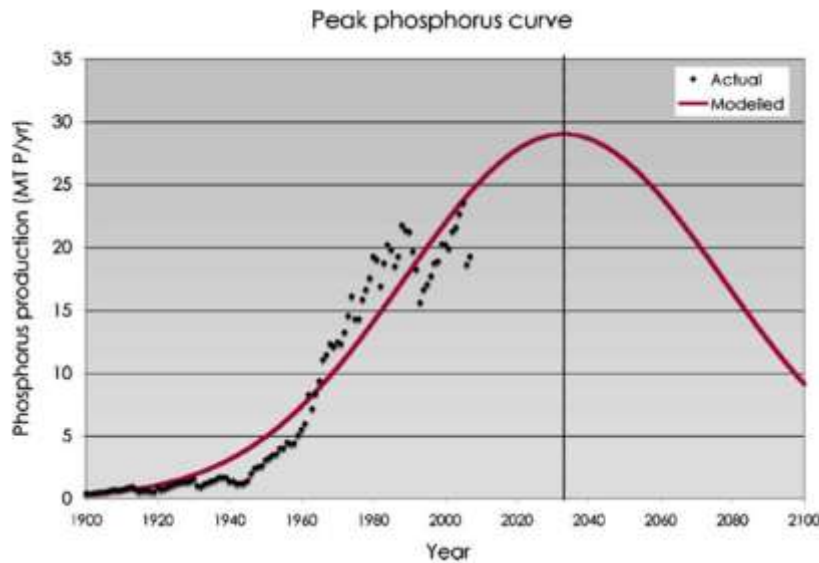


Figure A2.11: Peak phosphorus (Source: Cordell et al., 2009)

Future projections on production (GO scenario) according to van Vuuren et al. (2010)

The authors refer to the so-called GO scenario (Global Orchestration scenario) as developed by the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005)¹⁰⁶.

The phosphorus (P) GO scenario describes future Phosphorus markets under the assumption of no trade barriers and relatively high P demand. Figure A2.12 compares the historic trends in phosphate rock production and model results. It shows for the next decades globally increasing production levels. The main producers are Africa, China and the US. (van Vuuren et al., 2010): p. 433f). Some stabilization in the second half seems likely.

¹⁰⁶ The “story line” for the GO scenario is: rapid economic growth, focus on development, global cooperation; assumptions on population (in billions): 7.3 in 2020, 8.2 in 2050 and 6.9 in 2100. For more details on the Millennium Ecosystems Assessment scenarios: see (Millennium Ecosystem Assessment, 2005).

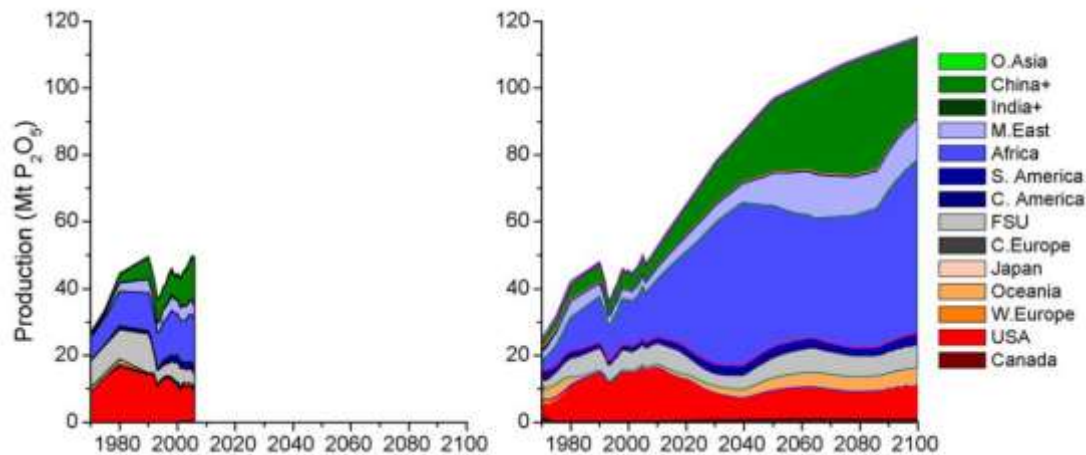


Figure A2.12: Historical and predicted phosphorus production (GO scenario) (Source: van Vuuren et al. 2010: p. 433)

Period 1970-2006 (historical data), period 2000-2100 (Millennium Assessment Global Orchestration MA GO scenario)

In all four MA scenarios (GO global orchestration scenario, OS order from strength, TG Technogarden, AM adaptive mosaic)¹⁰⁷ P use is expected to increase with major differences between them. The full range is between 49-78 Mt P₂O₅ in 2030 (44,5 Mt in 2000) (Source: (van Vuuren et al., 2010): p. 433).

¹⁰⁷ The 4 scenarios differ in terms of environmental management and in degree and scale of connectedness among and with institutions across countries borders. For more details see (Millenium Ecosystem Assessment, 2005)

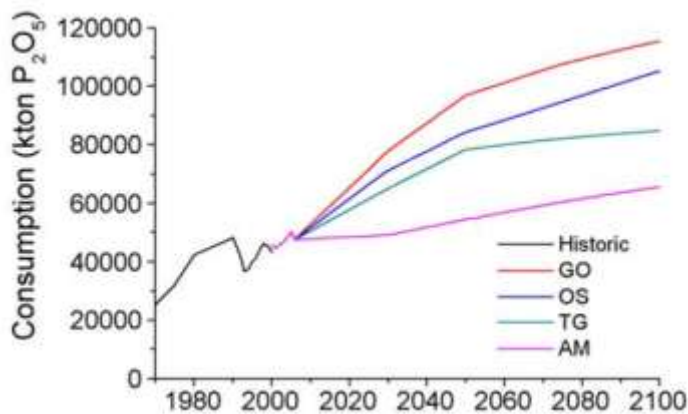


Figure A2.13: Total global p consumptions according to 4 MA scenarios (Source: van Vuuren et al. 2010, p. 433)

[GO global orchestration scenario, OS order from strength, TG Technogarden, AM adaptive mosaic]

A2.3.4 Global food security

The future of agriculture and global food security has recently been investigated by a prominent consortium consisting of UNDP, UNEP, UNESCO, the World Bank, WHO and the Global Environment Facility, as the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). The report, “Agriculture at a Crossroads” (2009), is a multi-stakeholder assessment of the agricultural system, its economic, social and environmental aspects and future challenges and possibilities. It aims to provide evidence-based analyses and assessments of the existing knowledge in regards to their relevance and reliability for national and international policy-making (IAASTD, 2009, 4).

Through an integrated assessment in which 10 different quantitative models are coupled (IAASTD 2009, 311ff), projections up to 2050 for the global agricultural system and related global environmental change have been generated. In the reference run a world is imagined in which there are no additional deliberate interventions in the form of new or intensified policies in response to the projected developments. It is based on UN medium population projections (8.2 billion people in 2050), medium economic growth scenarios from the MES (2005) and IEAs reference projections of future energy supply and demand, which in regards to the energy mix “is a conventional development scenario assuming no major changes in

existing energy policies and/or societal preferences” (IAASTD, 2009, 316). Fossil fuel prices are expected to remain relatively high, although below 2005-2007 levels. This leads to a projected increase of global final energy demand from 280 EJ in 2000 to 700 EJ in 2050 (IAASTD, 2009, 326) – the plausibility of such an increase in the light of the debate on peak fossil fuels, climate change mitigation regimes and geopolitical tensions around producing countries seems very optimistic.

Under these assumptions the reference run of the IAASTD (2009, 316 -319) projects a yearly increase of global food production by 1.2% per year until 2050. This growth results from rapid economic growth, a slow-down of population increase and rising affluence which leads to diversifying diets. Expanding food demand growth will have to be mainly met by increasing crop yield and growing livestock numbers. “For the crops sector, water scarcity is expected to increasingly constrain production with virtually no increase in water available for agriculture due to little increase in supply and rapid shifts of water from agriculture in water-scarce agricultural regions [...]. Climate change will increase heat and drought stress in many of the current breadbaskets in China, India and the United States [...]. With declining availability of water and land that can be profitably brought under cultivation, expansion in areas is not expected to contribute significantly to future production growth. [...] Although yield growth will vary considerably by commodity and country, in the aggregate and in most countries it will continue to slow down” (IAASDT 2009, 317). In addition, it has to be noted that the previously discussed emerging critical shortages of supply of phosphorous has not been incorporated into the analysis conducted by the IAASTD (2009). This will pose an additional challenge to global food security.

The composition of food demand is expected to grow across commodities until 2050, with total cereal demand projected to grow by 1,305 million tons or 70%, 50% for maize, 23% for wheat and 10% for rice. Demand for meat products continues to grow rapidly across all regions by 6 – 23 kilograms per person (IAASTD, 2009, 331).

In combination the strong demand increase and increasingly constrained production are projected to have the following effects: “Real world prices of most cereals and meat are projected to increase significantly in coming decades, reversing trends from the past several decades. Maize, rice and wheat prices are projected to increase by 21-61% in the reference world, prices for beef and pork by 40% and 30% , respectively, and for poultry and sheep and goat by 17 and 12%, respectively [...]. With rising prices due to the inability of much of

meeting projected demands while lowering greenhouse gas emissions, biodiversity losses, water use and water pollution. However, all four strategies are needed to meet our global food production and environmental goals; no single strategy is sufficient” (Foley et al. 2011, 341).

In addition to expected increases in agricultural prices, the volatility of food prices is the second important aspect of global food security (IMF and World Bank, 2011; FAO and OECD, 2011). “Not all price variations are problematic, such as when prices move along a smooth and well-established trend reflecting market fundamentals or when they exhibit a typical and well known seasonal pattern. But variations in prices become problematic when they are large and cannot be anticipated and, as a result, create a level of uncertainty which increases risk for producers, traders, consumers and governments and may lead to sub-optimal decisions. [...] Behind concerns about volatility lie concerns about prices levels and behind both, lie concerns about food security. While producers benefit, [...] consumers, especially poor consumers, are severely adversely affected by high prices” (FAO and OECD, 2011, 5).

Agricultural commodity markets have always been characterized by a high degree of volatility, due to three market fundamentals (FAO and OECD 2011, 8): 1) agricultural output varies due to environmental influences like weather and pests, 2) demand elasticities are relatively small in regards to price and supply elasticities are low, at least in the short run, and 3) because production is constrained by natural growing cycles it cannot respond quickly to price changes in the short run, thereby creating lagged responses and cyclical adjustments.

During 2011 important food price indices rose to similar levels as during the world food price crisis of 2007/8, with growing concerns about the future security of food supply. “International grain price variability (around its mean price) doubled during the period between 2005 and 2010 relative to the period between 1990 and 2005, sugar price variability tripled, and rice price variability is four times higher which is now similar to the variability experience in the 1970s. Climate change, land and water constraints, greater linkages with more volatile oil prices, and substantially higher commodity index investment flows place upward, not downward, pressure on price volatility. These factors are likely to persist in the short to medium-term suggesting that future volatility may be higher than that experienced in the 1980s and 1990s” (IMF and World Bank, 2011, 1).

A number of factors will contribute to price increases and possibilities for stronger volatility in the future. The growing world population and rising affluence will lead to increasing food demand by 70 – 100% until 2050 (FAO and OECD, 2011, 9). Furthermore agricultural commodities are becoming increasingly correlated with oil prices, which will “affect agricultural input prices directly and indirectly (through the price of fuel and fertiliser, for example). In addition, depending on the relative prices of agricultural crops and oil, biofuel production may become profitable (without government support) [...]. High and volatile oil prices [...] could therefore contribute to higher and more volatile agricultural prices, through higher input costs, higher demand for the commodities used in the production of biofuels (sugar, maize, vegetable oils), through competition for land with commodities that are not used directly for the production of fuel and possibly through financial investment in commodity baskets” (FAO and OECD, 2011, 9). Other drivers of future price increases and volatility are climate change impacts, slow growth of agricultural productivity, land and water constraints, protective policy measures adopted by some governments, a depreciating US dollar and to some extent investments in financial derivatives (FAO and OECD 2011 10f; IMF and World Bank, 2011, 2-8). IMF and Worldbank (2011, 3f) additionally refer to historically low global food stocks as another important factor in recent episodes of volatility; furthermore they point out that in the near future stocks will probably remain low. “This catalogue of factors points to a likelihood of higher real prices and a risk of increased volatility in future years. [...] The extent of potential future increases in price and volatility cannot be estimated accurately, but the risks are sufficiently large to warrant serious reflection about what can be done to mitigate it [...] and to manage the consequences, when, as is inevitable, episodes of high volatility occur” (FAO and OECD, 2011, 11).

The consequences of rising prices and increased volatility on food security are furthermore outlined by IMF and World Bank (2011, 9f). “Higher and more volatile food prices hurt food security if they diminish the ability of individuals to access food when they need it. Sudden and strong food price increases make it difficult for households to adjust, eroding purchasing power, reducing calorie intake and nutrition and pushing more people into poverty and hunger [...]. Higher prices are of the greatest benefit to farmers if they can be relatively certain about them and know about them in time to modify their production strategies, have access to inputs at a cost that is low enough to expand production profitable, and have the resources and knowledge to expand production beyond their own subsistence needs”.

Several strategies and recommendations have been put forward to reduce future food price volatility and manage its most adverse impacts (IMF and World Bank, 2011; FAO and OECD, 2011). The success of these strategies will have a large impact on the future of global food security.

A2.4 Key assumptions

This chapter addressed critical raw materials for the EU with focus on future projections. It comprised 14 raw materials (including the two material groups PGM and REE) which are essential for new technologies and environmental applications and meet the criteria of criticality for the EU as described above (high relative supply risk and economic importance). These materials were considered within a time horizon of ten years (according to European Commission, 2010). For 9 of them and two further materials (the so called “green minor metals”) estimates on longer time periods (up to 2050 according to Buchert et al., 2009) were taken from literature. For phosphorus long-time scenarios were available (van Vuuren et al., 2010; Cordell et al., 2009). As recommended by GPRI, phosphorus was added to the list of critical raw materials for the EU due to its high importance for food production and import dependence of the EU. Regarding the list it has to be stressed however, that even a small shift in one of the underlying variables of criticality may result in further extension of the list of critical materials for the EU (European Commission, 2010).

The main findings of the chapter are summarized in terms of key assumptions for the two extreme scenarios (friendly-tough) up to 2025 and 2050 (and in the case of phosphorus beyond 2050) according to basic assumptions listed below. It has to be stressed, that future projections on specific materials (e.g. specific REE) may differ from overall findings. For more details we refer to the selected literature.

Basic assumptions for both scenarios:

- Forces which will determine resource security are: global demand of emerging technologies, security of supply, substitutability, recoveries and recycling rates and – especially in the case of phosphorus - population growth.
- Food prices are increasing steadily over the long term

Basic assumption for the “friendly scenario”:

- Moderate demand growth (lower range of projections) of critical materials from emerging technologies and low supply risk, steady price increases (low recycling restrictions, new recoveries etc.)
- Lower range of projections for phosphorus demand and depletion, peak phosphorus after 2030
- The food security and environmental sustainability goals are met through consequent implementation of: stopping the expansion of agricultural land use, closing yield gaps, increasing agricultural resource efficiency and increasing food delivery by shifting diets and reducing waste
- Food price volatility kept under control by the risk management strategies as outlined by World Bank and IMF (2011)

Basic assumption for the “tough scenario”:

- Rapid demand growth (upper range of projection) of critical materials from emerging technologies, serious supply shortages, sharp increases in prices and high volatility (price shocks) etc.
- Upper range of projections for phosphorus demand and depletion, peak phosphorus by 2020
- Food supply cannot keep up with growing demand as projected. At the same time agricultural production causes severe environmental impacts further undermining the productivity of the food system (e.g. biodiversity loss, unsustainable levels of water use and pollution, land degradation, GHG emissions)
- Food price volatility is increasing significantly, causing regular food crises in different parts of the world

Further considerations: friendly versus tough

It is very likely that both worlds the “friendly” and the “tough” one will be confronted with increasing prices and higher supply risks. The possibility of price shocks as experienced recently (e.g. in the case of phosphorus; see also chapter 2) are likely to occur again, which is related to the “tough world scenario”. Taking long-term consequences into account, this classification may be misleading, though. According to Schüler et al. one could argue in contrast. Using the example rare earths, they state: “This steep increase is not only a burden

[...]. It offers the chance to address the problem of today's rare earth supply more depth and to build up a sustainable rare earth economy in all relevant sectors" (Schüler et al., 2011, p.I), see also NIC and EUISS, 2010)

Forces	Friendly Moderate demand growth, low supply risk, steady price increases	Tough High demand growth, serious supply shortages, price shocks
<p>Global demand of emerging technologies, supply risks, recoveries, substitutes, and recycling</p> <p>P: population growth, changing diets</p>	<p>Trends on critical raw materials for the EU (overview)</p> <ul style="list-style-type: none"> • Critical within the next decade: Antimony, beryllium, cobalt, fluorspar, gallium, germanium, graphite, indium, magnesium, niobium, platinum group metals (PGMs), rare earths (REE), tantalum, tungsten: demand from emerging technologies is expected to evolve sometimes very rapidly by 2030 (European Commission, 2010). These materials include all "green minor metals" (according to Buchert et al., 2009) but lithium and tellurium. Some of the latter are projected to become critical within the next years (Buchert et al. 2009, Schüler et al., 2011) • Production concentration within few countries combined with export restrictions: high share of worldwide production comes from China (antimony, fluorspar, gallium, germanium, graphite, indium, magnesium, rare earths, tungsten, and phosphorus), Russia (PGM), the Democratic Republic of Congo (cobalt, tantalum), Brazil (niobium and tantalum) and Morocco, West Sahara (phosphorus). 	
<p>up to 2025 (2030)</p>	<p>Overall demand increase from emerging technologies depends on the specific raw material. Demand indicators (demand/production): ranges will be between a factor of 0.2 (copper) and 3.97 (gallium) related to total world production in 2006 (European Commission, 2010 cf. Angerer et al., 2009, updated by BGR 2010)</p> <p>Green minor metals: Most critical within the near future: tellurium, indium and gallium (Buchert et al., 2009), REE (EC, 2011; Schüler et al., 2011);</p> <p>after 2014 and up to 2020: most critical REE (terbium, dysprosium, praseodymium, lanthanum, yttrium and europium according to Schüler et al., 2011), lithium, tantalum, palladium, platinum and ruthenium (Buchert et al., 2009);</p> <p>Phosphorus</p> <p>(Rapid depletion of extractable phosphate rock is not very likely, in the near term). However, increasing demand of non-organic P fertilizer and further increasing world production within the next decades will ultimately lead to depletion of high-grade phosphorus (van Vuuren et</p>	

	al., 2010)	
	<ul style="list-style-type: none"> • Moderate demand growth critical metals: > 20 % increase of total demand compared to 2007 (Buchert et al. ,2009) REE: rate: 4.5% per year • Low supply risks efficient recycling systems and high recovery rates, relevant substitutions are realised, no further export restriction from producing countries (e.g. by trade agreements), new mining projects, new discoveries (REE: unlikely within the EU) • Peak oil late (see 4.1.1) • Steady price increases, no price shocks 	<ul style="list-style-type: none"> • Rapid demand growth critical metals: > 50% compared to 2007 (Buchert, et al- 2009) REE: 9% per year criticality of some REE more severe than projected (Schüler et al., 2011) • High supply risks low recycling rates, low/unknown substitutability, > 90% share of global mining within few countries and further export restrictions (severe supply shortages) • Peak oil early (see 4.1.1) • Sharp price increases and price shocks, high volatility
	<ul style="list-style-type: none"> • Peak phosphorus by 2030 (Cordell et al. 2009, Rosemarin 2010, Zittel 2010) • Global P use: 49 Mt P₂O₅ in 2030 (Van Vuuren et al. 2010) 	<ul style="list-style-type: none"> • Peak phosphorus by 2020 (Zittel , 2010: lower range of estimate) • Global P use: 78 Mt P₂O₅ in 2030 (Van Vuuren et al. 2010)
	<ul style="list-style-type: none"> • Progress towards key food security and environmental sustainability goals (Foley et al. 2011) • Food prices increase steadily and volatility is under control (World Bank and IMF, 2011) 	<ul style="list-style-type: none"> • Food security situation problematic, environmental impacts large • Food price volatility high, supply cannot keep up with demand
2050 and beyond	<p>Green minor metals: Germanium and Cobalt become critical (Buchert et al. 2009). <i>No further projections on critical materials driven by emerging technologies available</i></p> <p>Phosphorus:</p> <p>Phosphorus has no substitute in food production. In a world of 9 billion people by 2050, securing sufficient phosphorus will be critical for future food security. Future production will concentrate in Morocco and China</p>	

<p>(Zittel, 2010). Western Europe is completely import depended (Rosemarin, 2004).</p> <p>Readily available global supplies may start running out by the end of this century. By then world's population may have reached a peak that some say is beyond what the planet can sustainably feed (Vaccari, 2009)</p> <p>The global demand is predicted to increase dramatically between 50 – 100% by 2050 (compared to current levels) with increased global demand for food and changing diets (Cordell et al., 2009). Depletion would be around 20–35%, in worst case scenarios about 40–60% of the current resource base would be extracted by 2100 (Van Vuuren, et al. 2010).</p> <p>Global reserves at present extraction rates will not last until 2100 (Rosemarin, 2010).</p>	
<p>Phosphorus</p> <p>demand: + 50%</p> <p>depletion: 20-35 % of current resource base by 2100 (Van Vuuren et al. 2010)</p>	<p>Phosphorus</p> <p>demand: + 100%</p> <p>depletion: 40-60% of current resource base by 2100 (Van Vuuren et al., 2010)</p> <p>Readily available global supplies may start running out by 2100 (Rosemarin, 2010, Vaccari, 2009)</p>
<p>Key food security and environmental sustainability goals fulfilled (Foley et al., 2011)</p> <p>Food prices increase steadily and volatility is under control (World Bank and IMF, 2011)</p>	<p>Food security situation problematic, environmental impacts eroding the food system</p> <p>Food price volatility high, supply cannot keep up with demand</p>

Table A2.3: Key assumptions on rising challenges to resource security

A2.5 References

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A3. Increasing climate change impacts

- Climate change is advancing rapidly.
- Unabated climate change could cause large-scale changes in the Earth System, which would have unpredictable consequences
- Accelerating trend of melting mountain glaciers and accompanying changes in water availability
- Sea level rise is regarded as the greatest potential risk in the long term.
- Changes in water resources will be the most visible impact with severe implications for food production
- Continued marked increases in hot extremes and decreases in cold extremes are expected in most areas of the globe
- Change in precipitation amounts and distribution: further increases in (very) heavy precipitation and increases in drought
- Increased risk of tropical cyclones to regions already endangered by hurricanes. Area at risk could expand towards the poles
- Severity of impacts highly dependent on adaptive capacities of societies
- Europe: Mediterranean countries will be hit hardest Hot spots” will be Greece, Portugal and Spain
- Governments steering capacities potentially overwhelmed, especially in fragile states
- Climate change, regarded as a threat multiplier of existing environmental and social problems, is increasingly perceived as international security risk

A3.1 Introduction: Why climate change?

Climate change¹⁰⁹ is within science now beyond dispute. There is substantial evidence that climate change is happening as a result of greenhouse gases (GHG) emitted since the industrial revolution.¹¹⁰ It is just beginning, but will steadily intensify for the foreseeable

109 According to IPCC climate change is “A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.” (IPCC, 2011: p.2)

110 In terms of global mean, temperature has increased by approximately. 1 °C above pre-industrial levels..

future, largely irrespective of the emission scenario due to the inertia of the climate and the atmospheric lifetime of GHG. Projections also suggest that climate change will progress substantially faster than in the last few decades. According to latest scientific evidence, the impacts will be probably even more severe than stated in the 4th Assessment Report (AR4) of IPCC published in 2007 (i.e. Allison et al. 2009, Meinshausen et al., 2009, Lenton et al., 2008, Smith et al., 2008 Rahmstorf et al., 2007). The German Advisory Group (WBGU) assumes, that “Climate change will become the most important driver of global environmental changes in the coming decades” (WBGU, 2007: p. 55).

Changes in water resources will be the most visible impact on human society (e.g. IISS 2011). This will lead to severe implications for food security, with increasing risks of land use conflicts between food and biofuel production (see chapter 4.1.1). Increases in weather extremes (heat waves, droughts, heavy precipitation, floods, storms and tropical cyclones even outside the already endangered areas), which have been observed during the last decade, are expected to be amplified further (Allison et al. 2009).

Climate change is also regarded as “threat multiplier”, exacerbating existing environmental and social threats and contributing to new conflicts, especially affecting fragile states¹¹¹. Although poorer regions of the world will be hit hardest by these impacts due to their limited adaptive capacities, wealthy states will be affected at least indirectly in terms of spreading risks such as triggered migration due to environmental and social crisis. This will also challenge mature industrial countries, including Europe. Thus, climate change is increasingly being perceived as an international security risk (e.g. Ahmed, 2010, IISS, 2011, WBGU, 2007). Therefore, climate change is at the top of the political agenda. The 2 °C degree target¹¹² was politically accepted by 16 industrial nations at the G8 summit in July 2009. Staying below this 2 °C target with a 50% probability corresponds to an atmospheric carbon dioxide (CO₂) concentration of below 450 ppm. Given the fact that humanity has already released half of that since pre-industrial times and in the light of severe and irreversible consequences of unabated climate changes it is beyond doubt that near time emission targets will be needed to reach this goal.

¹¹¹ *Fragile states*: Here, the state continues to perform in essence welfare and rule of law functions. However, its monopoly of the use of force is either severely restricted or entirely absent, and it does not completely control its territory or external borders. Many states which are formally democratic but which are challenged by separatist forces fit in this category (e.g. Colombia, Sri Lanka, Indonesia, Georgia), but others are authoritarian states (i.e. Sudan, Nepal). (Schubert et al., 2007: p.42)

After the description of the selected key literature this chapter reflects on planetary boundaries (limits of the Earth-system) in the context of the politically motivated 2°C target. Furthermore, short insights into large scale impacts of transgressing these boundaries (tipping points of the Earth system) are discussed, to point out how quickly and severely global warming could run out of control. Subsequently, observations and future projections on temperature and precipitation developments based on most recent findings are described. Thereafter, the consequences of climate change for Europe are summarized. The last section outlines climate change as security risk as it is increasingly perceived internationally.

A3.2 Key literature

There is a huge and increasing body of scientific literature on climate change. This chapter summarizes the results of recently published reports and outlooks which are based on latest scientific evidence on climate change (according to AR4 of IPCC 2007 and later scientific insights). It comprises also selected scientific papers on limits of the Earth System, an issue which is still underexplored.

Intergovernmental Panel on Climate Change: Climate Change 2007 Assessment Report 4 (IPCC 2007)

The Intergovernmental Panel on Climate Change (IPCC), established in 1988 by the United Nations Environmental Program (UNEP) and the World Meteorological Organization (WMO), is the leading international scientific body working on the assessment of (natural and anthropogenic) climate change and its impact on ecological and socio-economic systems worldwide. All member states of the founding institutions can participate in the plenary sessions (where the Bureau members are elected) and in the review process of the Panel. The panel does exclusively function as a scientific review body and a science-policy interface. “It does not conduct any research nor does it monitor climate related data or parameters.”¹¹³ The submission of scientific data and reports from scientists all over the world happens on a voluntary basis.

Since 1990 the IPCC has published four assessment reports (1990, 1995, 2001 and 2007) with a fifth one planned for publication in 2013/14. The reports serve to “provide rigorous and balanced scientific information to decision makers” and are “policy-relevant and yet policy-neutral, never policy-prescriptive.” (ibid.) In the production of the reports the IPCC selects the authors, which are nominated by governments and organizations. The report is peer-

¹¹³ <http://www.ipcc.ch/organization/organization.shtml> (accessed December 14, 2011)

reviewed by experts and governments, and finally approved by the IPCC and then published.

In addition to the IPCC Bureau, Plenary and Secretariat, the IPCC hosts three working groups and a task force:

- Working Group 1: The Physical and Science Basis
- Working Group 2: Climate Change Impacts, Adaptation and Vulnerability
- Working Group 3: Mitigation of Climate Change
- Task Force on National Greenhouse Gas Inventories

IPCC Assessment Report 4 (AR4): AR4 consists of three separate parts produced by the above-mentioned working groups and a synthesis report that contains a short summary for policy makers (IPCC 2007a). The latter provides an integrated view of climate change as the final part of the IPCC's Fourth Assessment Report.

The following section on climate change refers to partly updated results of working group 1 "The Physical and Science Basis" (IPCC, 2007b) and working group 2 "Climate change: impacts, adaptation and vulnerability" (IPCC, 2007c). It also refers to the Special IPCC Report on Climate Extremes.

IPCC SREX Report on Climate Extremes (IPCC 2011) Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation

A Special Report of Working Group I and Working Group II of the Intergovernmental Panel on Climate Change "Summary for policymakers" published in November 2011¹¹⁴ (IPCC, 2011).

This Summary for Policymakers presents key findings from the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX). The SREX approaches the topic by assessing the scientific literature on issues that range from the relationship between climate change and extreme weather and climate events ("climate extremes") to the implications of these events for society and sustainable development. The

¹¹⁴ The full report will be available in February 2012

assessment concerns the interaction of climatic, environmental, and human factors that can lead to impacts and disasters, options for managing the risks posed by impacts and disasters, and the important role that non-climatic factors play in determining impacts. (IPCC, 2011: p. 1)

The Copenhagen Diagnosis. Updating the World on the Latest Climate Science Allison et al. (2009)

Contributing authors:

Ian Allison, Nathan Bindoff, Robert Bindshadler, Peter Cox, Nathalie de Noblet-Ducoudré, Matthew England, Jane Francis, Nicolas Gruber, Alan Haywood, David Karoly, Georg Kaser, Corinne Le Quéré, Tim Lenton, Michael Mann, Ben McNeil, Andy Pitman, Stefan Rahmstorf, Eric Rignot, Hans Joachim Schellnhuber, Stephen Schneider, Steven Sherwood, Richard Somerville, Konrad Steffen, Eric Steig, Martin Visbeck, Andrew Weaver.

The purpose of this report is to synthesize the most policy-relevant climate science published since the close-off of material for the last IPCC report. The rationale is two-fold. Firstly, this report serves as an interim evaluation of the evolving science midway through an IPCC cycle – IPCC AR5 is not due for completion until 2013. Secondly, and most importantly, the report serves as a handbook of science updates that supplements the IPCC AR4 in time for Copenhagen in December, 2009, and any national or international climate change policy negotiations that follow. This report covers the Physical Science Basis evaluated by Working Group I of the IPCC. This includes:

1. an analysis of greenhouse gas emissions and their atmospheric concentrations, as well as the global carbon cycle;
2. coverage of the atmosphere, the land-surface, the oceans, and all of the major components of the cryosphere (land-ice, glaciers, ice shelves, sea-ice and permafrost);
3. paleoclimate, extreme events, sea level, future projections, abrupt change and tipping points;
4. separate boxes devoted to explaining some of the common misconceptions surrounding climate change science.

The report has been purposefully written with a target readership of policy-makers, stakeholders, the media and the broader public. Each section begins with a set of key points that summarises the main findings. The science contained in the report is based on the most credible and significant peer-reviewed literature available at the time of publication. The authors primarily comprise previous IPCC lead authors familiar with the rigor and completeness required for a scientific assessment of this nature (The Copenhagen Diagnosis: p. 5 Preface). The most significant recent climate change findings are:

1. Surging greenhouse gas emissions
2. Recent global temperatures demonstrate human-based warming
3. Acceleration of melting of ice-sheets, glaciers and ice-caps
4. Rapid Arctic sea-ice decline
5. Current sea-level rise underestimates
6. Sea-level prediction revised
7. Delay in action risks irreversible damage
8. The turning point must come soon

(The Copenhagen Diagnosis 2009 *Short Summary*)

Climate Change as a Security Risk (WGBU, 2007)

Authors: R. Schubert, H. J. Schellnhuber, N. Buchmann, A. Epiney, R. Grießhammer, M. Kulessa, D. Messner, S. Rahmstorf, J. Schmid

The report was published by the German Advisory Council on Global Change (WBGU), which is an independent, scientific advisory body to the German Federal Government set up in 1992 in the run-up to the Rio Earth Summit. The Council has nine members, appointed for a term of four years by the federal cabinet. The Council is supported by an interministerial committee of the federal government comprising representatives of all ministries and of the federal chancellery. The Council's principal task is to provide scientifically-based policy advice on global change issues to the German Federal Government. WBGU, 2007: preface).

The report summarizes the state-of-the-art science on the subject of "Climate Change as a Security Risk". It is based on the findings of research into environmental conflicts, the causes of war, and of climate impact research. It appraises past experience but also ventures to cast

a glance far into the future in order to assess the likely impacts of climate change on societies, nation-states, regions and the international system (WBGU, 2007: p.1).

“The core message of WBGU’s risk analysis is that without resolute counteraction, climate change will overstretch many societies’ adaptive capacities within the coming decades. This could result in destabilization and violence, jeopardizing national and international security to a new degree.” (ibid.)

A3.3 Key issues

(1) Where are the limits? The 2°C target

Discussion and research on boundaries, carrying capacity or limits of the Earth-System have a long tradition (e.g. Meadows et.al. 1972: “The limits to growth”). With “[a] safe operating space for humanity”, Rockström and colleagues (2009a) address this old and difficult question on the physical limits of the Earth in a new way. They present a new approach with the aim to identify biophysical preconditions for human (societal) development. They propose first quantifications on the safe limits outside of which the Earth-System cannot continue to function in the present stable state.

The so called 2°C target¹¹⁵, which was accepted by 16 industrial nations at the G8 summit in July 2009, stands in the context of this research. It means “containing the rise in global mean temperature to no more than 2 °C above the pre-industrial level” (ibid: p. 473). It is assumed that, if global warming could be kept within this limit, unacceptable climate change impacts could be avoided.

Planetary boundaries

„Now, largely because of a rapidly growing reliance on fossil fuels and industrialized forms of agriculture, human activities have reached a level that could damage the systems that keep the Earth in the desirable Holocene state. The result could be irreversible and, in some cases, abrupt environmental change, leading to a state less conducive to human development” (Rockström et al. 2009: p.472).

For the proposed concept so called planetary boundaries are defined, within which it can be expected that humanity can operate safely (Rockström et al. 2009b). These boundaries are

¹¹⁵ For scientific background information, refer to IPCC, 2007a,b,c. see also: Lenton et al. 2008, EU Climate Change Expert Group ‘EG Science’, 2008, Smith et al. 2009, Rockström et al., 2009, Rumors, 2010; Pilinszky, 2003)

closely associated with the planet's major biophysical processes and ecological subsystems. Nine such Earth-System processes and associated thresholds are identified, which if crossed, could generate unacceptable, in some cases irreversible, even abrupt environmental changes (see next section “tipping points”). The thresholds for different Earth-System processes are defined by critical values for one or more control variables. Rockström et al. propose to quantify seven of them.¹¹⁶ Table A3.1 shows identified Earth-system processes¹¹⁷ with their respective values for the proposed current boundary, pre-industrial and current status. The analysis suggests that boundaries in three processes have already been exceeded, which is depicted in figure A3.1. They are climate change, human interference with the nitrogen cycle and the rate of biodiversity loss. Furthermore, boundaries for global freshwater use, change in land use, ocean acidification and interference with the global phosphorous cycle may be approached soon. The authors stress that the individual processes are interconnected and tightly coupled. Consequently, this means if one boundary is crossed – which is already the case according to Rockström et al. – other processes and their respective boundaries are under serious risk, too.

¹¹⁶ For methodological details refer to Rockström et al. 2009a, 2009b

¹¹⁷ Two of them have not been determined yet.

PLANETARY BOUNDARIES				
Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1-1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N ₂ removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5-9.5	-1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km ³ per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis	To be determined		
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of Earth system thereof	To be determined		

Table A3.1: Planetary boundaries of major Earth-System processes - Boundaries in red have been crossed already (Source: Rockström et al., 2009: p.473)

In regard to climate change, the current atmospheric CO₂ concentrations are at 387 ppm¹¹⁸, which is about 100 ppm above the pre-industrial level (the change in radiative forcing is 1.5 W m²). The suggested critical threshold lies between 350 ppm and 550 ppm. The proposed boundary of 350 ppm “aims to ensure the continued existence of the large polar ice sheets” (Rockström et al., 2009a, 2009b). It is anticipated¹¹⁹, that global warming can be restricted to a maximum of 2 °C above pre-industrial levels, if the emission concentration can be kept below 450ppm CO₂ eq. (CO₂ equivalents). Given the already transgressed “climate change”

¹¹⁸ parts per million (10⁻⁶)

¹¹⁹ Recent evidence shows that cumulative budgets of CO₂ are a robust indicator for the expected warming (Weisz and Lucht, 2009 cf. Allen et al., 2009; Meinshausen, et al. 2009).

boundary and the interconnection with other Earth-System processes, the authors emphasize however, “ [...] that significant risks of deleterious climate impacts for society and the environment have to be faced even if the 2°C line can be held” (Rockström et al. 2009b cf. Richardson et al. 2009).

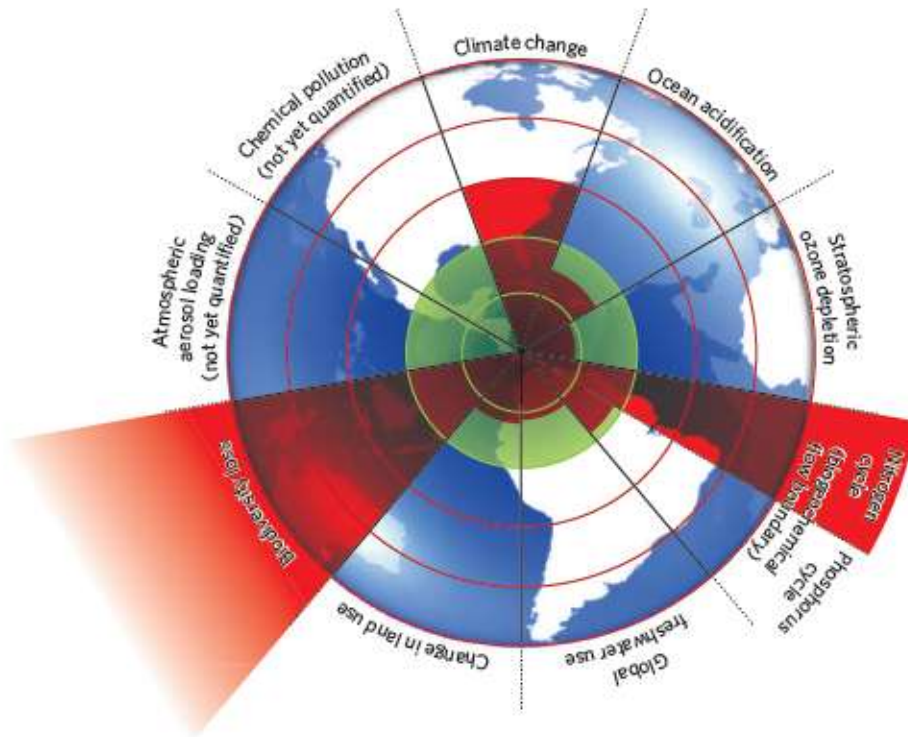


Figure A3.1: Beyond the boundary: The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded. (Source: Rockström et al. 2009: p.472)

There is increasing evidence, that some subsystems of the Earth-systems are already moving outside their stable states. The rapid declines in ice masses, observed sea level rise and their consequences are under serious concern.

(2) Transgressing the limits – tipping points of the Earth-System

In the event of global warming beyond 2–3 °C, the risk of qualitative (non-linear) changes - with far reaching unpredictable consequences - occurring in the climate system (in addition to gradual climate change) increases (WBGU 2007).

A short introduction to a highly complex issue

“At a particular moment in time, a small change can have large, long-term consequences for a system” (Lenton et al. 2008: 1786)

In chaos theory the term *tipping point*¹²⁰ refers to the behavior of high complex, dynamic systems. It is used to denote “a critical threshold at which a tiny perturbation can qualitatively alter the state or development of a system.” (ibid. p. 1786). The outcome of the development is not predictable. This is a specific characteristic of chaotic systems: small differences¹²¹ in initial conditions yield widely diverging outcomes. After the tipping point has been passed, a transition to a new state occurs (ibid.). Chaotic behavior can be observed in many natural systems, such as the climate.

Worryingly, “[h]uman activities may have the potential to push components of the Earth-system past critical states into qualitatively different modes of operation, implying large-scale impacts on human and ecological systems” (ibid. p. 1786). Lenton and colleagues therefore identified tipping elements of the Earth’s climate system¹²² “to describe subsystems of the Earth system (at least sub continental in scale) which can be switched – under certain circumstances – into a qualitatively different state by small perturbations.” (ibid. p. 1786). A tipping point, defined as “[...] the corresponding critical point - and a feature of the system – at which the future state of the system is qualitatively altered.” (ibid. 1786), is the point where a small increase in temperature or other change in the climate could trigger a disproportionately larger change in the future. This could lead to sudden and irrevocable changes in the climate, almost without warning (ibid.). Moreover, the authors warn, that

¹²⁰ The notion became popular by Gladwell’s book: *How Little Things Can Make a Big Difference* (Gladwell, 2000).

¹²¹ These differences cannot be calculated even if all system factors were known.

¹²² The study was undertaken by means of predicative models in combination with paleo-data and historical data. The focus was on policy-relevant potential future tipping elements, which resulted in a short list of tipping elements (a long list of about 100 candidates was considered). For methodological details refer to Lenton et al., 2009.

climate change could result in sudden and dramatic changes, if global average temperatures continue to rise.

Identified policy-relevant tipping elements

Figure A3.2 shows potential policy-relevant tipping elements in the climate system globally. The probably greatest threats (in terms of impact and likelihood) are a tipping of the Arctic sea-ice and the Greenland ice sheet. Six other tipping elements include the West Antarctic ice-sheet collapse, West African Monsoon shift and irreversible dieback of Amazon Rainforest (which could fundamentally alter agricultural production in Asia and Latin America, WBGU, 2007: p. 75) as well as the collapse of the Atlantic Thermohaline Circulation THC - probably the best known example.. For two elements the status as tipping elements is particularly uncertain (indicated by question marks): Permafrost¹²³ and Trundra loss and Climatic-Changed induced Ozone hole.

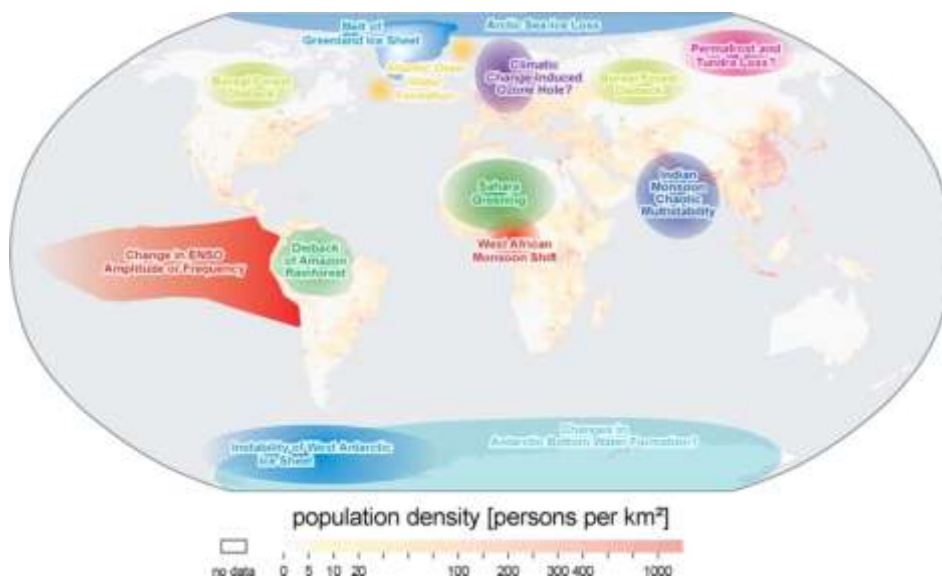


Figure A3.2: Map of potential policy-relevant tipping elements in the climate system and on global population density (Source: Lenton et al., 2009:p.1787 updated from updated from Schellnhuber and Held, 2002)

Subsystems indicated could exhibit threshold-type behavior in response to anthropogenic climate forcing, where a small perturbation at a critical point qualitatively alters the future fate of the system. They could be triggered this century and would undergo a qualitative change within this millennium. Systems are

¹²³ Permafrost refers to permanently frozen ground, which contains a large potential source of GHG (CO₂ and CH₄) that would amplify atmospheric concentrations if released.

excluded from the map in which any threshold appears inaccessible this century (e.g., East Antarctic Ice Sheet) or the qualitative change would appear beyond this millennium. Question marks indicate systems whose status as tipping elements is particularly uncertain.

Those 8 elements are positioned in a matrix according to their relative likelihood of occurrence and relative impact (risk)¹²⁴ (figure A3.3). Moreover it is stressed “[...] that most tipping point impacts would be high if placed on an absolute scale, compared with other climate eventualities.” (Lenton, 2011, p. 207). Most and probably all of these tipping elements are likely to be irreversible on a human timescale once they pass a certain threshold of change, and it is assumed, that the widespread effects of the climatic transition to the new state will be felt for generations to come.

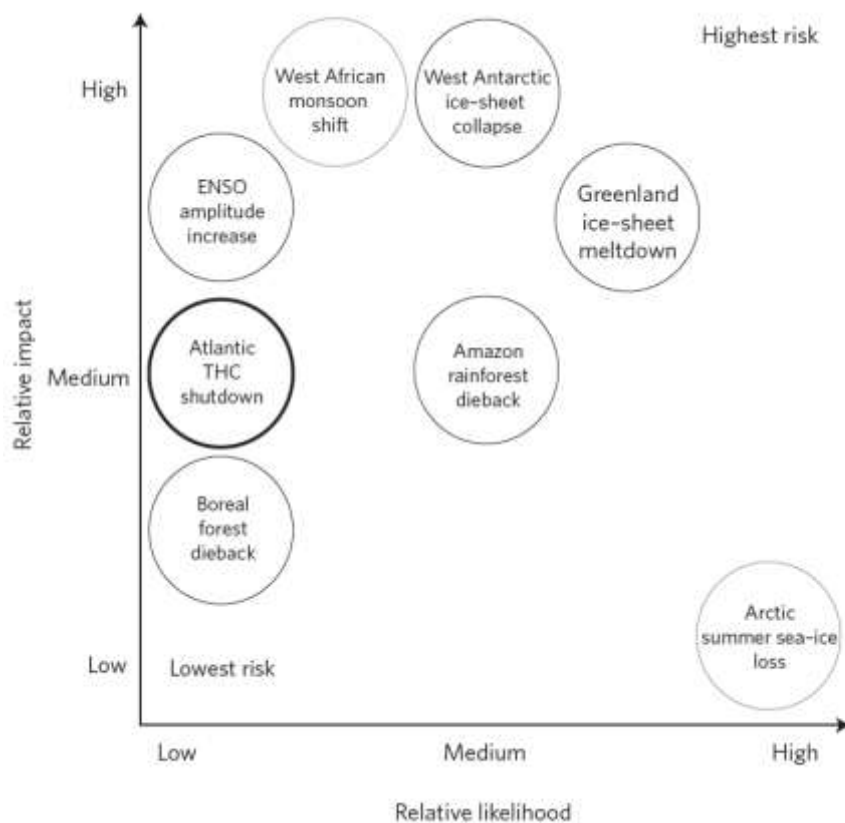


Figure A3.3: Risk matrix for climate tipping points - likelihood and relative impact (Source: Lenton, 2011: p. 207)

¹²⁴ The impacts are considered on the “full ethical time horizon of 1000 years” (for details see Lenton et al. 2009).

Arctic sea ice loss is declining faster as predicted by IPCC. The transition time is short (about 10 years). It is discussed, whether it is passing a tipping point already. Melting would lead to a sea level rise of 0,5 m or more.¹²⁵ It's decline is described below in more detail.

Melting of the Greenland Ice Sheet: Total melting could take 300 years or more, however the tipping point for irreversible change might occur within the next 50 years. It is estimated that melting would induce a sea-level rise between 2-7 m.

Impairment of the Atlantic Thermohaline Circulation (THC, Atlantic Deep Water Formation) has been discussed seriously¹²⁶. A major weakening, slowing or abrupt collapse of the THC¹²⁷ could have serious and unforeseeable consequences for North America and Europe as well as "global consequences for habitats and markets" (WBGU, 2007: p.75). According to the latest models, it seems unlikely to happen within this century, however (Formayer, 2011).

(3) Projections of gradual and very likely climate change: temperature and precipitation

This section reflects on climate system developments that are largely continuous and predictable and that have a high or extremely high likelihood of occurring. The development of the global temperature is foreseeable up to 2030. It is very likely to be in the range of + 0.4 to 0.6 ° C compared to 2005, irrespective of the emission scenario, because of the time lag between cause (emissions) and effect (warming) in the climate system. In the longer term (beyond 2050) temperature increases depend to a large extent on which emissions scenario is applied (WBGU 2007:p. 55). Projections on precipitation changes are less robust however.

Temperature

Important scientific insights in climate change research are no longer in doubt: (1) climate change is happening, (2) global warming is directly attributable to past emission of carbon dioxide and other greenhouse gases (GHG) since the beginning of the industrial revolution and (3) it will continue to have far-reaching consequences for human and natural systems.

¹²⁵ This is explained by a positive feedback concerning the Earth's albedo (reflection of sunlight). Ice and snow reflect most of the sun's radiation (ice-albedo positive feedback) while water and soil absorb it. Sea-ice melting amplifies the warming and thus the thermal expansion of oceans.

¹²⁶ See the so called and heavily criticized "Pentagon report" (Schwartz and Randall 2003).

¹²⁷ The Gulf Stream is the North Atlantic arm of the global THC and has an important influence on the climate in Western and Northern Europe as temperatures would drop dramatically without it.

IPCC AR4 concludes: “Warming of the climate is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global sea level” (IPCC, 2007a: p. 30). Figure A3.4. shows corresponding historical trends up to 2006. It presented “an unambiguous picture of the ongoing warming of the climate system.” According to recent observation the warming trend continues to climb (Allison et al., 2009).

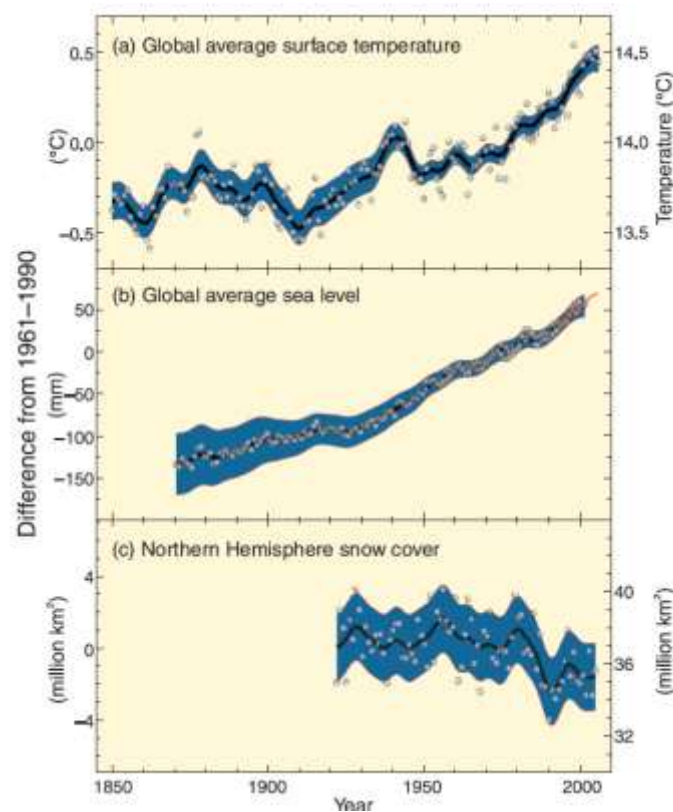


Figure A3.4: Observed changes in temperature, sea level and Northern Hemisphere snow cover. Differences are relative to corresponding averages for the period 1961-1990 (Source: IPCC 2007a: p. 31)

Mann et al. (2008) reconstructed trends in global and hemispheric surface temperature over the last 2000 years. Figure A.3.5 illustrates the development of surface temperature in the Northern Hemisphere, which leads to the conclusion, that recent temperature increases in this world region are likely anomalous in a long-term context (Allison et al., 2009 cf. Mann et al., 2008).

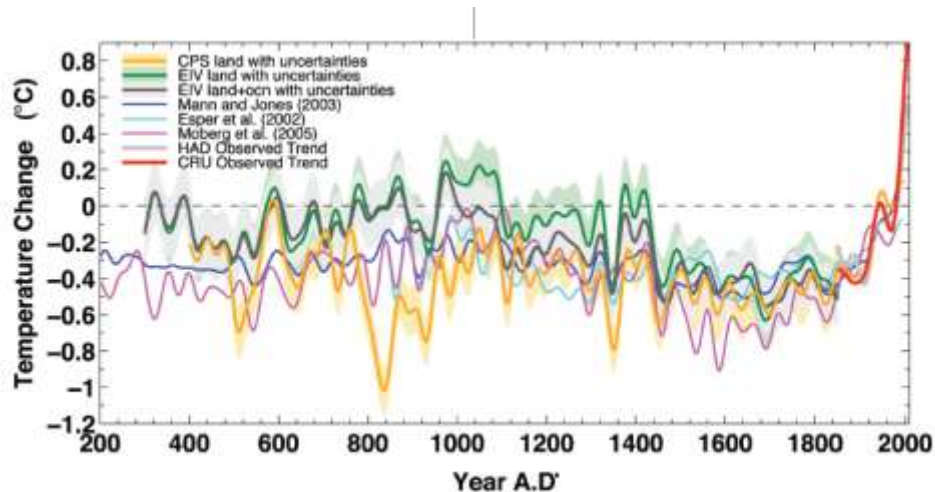


Figure A3.5: Comparison of various Northern Hemisphere temperature reconstructions (Source: Allison et al., 2009 cf Mann et al., 2008)

The three last decades were the warmest on record, with each of the three decade previous to that warmer than the decade before. 2005 and 2010 were globally the warmest years since instrumental records began (IISS, 2011: p.4, see also EEA, 2010b, Allison et al., 2009). The global mean temperature in 2009 was between 0.7 and 0.8 °C higher than in pre-industrial times. Moreover, the European climate has warmed more than the global average (the annual average temperature for the European land area was 1.3 °C above the 1850–1899 average) (EEA, 2010b: p.4)

The wide range of projected of global mean air temperature up to 2100 is mainly due to uncertainties in future GHG emissions. In the “business as usual” scenario (A1FI scenario, at the high end of emissions) global mean warming is projected to reach 4-7 °C by 2100. At the lower end of emissions (B1 scenario¹²⁸) it is projected to reach 2-3°C by the end of the century. Details are presented in figure A3.6, which includes the results of other emission scenarios as well as a reconstruction on historical warming¹²⁹ (Allison et al., 2009).

¹²⁸ The B1 scenario “[...] would require urgent, deep and long-lasting cuts in fossil fuel use [...]”. (Allison et al. 2009: p. 50)

¹²⁹ For details on the different IPCC scenarios refer to IPCC, 2007a: p. 44.

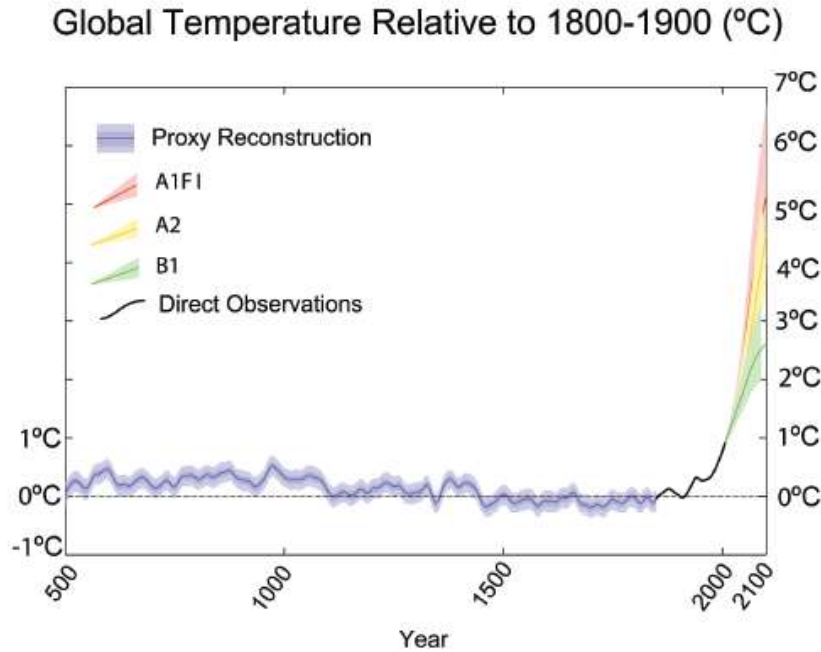


Figure A3.6: Reconstructed global-average temperature relative to 1800-1900 and projected global-average temperature out to 2100. The projections refer to B1, A2, A1FI IPCC scenarios (Source: Allison et al. 2009: p.50 (cf. Mann et al. 2008, the letter from IPCC AR4))

Furthermore, “The development of the global temperature up to 2030 is foreseeable: the rise in temperature compared to 2005 will very likely be in the range of 0.4–0.6 °C, irrespective of the emissions scenario assumed” (WBGU, 2007:p. 55). This is due to inertia of the climate and the atmospheric lifetime of GHG. CO₂ concentration, temperature, and sea level rise continue to rise long after emissions are reduced. Time periods can reach up to several millennia as it is the case with sea level rise due to ice melting (see figure A3.9). This means, even if greenhouse gas concentrations had been stabilised in the year 2000, temperature would still increase by 1.2°C above the pre-industrial level by the end of the 21st century (EEA, 2010a; b)

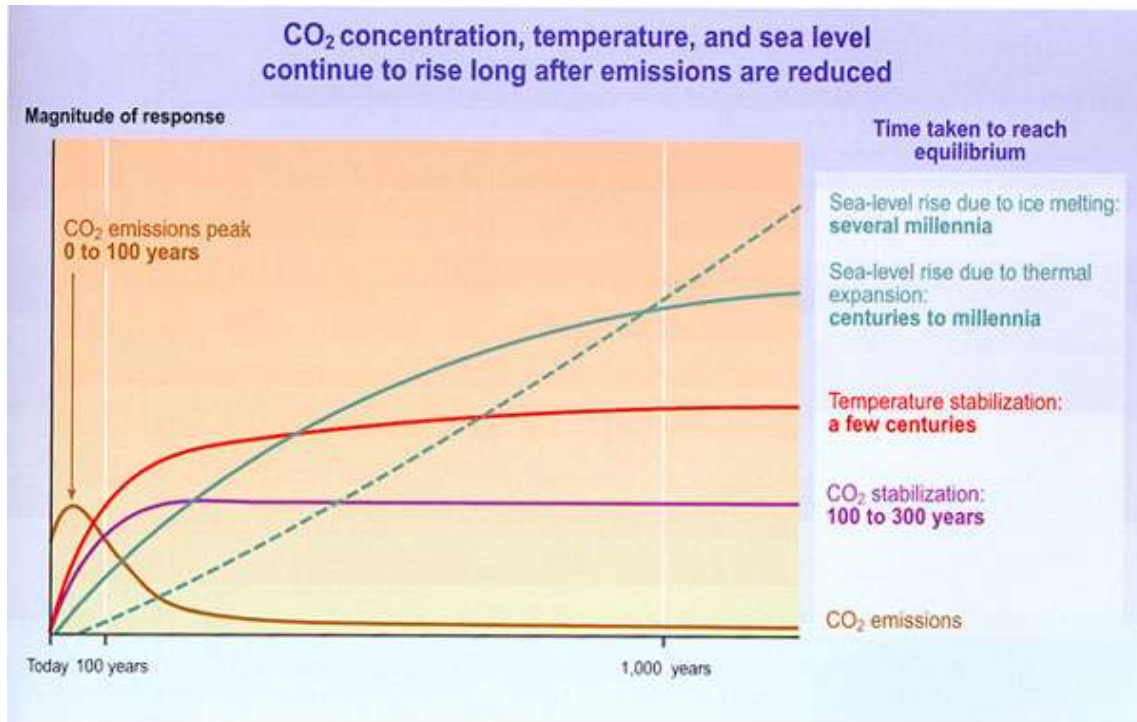


Figure A3.9: Inertia of the climate - characteristic time scales of some key processes (Source: IPCC 2007)

Additionally, the WBGU stresses that „There will be considerable regional variation in warming compared to the global trend, as indeed is already the case.” (WBGU, 2007: p.56 and figures A3.7 and A3.8). This is due to two effects: “First, the continents are up faster than the global mean (in some regions up to twice as fast, due to the moderating effect of the oceans). Second, higher-latitude regions are warming up especially quickly because shrinking snow and ice cover leads to increased absorption of solar radiation. As a result, people in two regions in particular are starkly affected by the direct increase in mean temperatures: the northern Polar regions (Alaska, Siberia), due to the particularly rapid rise in temperatures and its impact on permafrost soils and infrastructure; and the tropical climate zones, due to the fact that temperatures there are already high to start with.” (ibid.).

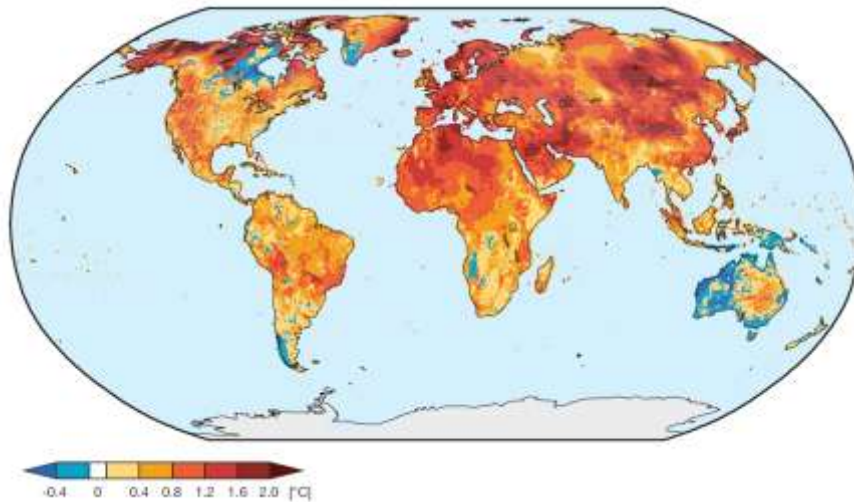


Figure A3.7: Linear temperature trend from measurements on land in the period 1975-2004 (Source: WGBU, 2007:p. 57; data: Potsdam Institute for Climate Impact Research (PIK) climate database)

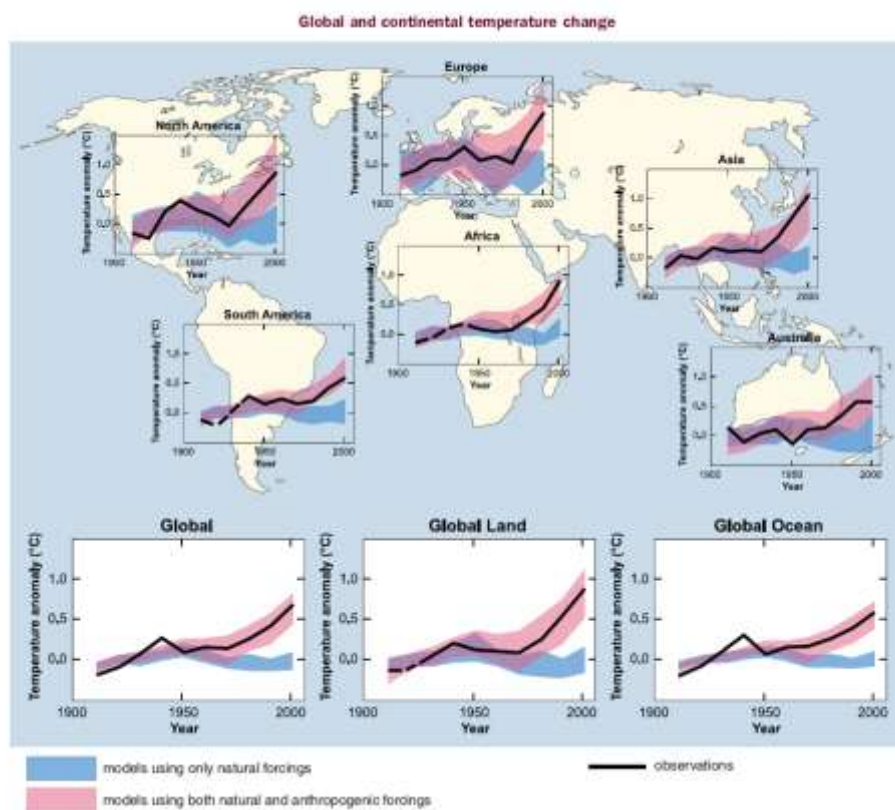


Figure A3.8: Comparison of observed continental- and global scale changes in surface temperature. Results simulated by models using either natural or both natural and anthropogenic forcing. Decadal averages of observations are shown for the period 1906-2005 (black line) plotted against the center of the decade and relative to the corresponding average for the 1901-1950 (Source: IPCC; 2007a: p. 40)

Precipitation

Globally average rainfall increases along with rising temperatures due to higher evaporation and growing quantities of water in the atmosphere. According to IPCC (2007) this equals 7% more water in the atmosphere and a 1-2% increase of rainfall (globally averaged) for every degree of warming (WBGU, 2007: p. 57 cf IPCC, 2007). However, there will be considerable regional variation compared to the global trend. These differences are related to the characteristics of the water cycle¹³⁰, which are altered and amplified by global warming. This results in increased evaporation in the subtropics and to heavier precipitation in the medium and higher latitudes (on average). These effects of global warming are already observable today: Arid areas have become drier in recent decades. It should be stressed however, that these trends can sometimes also be related to human interventions at regional level (ibid.).

Scenarios on future global precipitation patterns predict that high rainfall regions in the tropical belt and the middle to high latitudes will become more humid overall, while the arid regions of the subtropics will become drier. Projections show that the Mediterranean regions and Southern Africa could suffer from increasing aridity (WBGU, 2007:p. 58-59). These projections are less robust than those on temperature developments. Recent observation shows that changes in precipitation have occurred faster than predicted by some models, which could indicate that future changes will be more severe than predicted (Allison et al., 2009: p. 15).

(4) Melting of ice masses

Acceleration of melting of ice-sheets, glaciers and ice-caps

There is widespread evidence that both the Greenland and Antarctic ice-sheets, maintaining the largest ice reservoirs on land¹³¹, are losing mass at an increasing rate. Furthermore, melting of glaciers and ice-caps in other parts of the world has also accelerated since 1990 (Allison et al. 2009, WBGU 2007).

¹³⁰ One important aspect is the monsoon circulation. In some countries such as India and China agriculture and food security strongly depend on the monsoon rainfalls (WBGU, 2007).

¹³¹ The ice maintained equates to a sea-level of approx. 7m (Greenland ice) and approx. 6m (West Antarctic ice sheet) (WBGU, 2007).

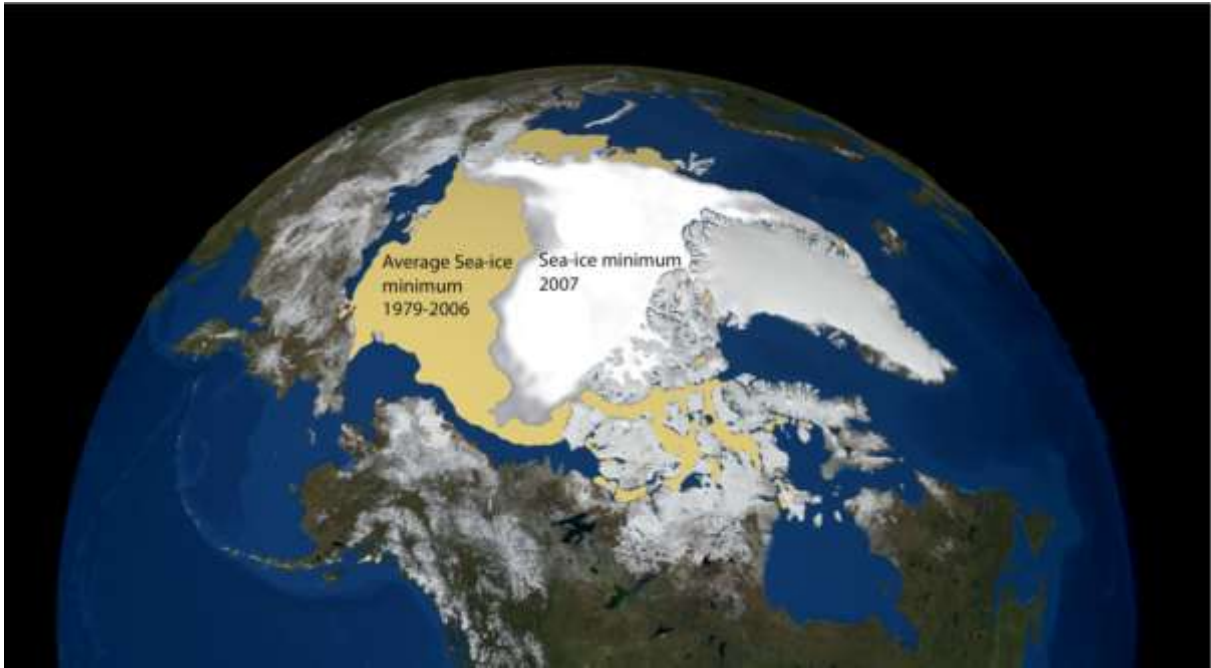
Arctic sea ice decline

Figure A3.10: Arctic summer sea ice retreat 1979-2007.

Arctic sea ice extent September 2007 compared to the average sea-ice minimum extent for the period 1979- 2006. (Source: Allison et al., 2009: p. 29; sourced from the NASA/Goddard Space Flight Center Scientific Visualization Studio)

According to recent observations, summer-time melting of Arctic sea-ice has far exceeded the worst-case projections from climate models of IPCC AR4 as shown in figure A3.10 and figure A3.11 (Allison et al. 2009). According to Allison and colleagues this rapid decline is “Perhaps the most stunning observational change since the IPCC” (ibid. p.29). They state that winter Arctic sea ice extent has also decreased, but at a slower rate (ibid.).

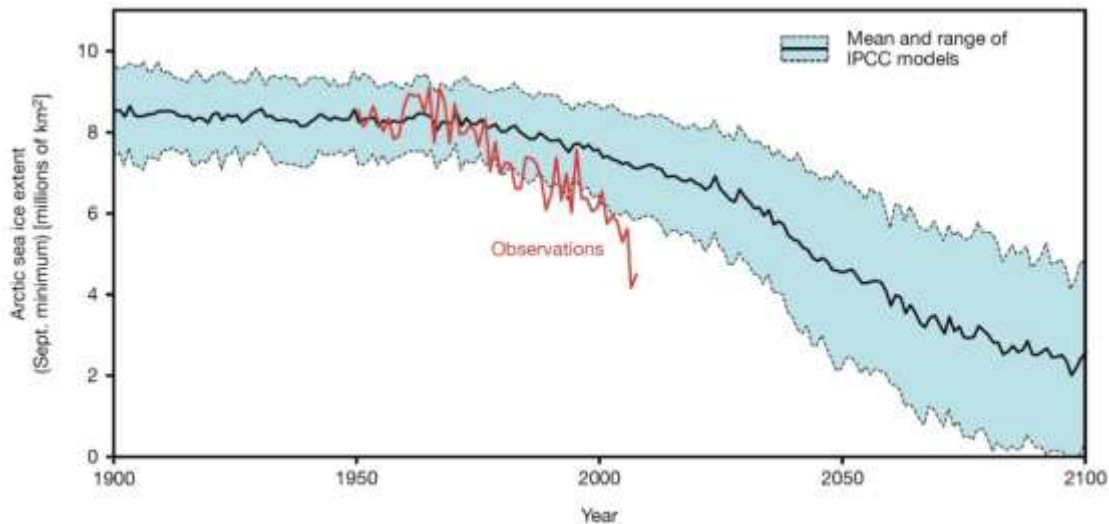


Figure A3.11: Observed and modelled Arctic summer sea ice extent. The Observed (red line) and modelled September Arctic sea ice extent in millions of square kilometers. The solid black line gives the ensemble mean of the 13 IPCC AR4 models while the dashed black lines represent their range. From Stroeve et al. (2007) updated to include data for 2008. The 2009 minimum has recently been calculated at 5.10 million km², the third lowest year on record, and still well below the IPCC worst case scenario. (Source: Allison et al. 2009: p. 30)

(5) Sea level rise

Sea-level rise has been observed as a “modern phenomenon” (IPCC 2007b). It is regarded as the greatest potential risk in the long term¹³². In the 20th century sea level rose 15-20 cm on average, this is due to the warming of the oceans and their subsequent thermal expansion as well as due to input of melt water. The level of uncertainty concerning the contribution of melting of continental ice masses to future sea-level rise is high, however (WBGU, 2007).

Based on recent research Allison and colleagues conclude, that current sea-level rise was underestimated by past IPCC predictions¹³³. Satellites show a global average sea-level rise of 3.4 mm/year over the past 15 years (Rahmstorf, 2007). “This acceleration in sea-level rise is consistent with a doubling in contribution from melting of glaciers, ice caps and the Greenland and West-Antarctic ice-sheets.” (Allison et al., 2009: p. 7). For the future warming scenarios of the IPCC, this results in a projected global sea-level rise of 0.5 to 1.4 meters in 2111 above the 1990 level (Rahmstorf, 2007: p. 368).

¹³² “[...] because the quantities of water contained in the continental ice masses could cause the sea level to rise up to 70m.” (WBGU, 2007:p. 63).

¹³³ Expected global sea-level rise without mitigation, according to IPCC 2007: around half a meter by the year 2100.

According to latest research best estimates range between ca. 1.0 and 1.4 meters from 1990-2100, depending on the emission scenario (see figure A3.12).

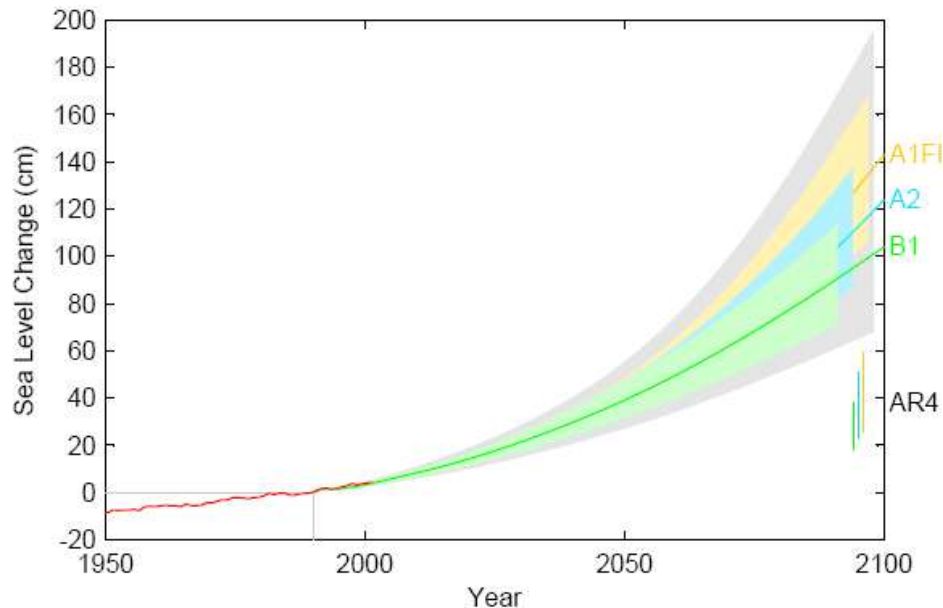


Figure A3.12: Future sea level rise. Future sea level rise primarily depends on our future greenhouse gas emissions. Depending on the emissions scenario (B1, A2, A1FI) the best estimates range between ca. 1.0 and 1.4 meters from 1990-2100. This is significantly more than corresponding estimates of the 2007 IPCC report ("AR4"). The red line shows tide gauge data (Church & White 2006). Graphs: Vermeer & Rahmstorf, 2009. Source: PIK <http://www.pik-potsdam.de/sealevel/> (accessed, December 20, 2011)

In the future sea level rise could threaten coastal cities and regions. Regions with high population density and concentration of assets and critical infrastructure **will particularly be** endangered. According to WBGU, 10–23% of the world's population live in the vicinity of the coast, i.e. within 100km of the coast and less than 100m above sea level at present time (WBGU, 2007). The number of people living in these areas is expected to rise in the future (IPCC, 2007b).

(4) Climate extremes

According to IPCC, the notion of *climate extremes*¹³⁴ refers to “extreme weather and climate events” (IPCC 2011: p.1). “There is evidence from observations gathered since 1950 of change in some extremes.” (ibid. p. 5).

Climate change will increase the frequency or severity of extreme events such as heavy rains, drought, heat waves and storms and tropical cyclones (also in extra tropical regions). These developments are largely continuous and predictable and have a high or extremely high likelihood of occurring, even if global warming could be kept below 2°C. Major warming will cause even more frequent and more severe extreme weather events (WBGU, 2007). “These direct impacts of climate change will have far-reaching effects upon societies and the lives of people around the world.” (ibid. p. 1). Regarding the impacts on societies, it must be borne in mind that “The character and severity of impacts from climate extremes depend not only on the extremes themselves but also on exposure and vulnerability¹³⁵.” (IPCC, 2011: p.1)¹³⁶

Allison and colleagues summarize the most significant recent findings on extreme events (Allison et al. 2009: p.15):

- Increases in hot extremes and decreases in cold extremes have continued and are expected to amplify further.
- Further increases in precipitation extremes, both increases in heavy precipitation and increases in drought are to be expected.
- Although future changes in tropical cyclone activity cannot yet be modeled, new analyses of observational data confirm that the intensity of tropical cyclones has increased in the past three decades in line with rising tropical ocean temperatures.

The IPCC AR4 concludes, that many changes in extremes had been observed since the 1970s as part of the warming of the climate system. These include more frequent hot days, hot nights and heat waves; fewer cold days, cold nights and frosts; more frequent heavy

¹³⁴ Defined by IPCC as “The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as “climate extremes.” (IPCC, 2011: p.2)

¹³⁵ "Vulnerability is a function of exposure to climatic factors, sensitivity to change and the capacity to adapt to that change. Systems that are highly exposed, sensitive and less able to adapt are vulnerable" (Allen Consulting, 2005: 159pp)

¹³⁶ Exposure and vulnerability, defined as potential impact, determine the adaptive capacity of a (social) system. For details refer to Füssel, 2007.

precipitation events; more intense and longer droughts over wider areas; and an increase in intense tropical cyclone activity in the North Atlantic, but no trend in total numbers of tropical cyclones (Allison et al. 2009: p. 15). Other weather extremes include severe thunderstorms (increased frequency have been observed in some regions) and wildfires in many regions with Mediterranean climates (e.g. Spain, Greece, southern California, south-east Australia). Moreover, further increases are expected in terms of frequency and intensity (Allison et al. 2007: p. 17).

Temperature extremes and heat waves

Increases in hot extremes (and decreases in cold extremes) have continued and are expected to amplify further in most areas across the globe due to further anthropogenic climate change (ibid., WBGU 2007). “Recent studies have confirmed the observed trends [...] and [have] shown that these are consistent with the expected response to increasing greenhouse gases and anthropogenic aerosols at large spatial scales.” (Allison et al. 2007). WBGU stresses that “Heat waves can have devastating consequences even in temperate zones and affluent countries, if society is ill-prepared to deal with them.” (WBGU, 2007: p. 56).¹³⁷ According to Munic RE, the heat wave in Europe in 2003 was “the biggest natural disaster that has occurred in central Europe in living memory.” (WBGU, 2007 cf. Munic RE, 2004). It is expected that in 2050 heat waves will have become the norm (WBGU, 2007 cf. Schär et al., 2004).

Precipitation extremes and drought

Recent research found that rains become more intense in already-rainy areas as atmospheric water vapour content increases (Allison et al. 2007: 15). “However, recent changes have occurred faster than predicted by some climate models, raising the possibility that future changes will be more severe than predicted.” (ibid.) Consequently, climate change will increase the risk of floods and storms damages. According to WBGU, this is due to anticipated increases in intense precipitation events, and higher-intensity tropical cyclones (see below), as well as sea-level rise (see above) (WBGU, 2007: p. 69). In addition, increases in droughts have been observed since the 1970s (Allison et al. 2009).

Overall further increases in precipitation extremes, both increases in very heavy precipitation in wet areas and increases in drought in dry areas are expected (ibid., WBGU 2007). Based on

¹³⁷ For instance, Germany saw the biggest losses in terms of wheat yield since at least 1960 during the heat wave in Europe 2003 (WBGU, 2007).

current studies, Allison and colleagues suggest “that heavy precipitation rates may increase by 5% - 10% per °C of warming, similar to the rate of increase of atmospheric water vapour” (Allison 2009: p. 17)

Tropical cyclones

According to IPCC it is likely that tropical cyclones will become more intense, which is associated with increases of tropical oceans temperatures (IPCC 2007a: p. 46). New analyses and recent observations confirm that the intensity of tropical cyclones has increased in line with the rising ocean temperature (Allison et al. 2009). This would threaten the regions already endangered by hurricanes, such as the Caribbean and the coastal areas of China and would have severe consequences for the socio-economic development of the affected countries. Furthermore, the areas at risk could expand towards the poles and directly affect Europe (WBGU 2007: p. 60).¹³⁸

(7) Impacts at different levels of warming

Major global warming could trigger considerable changes in natural systems i.e. shifts of the distribution of most plants and animals, melting of ice masses (as described above) or even inducing the complete melting of the Greenland ice sheet. These effects begin to occur even in “moderate” scenarios (3 °C global mean temperature rise) – higher temperature means that these effects occur more rapidly and with greater certainty (WBGU, 2007). “Carbon emissions during the future decades will essentially determine the magnitude of eventual impacts and whether the [so called] Anthropocene¹³⁹ is a short-term, relatively minor change from the current climate or an extreme deviation that lasts thousands of years. The higher the total, or cumulative, carbon dioxide emitted and the resulting atmospheric concentration, the higher the peak warming that will be experienced and the longer the duration of that warming.” (National Research Council of the National Academies 2011: p.4).

It is beyond doubt that climate change will lead to severe implications for natural as well as socio-economic systems (e.g. EEA 2010b). As aforementioned, it has to be stressed that the severity of impacts highly depends on the adaptive capacity of the affected (social) systems. Poorer regions of the world are expected to be hit hardest by its impacts due to their limited

¹³⁸ In 2005 two tropical storms reached reached Spain and Canary Island.

¹³⁹ According to the National Research Council of the National Academies the the Anthropocene is described as “a new geologic epoch[...] in which human activities will largely control the evolution of Earth’s environment.” (2011: p.4).

adaptive capacities. However, even wealthy states will be affected indirectly in terms of spreading risks such as triggered migration due to environmental and social crisis (e.g. WBGU, 2007).

Figure A3.13 provides an overview of which impacts can be expected per degree of warming in terms of several anticipated effects and impacts of global warming, including changes in stream flow, wildfires, crop productivity, extreme hot summers, and sea level rise (National Research Council of the National Academies 2011: p.8).

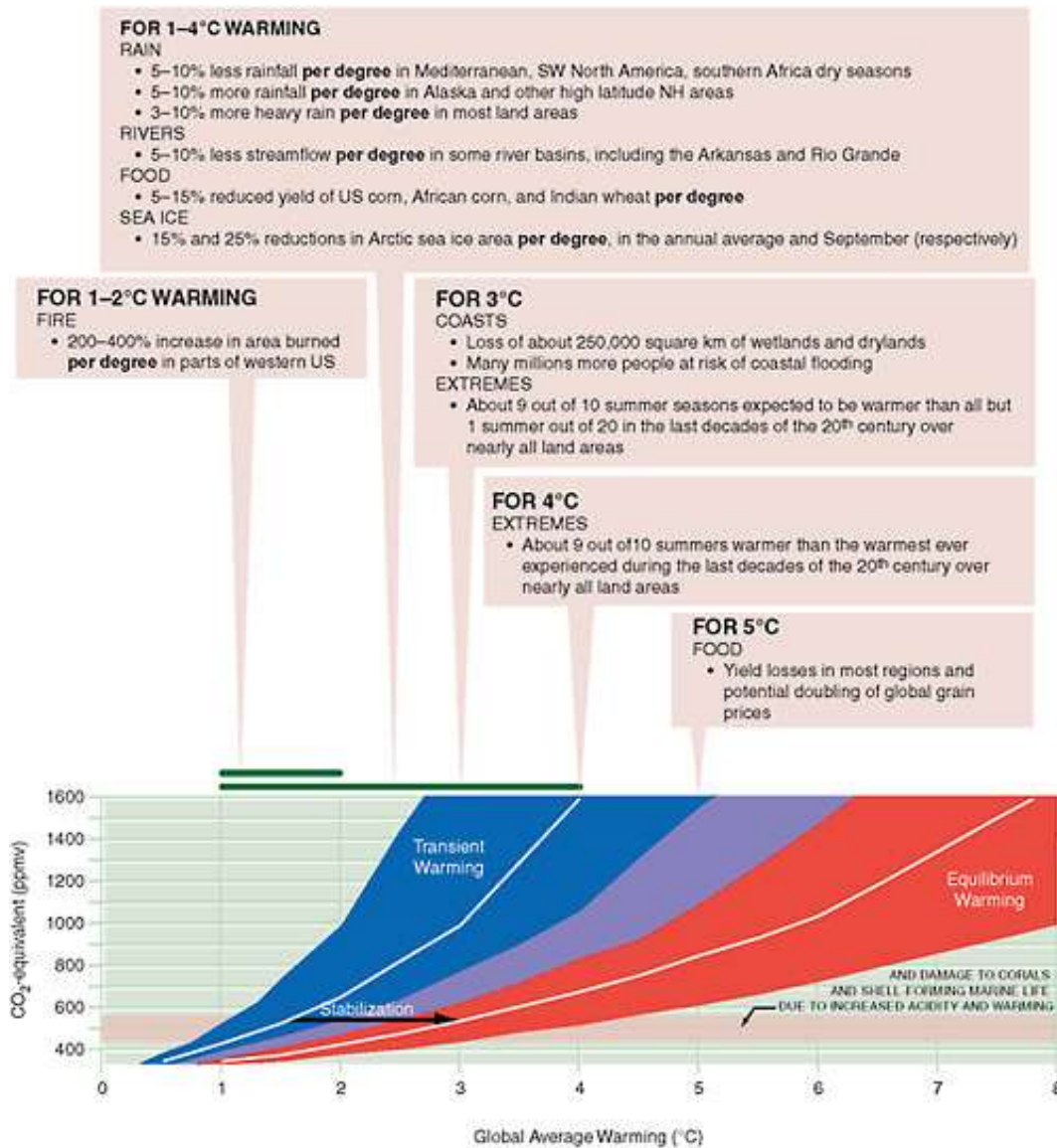


Figure A3.13: What impacts can be expected at different levels of warming. Several anticipated effects and impacts of global warming, including changes in stream flow, wildfires, crop productivity, extreme hot summers, and sea level rise are quantified - per degree of warming. The graphical part of the diagram shows how atmospheric concentrations of carbon dioxide correspond to temperatures—transient, or near-term warming (in blue), is only a fraction of the total warming (the equilibrium warming) expected to occur (in red). Source: National Research Council of the National Academies, 2011: p.8

(8) **Future impacts of climate change across Europe** Europe will be faced with increased risk of inland flash floods; more frequent coastal flooding and increased erosion from storms and sea level rise; glacial retreat in mountainous areas; reduced snow cover; increased aridity across southern Europe, as stated by IISS in a recently published report to the European Commission (IISS, 2011: p. 15).

Figure A3.14 gives more detailed insights into main past and projected impacts across Europe, as described by European Environment Agency (EEA). It distinguishes between seven main biogeographical regions within Europe (EU member countries).



Figure A3.14: Key past and projected impacts and effects of climate change for the main biogeographical regions of Europe

Source: EEA based on IPCC 2007 www.eea.europa.eu/data-and-maps/figures/key-past-and-projected-impacts-and-effects-on-sectors-for-the-main-biogeographic-regions-of-europe-1 (accessed, October 27, 2011)

According to Behrens and colleagues¹⁴⁰, Europe will be forced to confront impacts of climate change as weather-related disasters and extreme events such as storms, hurricanes, floods, draughts and heat waves. In this context, they remark that the aforementioned impacts will affect various regions differently. For instance, Northern Europe could even experience some positive effects, while Mediterranean countries are expected to suffer most. However, it is stressed that a lot of uncertainty about local and regional effects still remain (Behrens et al. 2010). The main findings of this study are: Northern Europe will be confronted with severe negative consequences in terms of more frequent extreme weather events. Furthermore this region could also benefit from higher crop yields, expansion of forest areas, enhanced forest-growth rates, and an increasing number of tourists (ibid. p.15). The Mediterranean countries will be hit hardest as their agricultural sector is very important in terms of GDP and employment. Therefore, those countries will experience the most negative development of natural conditions for crop cultivation (i.e. temperature increases, water scarcity, draughts, occasional flash floods and more forest fires) along with higher economic losses. In this context, the text describes Greece, Portugal and Spain as “particular hot spots, which are likely to suffer from water scarcity and loss of agricultural yields owing to desertification.” (ibid.p.5 cf. EEA 2008). Similar to global developments, poorer countries of Europe are expected to suffer most. Despite this, wealthier regions in northern Europe will face pressure in terms of increasing risks of conflicts and migration (ibid.)

As aforementioned climate extremes in the form of heat waves have special significance (see section above). Referring to WBGU, “The European heatwave in the summer of 2003 cost the lives of between 30,000 and 50,000 people.” This heat wave was “the biggest natural disaster to have occurred in central Europe in living memory” (WBGU, 2007: p. 57 cf. Munic RE 2004). Around 2050 it is expected that high summer temperatures such as those experienced in 2003 will have become the norm.¹⁴¹

(9) Climate impacts as a security risk

Within the international security community it is widely accepted that (anthropogenic) climate change is happening. Furthermore, climate change is regarded as a major potential

¹⁴⁰ Different effects of climate change on 11 indicator categories were analysed by distinguishing among 3 large European geographical regions: northern Europe, Central and Eastern Europe and the Mediterranean countries according to 11 indicator categories, comprising so called “climate change impacts indicators”. For details refer to Behrens et al., 2010: p. 2).

¹⁴¹ The recently published SREX report (IPCC 2011) gives detailed insights into the likelihood of impacts of heat waves in urban areas in Europe

security threat as existing environmental threats are exacerbated and concomitant social conflicts are reinforced. Accordingly, Ahmed considers that: “[w]ithout resolute counteraction, climate change will overstretch many societies’ adaptive capacities within the coming decades.” (Ahmed 2010, p.15) He also points out that “there is now overwhelming evidence that the greatest danger to civilization is not from competing external civilizations – but from the very social organization of modern industrial civilization itself in its current conjuncture.” (ibid. p.76) With reference to IPCC, he then remarks that threats such as sea level rise and global warming could “lead to irreversible, catastrophic effects [...] endangering the survival of all life on earth”. (Ahmed 2010 p.77f)

The WBGU’s report¹⁴² uses a similar line of argumentation identifying six major security risks for the international community which are due to climate change. “This could result in destabilization and violence, jeopardizing national and international security to a new degree.” (WBGU 2007, p.1) Firstly, they point out that not only today’s fragile states will become even weaker. As their capacities, i.e. state’s monopoly of force, to guarantee security within their borders are already underdeveloped it is most likely, in the course of climate change related catastrophes, that those capacities will further deprive. Additionally, the German Advisory Council underlines that due to environmental migration neighbour states could be easily affected by those growing tension and, as a consequence, “failing subregions” (ibid. p.5) could occur. (ibid. p.41ff) In terms of in terms of economic and social stability, water scarcity, soil degradation and extreme weather events economic growth rates are probable to stagnate as conditions for production alter and could persuade companies to relocate. This could lead to an economic downward spiral in respective areas inducing social deprivation and migration, again affecting broader regions (ibid., p. 70f). Moreover, climate change could have negative influence on food production, through “the level of soil fertility, the degree of damage already caused by soil degradation, the availability of freshwater, the heat and drought tolerance of plants and animals” (ibid., p. 96). As the Council points out, declining food production could easily induce food crises and escalate in conflicts over food (ibid., p.98).

Subsuming, climate change is primarily regarded as threat multiplier reinforcing existing problems. In respect thereof, Ahmed stresses that it is highly necessary “to fundamentally re-orient our understanding of the conditions and subjects of security, based on a new

¹⁴² WBGU, 2007. Climate Change as a Security Risk, Earthscan.

perspective which re-integrates human life as interdependent with, and inextricably embedded in, its natural environment.” (Ahmed 2010, p. 88).

A3.4 Key assumptions

Based on AR4 of IPCC 2007 and recent climate change literature this chapter reflected on the ongoing and future impacts and risks associated with climate change. As described above, changes in key global climate parameters indicate undoubtedly that climate change is happening. Impacts, attributable to human induced climate change, can be observed already. Furthermore various recent studies suggest that the climate will change faster than in the past. Some of these changes are already “locked in” for the foreseeable future and are - more or less - easy to predict, particularly in terms of global temperature increases. In addition to ongoing gradual change, tipping points of the Earth-system could be crossed, triggering non-linear changes which will further increase warming. Given these high risks, which are more likely to occur beyond global warming of 2°C, the future development after 2030 will strongly depend on near time GHG emission targets, “as the higher emissions are allowed to be in 2020 the lower they will need to be in 2050 to stay with the 2°C target” (Weisz and Lucht, 2009). Not only is Europe enormously challenged, but also the international community, as the above mentioned target can only be achieved by securing a political agreement among national states.

The main findings of the chapter are summarized in terms of key assumptions for two extreme scenarios (friendly-tough) up to 2025/2030 and 2050/2100 according to basic assumptions listed below. It has to be stressed that long-term predictions go along with high uncertainties, particularly in terms of tipping points.

Basic assumptions:

„Friendly“: increasing impacts, faster than in the past - lower range of projections; challenges for Europe/the world are still high as the coming decade(s) in terms of decision making will determine the future climate.

“Tough“: increasing impacts, faster than in the past – upper range of projections (partly more severe than projected in AR4: might be “friendly” in the long run though, as the more severe the impacts will be in the next decade the more likely international agreements on effective climate policy will be able (for a similar argumentation see (Schüler et al., 2011: p.I) and NIC,EUISS, 2010.)

2025/2030 and 2050: the pathway in between the two points in time refers to whether Europe and the world are in line with the 2°C until then.

Forces	Friendly gradual changes	Tough (triggering) abrupt changes
GHG emissions	Overall <ul style="list-style-type: none"> Increasing impacts, faster than in the past Future changes and future impacts (2030 and beyond) depend on GHG emission reduction (GHG emission rate) Keeping global warming within the 2°C target: most dangerous impacts could be avoided Most dangerous <ul style="list-style-type: none"> Crossing tipping points and triggering irreversible transitions of components of the Earth system into a new (unknown) state; consequences are unpredictable. E.g.: Melting ice masses (Arctic sea ice, Greenland ice sheet) and sea-level rise; Atlantic THC passing a tipping point, collapse unlikely to happen within this century 	
2025 /2030	Climate change is „locked in” +/- easy to predict Temperature rise between 0.4-0.6 °C comp.to 2005: very likely	
	<ul style="list-style-type: none"> Temperature rise +0.4 °C (compared to 2005) Increases in precipitation extremes: 5 % per °C of warming, and other weather extremes: heat waves, droughts.... Accelerating trend: melting of glaciers, Arctic sea ice decline, sea level rise faster than in the 20th c. (> 3.4mm/yr) 	<ul style="list-style-type: none"> Temperature rise +0.6 °C (compared to 2005) Increases in precipitation extremes: 10 % per °C of warming, and other weather extremes: heat waves, droughts... Accelerating trend: melting of glaciers, Arctic sea ice decline, sea level rise (much) faster than in the 20th c. (>> 3.4mm/yr)
Pathways	High global GHG emission reduction (80%) EU: 80% - 95% reduction in 2050 Global 2°C target reachable Triggering tipping points and abrupt changes are more likely to be avoided, abrupt/non-linear changes still possible though	Low global CO2 emission reduction, worst case: business as usual. EU: reduction goal not achieved Global 2°C target not reachable Triggering tipping points induced. Non-linear changes, even abrupt climate change in the future likely
2050 - 2100	Climate change depends on GHG emission reduction scenario in the past; 2050: CO2 emissions 80% , precondition for stabilizing the climate very	

	likely C02 reduction peak (late) ,precondition for a worst case scenario up to the end of the century and beyond Impacts are difficult to predict (high uncertainties)	
	Temperature rise: < 2°C compared to pre-industrial levels increase in precipitation/weather extremes, vanishing of ice masses accordingly (Arctic sea ice, glaciers)	Temperature rise above 2°C or far above + 3-7 °C until 2100 compared to pre-industrial levels increase in precipitation/weather extremes , vanishing of ice masses accordingly
	<ul style="list-style-type: none"> • Greenland ice sheet: stable • <i>Sea level rise < 0.5 m</i> • No tipping points triggered • No positive feedback loops 	<ul style="list-style-type: none"> • Glaciers disappear rapidly , Arctic ice free in summer • <i>Sea level rise 0,5-2 m until 2100 recent results: 1-1.4m</i> • Green land ice: tipping induced • <i>THC tipping induced</i>

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Appendix B: Societal Megatrends

B1. Population dynamics

- Slow-down of global population growth and peak population expected by 2060
- Global ageing
- Rapid Urbanisation
- Increasing migration flows due to climate change impacts

B1.1 Introduction

Since environmental pressures are influencing global developments it's crucial to take into account, "that basic material conditions, like population, economic production, urbanization and geographical all affect the environment [...]" (York et al., 2003). In a recently published paper (Dietz et al. 2009) the same authors identified population size and affluence as the principal drivers of anthropogenic environmental stressors. Therefore it is a key issue when depicting possible scenarios to estimate the possible future population – by combining absolute numbers of people with their demographic attributes like sex, age, education, family status, household sizes, and demographic processes like birth, death, migration and the spatial distribution of people by geographic region and types of settlements (rural, urban).

It is not just that population size matters for energy consumption, the energy system matters for population size. Especially the transition of agricultural into fossil fuel based industrialized societies suspended physical limits to population growth. This created the pre-conditions for the phenomenon of the so called „demographic transition“.

Initially this pattern was observed in Europe in mid-19th-century¹⁴³, but it has been found appropriate for the so called developing countries in the 1960ties, too. (e.g. Knodel and van de Walle, 1979). In the process of a demographic transition, populations move from the

¹⁴³ Tilly makes an important distinction: his question is how and why basically agrarian populations became first an urban industrial proletariat, and later into a bourgeois society. The first change leads to continued high fertility; the second to fertility decline. (Kirk, 1996, p. 373)

initial state of small, slowly growing populations with high mortality and fertility to a state of low mortality and fertility. Generally the decline of death is followed by the decrease in birth rates some decades later. As a consequence, the steadily growing difference between high birth rates and low death rates has created a huge population increase. As shown in Figure B1.1, the longer the period of a transition (time), the higher the increase (population growth rate) in numbers of total population.

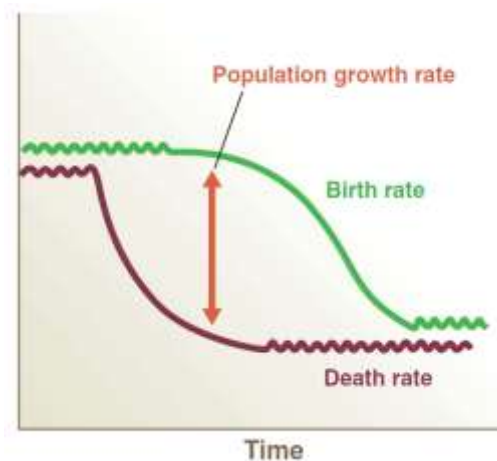


Fig. B1.1 Stylized model of the demographic transition (Source: Bloom, D.E. 2011. *7 Billion and Counting*. *Science* 333, 562-569)

The major strength of the demographic transition theory is the prediction that this will occur in any society that is experiencing modernization (or *westernization* within the meaning of Caldwell¹⁴⁴ or a socio-ecological transition from a biomass based agrarian to a fossil fuels based industrial regime).

The following trends are very likely to evolve at a global level by 2025. They will have a huge impact on societies, particularly with regard to their demand of natural resources and

¹⁴⁴ "Caldwell, [...] makes an important distinction between 'modernization' and 'Westernization'. The first is structural as in economic organization; the second a copying - two very different processes. [...] The primary force of change appears to be Westernization, which includes ideas of progress, secularization, mass education, and mastery over the environment. This process can precede economic development, as it has increasingly done in less developed areas. Caldwell's argument is supported by the fertility declines which have occurred at very low levels of modernization, as in Bangladesh [...]. In his view an important export of Westernization is the predominance of the nuclear family with its concentration on expenditure for one's children, e.g. on education. Caldwell's name is identified with his wealth flow theory of fertility decline [...] the fundamental issue in demographic transition is the direction and magnitude of intergenerational wealth flows. At first, in pre-modern societies, the flow is from children to parents or, more broadly, from the younger to the older generation. Wealth is defined here as including money, goods, and resources. When there is a transition from the extended to the nuclear family, the pendulum swings and the direction of the flow is now from parents to children. In this situation, being childless is the most rational economic behaviour! But, of course, couples continue to procreate for social and psychological reasons, though they have many fewer children than formerly." (cf. Kirk 1996, p. 371-372)

energy, which is dependent not only on their economic structure, but also on the requirements of their population.

Although these megatrends are happening on a global level, it is important to acknowledge that they will emerge differently among regional levels or country groups. While the slowdown of population growth and the trend of urbanization have been dominant trends in the second half of the 20th century, global ageing is a 21st century phenomenon (e.g. Kinsella, 2000; UNPD, 2011a)

B1.2 Key Sources

We worked with the latest United Nations Department of Economic and Social Affairs Population Division assumptions that are supported by the UN population scenarios (UNPD, 2011a) regarding future trends in mortality, fertility and migration. It is the twenty-second round of global demographic estimates and projections. These projections are used by all entities of the United Nations, widely in academic research or research centres, in many international organizations, and the media. “Being the official United Nations population estimates and projections, the results of World Population Prospects are considered to embody the authoritative view of population levels, trends and characteristics.” (UNPD, 2011b¹⁴⁵) The following assumptions are included in United Nations Population Office scenarios (UNPD 2011d) ¹⁴⁶

Mortality: The *normal- mortality* assumption is based on models of change of life expectancy produced by the United Nations Population Division. The selection for each country is based on recent trends in life expectancy by sex. Assumptions regarding future trends of HIV/AIDS epidemic are included in the projections. The model incorporates a certain slowdown in the reduction of general mortality risks not related to HIV / AIDS:

Fertility: The *medium variant most* commonly used assumes the average woman in 2100 will have two children. If she had half a child more (high fertility variant), or less (low fertility variant), the picture would change dramatically.

¹⁴⁵ See <http://esa.un.org/unpd/wpp/Other-Information/faq.htm#q20>

¹⁴⁶ See http://esa.un.org/wpp/Documentation/pdf/WPP2010_Highlights-Chapter%20V.%20Assumptions_19-May-2011.pdf

Countries are grouped in *high fertility countries* (no fertility reduction until 2010 or only an incipient decline), *medium fertility countries* (fertility has been declining, but the estimated level was still above 2.1 children per woman in 2005-2010) and *low fertility countries* (total fertility at or below 2.1 children per woman - the so called “replacement level” - in 2005-2010).

The *medium fertility variant* is based on empirical fertility trends estimated for all countries for the period 1950 to 2010.

By 2020-2025, fertility in the *high variant* is therefore half a child higher than that of the medium variant. Consequently, countries reaching a total fertility of 2.1 children per woman in the medium variant have a total fertility of 2.6 children per woman in the high variant. Such high rates of change will lead to rapid growth of the population, which keeps on gaining a billion people every 10 or 11 years during the whole 21st century.

By 2020-2025, fertility in the *low variant* is therefore half a child lower than that of the medium variant. Consequently, countries reaching a total fertility of 2.1 children per woman in the medium variant have a total fertility of 1.6 children per woman in the low variant.

The low variant, which maintains fertility half a child below than that of the medium variant, produces below-replacement fertility in all countries and results in a declining global population, as indicated by the negative rates of population change that it projects after 2040-2045.

Migration: With the *normal migration assumption*, the future path of international migration is based on past international migration estimates and under consideration of the policy stance of each country with regard to future international migration flows. Projected levels of net migration are generally kept constant over the next decades and by the mid-century it is assumed to gradually decline to zero in 2100.

IIASA, whose population prospects are in use too (see for example Nakicenovich and Swarft 2000 used for the IPCC emission scenarios or for the SOER report published by EEA 2010) uses a different method: the forecasts include qualitative „variables“, like projections of education and process them in a multistate model. Education has impacts on fertility rates (Lutz, 2011) and household sizes could become relevant for energy scenarios (O’Neill, 2001; 2010).

B1.3 Key issues

B1.3.1 Slow-down of global population growth. Peak population expected around 2060

According to the UN Population Prospects (2010), the world population will be growing at a rate of 1.1 per cent per year between 2010 and 2015 and will slow down during the 21 century. Whether population size is likely to stabilize or decline after a peak during the second half of the twenty-first century has been discussed among scholars. Lutz (2001) states, that the possibility that world population will peak before 2100 and begin to decline afterwards is likely to be 80 – 90%.

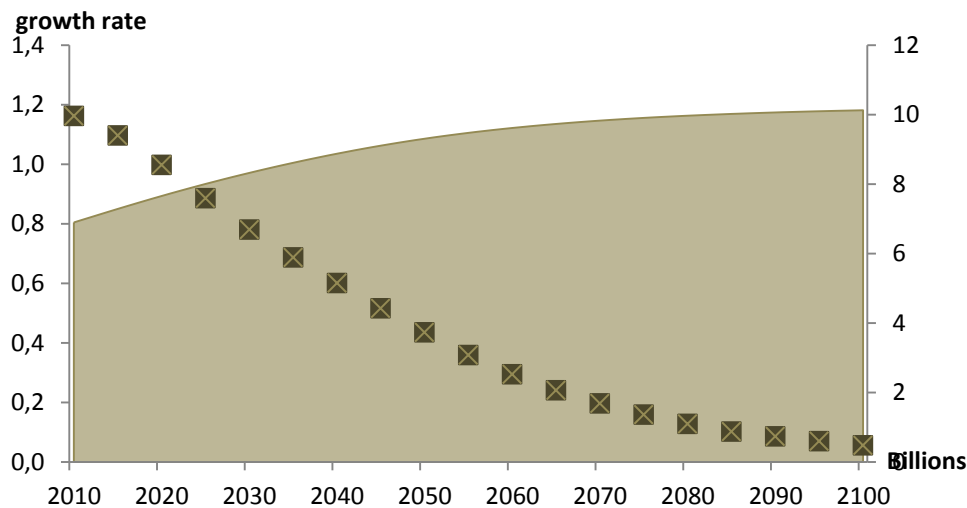
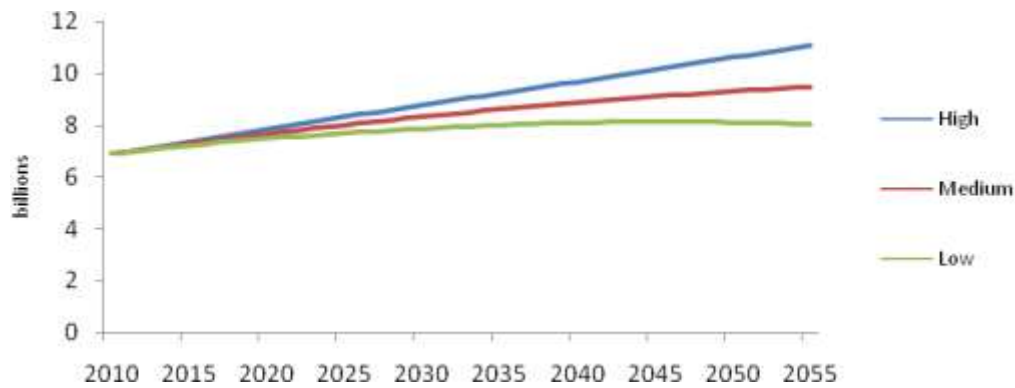


Fig. B1.2 World population and average population growth 2010-2100 (Source: UNPD 201a), medium fertility variant)

Despite this predicted sharp decline, the rate of population change will remain positive during the twenty-first century, implying that world population is growing continually (medium fertility variant and instant replacement). The differences between the medium fertility variant and the low and high fertility variants (for an explanation, see above) seem small, but make a huge difference in population forecasts as shown in figure 4.3.



*Fig.B1.3 World population prospects 2010-2055, all three fertility variants considered.
(Source: UNPD 2011a)*

Differences among country groups¹⁴⁷

In 2010, 14 % of total population lived in mature industrial economies. This percentage will slowly decrease to 13% by 2025 and to 12% by 2050. At the end of the century, 11% of total population will live in these countries. Among this group, Europe's population is projected to peak 0.74 billion around 2025 and decline afterwards. This very small decrease in total population share can be explained with reference to the predictions for North America and Oceania, where according to the UN assumptions population will continue to increase slowly until 2100. This explains also the almost stable positive population growth rate during the twenty-first century for the mature industrial economies.

The emerging economies (BRIC and next eleven) will remain the most populous group of countries during the twenty-first century, as the world's countries with the most inhabitants nowadays are China and India. In 2010 these countries were inhabited by 61% of the world's population, in 2025 this will be 60% and 56% in 2050 .By 2100 this decline will have reached 48%. The population growth rate will decline sharply from 1.1 % to 0.7 % in 2025 and to 0.2% in 2050. After that the population growth rate will become negative, which means that this group of countries is facing a population decline.

Most of the future population growth will happen in the remaining countries, in the so called Rest of the World. In 2010, approximately a quarter of total population lived in these countries. This share will be increasing to 27% in 2025 and to 31% in 2050. By the end of the century 40% will live in these countries. A stabilization of the population in the upcoming decades is not in sight, although the growth rate will fall from 1.3% in 2010 to 0.9% in 2025

¹⁴⁷ Differences in absolute numbers, percentage and growth rates are shown in figure 4.4 a –c. We are referring in the text and the figures to UNPD 2011a, medium fertility variant, if it's not specified differently.

and 0.4% in 2050. From 2050 to 2100, a further decline of the growth rate is expected, levelling around zero in the last decade of the century.

Fig. 4.4 a)

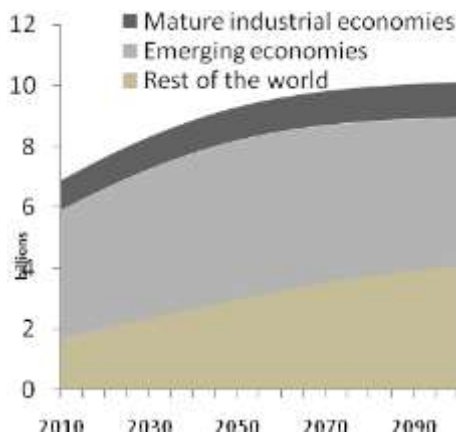


Fig. 4.4 b)

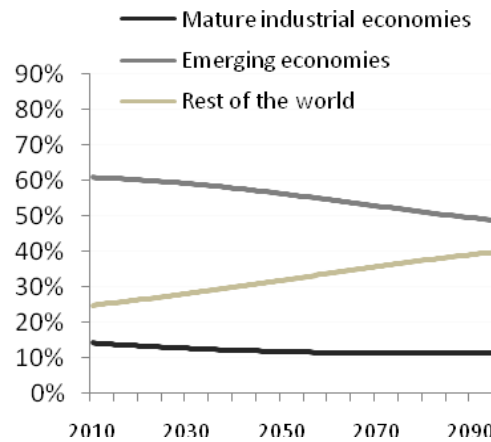


Fig. 4.4 c)

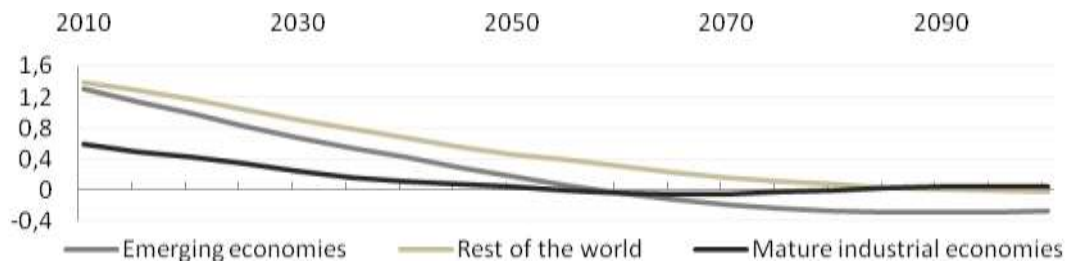


Fig. B1.4 a)-c) Differences between mature industrial economies, emerging countries and the rest of the world a) Population development in absolute numbers, b) in Percentages, c) different growth rates (Source: UNPD 2011a, medium fertility variant)

In contrast to the UN predictions, our country groups are not showing any clear regional differences. But it is noteworthy that, from a regional perspective, Asia will remain the most populous region. A population peak is projected in the 2050s followed by a slow decline. Until the mid-1990s Europe was the second most populous region in the world, but had been surpassed by Africa. According to UNPD (2011a) the population of Africa surpassed a billion in 2009 and is expected to increase by another billion by the mid-2040s, even as its fertility drops from 4.6 children per woman in 2005-2010 to 3.0 children per woman in 2040-2045.

B1.3.2 Ageing

According to UNDP (2011a) ageing is becoming a global megatrend of the 21st¹⁴⁸ century and its future paths result from specific combinations of declining fertility and increasing life expectancy (Lutz et al., 2008, p. 716). Lutz et al. (2008) calculated the cumulative probabilities of reaching a proportion of people aged 60+ of one third (33.3%) or more for the world and selected regions by calendar year (figure B1.5). Prior to 2050, only for Japan / Oceania, Europe and the European Soviet Union the cumulative probabilities will be 75% or above. Sub Saharan Africa still has a large proportion of young people (according to Lutz 2008 44% of the population are below 15) and it is unlikely that more than one third of its population will be 60+. For the world as a whole it is expected a 50 percent chance for the latter by 2100.

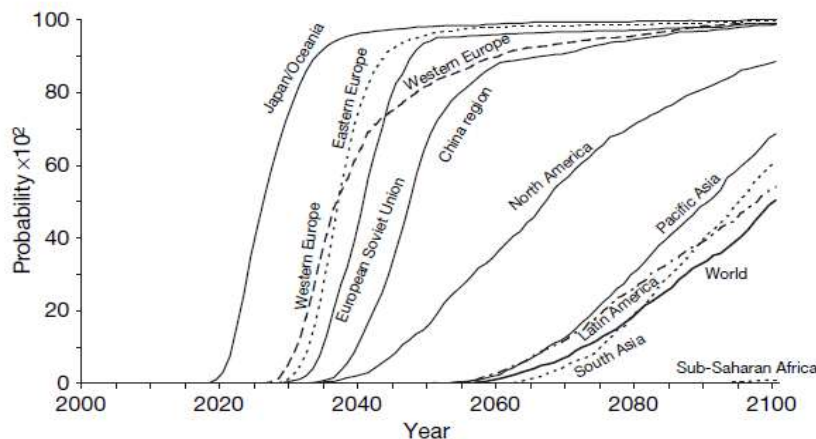


Fig. B1.5 Cumulative probabilities of reaching a proportion of people aged 60+ of one third (33.3%) or more for the world and selected regions by calendar year. Source: Lutz et al., 2008, p. 718.

A change in age structure is closely linked to a higher life expectancy that depends on improvements in diets, health, environmental and socio-economic conditions. Figure B1.6 shows the share of youth, people in working age (15-64) and people over 65 for 2010. Mature industrial economies had the smallest proportion of youth, followed by the emerging economies. In the rest of the world people between 0 and 14 represented one third of the total population. People aged from 15-65, the potential labour force, represent in all three

¹⁴⁸ UNDP (2011a) assumes that the European population has been ageing since 1950, in Northern America, Oceania, Latin America and the Caribbean, as well as in Asia since the 1970 (measured by an increasing median age).

country groups a huge percentage of the total population ranging from 60.4% in the countries grouped as rest of the world, to 63.4% in the mature industrial economies and 66.6 percent in the Emerging economies.

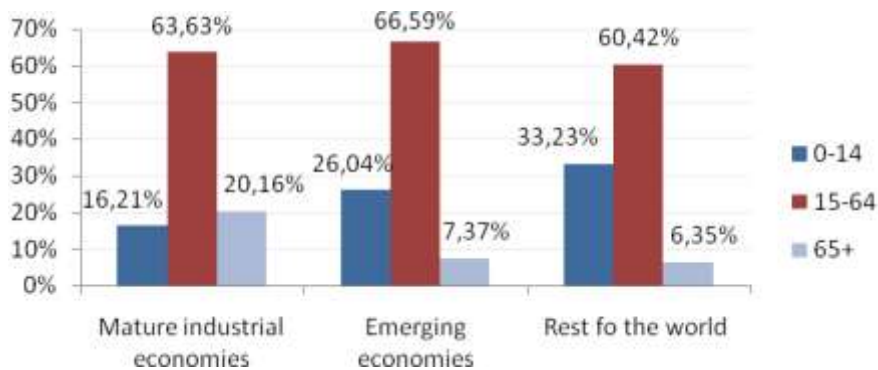


Fig. B1.6 Age distributions 2010 (Source: UNPD, 2011a)

Figure B1.7 shows prospects for age distributions in percent for 2025 and 2050 in different country groups. Mature industrial and Emerging economies are undergoing a decline of potential working force (figure B1.7 a- d) while in the rest of the world, the potential working force is still growing slowly until 2050 (figure B1.7 e -f). In mature industrial economies working force will shrink significantly between 2025 and 2050, where almost half of the population will be under 15 years or over 65 years. The emerging economies will be faced with no significant decrease of working force until 2025. Thereafter working force will fall off.

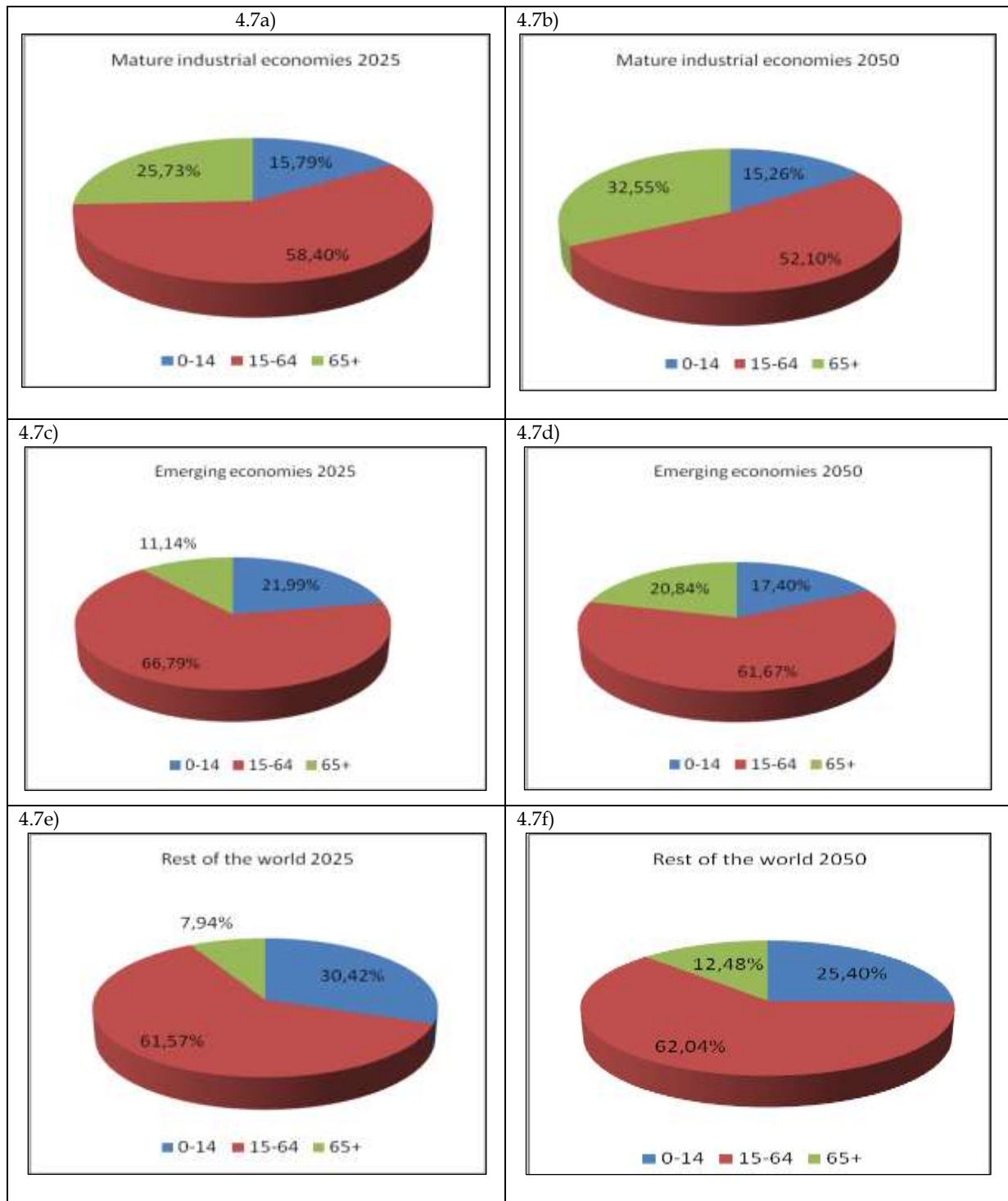


Fig. B1.7 Percentage of different age groups (0-14; 15-64; 65+) among mature industrial economies, emerging countries and the Rest of the world. Source: UNPD, 2011a, medium fertility variant

The ageing of societies represents a success in human history in one sense, but it also poses several challenges to policy-makers when allocating resources for the elderly.¹⁴⁹

Ageing represents a challenge for intergenerational solidarity, too. Due to the changes in family patterns (e.g. more divorces, more re-partnering, smaller family sizes, rising female participation in the labour market)¹⁵⁰ social protection systems have to find social cohesion to support people to co-operate as much as possible within and between generations.

The dependency ratios¹⁵¹ will change as a consequence of ageing populations. The number of dependent people may substantially rise in some countries, but it should be acknowledged, that in some countries the rise in elderly dependency will be offset by a fall in youth dependency, associated with falling fertility rates, as suggested by Bloom (2011). In general, this is true for emerging economies and for the rest of the world, where the dependency ratio will be smoothly declining during the next decades. For the mature industrial economies, the dependency ratio will considerably grow (figure B1.8). As figure B1.9 shows, the old age dependency ratio will be increasing in the upcoming decades in every group of countries.

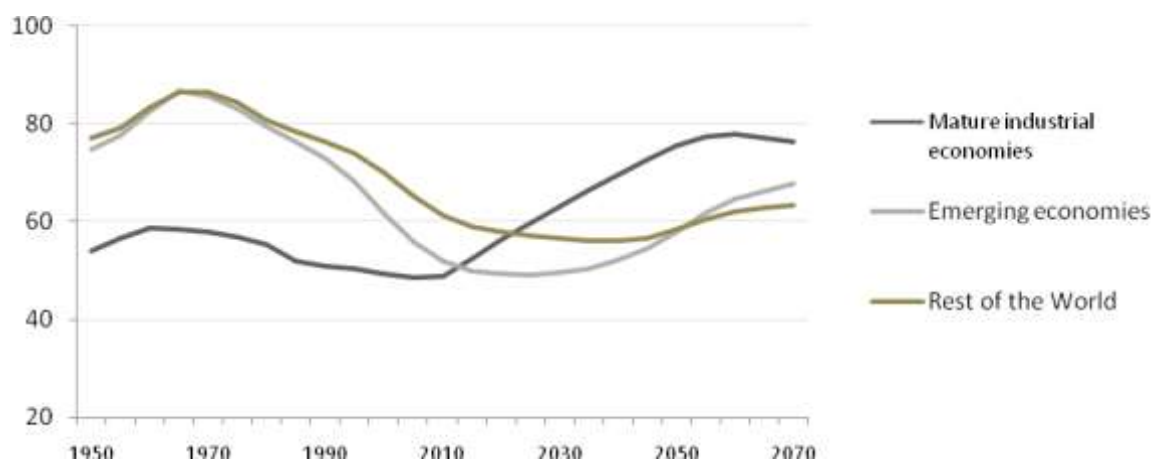


Fig. B1.8 Average of total dependency ratio in mature industrial economies, emerging economies and in the Rest of the World. 1950-2100 (ratio of population 0-14 and 65+ per 100 population 15-64), 1950-2070, Source: UNPD, 2011a, medium fertility variant)

¹⁴⁹ These resources could be healthcare or pension systems that have to be financed by the public or privately

¹⁵⁰ For details see for example the OECD Family Database, www.oecd.org/document/4/0,3746,en_2649_34819_37836996_1_1_1_1,00.html

¹⁵¹ The number of dependent people (not economic active, like retirees or children and adolescents of school age) per independent person (economic active persons)

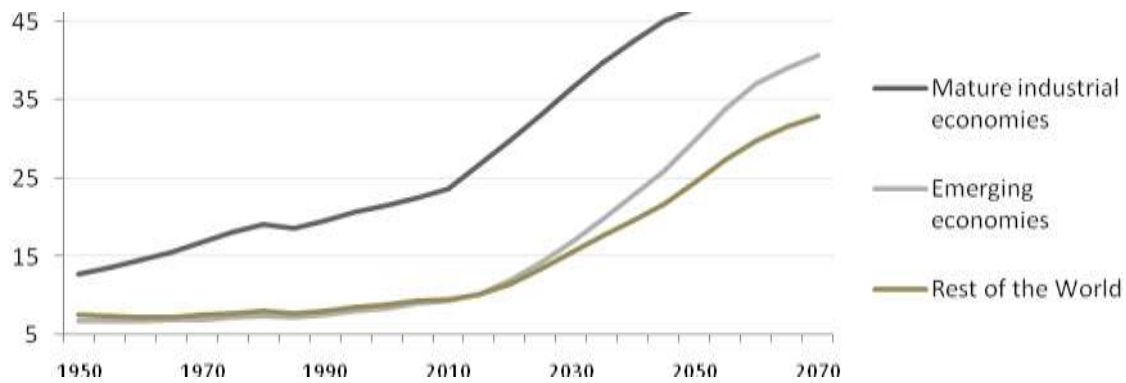


Fig.B1.9 Average of old age dependency ratio. 1950-2100 (ratio of population 65+ per 100 population 15-64), in mature industrial economies, emerging economies and in the Rest of the World 1950-2070 Source: UNPD 2011a, medium fertility variant

NIC (2008) provides a map of the global age distribution for 2005 and 2025. The “oldest” countries—those in which people under age 30 form less than one-third of the population—will mark a band across the northern edge of the world map. In contrast, the “youngest” countries, where the under-30 group represents 60 per cent of the population or more, will nearly all be located in Sub-Saharan Africa (figure 4.10). In the Northern hemisphere the decline of youth and young adults will be likely impact on the labour market system with its related social system

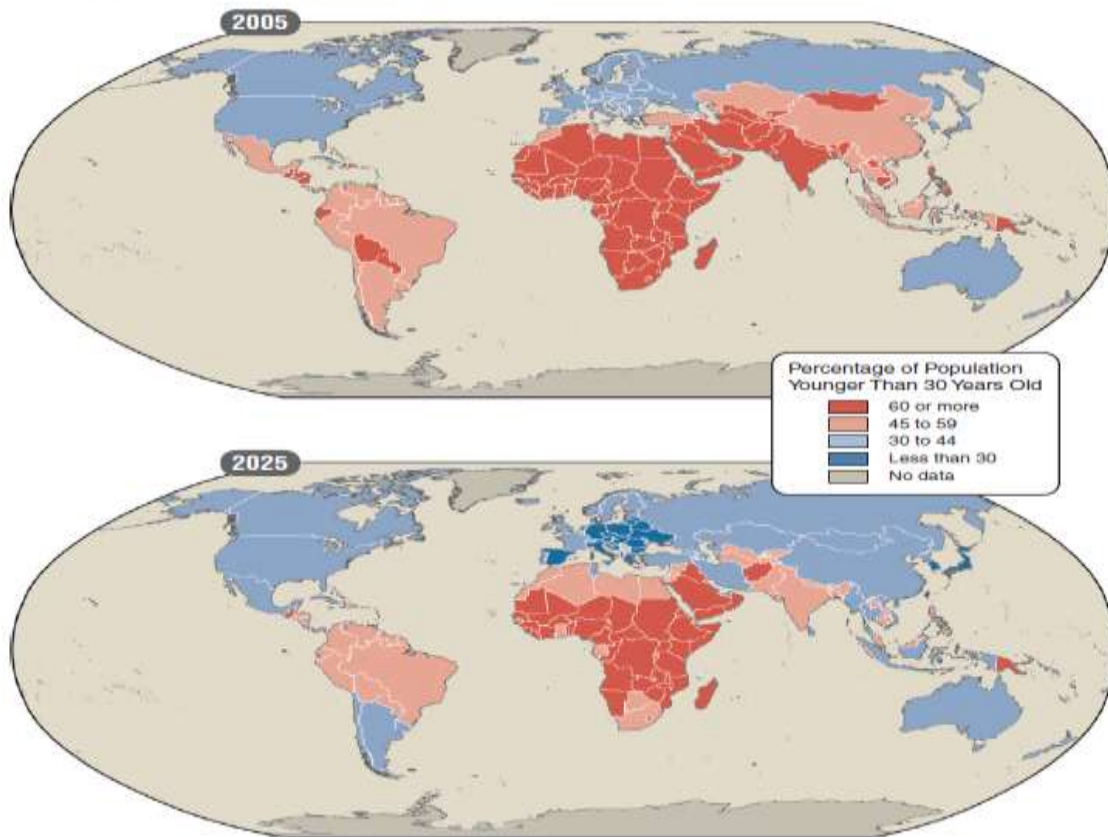


Fig. B1.10 World age structure 2005 and 2025 (Source: NIC 2008)

Shifts in age structure generally leads to new service demands and economic requirements (e.g. Kinsella, 2000; 2001), especially in the mature industrial countries where the demand of a growing long-term care sector in the coming decades is looming, especially due the needs of the elderly that suffer from noncommunicable diseases, such as cardiovascular diseases, cancer, or diabetes, that are currently responsible for approximately 60% of deaths (WHO 2008). It should be mentioned that there are major differences among elderly people. A person in his or her mid- 60ties is not comparable to a person in his or her early eighties, due to the special needs (e.g. Care) of the latter group. In high income OECD countries, the share of population over 80 years will rapidly increase. Japan, the United States and the EU 27 will have the largest proportion of people over 80 in 2025 (figure B1.11). In emerging economies, as Korea, Brazil and China, the share of population over 80 will also rise. The respective countries will have to cope with these developments.

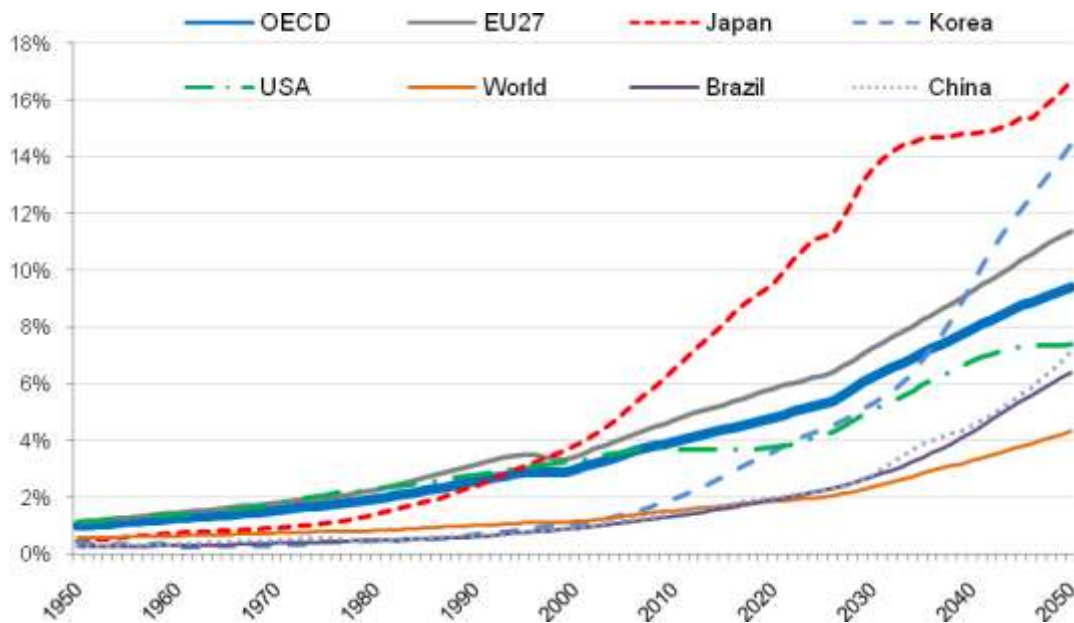


Fig. B1.11 Percentage of the population aged 80+ for OECD and selected countries (regions) (Source: OECD Labour Force and Demographic Database, 2010, published in OECD 2011, p.62)

This is especially true for long-term care systems, on which pressures are expected to grow. OECD (2011) indicates the reasons for this well predictable development:

- Despite the speed of ageing, which considerably varies across countries and uncertainties about future trends in disabilities among the elder population, the demographic transformation to an ageing society will increase the demand for LTC-systems in every society going through this process.
- Changing societal models, like smaller family sizes, female participation in the labour market (as mentioned above) are likely to contribute to a decline in available family carers, leading to a growing necessity for paid, professional care.
- Rising wealth of individuals implies that they request a better quality and more patient-orientated and well-coordinated care service.
- Technological change could lead to new possibilities for LTC-services at home, but might require a different organization of care.

Thus, the demand for LTC services and the care- job market will be growing considerably during the next decades. As OECD (2011) has analysed recently, the size of the LTC workers is increasing along with the share of population over 80 years. A large proportion of LTC workers are female and middle aged, employed in institutional care although most care

recipients receive care at home. Usually they are part-time employees, in general with low wages. Many OECD countries employ migrant workers, which play a significant role in some countries. In some countries, illegal migrants participate in the LTC workforce, too (for details see OECD, 2011, p. 26).

According to Kinsella (2001) in a majority of developing countries as a result of the migration of young adults to urban areas elderly remain in rural areas. This out-migration of young people may leave the elderly without the direct support of their families, but those migrants could have improved their financial situation. This monetary resources may be used to help their elderly relatives still living in their rural birthplace. Important factors are the living conditions of the rural elderly, that sometimes are very harsh and additionally lack of healthcare and other services to ill or disabled people. This poses additional difficulties for the elderly, despite in rural areas community and voluntary activities, to support the elderly tend to be likelier as in cities.

Ageing and CO₂ emissions

According to O'Neill et al. (2010) changes in the composition of a population can have effects on CO₂ emissions. Due to its influence upon the labour market ageing can contribute to their reductions in the long term up to 20 per cent under constant retirement policy scenarios, particularly in the industrialized countries. Household size has little influence on emissions beyond this, captured by Ageing. It is crucial to consider urbanization and ageing projections in key regions of the world to improve the understanding of the potential range of future energy demand and emissions.

B1.3.3 Urbanization

In 2008 the United Nations declared that one-half of humankind lived in cities and that the world's urban population would increase until the end of the century (figure. B.1.12). According to Satterthwaite (2007) and PRB (2008), definitions of „urban“, are differing among nations (e.g. in one country a centre of 100 dwellings could be defined as urban, in another country a city with more than 50,000 inhabitants) – the urban population will be distributed among urban areas of all sizes, and it is predicted, that most urban growth in the next decades will occur in smaller cities and towns and not in mega-cities. (UNPD, 2010a; PRB, 2008)

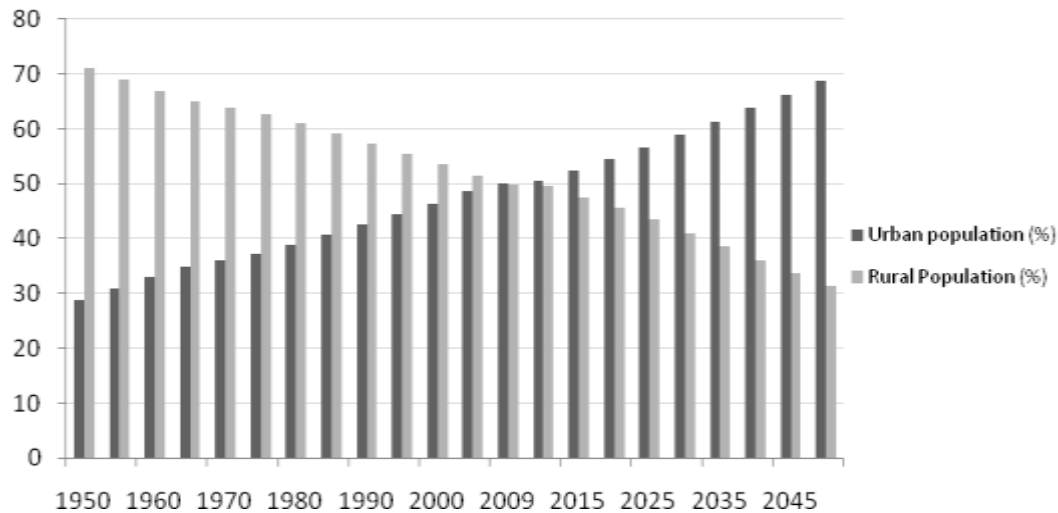


Fig. B1.12 urban and rural population as a percentage of total world population 1950-2050 (Source: UNPD 2010a, medium fertility variant)

Virtually all foreseeable future population growth will happen in the urban areas of Asia and Africa (UNPD, 2010a ; Cohen, 2004; see also figure B1.14.). Table B1.1 shows the percentage of urban population and the rate of urbanization for different development groups. On a global level, the rate of urbanization will slow down until 2025 and 2050. It will remain higher in less developed regions (Asia and Africa) than in more developed regions. The most part of urban population growth is because of natural increase, a smaller part is driven by youthful moving in from rural areas to the cities searching for employment or a better life. Such migration patterns vary from country to country or also regionally. (Tacoli et al., 2010)

Table B1.1 Percentage of urban population and the rate of urbanization for different development groups for selected periods (Source: UNPD, 2010a)

Development group	Percentage urban					Rate of urbanization (%)			
	1950	1975	2009	2025	2050	1950-1975	1975-2009	2009-2025	2025-2050
World.....	28.8	37.2	50.1	56.6	68.7	1.02	0.87	0.77	0.77
More developed regions	52.6	66.7	74.9	79.4	86.2	0.95	0.34	0.36	0.33
Less developed regions.....	17.6	27.0	44.6	52.3	65.9	1.71	1.48	0.99	0.92

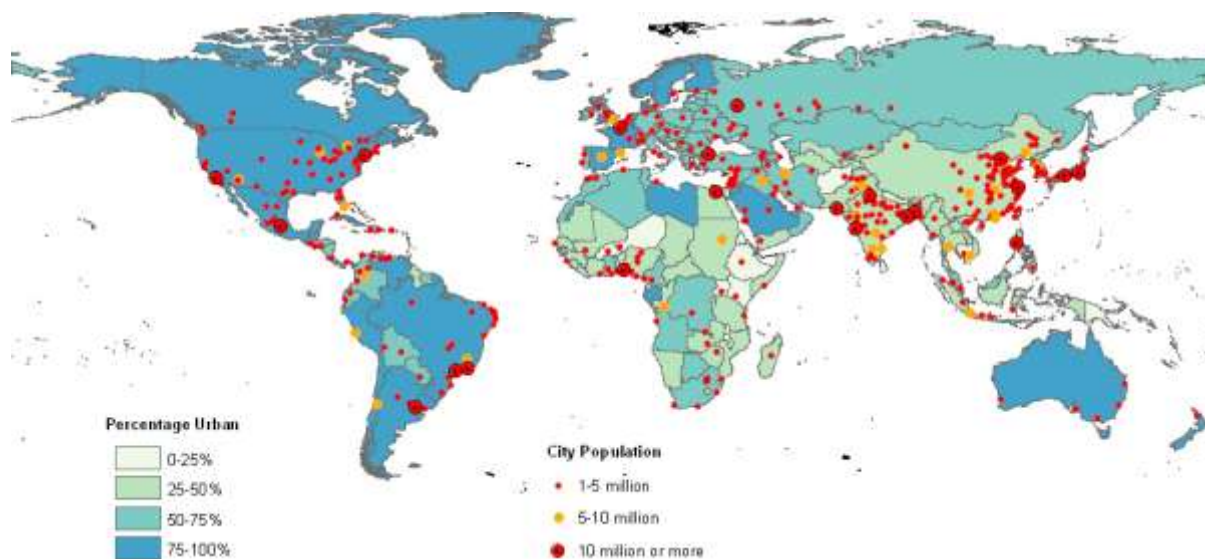


Fig. B1.13 Urban Agglomerations in 2009 (proportion urban of the world: 50.1%) (Source: UNPD 2010a, World Urbanization Prospects, the 2009 Revision. http://esa.un.org/unpd/wup/maps_1_2025.htm)

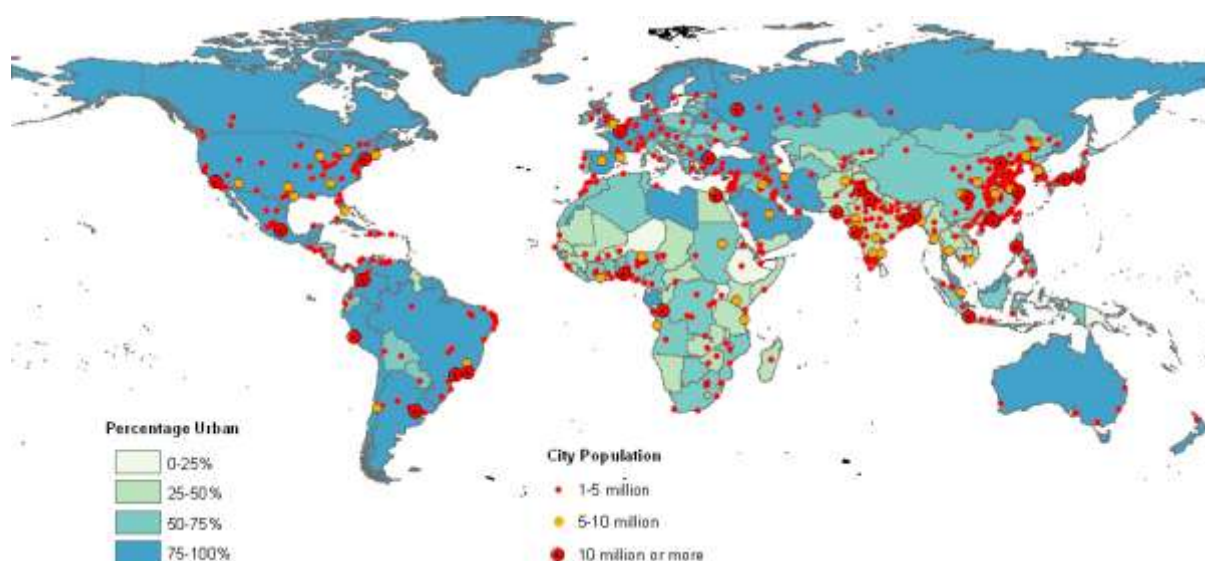


Fig. B1.14 Urban Agglomerations in 2025 (proportion urban of the world: 56.6%)
(Source: UNPD 2010a, World Urbanization Prospects, the 2009 Revision.
http://esa.un.org/unpd/wup/maps_1_2025.htm

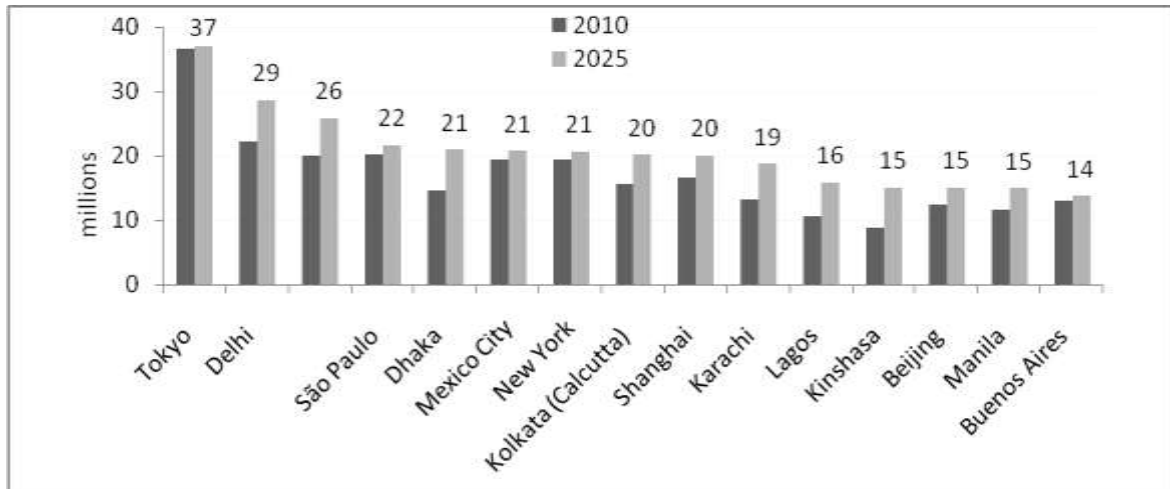


Fig.B1.15 The fifteen biggest cities in 2025 compared with the 15 biggest cities in 2010.
Source: UNPD 2010a

The highest number of urban agglomerations, which will be the biggest cities in 2025 will be situated in emerging economies (India, Brazil, Mexico, Bangladesh, Pakistan, Nigeria, China, Philippines).

Urbanization and urban growth are strongly interlinked to economic integration and the endeavour (both national economies and cities) to be competitive in the global marketplace. Urbanization and urban growth have become some of the most crucial challenges of the twenty-first century. (e.g. Cohen, 2004).

After UNPD (2010 a) and PRB (2008) virtually all growth of urban population will take place in the less developed regions (for details see figure. B1.13 and figure B1.14). According to Garau, et al. (2005) (UN Millennium Project) one third of urban population lived in dire conditions. In contrast to cities in mature industrial economies, cities in less developed regions are the location of the extremest poverty. But the predicted rapid urbanization process in less developed countries poses not only societal challenges but also opportunities. Urbanization can be a powerful driver for improving the quality of life of the population, if the social exclusion of the poorest ends. The UN Millennium Project claims the following necessary investments for urban development: improving security of tenure for slum dwellers, upgrading slums and improving housing, expanding citywide infrastructure and

effective service delivery, solving the garbage problem, creating urban jobs through local economic development, and providing alternatives to slum formation.

Cities and the environment

Resource use and energy consumption

Due to agglomeration and concentration the delivery of services in different sectors, as education, healthcare or water availability seems to be easier and more efficient as in rural areas. According to Krausmann et al. (2009) and UNEP (2011a) more dense forms of living could lead to a lower consumption level of many raw materials too, while the level of comfort will be equal. The range of overall material consumption varies significantly between cities due to two reasons: On one hand different industrial and economic production activities of cities under a territorial perspective (e.g. major harbours, industrial centres) and on the other hand income and the related lifestyle, based on a consumption perspective (Weisz and Steinberger, 2010). According to the authors, key issues to reduce material and energy flows are: the reduction of car dependence in cities by fostering the quality of public transport and deterrent to automobile use like high parking fees, the reduction of material and energy requirements for buildings. Reducing emissions and material consumption on a household level may be a special challenge, because it will be a challenge in changing high-income related lifestyle.

Cities and Climate change

Cities and climate change are co-evolving. Rapid urbanization can quickly transform environments from native vegetation into an artificial infrastructure. This new environment increases heat storage capacity resulting in a formidable change in the urban climate compared with neighbouring rural region (Luber and Mc Geehin 2008). The 2003 European heat wave has demonstrated the lethality of such extreme events. Robine et al. (2008) estimated more than 70,000 additional deaths, especially in European cities. Thus, public health response plans and effective monitoring and communication strategies play an important role in reducing the negative impacts on urban population (e.g. Luber and Mc Geehin 2008). Another important factor is the reduction or mitigation of urban heat islands, as communicated for example by EPA¹⁵². Heat waves could have further impacts on air

¹⁵² See for example <http://www.epa.gov/heatisland/mitigation/index.htm>

quality and water availability, both deteriorating human health¹⁵³. Cities are also vulnerable to other extreme events like floods or storms (e.g. McMichael et al., 2003). The key question is how to cope with the future climate conditions, securing health and the provision of infrastructure, energy, transport, electricity and potable water. Adaptive and better urban planning and the request of innovative solutions could be a motor for green jobs. (UNEPb, 2011, see especially p.183)

B1.3.4 Migration

Migration is the most volatile component in population dynamics. Under the condition of an increasingly globalising world migration patterns become more complex and dynamic with a large set of influencing factors (Castles, 2000; 2010; Betts, 2011). Migration is a wide interdisciplinary research field, with manifold of theories (e.g. sociological, macroeconomic, microeconomic, geographical and unifying theories), methods and prediction models, as shown for example by Bijak (2006; 2011).

Therefore we reduce our focus to 1) general global trends and 2) in a second step we bring light in some aspects of a special kind of forced migration, which is induced by changing conditions of the natural environment. Therefore we relate possible migration processes to climate change - another major contemporary and future global trend - and its possible impacts that could affect population displacements within a nation or between nations (international migration).

¹⁵³ Most vulnerable to climate change are children, the elderly and the poor (Luber and Mc Geehin 2008)

Recent trends in migration stocks

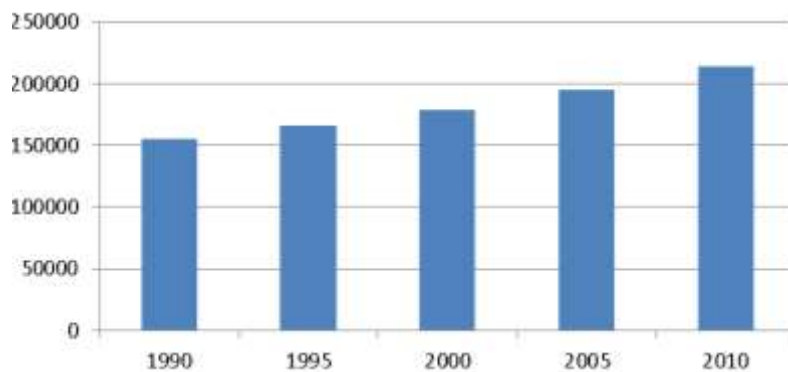


Fig. B1.16 Global migration stocks increased from 1990 to 2010 in thousands (Source: UNPD, 2009)

Global migration stocks in the last decades have been increasing considerably (figure B1.16). If different world regions are compared (figure B1.17) there is evidence that immigration is especially an issue for more developed regions like Europe, Northern America and parts of Asia. International migration remains the most important driver of European population growth; as van Nimwegen and van der Erf (2011) affirm about 80% of the overall population growth in the European Union is caused by migration.

International migration results in an increasing demographic diversity of the population of the European Union and is linked to growing socio-cultural diversity, for example in living arrangements and demographic behaviour. Coleman (2006a) raised the hypothetical question, if a „third demographic transition“¹⁵⁴ is on the way in the more developed regions, like Europe and Northern America and came to the results that this won't be happening before the beginning of the 22th century and that its significance would depend on continued distinctiveness and self-identification of the populations concerned, and on the integration of minorities to native norms, or conversely the mutual adaptation and convergence of all groups.

¹⁵⁴ The first demographic transition described the reduction of birth and death rates from traditionally high levels to the low levels now nearly universal in industrial societies, while the second demographic transition is explained by changing living arrangements and sexual behaviour resulting in a change of values. The concept of the third demographic transition includes a transformation of ethnic and racial composition of some developed regions, like Europe.

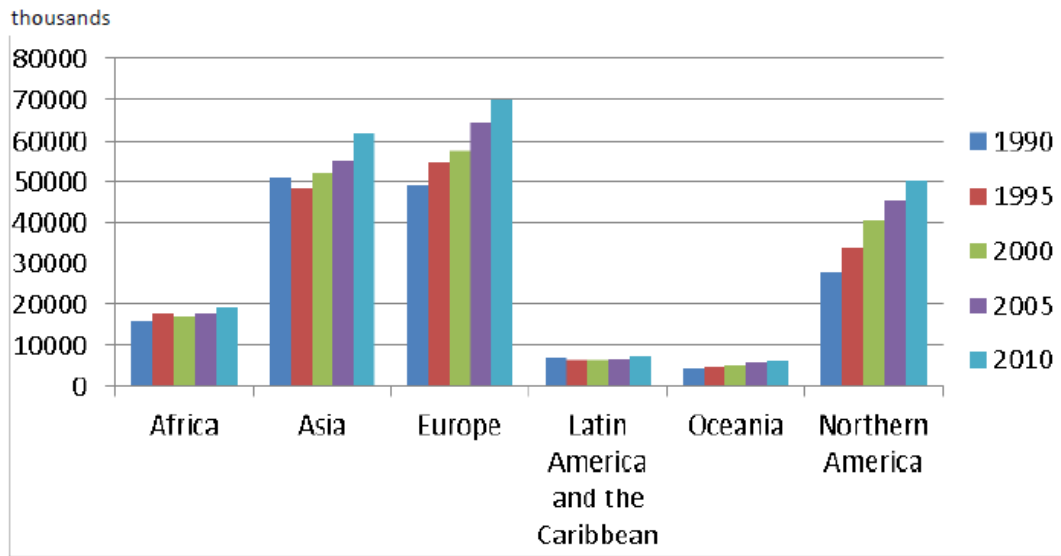


Fig. B1.17 Estimated number of international migrants ad mid-year (Source: UNPD 2011a)

UNPD (2011) highlights the *role of youth* and young adults (as defined as people aged 18-29) in relation to migration. They are the most mobile among people of all ages. For young people migratory decisions are often related to important life transitions, such as obtaining higher education (student mobility, with the possibility to work for a specific time period in the host country after finishing their studies, as is standard in most of the OECD countries), getting employment and family reunification and marriage arrangements. Another case is humanitarian migration, which includes refugees, asylum seekers and other persons in need of protection.

For developed regions, where population is shrinking and ageing, like in Europe, the question of how skilled the migrants are has become very important: Such regions are increasingly dependent on inflows of skilled labour. But according to Chaimie (2007), 85% of unskilled labour from developing countries has gone to the EU.

In developed countries international migrants of working age from (20–64) represent 62% of all migrants of working age. Therefore, they significantly contribute to an increase of the support ratio (see figure B1.18).¹⁵⁵ But it's also worth to mention that on the other side Europe, as an example of a more developed region, hosts 11.9 million of international

¹⁵⁵ The ratio of persons of working age (20 to 64) to dependants (persons under 20 plus those aged 65 or over)

migrants aged 65 or above, which represents 44 % of all older migrants (UNPD 2010, pop facts international migration).

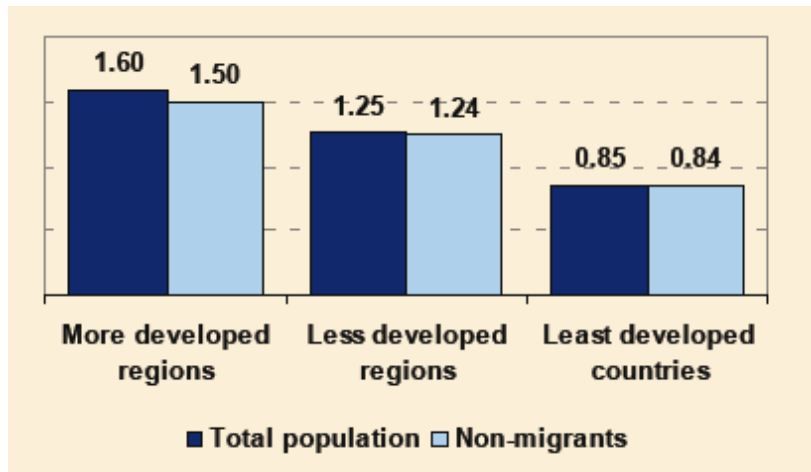


Fig.B1.18 Support ratio 2010 for different types of regions / countries (Source: UNPD 2010b)

Trends in migration governance

The politicization of migration took a prominent place in the beginning of the 1990ies, when the Soviet Block collapsed and the Asian financial crisis unfolded. States acted „ad hoc“ in a short term perspective, driven by these spectacular events of political and economic change (Castles, 2000; Coleman, 2006a; 2006b). Another point is relevant: The dominant political discourse sees migration as being dysfunctional and harmful and as a problem that needs to be ‘fixed’ by appropriate policies. The repressive possibility is tight border control, the more liberal one is addressing the ‘root causes’ of migration especially poverty and violence in origin countries so that people do not have to migrate (Castles, 2010). Emerson et al. (2011) identify non-state actors as significant players in the management of migration. They play an important role for reducing costs and enhancing the ability of the states to respond to illegal border crossing and mass arrivals of immigrants, as happened recently in Southern Italy and Greece.

For reasons of „political control“, it is obviously important to divide migrants into different groups. According to Castles (2000) migrants could be divided into the following categories:

- Temporary labour migrants (for example guest workers, which migrate for a certain period of time to take employment and sending money home)
- Highly skilled and business migrants: moving within the international labour market of their institutions or seeking employment in the labour market for scarce skills. Such migrants are encouraged to come through „special skilled and business migration“ (Castles, 2000, p.270) programmes by many countries
- Irregular migrants entering a country without the necessary legal documents, in some cases immigration countries tacitly permit such migration, since it allows labour force mobilization in response to the demand of employers. This means that employers don't have to burden social costs or measures for protection of employees
- Refugees fulfil the criteria of the 1951 United Nations Convention relating to the Status of refugees
- Asylum-seekers: people who move across borders in search of protection, but who may not fulfil the strict criteria of the 1951 Convention.
- Forced migration: in a broader sense, this includes not only refugees and asylum-seekers but also people who are forced to move by environmental catastrophes or development projects (such as new factories, roads or dams, e.g. the three Gorges Dam in China, after 13 years of construction in 2006 the reservoir had submerged 13 cities, 140 towns, 1350 villages and about 1600 factories (Jäger et al., 2009))
- Family members, also known as family reunion or family reunification migrants
- Return migrants who return to their countries of origin after a period in another country.

It should be mentioned that there are agreements between states but there is a lack of both a formal multilateral institutional framework (like a United Nations Migration Organization) and an international migration regime that regulates state's responses or policies to international migration. There exists the International Migration Organization (IOM), but it has no clear mandate provided by the international community and serves as a paid service provider for individual states¹⁵⁶. (Betts, 2008; 2011)

Future trends in Migration Flows

¹⁵⁶ With exception of UNHCR, based upon the 1951 Convention on the Status of Refugees, seen as an formal refugee regime created by the international community.

According to UNPD (2009) net migration forecasts for 2025 and 2050, net migration will decline significantly after 2030 except for Africa and Northern America, where a decline in net migration is predicted after 2050 (figure B1.19).

The net migration of people from rural to urban areas and from poorer to richer countries likely will continue apace in 2025, fuelled by a widening gap in economic and physical security between adjacent regions. Europe will continue to attract migrants from younger, less developed, and faster growing African and Asian regions nearby. However, other emerging centres of industrialization—China and southern India and possibly Turkey and Iran— could attract some of this labour migration as growth among their working-age populations slows and wages rise. Labour migration to the United States probably will slow as Mexico's industrial base grows and its population ages—a response to rapid fertility declines in the 1980s and 1990s—and as competing centres of development arise in Brazil and the southern cone of South America (cf. NIC 2008).

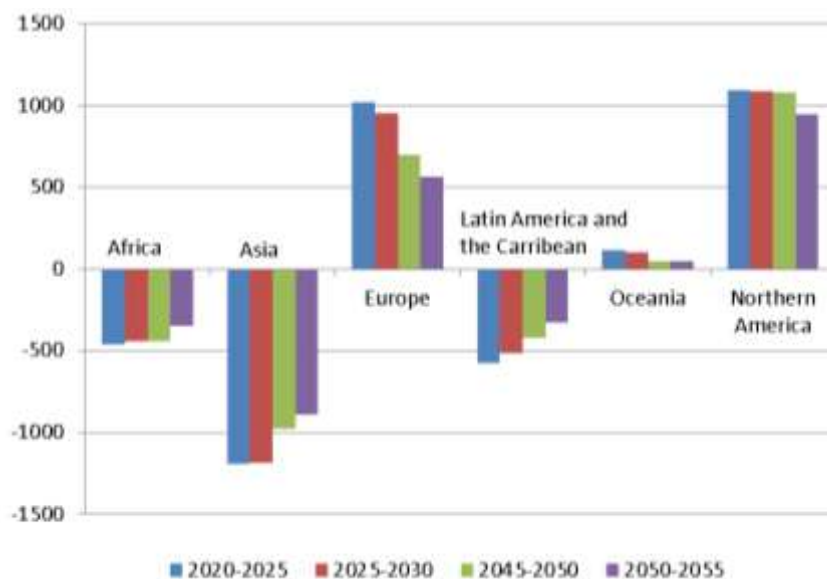


Fig. B1.19 Net migration (per year) both sexes combined, in thousands (Source: UNPD 2009)

The future trends as predicted in Figure B1.19 could be forced by environmental change especially climate changes, as Nicholas Stern (2007), Christian Aid (2007), the AR 4 (IPCC 2007), WGBU (2007) and MEA (2005) pointed out. UNEP (2007) suggests in an assessment of

the conflict in Sudan that regional climate change contributed to instability and conflict in Darfur and forced indirect flee and migration.¹⁵⁷

Therefore the topic of environmentally forced migration should be discussed in the section below, because it could become a further push factor in future.¹⁵⁸

Migration and climate change

Climate change as a major driver of environmental change, could have several impacts on migration patterns: As McLeman and Hunter (2010) note, the combination of rising GHG emissions, population growth in highly exposed regions (less and least developed countries), and their inability to build adaptive capacity among the most vulnerable, will certainly lead to large-scale population displacements and migrations. The beginning of such migrations will likely occur within two decades, and will find expression in patterns similar to past climate-related migration.¹⁵⁹ One trend is that most migrants are moving within their own countries or geographical regions, for example rural-urban migration or migration from coastal zones to other areas within the border of the country. These persons are the so called “internally displaced persons”, IDPs. In some cases, these events may lead to the destabilization of governments or regional conflicts and insecurity (see for example Welzer, 2010, who outlines the connections between climate change, security, responsibility and justice), and may undermine regional economic productivity, thereby creating self-reinforcing stimuli for additional migration.

A smaller but still significant number will use existing transnational communities and migration networks to make their way to developed nations as migrants, legal or otherwise, and will need to be accommodated and incorporated.

Martin (2010) for example identifies four possible paths recognized in literature, in which climate change can affect migration:

- 1) Intensification of natural disasters, such as hurricanes and cyclones that destroy housing and livelihoods and require people to relocate for shorter or longer periods;

¹⁵⁷ Critical refutations come from Bruno Tertrais (Tertrais, 2011)

¹⁵⁸ Standard migration literature classifies forces considered by migrants as network, pull, and push forces: network forces affect the move from location A to location B, push forces operate in A and push people to leave A, and pull forces operate in B and attract people to B (cf. (Reuveny, 2007)).

¹⁵⁹ For example migration related to the 1930ies “dust bowl event” and hurricanes Katrina and Mitch as McLeman and Hunter (2010) describe.

- 2) Increased warming and drought that affects agricultural production, reducing people's livelihoods and access to clean water;
- 3) Rising sea levels that render coastal areas uninhabitable; and
- 4) Competition over natural resources, which may lead to conflict and, in turn, precipitate displacement (see Raleigh et al., 2008; Renaud et al., 2007; Brown, 2008 ; Kniveton et al., 2008).

Adamo (2008) cf. Hugo (2008, p. 32) summarizes some estimates of environmentally displaced people due to the impacts of climate change:

- People at risk of sea level rise by 2050: 162 million (Myers, 2002)
- People at risk of droughts and other climate change events by 2050: 50 million (Myers (2002)
- People potentially at risk of being displaced because of desertification: 135 million (Almeria Statement 1994)
- Number of people who have fled because of floods, famine and other environmental disasters: approximately 24 million (UNHCR, 2002, p.12)
- Environmentally displaced people by 2010: 50 million (UNFCCC, 2007)
- Refugees due to climate change by 2050: 250 millions (Christian Aid, 2007)
- People estimated to become permanently displaced "climate refugees" by 2050: 200 million (Stern, 2006)

Due to the factor that there is no clear, accepted definition of environmental migration and different methods to estimate the potential flux of migrants forced by environmental causes, the estimates are not consistent.¹⁶⁰

As Black et al. (2008; 2011) point out, there are two approaches to relate climate change to migration: (a) to identify the major types of socio-economic impacts that have been identified in climate science, and consider ways in which these might lead to increased (or reduced) migration (see for example the approach of Jäger et al. (2009) or for an overview Black et al. (2008, p. 64 – 69)) and (b) to identify the major patterns and drivers of existing migration, and

¹⁶⁰ For a methodological discussion see Piguet, 2010; a recent example for a two-country, general equilibrium, overlapping generations model is given by Marchiori and Schumacher (2011), for a critical review on studies on environmental migration and the used concepts and methodologies see Jonsson (2010).

consider the ways in which these might be sensitive to climate change impacts (see Black et al., 2011, p. 70-71.)

To assess migration patterns related to climate change it is necessary to distinguish between slow and rapid onset change, because migration patterns differ.

Rapid onset and slow onset changes

In 2011, IDMC and NRC published a study on displacement due to natural hazard induced disasters and provide global estimates for 2008 to 2010.

They classify disasters in a first step climate related disasters and geophysical disasters. Their global estimates for 2008 – 2010 shown in table B1.2– suggest that climate related disasters as flood and storms have serious impact on internal displacement of people.

Table B1.2 Number of displaced people (millions). Source: IDMC and NRC, 2011

Cause of displacement	2008	2009	2010
Climate-related disasters	20.3	15.2	38.3
Geophysical disasters	15.8	1.5	4.0
Total	36.1	16.7	42.3

They distinguish climate related disasters and geophysical disasters in two categories: sudden and slow onset disasters as shown in table B1.3. Within the years 2008 -2010, floods and storms are the most crucial events driving displacement. Geophysical disasters (volcanic eruptions, earthquakes and tsunamis) were also significant in the global figures. Climatological hazards, including extreme temperatures and wildfires, were relatively insignificant in terms of their impact on displacement. (IDMC and NRC, 2011)

Table B1.3 hazard classification after IDMC and NRC 2011

Climate-related hazards	Meteorological Tropical, extra-tropical and storms	Hydrological Floods and wet mass movement Long-lasting subsidence	Climatological Extreme temperature and wildfire Drought
Sudden onset			
Slow onset	–		
Not climate-related hazards	Geophysical	Biological	–
Sudden onset	Earthquakes, volcanic eruption, dry mass move-ments	Epidemics, insect infestation, animal stampede	–
Slow onset	Long-lasting subsidence	Epidemics, insect infestation	–

While here it could obviously be the environment that causes migration, Hugo (2008) adds another issue: the social dimension: „Poorer countries and groups can be at a disadvantage because they do not have the resources to put in place sophisticated warning systems or to fund a rapid, planned, well provisioned flight from the disaster and to subsequently assist the victims to recover. Moreover, some natural disasters may have their root causes in long term political, social, economic or agricultural policies which have disturbed environmental balance“ (Hugo, 2008, p.19). The author provides a topology of disasters (p. 26) related to the environment which are likely to force migration derived from Richmond (1993). Richmond stresses out, that those factors are interconnected and that also predisposing conditions play an important role.

Furthermore Richmond (1993) emphasises, that migration processes may have positive effects on the origin area through reduction of population pressure on the local environment and hence reduce the likelihood of the occurrence of an environmental disaster. Similarly, environmental policies introduced as a result of those disasters may influence migration.

Environmental degradation could occur when population growth sets pressure, especially in Less Developed Countries, on natural systems through extension of settlement into ecologically fragile areas which are particularly vulnerable to degradation or through intensified land use which can lead to soil degradation. Here the environmental change is not as sudden as a catastrophic environmental disaster. Therefore its impacts often remain unnoticed. Environmental degradation could be related to the category „environmental forced migrant“, explained by Renaud et al. (2007; 2011)

An attempt to link climate change with migration is provided by Black et al. (2008), who give an overview of slow onset change and abrupt / rapid change, the climate impacts and the related societal impacts and links them to main types of migration, likely to be impacted for the African continent (see Black et al. 2008, 2011, p. 64 ff). Their division into slow onset and rapid onset changes differs from the view of the former cited report compiled by IDMC and NRC (2010), because they relate the categories very closely to climate change. They stress the importance that also slow onset changes are gradual changes, but that they have different impacts on societies as the below mentioned abrupt or rapid onset changes. They mention for example as slow onset changes increased atmospheric CO₂, temperature increase, sea level rise, changes in precipitation, increased frequency and length of heat waves, decline in frost days, fewer mid-latitude storms.

Rapid onset changes in their definition are the collapse of the thermohaline circulation, the rapid melting of the Greenland and West Antarctic ice sheets, accelerated change caused by increased emissions of methane from thawing permafrost or warmer sea, and release of carbon from soil and dieback of Amazon, permanent El Nino.

For Europe climate change related events – as presented in table B1.14 are likely to become relevant in the coming decades and could force migration flows. Most of the persons will migrate within the borders of their native countries.

As presented in table B1.4, in 2020, the Atlantic and the northern parts of Europe could be affected by increasing risks of floods due to increasing river runoff. This risks could lead to (short-term and localized) displacements in riverine settlements.

The southern parts of Europe in 2020 could be affected by increased water scarcity and drought. The same risk will consist in 2050. This could force population movements from rural to urban areas.

In 2050, in the Mediterranean the extent of areas affected by droughts and heat related extreme events will increase. Generally, yield will decrease. Jäger et al (2009) published a case study for Spain, with the results, that water shortage and droughts could affect migration, the changes brought by climate change could become significant *push factors*, especially in the major area of horticulture cultivation, in Almeria

In atlantic and northern Europe, but also in the Mediterranean increasing wind speeds and storm intensity and a shift of storm centre's maxima closer to Europe's coasts (as predicted between 2010 and 2030) and flooding and erosion could affect estuaries, deltas and embayments. Some SRES scenarios indicate an increased risk of flooding and erosion after

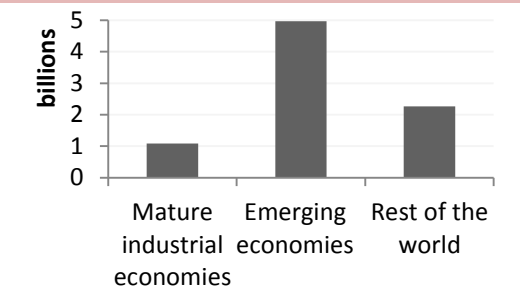
2050 for the Baltic and Arctic coasts. In the low tidal range of the Mediterranean and the Black Sea regions, sea level rise could increase gradually the potential damage from storm surges and tsunamis. Migration from Europe's beaches and low lying coasts into the interior around is likely to occur. IPCC's WGII (2007) estimates, that 2050 in Nile coastal delta < 1 million people will be displaced potentially, in the Sebou and Moulouya delta (Morocco) between 5,000 and 50,000 and the same numbers for the Rhine delta (The Netherlands). Jäger et al. (2009) gauge, that Egypt is one of the most vulnerable parts in the Mediterranean: The Nile delta is the most important agricultural land, but lies widely below the sea level. If sea level rises, even if it's only one meter, a quarter of the Nile delta would be flooded. This will force about 10% of Egypt's population to migrate from their homes.

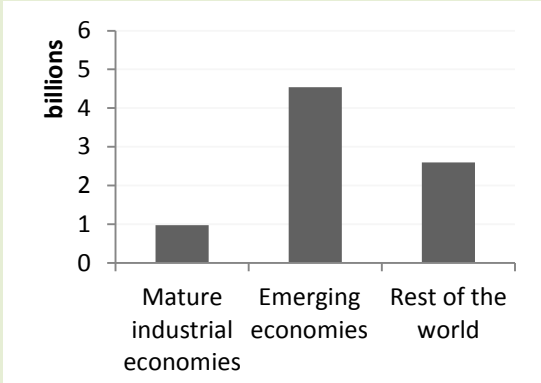
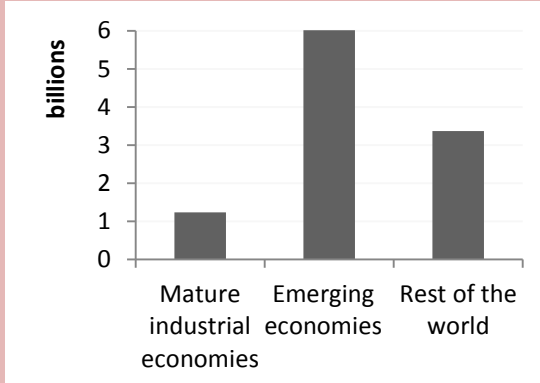
Table B1.4 European regions to be affected by climate change (assumptions for 2020 and 2050) associated with potential population displacements. Sources: Mc Leman and Hunter 2010, IPCC, 2007 , Jäger et al., 2009.

Expected Change (IPCC 2007)	European regions to be affected (IPCC 2007)	Level of confidence (IPCC 2007) ¹	2020 - societal risks	2050 - societal risks	Associations with potential population displacements / migration (after Mc Leman and Hunter 2011, p. 456 ^a and IPCC 2007 ^b)	Case studies (based on EACH-FOR scenarios, Jäger et al 2009)
increases in annual river runoff	Atlantic and northern Europe	**	up to 15% increase (northern Europe); increasing risk of winter flood, flash flooding, snowmelt flood shifts from spring to winter		risk of flood displacements in riverine settlements ^a (sudden onset disasters -> short term migration, localized movements)	
decreases in annual river runoff	central, Mediterranean and eastern Europe	**	up to 23% decrease (southern Europe); increased water scarcity and drought	20-30% (south-eastern Europe), increased water scarcity and drought	increased water scarcity and drought- related population movements ^a (slow-onset climate processes -> impacts on agricultural labour, rural-urban migration)	
increase extent of areas affected by droughts and heat related extreme events	Mediterranean (Portugal, Spain) and parts of central and eastern Europe	**		general decreases in yield (especially in the Mediterranean area), increasing water demand	increased water scarcity and drought- related population movements ^a (slow-onset climate processes -> impacts on agricultural labour, rural-urban migration)	Spain: water shortage and droughts could affect migration; environmental changes brought by climate change could become significant "push factors" (slow-onset climate processes)

increased risk of erosion, flooding and extreme storms, sea level rise	Atlantic and northern Europe, Mediterranean Europe	***	Increase in wind speeds and storm intensity in the north eastern Atlantic, with a shift of storm centre maxima closer to Europe's coasts. (2010-2030); high wave and storm elevations will cause erosion and flooding in estuaries, deltas and embayments	Baltic and Arctic coasts under some SRES scenarios indicate an increased risk of flooding and erosion after 2050, in the low tidal range of the Mediterranean and the Black Sea regions sea level rise could significantly increase potential damage from storm surges and tsunamis	inland migration from Europe's beaches and low-lying coasts; Population potentially displaced by current sea - level trends to 2050 for selected coastal deltas: Nile (Egypt): < 1 million; Sebou and Moulouya (Morocco): 5,000-50,000; Rhine (The Netherlands): 5,000 - 50,000	Egypt: The Nile delta is the most important agricultural land of the country, but lies widely below the mean sea level. A rise of sea level of 1 m would flood a quarter of the Nile delta forcing about 10% of Egypt's population from their homes
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B1.4 Key Assumptions

	friendly	tough
	<p>Low fertility variant. Total population: 7.65 billions</p>  <p>Fig. 4.20 Total population 2025 (for mature industrial economies, emerging economies and the Rest of the world) Source: UNPD 2011, low fertility variant</p>	<p>High fertility variant. Total population: 8.3 billions</p>  <p>Fig. 4.21 Total population 2025 (for mature industrial economies, emerging economies and the Rest of the world) Source: UNPD 2011, high fertility variant</p>
2025	<p>Low migration pressure</p>	<p>Medium migration pressure Migration pressure increases, especially on mature industrial economies. Reasons for this pressure could be on the one hand pull factors (country A attracts people for example, due to job availability or better living conditions and people are moving to A), on the other hand push factors (the living conditions in country B are declining, for example, due to economic reasons (no jobs available), social reasons (conflicts) or environmental reasons and people will migrate to country A).</p>
	<p>Low range of internally displaced people (See for example table 4.4)</p>	<p>Increasing numbers of internally displaced people due to climate change The number of internally displaced people will increase due to climate change related events. (See for example table 4.4), like floods and erosion. These movements are likely to be more local or regional, not international.</p>

	friendly	tough
	<p>Low fertility variant. Total population: 8.1 billions</p>  <p>Fig. 4.22 Total population 2050 (for mature industrial economies, emerging economies and the Rest of the world) Source: UNPD 2011, low fertility variant</p>	<p>High fertility variant. Total population: 10.6 billions</p>  <p>Fig. 4.23 Total population 2050 (for mature industrial economies, emerging economies and the Rest of the world) Source: UNPD 2011, high fertility variant</p>
2050	<p>Number of internally displaced people low</p> <p>The number of internally displaced people will be low due to previous investments in adaptive capacity building.</p>	<p>Large numbers of internally displaced people due to climate change impacts</p> <p>IPCC (2007, WGII) estimates, that 2050 in Nile coastal delta < 1 million people will be displaced potentially, in the Sebou and Moulouya delta (Morocco) between 5,000 and 50,000 and the same numbers for the Rhine delta (The Netherlands). The increase of extreme events, such as droughts and water scarcity and related famines will force internal migration. (for estimates see the chapter migration and climate change)</p>
	<p>Migration pressure low</p> <p>According to UNPD (2011) net migration forecasts for 2025 and 2050, net migration will decline significantly after 2030 except for Africa and Northern America, where a decline in net migration is predicted after 2050.</p>	<p>Strong migration pressure on mature industrial economies</p> <p>Mature industrial economies will have to face strong migration pressure from less developed regions (like Sub-Saharan Africa) or regions affected by conflicts. Emerson et al. (2011) identify non – state actors as significant players in the management of migration. They play an important role for reducing costs and enhancing the ability of the states to respond to illegal border crossing and mass arrivals of immigrants.</p>

		<p>Ageing society in mature industrial economies not adequately handled</p> <p>The pension system will collapse; the risk of impoverishment will affect the elderly. Public healthcare will not be sustained anymore and the access to care is a question of the capacity to finance it privately.</p>
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B2. Shifting Economic and Political Centres of Gravity

- Western economic and political hegemony slowly waning. The world changes towards multipolarity & interdependence (c.f. „Interpolarity“, Grevi 2009)
- This shift is triggered by rapid economic growth in emerging economies and slow growth in mature economies
- Volatility could become a factor for destabilising world economy
- Intensified global economic interconnectedness (through trade, investment, global production chains) increases interdependence and stresses international relations
- International relations might become more collaborative or more confrontational

B2.1 Introduction

The vast majority of those engaged in the debate on the transformation of global order share the view that American power is decreasing. Therefore, the bottom line is not whether or not unipolar order comes to an end, but the form the new order will take. To use Ikenberry's words: "Everyone agrees that the global system is transforming. The distribution of capabilities – of wealth and power – is shifting away from the North and West toward the East and South [...] [i]n the view of many, the world is undergoing a "return to multipolarity." The question is: what sort of order will take shape amidst these multipolar shifts in wealth and power?" (Ikenberry, 2011)

Another central point of discussion relates to the extent of expected change. Is order itself, meaning the underlying principles of liberal order, waning or are we, paraphrasing Ikenberry, experiencing a crisis or even decline of hegemonic power (Ikenberry, 2010; Serfaty, 2011; Nye Jr, 2010; Supreme Allied Commander Transformation - SACT, 2009; National Intelligence Council, 2008; Jacques, 2009; Zakaria, 2009)? If the latter is the case are we witnessing relative or absolute decline; referring to Nye: „[t]he word „decline“ mixes up two different dimensions: absolute decline, in the sense of decay, and relative decline, in which the power resources of other states grow or are used more effectively.“ (Nye Jr, 2010) Serfaty argues along similar lines: "In the 21st century, the post-Western world, should it be confirmed, need not to be about the decline of Western powers, including the United States, but about ascendancy of everyone else." (Serfaty, 2011)

B2.2 Key Literature

Perspectives on the Changing Global Distribution of Power: Concepts and Context

(Young, 2010)

Professor Alasdair R. Young¹⁶¹ works at University of Glasgow at the School of Social and Political Sciences. His main areas of research include international political economy, international cooperation, trade and regulatory politics, US-EU economic relations, WTO dispute resolution, democratic legitimacy and international institutions.

Outgoing from the ever more common characterization of global order to be multipolar, Young scrutinizes whether emerging powers are willing to replace the current global order and its institutions. Therefore, he examines the understanding of power in international relations. Following this, he issues the current global distribution of power and emphasizes the ongoing shift of power by determining “the state actors that “matter” in contemporary world politics ...” (p5).

Young has come to the conclusion that the emerging powers “are not primarily interested in replacing the institutions of global governance, but in having greater say within them. Thus while the ‘rules of the game’ of international politics probably will change, they are unlikely to do so beyond all recognition. Thus what changes there are will likely occur within a broader trend of continuity.” (p.12)

The inter polar world: a new scenario (Grevi, 2009)

Giovanni Grevi¹⁶² is senior researcher and research coordinator at FRIDE (A European Think Tank for Global Action). His main areas for research include reform of global governance and multilateralism, EU security and defence policy, and EU institutional reform.

¹⁶¹“Alasdair's teaching and research focus on the interaction between trade and regulatory policies and politics, with particular reference to the European Union and World Trade Organisation. Before joining Glasgow, he was a Jean Monnet Fellow at the European University Institute in Florence, Italy and a Research Officer in the Sussex European Institute, UK. He has also worked for the US Foreign Commercial Service in Budapest and for Foreign Policy and the Woodrow Wilson International Center for Scholars in Washington, DC. He has contributed to consultancy reports for the British Foreign and Commonwealth Office, Treasury and Department for International Development and the European Commission's Directorates General for External Relations, Trade, and the Internal Market. His DPhil from the University of Sussex was awarded the Political Studies Association's Lord Bryce Prize for Best Dissertation in Comparative and International Politics for 2000.” (<http://www.gla.ac.uk/schools/socialpolitical/staff/alsadairyoung>, accessed 14 December 2011)

¹⁶²“Giovanni Grevi is a senior researcher and research coordinator at FRIDE. Before joining FRIDE, Giovanni served as senior research fellow at the EU Institute for Security Studies (EUISS) in Paris between 2005 and 2010. Prior to that, he worked at the European Policy Centre in Brussels as policy analyst (1998 to 2002) and as associate director of studies (2002-2005). He holds an MSc from the London School of Economics (LSE) and a

Grevi's starting premise is a changing world, which possibly also causes fundamental changes in international relations. With this in mind, he outlines main causes of expected change, in a first step. Thereafter he continues to present his concept of interpolarity more detailed.

First, he argues that the world faces a great transition by depicting two fundamental trends driving change in the international system: multipolarity and interdependence. His argument is "that many factors point to the emergence of and 'interpolar' world. Interpolarity can be defined as multipolarity in the age of interdependence." (p.5)

Therefore, the challenge will be to find a balance between new power relations and changing governance structures. Grevi points out that there are three possible answers to the question, how a multipolar world will develop. Regarding this he says: "[t]he big question is whether the emerging multipolar system will be a confrontational, competitive or cooperative one." (p.27)

[Further information: Effective Multilateralism – G20 (Jokela, 2011), Policy-Making in an Interdependent World (Moran, 2010; WBGU, 2007), Climate Change as a Security Risk (WBGU, 2007); Globalizing Insecurity: The Convergence of Interdependent Ecological, Energy, and Economic Crises (Ahmed, 2010)]

The View of Old and New Powers on the Legitimacy of International Institutions

(Zürn and Stephen, 2010)

Michael Zürn and Matthew Stephen work at WZB (Social Science Research Center Berlin)¹⁶³. Since 2004 Zürn¹⁶⁴ is Director of the Research Unit for Transnational Conflicts and International Institutions, and additionally, he heads the WZB Rule of Law Center as well as the Bridge Project "The Political Sociology of Cosmopolitanism and Communitarianism". He is Professor of International Relations at the Free University of Berlin and was founding Dean of the Hertie School of Governance¹⁶⁵ from 2004 to 2009.

Matthew Stephen¹⁶⁶ is Scholarship Holder of the Research Unit Transnational Conflicts and International Institutions, and since 2009 PhD candidate at the WZB in conjunction with doctoral scholarship from the Berlin Graduate School for Transnational Studies¹⁶⁷.

PhD from the Université Libre de Bruxelles." (<http://www.fride.org/expert/542/giovanni-grevi>, accessed 17 December 2011)

¹⁶³ For further information see: <http://www.wzb.eu/en>

¹⁶⁴ To learn more about Michael Zürn see: <http://www.wzb.eu/en/persons/michael-zuern>

¹⁶⁵ For further information see: <http://www.hertie-school.org/>

¹⁶⁶ To learn more about Matthew Stephen see:



Changing global balance in international affairs is most often conceived as a result of emergence of “new powers such as China, India and Brazil and the renewed assertiveness of Russia.” (p.91)¹⁶⁸ However, another important aspect has to be borne in mind, namely the growing importance and authority of international institutions and non-state actors. Zürn and Stephen point out that a changing global balance of power coincides with increase in the authority of international institutions. In this paper, the authors focus on international institutions arguing that they have become political authorities. Zürn and Stephen reinforce this argument referring to the concept of legitimacy¹⁶⁹ and different sources of legitimacy. Finally, they analyse approaches to the subject of legitimacy of established and emerging powers, as a state’s approach towards sovereignty impinges the role of international institutions and therefore, is an essential condition for the future shape of global governance; whether international institutions are an instrument or a political authority in its own right.¹⁷⁰

Global Governance 2025: at a critical juncture (NIC and EUISS, 2010)

As the Intelligence Community’s¹⁷¹ (IC) center for mid- and long-term strategic thinking the National Intelligence Council (NIC) leads the compilation of reports, such as the National Intelligence Estimates (NIE). Until now, the NIC has produced four editions of Global Trends report; the most recent one, Global Trends 2025: A Transformed World, was published 2008.

¹⁶⁷ For further information see: http://www.transnationalstudies.eu/home.php?nav_id=363

¹⁶⁸ Here Zürn and Stephen refer to Young (Young, 2010)

¹⁶⁹ Here, they refer to Luhmann (1969) providing six sources of legitimacy. Three of them, namely “good outcomes based on expertise”, “serving sense of community”, and “acceptance of individual rights and legality” are related to the outputs of a political order and its policies. The latter three refer to input side of political order and its policies: “accountability of power-holders”, “participation in selection of decision-makers and in the decision-making process”, and “open debate about the common interest of a collective”. (p.94)

¹⁷⁰ Referring to Kahler and Krasner, the authors outline the main features of Westphalian notion of sovereignty as “the principle of non-intervention into domestic affairs and – closely related – the consensus principle for agreements among states. Sovereignty involved three norms: first, that the ruler of a state exercises sole authority over the territory of that state; second, that all states are judicially equal; and third, that state parties are not subject to any law they do not consent. In this view, international institutions are considered as instruments of the territorial state, without possessing a political authority in their own right.” (p.91f) (Krasner, 1988; Kahler, 2004)

¹⁷¹ The IC consists of Office of the Director of National Intelligence (ODNI), Central Intelligence Agency (CIA), Defense Intelligence Agency (DIA), Department of Energy (DOE; Office of Intelligence and Counterintelligence), Department of Homeland Security (DHS; Office of Intelligence and Analysis), Department of State (Bureau of Intelligence and Research), department of Treasury (Office of Intelligence and Analysis), Drug Enforcement Administration (DEA), Office of National Security Intelligence), Federal Bureau of Investigation (FBI), National Geospatial-Intelligence Agency (NGA), National Reconnaissance Office (NRO), National Security Agency/ Central Security Service (NSA), United States Air Force, United States Army, United States Coast Guard, United States Marine Corps and United States Navy.

The European Union Institute for Strategic Studies (EUISS) is an agency of the European Union. The institute was established in 2001 as a replacement of the Western European Union Institute for Strategic Studies. As an agency of the European Union it provides analyses and forecasts to the High Representative for Foreign Affairs and Security Policy. Besides the Chaillot Papers, the Institute's flagship papers, and Occasional Papers EUISS provides reports of major projects.¹⁷²

For the first time in its history, the NIC collaborated with a non-US institute on a report. Beyond cooperation between NIC and EUISS, *Global Governance 2025* brought together a wide range of people in an inclusive process. Within the process not only governmental officials were consulted, but also persons in the areas of business, science, NGOs, and think tanks. Additionally, media representatives from Brazil, China, India, Japan, Russia, South Africa, and the Gulf region had the opportunity to participate in this process.

As scope and breadth of international issues change, the report poses three important questions the international community has to face: How will international institutions respond to an expanding agenda overtaxing their structures? Facing a changing distribution of power, will emerging multipolarity enhance or erode multilateralism? Lastly, will new actors and upcoming adjusted collaborations¹⁷³ fulfil the requirements mentioned before?

[Further information: *End of Dreams, Return of History* (Kagan, 2007), *Moving into a Post-Western World* (Serfaty, 2011), *Multiple Futures Project: Navigating towards 2030* (Supreme Allied Commander Transformation - SACT, 2009), *Climate Change as a Security Risk* (WBGU, 2007)]

¹⁷² The institute's research team is subdivided into nine division: 1. Mediterranean and the Middle East, 2. China and East Asia, 3. Russia and the eastern neighbourhood, 4. Sub-Saharan Africa, 5. Security and defence policy, 6. Iran, Iraq and the Persian Gulf, 7. EU-US relations, 8. India, Afghanistan and multilateralism, and 9. Disarmament and non-proliferation.

¹⁷³ On one hand, the report observes the growing importance of informal grouping, such as G20, the Major Economic Forum (MEF) and regular meetings of the BRICS (p. 19f). On the other it is referred to closer regional cooperation, such a ASEAN in Asia, UNASUR, MERCOSUR IIRSA 8Integration of the Regional Infrastructure in South America) in South America and AU, APSA in Africa (p. 49ff). (NIC and EUISS, 2010)

B2.3 Key Issues: Changing world order, where to?

B2.3.1 Political and military power

Talking about a shift of global power one has to take a nuanced view of the term. First a distinction may be drawn between **hard** and **soft power**.

Hard power includes, according to the classical understanding of international relations, “economic size; technological sophistication; and military strength” (Young, 2010; Mearsheimer, 2001; Waltz, 1979).

A further aspect of power is **soft power**, coined by Joseph S. Nye (Nye Jr, 1990). According to Young soft power enables actors to have bearing through less direct means. With this in mind, Barnett und Duvall introduced **institutional power**, pointing out: It “is actors’ control of others in indirect ways. Specifically, the conceptual focus here is on the formal and informal institutions that mediate between A and B, as A, working through the rules and procedures that define those institutions, guides, steers, and constrains the actions or (nonactions) and conditions of existence of others.” (Barnett and Duvall, 2005)

Young defines power resources, namely economic size, technological sophistication and military might, and how these can be translated into power.

By means of a brief discussion on different concepts of power Young introduces different depictions of the international system: 1) One pair of opposite relates to the scope of effectiveness of power, which is to say whether aggregated or relational power is more useful in international relations. The depiction of aggregated power is claiming that the contemporary world order has to be interpreted as unipolar, since “preponderance of the US across the whole range of powers resources” (p3) remains¹⁷⁴. The other approach implies a multipolar world focussing on “the rapid and projected economic development of a number of ‘middle-ranked great powers’”¹⁷⁵. 2) Another emphasis focusses on the referent object to which power is related. Proponents of a unipolar order claim that the United States, relative to other state actors, prevails as hegemon, since US aggregate power, defined as ability to realise their objectives in any situation, surpasses emerging powers’ capacity. In contrast, the arguments of those put forward the thesis of a multipolar world are more focused on rising power capacities of emerging powers.

¹⁷⁴ Baldwin criticizes this approach pointing out: “One problem with this approach is that what functions as a power asset in one situation may be a power liability in a different situation.” (p.179) (Baldwin, 2002)

¹⁷⁵ The term “middle-ranked great powers” refers to Ikenberry, Mastanduno and Wohlforth (p.16) (Ikenberry et al., 2009).

First, Young discusses economic size, and depicts it as “a power resource in its own right” (p.6). His argument refers to the economic power resource’s capacity to be converted into other power resources, such as military might or technological sophistication. In order to assess economic size he refers to measurements performed by IMF and World Bank.¹⁷⁶ The recorded growth rates suggest the onward change in distribution of economic power resources.

Technological sophistication acts as a fundamental link between economic size and military might. In order to translate economic power resources into military power technology is required to create and maintain military power. An essential indicator for detecting technological sophistication, according to Young – and also viewed by Susan Strange as a central facet of “structural power”¹⁷⁷ –, are shares of patent filings. Concerning this, Young refers to data from World Intellectual Property Organization.¹⁷⁸ According to presented data, the United States, EU and Japan still have a much stronger position than the emerging powers (Brazil, China, India, Russia, and South Africa).

As Young points out, “[m]any scholars, not only realists, emphasise the importance of military power resources.”¹⁷⁹ Military power resources are measured in military expenditure and armed forces (including nuclear weapons) as the figures below (see figure B2.1), produced by SIPRI¹⁸⁰, show. These figures clearly show the continuing military prowess of the United States.

¹⁷⁶ The data used in the paper derive from International Monetary Fund, World Economic Outlook Database, October 2009 and World Bank Data Catalog.

¹⁷⁷ “Today the knowledge most sought after for acquisition of relational power and to reinforce other kinds of structural power (i.e. in security matters, in production and finance) is technology.” (p.31) (Strange, 1998)

¹⁷⁸ World Intellectual Property Organization: <http://wipo.int>

¹⁷⁹ Hereto Young, inter alia refers to Keohane and Nye (Keohane and Nye, 2011) and Strange (Strange, 1998)

¹⁸⁰ Stockholm International Peace Research Institute: <http://sipri.org>

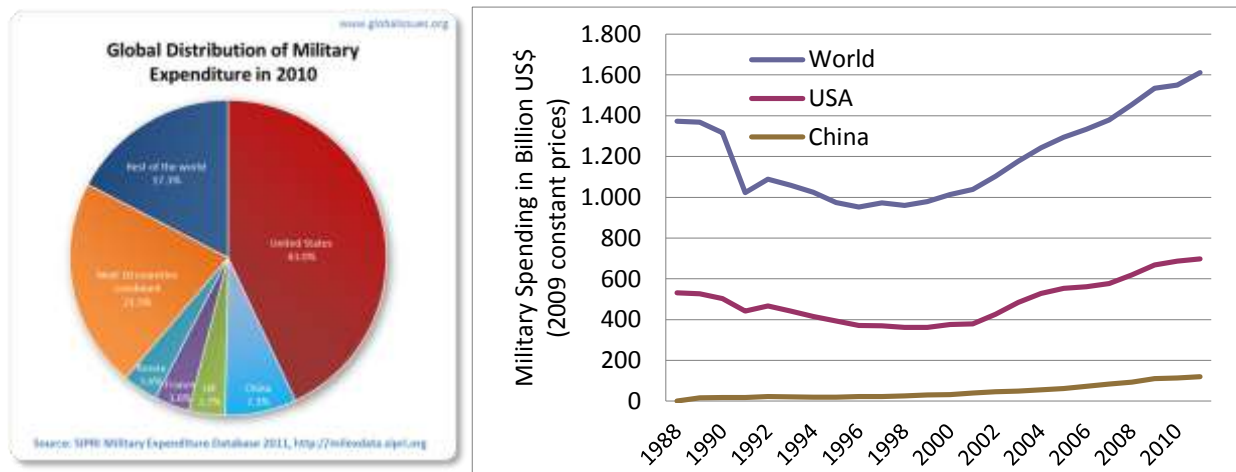


Figure B2.1 Global military expenditure patterns (Source: Stockholm International Peace Research Institute, Background Paper on SIRPI military expenditure data, 2010 <http://www.sipri.org/research/armaments/milex/factsheet2010>) (accessed December 30, 2011)

Lastly, Young mentions a subtle, nonetheless a key issue, form of power (p.9). As designated by Young, ideational power refers to the status of an actor and his capacity to set agendas and influence or even define norms¹⁸¹. In terms of a possible change of global governance, Young depicts this power resource as the “ability to reform (or oppose reform of) existing international institutions.” (p.10)

Grevi emphasizes three essential Indicators for the shifting of power resources. Referring to the Military Balance 2008, he states, in agreement with most scholars and military experts, that the United States outreach any other state, as US military expenditure expressed as percentage of world total spending accounted for 48 per cent. (Adderley et al., 2009)

In terms of economy, Grevi remarks that a shift in power is most notable. Looking at growth rates of the BRICs, especially China will be endowed with major power resources. Grevi emphasizes that “[a]s a share of world Gross Domestic Product (GDP) in Purchasing Power Parity (PPP)¹⁸² terms [...] China may become the largest world economy [...] with almost 20 percent of global GDP ...” (p.17)¹⁸³ However, he indicates “that the picture looks quite different in terms of market exchange rates. On that basis, the EU, the US and Japan together still account for over 60 percent of world GDP.” (p.17)

¹⁸¹ To make his point clear, Young compiled a list describing the „formal status (of state actors – editor’s note) in international institutions“. (p.9) (Young 2010)

¹⁸² Taylor gives a selective insight into Purchasing Power Parity providing a critical literature review. (Taylor, 2003)

¹⁸³ The Data mentioned refers to the Economist Intelligence Unit’s Report “Foresight 2020” (see: http://graphics.eiu.com/files/ad_pdfs/eiuForesight2020_WP.pdf accessed 17 December 2011)

Another indicator, which Grevi provides, refers to endowment with, access to and dependency on resources and energy. He points out that tendencies towards a growing dependency will intensify more and more. Not only will countries, best endowed with resources¹⁸⁴, have a greater share in economic power resources, but also will competition between the major global powers will become increasingly fierce. (p.18)

Lastly, Grevi accentuate that knowledge and innovation are crucial aspects of power, as “economic prosperity and political attractiveness of any country” are reliant on these sectors. Current figures for research and development (R&D) confirm the continued leading of established powers in terms of investment and innovation. However, the figures from OECD’s Science, Technology and Industry Outlook 2008¹⁸⁵ clearly show a shift in share – referring to global R&D expenditure – towards emerging powers. In this context, Grevi stresses China’s exceptional efforts, as “expenditure has been growing at a staggering annual rate of 18 percent between 2000 and 2006, approaching the EU level of R&D intensity (ration of expenditure to GDP).” (p. 19)

B2.3.2 Shifts in the world economy: rising importance of the emerging economies

These shifts can also be observed in the world economy, as represented by shares of global GDP. The major reports dealing with future prospects for the world economy usually only deal with short time spans of a few years. (c.f. IMF, 2011, WB, 2011) A recent analysis by the IMF for example clearly shows the large uncertainties involved in projecting GDP growth rates (Figure B2.2). When operating at longer time periods such as until 2025 and beyond, only a few sources are available and are usually based on historical long term trends. Obviously these projections only work under rather strict assumptions and only indicate certain possibilities.

¹⁸⁴ “While coal resources are evenly distributed, oil and gas are concentrated in a few geopolitical critical countries. The largest oil reserves are located, in decreasing order of magnitude, in Saudi Arabia, Iran, Iraq, Kuwait, the United Arab Emirates (UAE), Venezuela and Russia. The largest gas reserves [...] are in Russia, Iran, Qatar, Saudi Arabia, UAE, the US and Nigeria.” (p.18) Grevi refers to the World Energy Council’s “Survey Energy Resources 2007” (Grevi 2009)

(see: http://www.worldenergy.org/documents/ser2007_final_online_version_1.pdf accessed 12 December 2011)

¹⁸⁵ See: <http://www.oecd-ilibrary.org/docserver/download/fulltext/9208101e.pdf?expires=1324143426&id=id&accname=ocid76020525&checksum=399EC416E1409CADF05C7A316D77EC5C> accessed 12 December 2011

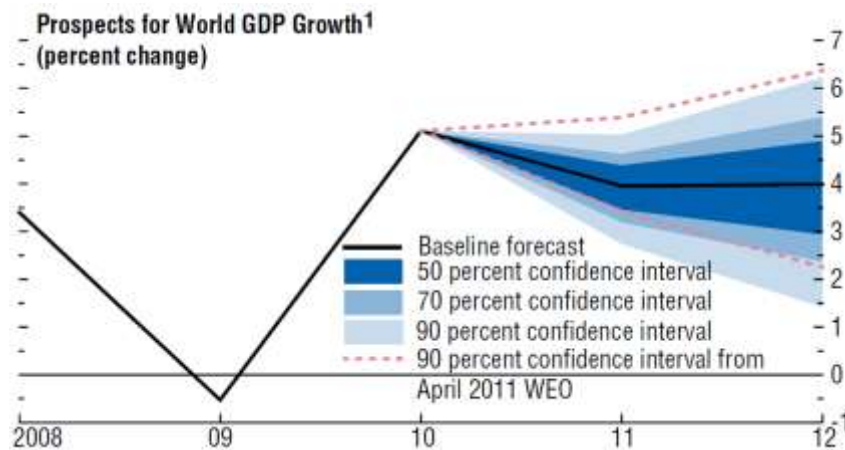


Figure B2.2: Prospects for world GDP growth for 2012 (IMF, 2011, 17)

Poncet (2006) investigates the growth generated by the rise of large developing countries (especially China & India) as the major source of change in the world economy for the coming decades. Long-term scenarios for world economic growth are based on the latest demographic projections from the United Nations, with models of physical capital accumulation and productivity growth used to model countries' GDP growth and income per capita until 2050. On the cautious side, Poncet notes that (ibid. 2006, p. 42): "it is necessary to acknowledge that projections are the more likely to be proven wrong that they are made over a very far horizon. (...) Energy-related constraints may in fact modify drastically the engine of growth in a decade or two."

These projections are based on a neo-classical growth accounting framework (with labour force growth, capital accumulation and total factor productivity (TFP) as key drivers), and estimations of the parameters of a catch-up model of technology diffusion. TFP growth and technology diffusion in the model also leads to appreciating real exchange rates. Domestic productivity growth is assumed to be higher than in the USA because in the low-cost environments of emerging markets (wages, cost of living) higher returns to capital than in the US can be expected, which attracts foreign direct investments, technology transfers and capital inflows.

Summarizing, Poncet (2006, p. 5) states that "[...] today's advanced economies are to become a shrinking part of the world economy: in less than 50 years, China and India together could match the size of the US in current dollars (26.6 against 26.9% of the world GDP in 2050). China and India will stand out as an engine of new demand growth and spending, their GDP will grow at yearly average rate of 4.6 and 4.5%, respectively between 2005 and 2050. The largest economies in the world (by GDP) may no longer be the richest (in terms of

income per capita)". From the current G7 group, only the US, Japan and the United Kingdom may remain in that group until 2050. China, South Korea and India are expected to overtake France, Italy and Canada before then.

The results from O'Neill and Stupnytska (2009) convey a quite similar message, even when taking into account the effects of the financial crisis. Using their Goldman Sachs Growth Environment Score composite index they conclude: "The 2007-2009 financial crisis has been a major challenge for all of the world economy. [...] the BRIC and N-11 economies collectively appear to have withstood the crisis better than many of their developed-country counterparts. Indeed, their contribution to world economic activity has increased even more through the crisis, and since. This is likely to continue in the near, medium and long term" (ibid. 2009, p. 27). According to their projections, it is very likely that China's GDP could already become as big as the US's by 2027, and that the BRICs could become as big as the G7 by 2032.

The Conference Board (TCB) also regularly publishes long term forecasts for the global economy and world regions. They model long term growth trends according to the growth accounting framework, which decomposes output growth into the components capital and labour inputs and the so-called total factor productivity, which is supposed to capture technological progress and gains in production efficiency. "Trends are important for projecting future growth, because they depict how an economy grows on the basis of its potential which is determined by the available labor force, capacity in capital and technology base. [...] In the long run, countries grow according to their trend. In the short run, however, countries deviate from their long-run path due to temporary deviations primarily due to business cycle dynamics. Occasionally, shocks can also occur which have a deep impact on the structure of the economy, which can permanently change the course of its long-run trend." (see Chen et al., 2011, 18, for a longer discussion of the TCBs methodology)

According to their results global growth is likely to slow down to about 3% per year on average in the next decade. The recovery of the advanced economies will be more than offset by a gradual slowdown in emerging economies. (The Conference Board, 2012)

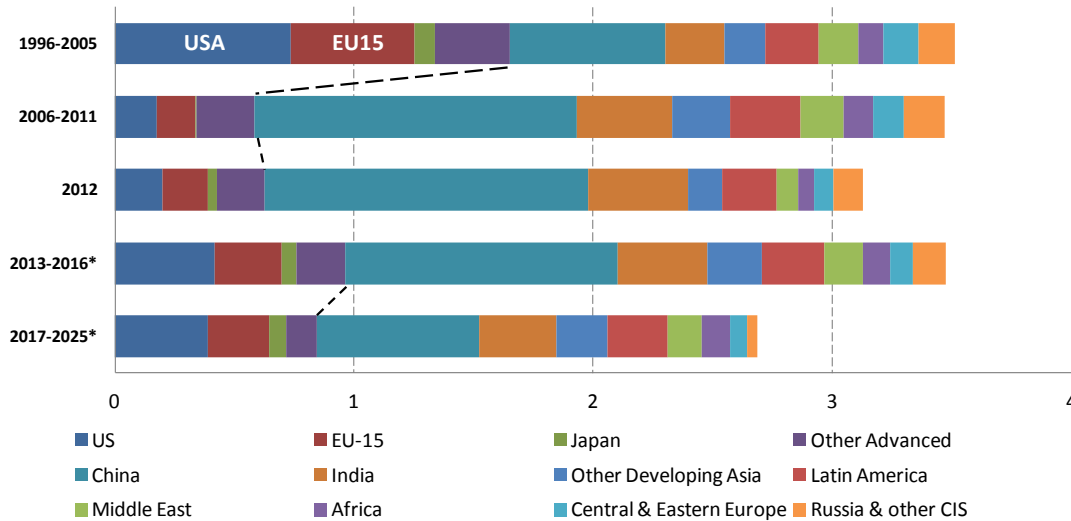


Figure B2.3: Changes in global economic growth rates from 1996 – 2025 (The Conference Board 2012a)

Interestingly TCB also investigated optimistic and pessimistic scenarios for the world economy. (Chen et al., 2012, p. 19f) In the optimistic scenario countries underperforming relatively to the base scenario in recent periods recover till 2025 (meaning that they catch up with their growth rate of the base scenario). The pessimistic scenario assumes that countries that outperformed in recent periods fall back to the trend output level and the GDP growth will allow those countries to meet the output level of their trend and would continue to until 2025.

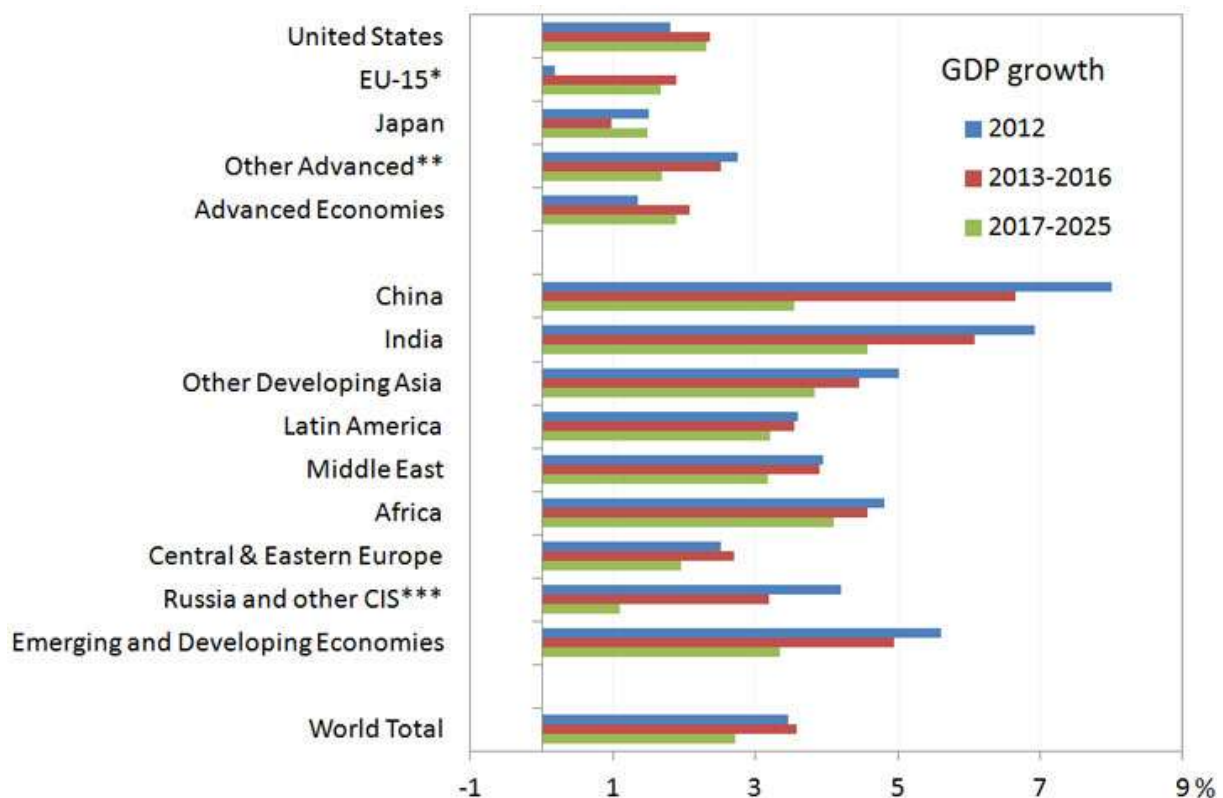


Figure B2.4: GDP growth rates for the world economy and world regions (The Conference Board 2012b)

B3.3.3 From a unipolar to a multipolar world order

A broad review of literature shows that the overwhelmingly majority of scholars and experts observe the end of unipolar world order. In this context, Richard Haass even speaks of a “tectonic shift” (Haass, 2008).

As power shifts, the unresolved question remains, whether U.S. (and Western) power declines in absolute or relative terms. On the one hand, Higgott points out that a multipolar world order is emerging with the BRICs as new poles of the system and rising influence of non-state actors¹⁸⁶ (Higgott, 2010), due to the fact that countries such as China and India become more powerful. Herolf, along this line, emphasizes that the financial crisis of 2008

¹⁸⁶ “They [BRICs] will also be accompanied by those increasingly influential non-state actors (from both civil and non-civil society) through to the new and emerging transnational regulatory networks of both public and private policy makers and regional agencies and actors.” (p.2)

intensified the changes in global power relations, as it “[...] made the weakness of the US economy obvious.” (Herolf, 2011)¹⁸⁷

Richard Haass, for example, established the term nonpolarity (Haass, 2008). He points out that as a result of a wide range of influential actors, multipolarity as a theoretical term is insufficient. He also remarks that an age of nonpolarity can be either multilateral¹⁸⁸ oriented or “cauldron of instability”. (Haass, 2008) Ferguson outlined an unlikely global order characterized by a power vacuum. In such a new anarchic era neither a hegemon nor a balance of power can be preserved. In this era of nonpolarity, in which economic stagnation rules and “civilization’s retreat into a few fortified enclaves, order disintegrates into disorder.” (Ferguson, 2004) Hamilton refers here to a “nobody-in-charge world”. He points out that states, as main actors in the international system, are challenged by non-state actors. (Hamilton, 2010)

When it comes to multipolarity, one has to define first, what this order implies. Looking at the preliminary requirements of multipolarity, power is distributed among three or more great powers in such a way that none is in a position to prevail over the others and acquires undisputed primacy in the system. This does not exclude, however, that one power or more large powers are considerably stronger than others. (Grevi, 2009) In a balance of power major actors establish relationship bringing stabile conditions to the system as a whole. (Deutsch and Singer, 1964, p. 390) Grevi emphasizes that “[c]oncerning the scope of balancing, in a multipolar system great powers co-exist and often compete at the global and regional level, including by forming balancing coalitions and alliances.” (p.23) (Grevi, 2009)

In terms of cooperativeness, the concept of multipolarity neither inclines to cooperation nor confrontation. According to Stanley Hoffmann, not the number of poles, but the goals of states determine, whether a multipolar world is more cooperative or more confrontational. (Hoffmann et al., 1990) Keohane emphasizes the role of international institutions in defining cooperativeness of global order. He says, that states are self-interested and “that international institutions help to shape the expectations of states and are therefore crucial determinants of state behaviour. (Hoffmann et al., 1990, p. 194) Grevi, along with both, says: “Certainly, some powers may be more pivotal than others to global cooperative efforts on specific issues.” (Grevi, 2009)

¹⁸⁷ Granholm points out that on the other hand countries like China, India and Brazil managed the consequences of the financial crisis quite well (Granholm et al., 2010)

¹⁸⁸ However, he qualifies relationships to be more selective and situational, referred to as “multilateralism à la carte”.

Both, the NIC and EUISS, share the opinion that the international system will change dramatically due to the rise of new powers (e.g. NIC defined the following groups in Global trends 2025 (NIC, 2008): “Rising Heavyweights”¹⁸⁹, “Other Key Players”¹⁹⁰, “Up-and-Coming Powers”¹⁹¹). The further globalizing economy, transfer of relative wealth and economic power from the West to the East, and the emerging influence of non-state actors will challenge global governance¹⁹² as we know today.

With rising new powers the emergence of a multipolar world becomes apparent. This even more, as NIC and EUISS point out, stresses the need for effective international cooperation. Here too, NIC and EUISS call for the need to enhanced global cooperation. USA will remain the single most powerful country, but will be less dominant.

In his book “A post-American World”, Zakaria claims that world order inevitably changes because of rise of the rest. Therefore, he points out that the United States has to recognize this fact, but faces a choice of either to stabilize emerging order by ceding some of its power and in order to shape a post-American order. Otherwise, if the U.S. only watches indifferently the rise of the rest, Zakaria expects a more nationalistic and disintegrated world tearing apart the existing order. (Zakaria, 2009)

In terms of multipolarity, Nye takes a more differentiated view on power distribution. He points out that power, manifested through world’s economic output, global military expenditure and soft power resources (cultural and educational) already is heavily unequal distributed for some time. Today’s debates focussing on (relative¹⁹³) decline¹⁹⁴ of the US are, according to Nye, misleading, because distributed power resembles a “complex three-dimensional chess game”. On the top chessboard, as he says, there is military power, which will remain unipolar for quite some time. On the second there is economic power, being multipolar already for more than a decade, as Europe, Japan, and China have already a big

¹⁸⁹ China and India

¹⁹⁰ Russia, Europe, Japan and Brazil

¹⁹¹ Indonesia, Turkey and Iran

¹⁹² “The term global governance as used in this paper includes all the institutions, regimes, processes, partnerships, and networks that contribute to collective action and problem solving at the international level. This definition subsumes formal and informal arrangements as well as the role of nonstate actors in transnational settings. Regional cooperation may also be regarded as an element of global governance insofar as it contributes to broader efforts. Governance differs from government, which implies sovereign prerogatives and hierarchical authority. Global governance does not equate to world government, which would be virtually impossible for the foreseeable future, if ever.” (NIC and EUISS, 2010) (p.1)

¹⁹³ Nye refers to NIC report pointing out: “[T]he U.S. will remain the preeminent power, but that American dominance will be much diminished.”

¹⁹⁴ Nye rejects the thesis of “imperial overstretch”, but rather sees the risk of domestic underreach (curtailed immigration in terms of demographics, economic growth, and soft power – USA as a magnet). Therefore, Nye states a mix-up of different dimensions of decline: 1) absolute decline in the sense of decay, and 2) relative decline referring to growing power resources of other states.

share of world economy. Finally, on the bottom chessboard there is the “realm of international relations”, including a variety of actors (non-state actors: bankers, terrorists, hackers) and challenges such as pandemics and climate change. Thus, Nye views a narrative of hegemonic decline as inaccurate. The US will remain the single most powerful actor in international relations, yet facing the rise of new powers (states and non-state actors). He concludes that power in the 21st century should necessarily be seen differently. Powerful actors combine soft and hard power to form “smart power”. (Nye Jr, 2010)

Young designates a group of global powers saying “there is a broad consensus that the state actors that ‘matter’ in contemporary world politics are Brazil, China, India, Japan, Russia and the United States.” (p5)¹⁹⁵ The European Union and South Africa¹⁹⁶ are also added to this list, yet not for the aforementioned reason. On one hand, the EU’s capacity to act as a global power is hindered by the requirement of unanimity (Whitman, 2010). Despite this the role of EU as a political factor in international relations becomes increasingly important. On the other hand, Young justifies the addition of South Africa to the list of “state actors that matter” with its close ties with Brazil and India (IBSA) and the state’s membership of G20 (as the only African state).

As to the question whether a shift of power will impinge on global governance, established after Second World War, Young also asks for caution in emphasizing three reminders. Firstly, United States’ decline was projected several times already. Yet he points out, “given the US’s preponderance with regard to many power resources” (p.12), that it would be hasty declaring the above mentioned. Secondly, although trends may exist to believe that emerging powers’ gain in influence is growing further as in recent times, it should be borne in mind that states as China and Russia, for example, face serious internal tensions.¹⁹⁷ Another aspect to be considered important refers to the historic precedent when Soviet Union collapsed and global balance of power shifted dramatically. Despite this historical upheaval, international institutions outlasted. One significant difference between the above mentioned and the contemporary shift might be with respect to states, which get more powerful. Whereas Soviet Union’s enhanced United States’ power (a protagonist of the respective global order), current changes occur in favour of emerging powers.

¹⁹⁵ Young emphasizes Waltz’ point (Waltz, 1979) which indicates “that whatever the challenges of precisely ranking the power of states there is usually a common-sense consensus about which actors are great powers.” (Young, 2010)

¹⁹⁶ In contrast to Young, other scholars, such as Haass (2008) and Manning (2010), consider South Africa only as a regional power.

¹⁹⁷ Young refers to Breslin and Tsygankov, who delve into the internal pressures which China and Russia face. (Breslin, 2010; Tsygankov, 2010)

Taking Krauthammers “unipolar moment” (Krauthammer, 1990) as a starting point, referred to as an interlude¹⁹⁸, Serfaty sees this moment over. Agreeing with Zakaria he argues that the 21st century’s order is moving into a post-Western world. The reason is not necessarily one of decline, “but about the ascendancy of everyone else.” (Serfaty, 2011) If a post-Western world is to emerge Serfaty asks, who will be able to catch up with the great power USA or at least gain significantly influence? A large cluster of emerging world powers, regionally influential states and groups of rising influence will shape a new order.¹⁹⁹

Serfaty sets out three core conclusion to help settle into a post-Western world. First of all, the transatlantic partnership will be the least dispensable bilateral relationship, but too narrow to be sufficient for the new world order. The multitude of challenges such as negotiations over Iran, climate change, or global trade maybe handled under US leadership and transatlantic solidarity, but a broader basis of states is needed to face those successfully. Possibly an alliance of democratic nations will be established, including Japan and South American states²⁰⁰ and African states. Another attractive partner might be India as world’s largest democratic and secular country. (p. 14ff)

Concerns that China and India will form a coalition (“Chindia”) are, according to Serfaty, not very realistic. Both states are more interested in the USA and Europe than in each other. He considers: “Neither country holds a “card” that it can effectively play with the other, or even with others, against the West.” (p.16) Besides occasional partnerships²⁰¹, he emphasizes the fact that they “remain political adversaries, economic rivals, and security risks.”²⁰²

Lastly, Serfaty questions the future role of Russia. In this context, he remarks that whether relations between Russia and China or India are going well they do not pose a threat to the West. Although Russia is not a Western power, its future is with the West as Russian

¹⁹⁸ “Unipolar systems have been historically rare and geographically confined at most geostrategic interludes during which weaker nations combined to entangle Gulliver with thousand strings. What is surprising, though, is not only now quickly this most recent moment ended, but also how quickly a consensus has emerged about an inevitable and irreversible shift of power away from the United States and the West.” (p.7) Similar to Nye Serfaty refers to the National Intelligence Council according to the emerging shift of power. Additionally, Serfaty points out that, NIC’s earlier assumptions about power distribution and the future role of the US were more positive (NIC, 2004) compared with their latest report.

¹⁹⁹ Serfaty views the EU, Russia, China, India, and Japan as emerging powers, whereas Brazil, Turkey, South Africa, and Indonesia, according to him, will be regional powers.

²⁰⁰ Serfaty lists Brazil, Argentina, and Mexico in South America. In Africa he enumerates Nigeria, South Africa, and Morocco

²⁰¹ Serfaty mentions the Doha round of trade negotiations, Copenhagen, and Cancun (p.16). (Serfaty, 2011)

²⁰² Serfaty points out: “Each fears the other’s hegemonic impulses [...] India’s security concerns include Pakistan’s drift toward China as its primary supplier of military hardware and nuclear technology conducive to dual uses, as well as an old-standing Chinese ambition to develop Pakistan as a hub for markets and production centers in the Middle East and Africa [...] Finally, just as with Japan, China has territorial issues with India, it has claims on the North-Eastern Indian state of Arunachal Pradesh, a territorial piece of Uttar Pradesh, the largest Indian state with a population twice that of Germany.” (p.16f) (Serfaty, 2011)

economic interests are centred on broader relations with, and access to, Western markets, money, and technologies. Serfaty outlines the difficulties²⁰³ Russia faces and the need for strategic and privileged partnerships to exercise influence on a global level. (Serfaty, 2011)

Summarizing, he observes a century ahead unprecedented as “[i]n neither of the past two centuries did the need for a new world order require global assembly [...] There now is a pressing need for new structural design to accommodate the new cast of characters.” (p. 19) He points out that it is imperative, what the United States and Europe undertake to ensure a stable global order. Therefore, he concludes: “Only the next few years will tell whether a new generation of political leaders in the United States, as well as in Europe, will be able to grasp the enormity of what their predecessors achieved during the past century for what Dean Acheson defined as “half of the world”²⁰⁴ and how much can still be done in the 21st century for the other half.” (p.20)

Additionally, power will shift towards non-state actors, too. What the NIC called the “multiplicity of actors” (NIC, 2008, p.81), can be seen both as a chance or a threat to global governance. The report emphasizes, “[o]n the positive note, transnational nongovernmental organizations, civil-society groups, churches and faith-based organizations, multinational corporations, other business bodies, and interest groups, have been equally, if not more effective than states at reframing issues and mobilizing publics [...] [h]owever, hostile nonstate actors such as criminal organizations and terrorist networks, all empowered by existing and new technologies, can pose serious threats and compound systemic risks.” (p. iv) (NIC, 2008; NIC and EUISS, 2010)

Interdependence

The report detects three “effects of rapid globalization” requiring an effective global governance. First, the process of interdependence continues to grow, whether one talks in terms of economy, climate change or resources issues.

At the same time, “redistribution of power at the global level” (p.9) becomes more and more perceptible. In terms of classical international relations, this shift in power inevitably would lead to multipolarity. Additionally to the above mentioned challenges, he states that “[a]ll

²⁰³ Potential problem areas: “to the east, with a populous China next to Russia’s least populated territories; to the south, with Muslim post-Soviet republics open to Islamic influence, the consequences of which are already bitterly felt in Chechnya; and to the west, where earlier NATO enlargement and ongoing EU enlargement have moved deeply into Russia’s former security zones and economic space.” (p. 19) (Serfaty, 2011)

²⁰⁴ Dean Acheson, 1969. Present at the Creation: My Years at the State Department. W.W. Norton and Company, New York, p. xvii

major powers are exposed to the unprecedented conjunction of the economic, energy and environmental crisis and none of them can successfully confront these challenges on its own.” (p.5).²⁰⁵ He also points out that neither dimension of change is new per se but, as the financial and economic crisis shows, both the shift in the global power system and mutual dependence are growing in scope and pace at the same time. The interaction of these two basic trends is reshaping the international system and will have long-term implications at all levels. (Grevi, 2009)

Referring to Rosenau, growing interdependence is also a result of transformation of the Westphalian system. Previously sovereign states were protagonists in international politics. Today, states are challenged by a set of non-state actors, ranging from private corporations to a multitude of NGOs. Rosenau describes this as a world of governance that has dismantled the hierarchies of “government” in place of ‘a set of regulatory mechanisms [...] which function effectively even though they are not endowed with formal authority’. (Rosenau, 1992, p.5)

Moran points out that the term interdependence “is usually gathered under the umbrella of economic globalization. True, there is contention surrounding this subject: about the very meaning of globalization; about how far the changes that have undoubtedly occurred since the early 1970s are, indeed, historically novel, or only amounted to the recreation of an older pattern disrupted by the great wars of the twentieth century; and about just how truly ‘global’ have been the processes creating an economically interdependent world.” (Moran, 2010 (p. 27)²⁰⁶

²⁰⁵ **Economic interdependence:** “[T]he crash of the US subprime market spectacularly illustrates the nature of global economic interdependence. The globalisation and deregulation of finance has enabled large transfers of wealth [...] but also has entailed the exposure of all liberalised financial markets to the collapse of a system ultimately based on a pile of debt. [...] [T]he impacts will be relatively harder on the US, the EU and Japan than on, for example, China and India. These countries, however, are suffering too as their exports to rich countries contract and foreign investment shrink.” (Grevi, 2009, p.24)

Energy security: “Under the International Energy Agency (IEA) reference scenario, both global energy demand and CO2 emissions will jump by 45 percent between 2006 and 2030. By then, it is envisaged that fossil fuels will still cover 80 percent of the world primary energy mix. As a result, the global competition for these resources will only intensify.” (ibid., p.25)

Climate change: “There is widespread consensus that these growth rates (energy demand and CO2 emissions) are unsustainable and will trigger catastrophic climate change. The latter will accelerate the depletion of natural resources, engender the propagation of old and new health scourges, and disproportionately affect already poor regions whose population is expected to expand exponentially. In this context, climate change would act as a “threat multiplier” and further undermine the stability and security of fragile states.” (ibid., p.25)

²⁰⁶ In this context Moran refers to Scholte saying that the phenomenon [interdependent world, editor’s note] “accelerated globalization of recent decades has left almost no one and no locale on earth completely untouched, and the pace has on the whole progressively quickened with time” (Scholte, 2005, p. 119). She also accentuates that the critical domain of finance “has shifted very substantially out of the territorialist framework that defined

Cooperative or confrontational world

To provide a comprehensive overview we offer two basic lines of development. On the one hand, the world might head towards cooperative order, where established and emerging powers rely on international institutions, as challenges such as economic interconnectedness, climate change, and resource security, are perceived as common matters. On the other hand, global order might turn more confrontational, as established powers and emerging powers not only compete over geopolitical aspects, but also in terms of worldviews.

Nevertheless, it is a difficult task to differentiate, whether or not assumptions can be considered realistic or unrealistic. Not only has the variety of concepts, but also manifold implications entailed, addressed a broad spectrum of questions.

most banking, securities, derivatives and insurance business before the middle of the twentieth century” (Scholte, 2005, (p. 113).

Cooperative

Giovanni Grevi's concept of **Multilateralism in an interpolar world** closely links the emerging shift in powers with increasing interdependence due to global challenges in economic, energy, and environmental terms. (see also National Intelligence Council, 2008; Solana, 2008; WBGU, 2007)

Promoting an interest-based, problem-driven, and process-oriented approach, "[t]he key will be to harness what works best in different formats and make them compatible and mutually reinforcing." (Grevi, 2009, p. 31) This implies that more emphasis is put on informal cooperation. (p.32) Furthermore he remarks a decisive role of major powers, in order to face the aforementioned challenges. Referring to Ikenberry, the international community would become more hierarchical, as roles and responsibilities are more differentiated. (Ikenberry, 2009, p. 73) In Grevi's view, summit diplomacy, because of its flexibility²⁰⁷, is more effective, in terms of managing certain problems. (Grevi, 2009, p.32f)

Summing up, the indicators, provided by Grevi, conclude an ongoing shift in power. Additionally, Grevi emphasizes that the world will face "a more diverse and heterogeneous international system, where emerging and resurgent players not only assert their individual interests but also promote their distinctive worldviews." (p.7)

The fundamental question is whether the emerging international system will transform into sheer confrontational multipolarity or cooperative multipolarity. The latter, hereinafter called interpolarity, would be guided by pragmatism; citing Grevi: "Interest-based interpolarity is problem-driven in so far as it builds on the expanding range of serious challenges that require cooperative solutions for the simple reason that they affect many countries in a context where no country, no matter how powerful, can unilaterally provide for its prosperity, stability and security." (p.29) On this basis, Grevi points out the importance of reform of international institutions and the need for greater role of summit diplomacy, in order to make multilateral order "fit for the new scenario of interpolarity." (p.31)

Zürn and Stephen consider an ongoing trend towards **Supranationalisation**. In their view, international institutions become important for managing globalisation. Linked to the emergence of new powers along with a changing distribution of power, international institutions have to confront the challenge of accountability and participation. (p.98)

²⁰⁷ "Informal fora will boost the top-level coordinating and agenda-setting function of this summit without burdening its agenda with too many issues and excessive detail." (Grevi, 2009, p. 24)

International institutions have to respond to the rise of new powers and reflect ongoing changes, in order not to forfeit legitimacy of international institutions. First of all, the growing number of “international agreements, covering more and more areas” (p.92) supports their theory. The number of countersigned agreements has grown from 942 (1969) to 6,154 (2010). Additionally, they notice a change in “negotiation or decision phase”, as the majority principle is more and more often used.²⁰⁸

They also claim that along with a greater number of international rules, tasks of “monitoring and verification” brought up new actors. Not only are they non-state actors (such as NGOs), but they also “regulate activities within the boundaries of sovereign territories.”²⁰⁹ Another significant aspect Zürn and Matthew depict relates to international judicial bodies as interpreters of rule, as their numbers, referring to PICT²¹⁰, nearly quadrupled from 1960 to 2004. (p.92)

In this context, they also point out that the “readiness to levy material sanctions against violators” (p.92) increased. According to Binder, “[e]specially since 1989, cases of gross violation of human rights have increasingly been responded to with military force and economic sanctions (Binder, 2009). Also, the UN experienced an upgrading of its role setting up “transitional administrations with far-reaching executive, legislative and judicial powers” (p.92), i.e. in Kosovo and East Timor.

By the example of climate change, Zürn and Stephen emphasize an increasing diversity of non-state actors taking part in political process. “Knowledge bodies”, such as IPCC, play more and more an important role, as they weaken “the ability of single governments to oppose international norm development processes.” (p.93)

Altogether, Zürn and Stephen detect that “[t]he political authority of international institutions makes it increasingly difficult for states that wish to appear legitimate to ignore them, and this increases states’ interest in shaping the global governance order.” (p.93)

²⁰⁸ United Nations Treaty Service: <http://treaties.un.org/Home.aspx?lang=en>, accessed 6 December 2011

²⁰⁹ United Nations Economic and Social Council; regarding the numbers of NGOs see: <http://esango.un.org/paperless/content/E2009INF4.pdf>, accessed 6 December 2011

²¹⁰ The Project on International Courts and Tribunals (PICT) was established in 1997. Initially, it operated as a framework of collaboration between academic institutions in New York and London (the Center on International Cooperation (CIC), New York University, and the London-based Foundation for International Environmental Law and Development (FIELD) and subsequently, the Centre for International Courts and Tribunals, University College London). For further information see: <http://www.pict-pcti.org/index.html> accessed 18 December 2011)

Confrontational

Within implies a world ranging from competition to rivalry. Since relations between major powers are increasingly strained international cooperation wanes. In this context Grevi mentions the rise of negative power (or power of denial). This aspect of power primarily is regarded to military might. However, he also emphasizes that “the increasing importance of negative power – the power to deny others the fulfilment of their objectives – is an important feature of the emerging international system. The possession of and the access to natural resources and notably energy reserves affect the balance of (positive and negative) power to a much greater extent than in the past because of growing demand and the associated geopolitical competition for resources. (Grevi, 2009, p21) Though, common challenges are recognized major actors act self-interested.

According to this, Grevi remarks that access to natural resources and energy becomes increasingly central in international relations, attempts to become more influential in respective world regions will likely lead to more competition. He also considers that “[w]hile the impact of the financial crisis is very serious, however, the impact of planetary crisis would be disastrous and irreversible.” (Grevi, 2009; Scheffran et al., 2011; Grevi, 2009; Moran, 2010; Military Advisory Board, 2007)

For all their differences, the concepts share emphasis on the influence of distribution of power on shaping international institutions and hence global governance. In light of this consideration, Young states that - irrespective of whether it is about the structure of international organizations²¹¹, the outcomes or dealing with internationally defined standards²¹² - shifts in balance of power are a challenge to international institutions. Therefore, both formal (UN Security Council, IMF) and informal (WTO, G20) institutions are under considerable pressure for reform.

Zürn and Stephen assert that some obstacles still have to be overcome in order that international institutions gain more legitimacy. Therefore Zürn and Stephen provide “five propositions about the prospects for legitimacy of international institutions today” (p.96)

Today’s legitimization of international institutions primarily is based on technocratic justification. However, what seemed undisputed for a long time starts to crumble, as “what

²¹¹ Mearsheimer, as proponent of neo-realism, stresses a state’s position and behaviour in international relations as significant impact on international institutions. (Mearsheimer, 2001) According to neoliberal institutionalism, a discrepancy between the current balance of power and the shape of international institutions is severely threatening the latter (Stein, 2008)

²¹² Young refers to Price (Price, 1998) saying: “[C]hanges in the distribution of power matter, particularly to the extent that great powers advocate, endorse or oppose the development of new international norms.” (p4)

was seen as technocratic interventions by the International Monetary Fund (IMF) to restore economic fundamentals based on impartial expertise are now widely seen as having aggravated economic difficulties and implemented policies favourable to Washington.” (p. 96) Ikenberry and Wright detect a loss of confidence in the so called Bretton Woods institutions. “However, the widespread perception that the IMF grossly mishandled the Asian financial crisis and the collapse of Russian and Argentina’s economies prompted governments to reduce, and even eliminate, their reliance on the IMF.” (Ikenberry and Wright, 2008)

Continuing this argument, Zürn and Stephen assert that international institutions are perceived as pro-Western biased and lack accountability. Furthermore, powerful states violate international rule, as they “can and do skirt the rules if they are inconvenient.” (p.97) Closely related to the above mentioned argument, Zürn and Stephen indicate double standards towards international institutions antagonizing the demand for “more equal distribution of influence in international institutions”. (p.97) The United States is a good example how rhetorics diverge from implementation. Neither the Kyoto Protocol nor Rome Statute²¹³ was ratified by the US. In view of the Rome Statute, it should be kept in mind that other powers, such as China, Russia and India, denied to ratify as well. Of course, the point of Zürn and Stephen is that the United States strongly support international regimes, yet rhetorically, but emphasize American sovereignty at the same time.

Another critical issue for legitimacy of international institutions is the principle of non-intervention. In this case, tensions between international institutions and emerging powers and the USA arise, according to the appropriate forum of decision-making. Whereas the European Union seems willing to delegate some of its sovereignty to international institutions, Zürn and Stephen argue that “[m]ost rising powers see the UN General Assembly and its related institutions as more legitimate and representative because they adhere to one state, one vote procedure, and therefore restrict the ability of Western countries to dominate the agenda or to get their own way.” (p.97)

B2.4 Key Assumptions

As described in the previous chapters most scholars and experts expect major shifts in power on a global level. Therefore the key question is, whether the contemporary international

²¹³ The Rome Statute forms the basis of the International Criminal Court (ICC). To this day 120 countries are State Parties to Rome Statute of the International Criminal Court. For further information see: <http://www.icc-cpi.int/Menus/ASP/states+parties/> accessed 18 December 2011

system will be up to the challenges ahead. This realignment not necessarily implies a complete overthrow of existing structures and institutions. Yet, as the NIC emphasizes in 2008, it is unlikely to see an overarching, comprehensive, unitary approach to global governance. (NIC, 2008)

Once more, it has to be stressed that cooperative approaches not necessarily ensure a sustainable future, as well as a more confrontational world not necessarily result in catastrophic outcomes.

	friendly	tough
Economic shift	<p>Mature industrial economies' share in world GDP declines from 50% in 2011 to 45% in 2025</p> <p>EU15 declines from 18% to 15%</p> <p>Emerging economies' share in world GDP increases from 30% to 37%</p> <p>China increases from 16% to 20%</p> <p>India increases from 6% to 8%</p> <p><i>(own calculations²¹⁴ based on The Conference Board, 2012b, base scenario)</i></p>	<p>Mature industrial economies' share in world GDP declines from 50% in 2011 to 40% in 2025</p> <p>EU15 declines from 18% to 13%</p> <p>Emerging economies' share in world GDP increases from 30% to 43%</p> <p>China increases from 16% to 25%</p> <p>India increases from 6% to 9%</p> <p><i>(own calculations²¹⁵ based on The Conference Board, 2012b, pessimistic for mature and optimistic scenario for emerging)</i></p>
Economic growth	<p>Annual GDP growth rates 2012-2025:</p> <p>Mature economies: 1,9% for 2012-2016 and 1,9% for 2017-2025</p> <p>EU15: 1,5% for 2012-2016 and 1,7% for 2017-2025</p> <p>Emerging: 6,0% for 2012-2016 and 3,4% for 2017-2025</p> <p><i>(own calculation based on The Conference Board, 2012b, base scenario)</i></p>	<p>Annual GDP growth rates 2012-2025:</p> <p>Mature economies: 1,1% for 2012-2016 and 1,3% for 2017-2025</p> <p>EU15: 0,4% for 2012-2016) and 1,0% for 2017-2025</p> <p>Emerging: 7,9% for 2012-2016 and 4,6% for 2017-2025</p> <p><i>(own calculation based on The Conference Board, 2012b, pessimistic for mature and optimistic scenario for emerging)</i></p>
Volatility	no upward or downward trend in commodity price volatility over time compared to recent decades (<i>Calvo-Gonzales et al., 2010</i>)	Continued uptick in price volatility in a number of commodities

²¹⁴ Friendly assumes slow but steady growth in Europe that allows for adequate responses to challenges ahead and relatively moderate growth in emerging countries so that demand for resources grows moderate as well (meaning less challenging to European resource security).

²¹⁵ Tough assumes very low growth rates for Europe that challenge stability (financially and politically through high unemployment rates and polarization in society) and quite high growth rates in emerging economies due to growing domestic markets and increasing trade between emerging economies themselves and with developing countries. These assumptions require further considerations for a consistent scenario in a next phase of scenario development.

	<p>Food and agricultural prices: Lessons learnt from previous periods of high volatility lead to successful implementation of measures to reduce price volatility and to better deal with consequences (FAO <i>et al.</i> 2011)</p> <p>Oil price: due to improved price finding mechanisms and management of stocks reduced oil price volatility</p>	<p>Food and agricultural prices: Higher and more volatile agricultural commodity prices persist, largely due to continuing uncertainty on the supply side, against projected rising demand (FAO <i>et al.</i> 2011)</p> <p>Oil price: volatility remains high and negatively affects investment and economic activity</p>
Inter-national relations	<p>Reformed cooperative international relations</p> <p>Common challenges dealt by weak international cooperation</p> <p>Little reform of existing international institutions</p> <p>Summit diplomacy</p> <p>(see NIC and EUISS, 2010, Scenario I: "Barely Keeping Afloat" and Scenario III: "Concert of Europe Redux")</p>	<p>Confrontational international relations</p> <p>Resolving common challenges dominated by self-interested actors</p> <p>Attempts to resolve challenges by Military, economic and resource/energy competition</p> <p>Increased military conflicts and armament</p> <p>(see NIC and EUISS, 2010, Scenario II: "Fragmentation" and Scenario IV: "Gaming Reality: Conflict Trumps Cooperation")</p>

Scenario I: "Barely Keeping Afloat" considers no fundamental changes, as "no one crisis will be so overwhelmingly as to threaten international institutions even though collective management advances slowly." (p. vi; NIC and EUISS, 2010). Therefore, present institutions remain largely unreformed. Over the next years, this scenario is regarded as the most probable one. However, due to inability to adapt international institutions they are unprepared for major crisis over the long term. (NIC and EUISS, 2010)

Scenario II: "Fragmentation" depicts a global order of inward looking major powers and regional coalitions. Globalization will slow down considerably, as "Asia builds a regional order that is economically self-sufficient [...] [whereas; editor's note] Europe turns its focus inward as it wrestles with growing discontent with declining living standards. With a growing work force, the US might be in a better position but may still be fiscally constrained if its budgetary shortfalls and long-term debt problems remain unresolved." (p. vi) (NIC and EUISS, 2010)

Scenario III: "Concert of Europe Redux" could turn out to be the most sustainable one over the long term, as "severe threats to the international system – possibly looming

environmental disaster or a conflict that risks spreading – prompt greater cooperation on solving global problems.” (p. vi) Under this scenario a stable concert of powers, consisting of the United States, China, India and the European Union, emerges. (p.27f) (NIC and EUISS, 2010)

Scenario IV: “Gaming Reality: Conflict Trumps Cooperation”, due to domestic disruption, of nationalistic pressures and tensions between major powers occur. Global institutions remain unreformed and unable to promote global concerted action; not even regional collaboration comes about. (NIC and EUISS, 2010)

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B3. Growing ICT use and knowledge sharing

- Increasing use of ICT tools for analysing and managing complex systems
- On-going digital accumulation of information and knowledge by means of new ways of learning, web 2.0, open access/source, right to internet and the need of new literacy
- Emancipated citizenship: by means of transparency, open governance, participation, social mobilization
- Right to internet and digital inclusion contribute to social inclusion efforts
- Ambient intelligence: support daily living

B3.1 Introduction

Within the well-nigh unmanageable range of ICT-related topics some aspects are discussed here in detail. According to a world becoming ever more complex, on the one hand, undoubtedly ICT tools can help to resolve complex sustainability problems – yet, it also is necessary not to forget possible risks such as growing human dependence on ICTs and probable susceptibility of systems. Additionally, clearly many new technologies could be helpful in providing more open and transparent governance structures. However, respective technologies could easily lead to the opposite depriving standards of democratic governance, as we know them today. On a more individual level, ICTs can provide opportunities of new ways of learning as well as they can make our daily lives more comfortable. But there again, the reviewed literature accentuates high risks to citizens as well. New ways of learning require consequently a new literacy. This means, as a corollary, that denied access, i.e. for financial reasons, might induce new illiteracy and therefore societal divides. It also has to be mentioned that digital storing of private information could threaten the right to privacy, not only in terms of criminal offence. As gathering information becomes easier governments and private companies could be tempted to deprive well-known standards of privacy for the sake of consumer-friendliness and the welfare of citizens.

Concerning ICT-related ecological issues, there are two sides to this coin, too. New technologies will surely offer opportunities to create more energy efficient systems, i.e. smart grid, and consumer patterns. Contrary thereto, an increased use of energy saving ICTs nonetheless could induce growing energy consumption accelerating a rebound effect.

The following pages are offering a short overview on the complex subject of ICT, bearing in mind that we only show an excerpt of the broad spectrum.

B3.2 Key Literature

The FuturICT Knowledge Accelerator: Unleashing the Power of Information for a Sustainable Future (Helbing, 2010)

ICT is forcing the rapid increase of connectivity between people, institutions, organizations and political actors. In the twenty-first century the world has to be able to cope with certain challenges, for which ICT can be used as a part of the solution. But it's important to recognize, that those challenges can't be solved solely by technology, but require an understanding for the collective social dynamics as roots of those problems and as a key to their solutions. (Helbing, 2011) In the "FuturICT Flagship" Project "the ultimate goal [...] is to understand and manage complex, global, socially interactive systems, with a focus on sustainability and resilience."²¹⁶

To achieve this goal, further research is necessary to "build a knowledge accelerator to address the challenges of the twenty-first century." (Helbing, 2010, p. 5) According to the author this will include the creation of:

decision-support tools for complex systems²¹⁷ as well as social super-computing²¹⁸, an innovation accelerator to support efficient progress and investments in science and technology, a peer-to-peer reputation and privacy-respecting recommender system, "knowledge engines"²¹⁹, crisis observatories (for financial and socio-economic instabilities, conflicts, epidemics, environmental changes, etc.)²²⁰, individually customizable reputation and recommender systems that respect privacy, a **Living Earth Simulator** for global-scale simulations involving interactions of up to 10 Billion agents, coupled to a simulated and/or measured environment. (Helbing, 2010, p. 5)

²¹⁶ See also: <http://www.futurict.eu/the-project>

²¹⁷ "Integrated data collection, modelling, simulation, visualization, design [...] based on novel approaches such as simulation concepts (multiple world view, parallel world scenarios, ...)" (p.5)

²¹⁸ "including a socio-economic modelling language (p.5)

²¹⁹ "combining real-time data collectors with social information theory to harvest the knowledge of humanity" (p.5)

²²⁰ These could include "a whole earth and policy simulator, plus a contingency and resilience toolset, available for everyone. [...] A novel theory of socio-economic robustness and an understanding of "social pathologies" (riots, panic, etc.) [...] The tools required for an **international socio-economic crisis management center** [...] Showcases (demonstrators) regarding the global financial system, sustainable transport, energy generation and production, epidemic forecasting, and a disaster and evacuation management. (p.5)



Road-mapping the societal transformation potential of social media (Ahlqvist et al., 2010)

The functional definition of social media “refers to the interaction of people and also to creating, sharing, exchanging, and commenting contents in virtual communities and networks.” (cf. Toivonen, 2007) Social participation is organised on different levels: from an interpersonal to a global level. Social media are driven by user activities, where the boundaries between user and consumer are blurry. Users are supplying and distributing contents suppliers and are an important element in the selection and filtering of relevant contents and services. (Ahlqvist et al., 2010)

According to Ahlqvist (2010), key aspects such as content, communities and web 2.0²²¹ are relevant for defining social media. The emergence of social media is closely interlinked with the rise of new channels, which are used as spaces for self-expression and grass root activism. They also resulted in disruptions in business models in cultural industries (e.g. debates of illegal music and video downloads, and “digital criminality” have been arising after 2000, the development of open source software, e.g. LINUX). New channels, however, facilitated knowledge sharing tools (wikis, e.g. wikipedia) whereby the knowledge provided is non-authoritative. Nonetheless, those “new channels” have the potential for transformation, at least with regard to society, economy and the local environment. (Ahlqvist et al., 2010)

Learning Spaces: an ICT-enabled model of future learning in the Knowledge-based Society (Punie, 2007)

Punie points out that “[t]here are a number of (possibly disruptive) trends and challenges that are expected to shape future learning in the knowledge-based society and that can already be observed today.” (p. 187) Whether one takes into account the opportunities of broadband internet or new ways of storing and sharing of information, the way we communicate and learn will change dramatically, since “Europe will face important social and technological challenges in the years to come” (p.187).

According to learning, Punie also attests new environments for learning. As to changing infrastructure “learning landscapes”, as coined by Punie, will be quite different from what it is today. Due to “infrastructure convergence [...] the rise of new wireless technologies [...]

²²¹ He details content as information, photos, videos, information tags, etc. and communities as the social interaction among users through applications, new channels. Finally, he describes Web 2.0 as increase and simplification of participation possibilities.

content/media convergence [...] multi-modal devices“ (Punie, 2007, p.188) places and ways will be newly defined. Yet another listed trend concerns so called “Ambient Intelligence (AmI)”²²² Referring to the joint contribution, together with Burgelman (Burgelman and Punie, 2006), Punie remarks the resulting opportunities to “facilitate social learning via synchronous, media-rich virtual learning environments.” (Punie, 2007) (p, 188) With all chances provided by ICT, in his concluding statement, Punie underlines that “[i]t is, however, of crucial importance to make sure that future learning opportunities are socially inclusive and thus provided to all, especially to dis-advantaged people, families and groups.” (p. 197)

Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies (Bertot et al., 2010)

Bertot and his colleagues focus on ICT-related chance for a culture of transparency. They point out that “[t]he combination of e-government, social media, Web-enabled technologies, mobile technologies” – subsumed under the term ICT – could possibly become agents of change²²³ having “the potential to enhance existing and foster new cultures of openness.” (Bertot et al., 2010) (p.267) In this context, they detail not only chances and challenges, but also potential barriers stating: “ICTs have sometimes been successful in identifying and removing corruption, but they have also created new means and opportunities for corrupt behavior.” (Bertot et al., 2010; Heeks, 1998) Yet another challenge (or even barrier) does not concern technological obstacles²²⁴, but a possible digital divide, due to technological (il)literacy, usability, accessibility, and functionality. (Bertot et al., 2010) (p.268) Lastly, the authors point out that apart from potential barriers “[t]he extent to which ICTs can create a culture of transparency and openness is unclear; however, initial indications are that ICTs

²²² Alternatively, Punie introduces “ubiquitous computing”. Defining the term Punie relates to ISATG. ISTAG details AmI as “a vision of the Information Society where the emphasis is on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions. People are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way.” (ISTAG, 2001) p. 1

²²³ According to the above mentioned argument, Bertot et al. remark: “traditionally, new ICTs have favoured those already in power. By improving lines of communication ICTs – like telegraphs and then telephones – were able to provide a tool of increased effectiveness in colonial administration and control” (p.267).

²²⁴ Rather than technology development being the barrier, technology access and literacy may be a concern in the near term. In the U.S., for example, nearly 40% of households still do not have Internet access (U.S. Census Bureau, 2009). This ranges quite differently for nations, with South Korea having Internet penetration of over 94.2%, Iceland with 83.2%, Denmark with 74.1%, down to Italy with 30.8%, Greece with 22.5%, Mexico with 9.8%, and Turkey with 1.7% (OECD, 2008).

can in fact create an atmosphere of openness that identifies and stems corrupt behaviour.” (Bertot et al., 2010, p. 269)

Envisioning Digital Europe 2030: Scenarios for ICT in Future Governance and Policy Modelling (Misuraca et al., 2010)

Envisioning Digital Europe 2030: Scenario Design on ICT for Governance and Policy Modelling²²⁵ provides four scenarios on how Europe will change in course of ICT by 2030. Special focus is put on governance and policy modelling as well as consequent opportunities and risks. Furthermore, Misuraca and her colleagues outline possible implications on citizens, businesses and public services “influenced by the technological and societal ‘speed of change’” (p.347) accentuating “that the world we will be living in by 2030 will be radically different from the world we are living in today.” (p.347)

B3.3 Key Issues

ICTs: opportunities for committed citizens (Bertot et al., 2010)

According to Bertot, ICT-related developments, in terms of being a challenge, will particularly relate to societal aspects such as digital divide. Therefore, technology literacy as well as “[u]sability²²⁶ [...] [a]ccessibility²²⁷ [...] and [f]unctionality²²⁸ will be crucial “to provide a broad base of technology access [...] to ensure the broadest ability to participate in e-government services and resources. (Bertot et al., 2010, p. 268)

In terms of social media, Bertot and his colleagues stress the fact that “to truly ‘democratize data’” (Bertot et al., 2010, p. 269) will require technically educated citizens, otherwise only a small group is able to participate.²²⁹ Another opportunity, according to social media, is what the authors call citizen journalism as individuals become able not only to question

²²⁵ “This paper is based on the findings of the Visionary Scenario Design conducted by the Institute for Prospective Technological Studies (IPTS) as part of the **CROSSROAD Project**, an FP7 Support Action implemented during 2010. The main goal of CROSSROAD is to build a roadmap to provide strategic directions for future research in the area of ICT for Governance and Policy Modelling.” (Misuraca et al. 2010, p.347)

²²⁶ Bertot details usability as “the design of technologies in such ways that are intuitive and allow users to engage in the content embedded within the technology” (p. 268).

²²⁷ Viewing accessibility, Bertot defines this as “the ability of persons with disabilities to be able to access the content through adaptive technologies (in fact, some mobile technologies such as the iPhone are completely inaccessible to persons with visual impairments due to the touch screen design which lacks a tactile keyboard)” (p. 268)

²²⁸ Finally, Bertot defines functionality as “the design of the technologies to include features (e.g., search, e-government service tracking; accountability measures, etc.) that users desire.” (p. 268)

²²⁹ He refers to Obama’s initiative to provide great amounts of governmental data to the public through www.data.gov (accessed 21 December 2011).



government's decision, but to control their government, such as drawing attention to corruption, ect. (Bertot, et al., 2010, p. 269) In this context, Shirky argues that "the communications landscape gets denser, more complex, and more participatory, the networked population is gaining greater access to information, more opportunities to engage in public speech, and an enhanced ability to undertake collective action." (Shirky, 2011) (p.28)

Complex system, strongly connected world (Helbing, 2011)

Helbing accentuates that we are living in an "information society", and the access to information is not only a privilege for an elite, but also possible for the so called average citizen. The challenge is the efficient transformation of information into knowledge. (Helbing, 2010)

In this context, Helbing (2010) adds the following issues becoming relevant in the future²³⁰:

Customized Information Services: Customers should be equipped with services to discover and evaluate information, in order to be enabled for individual decision-making. To this effects, user orientated services should provide the right information in the right time and at the right place as efficiently as possible suppressing unwanted or unneeded information. Also, effective information archives for future use will become important.

"Innovation Accelerator": In terms of knowledge and innovation, respective tools should facilitate the dissemination of ideas, methods and data. Additionally, new publication concepts should be supported. Likewise, new ICT tools should pave new ways to more efficient scientific co-creation and collaboration.

Personalized Education: Similarly, ICT should provide platforms enhancing individual and collective learning. In this regard, efficient sharing of information, scenarios, and best practices should be guaranteed by those tools. In this context, Punie remarks the crucial role of Broadband Internet saying: "access is becoming more widespread, especially in well-advanced economies, driven by peer-to-peer file sharing and always-on features. The combination of large bandwidth and permanent access can impact the way learning content is consumed and shared with others". (Punie, 2007, p.187) In terms of personilised learning he also points out the importance of blogs and podcastings in combination with RSS (Real Simple Syndication) as learning is possible almost anywhere. Another crucial aspect of education relates to the costs, as Punie says. Here, he argues that on one hand, "[i]t is

²³⁰ For Helbing ICT should respect the privacy of costumers / users, although it isn't mentioned here

becoming cheaper to store information digitally than on paper.” Additionally, providers of open sources (software and content) not only make it possible to co-develop knowledge and information, but also to reach out to a wider public – due to free access. (Punie, 2007) (p.188)²³¹ Hearn and Rooney argue along similar lines referring to established internet companies such as Google, Yahoo, Ebay, and Skype, which regularly launch new and innovative services that may have implications for learning, such as Google Scholar, Google University Search, Yahoooligans!, or the Yahoo! Webguide for kids. (Hearn and Rooney, 2002)

Smart Cities, Transport, Traffic and Logistics: ICT will provide better planning tools for coordinated and environmental-friendly travel activities and logistics and more flexible, efficient and scalable control approaches for transport and logistics systems will be developed and invented. Congestion generates losses of productive time, wastes energy, and pollutes the environment. It creates economic losses of 10 Billion US\$ each year in the US alone. Increasing the capacity of the transport system by 5 to 10% by better coordination could possibly reduce cumulative delay times by up to 50%, amounting to several Billion US\$ in the US alone. The related reduction of CO₂ emissions would be significant as well. (Helbing 2010, p. 10)

Smart Energy Production and Consumption: Highly decentralized energy production and consumption in “smart grids” needs new coordination schemes, including a precedent identification of the behavioural laws of electricity producers and consumers (peak times, periodicities and extremes). ICT could help to stimulate incentive structures, to match supply and demand and promote concepts for local and diverse energy production and consumption; and find ways how people could be stimulated to reduce their energy consumption, to meet the CO₂ emission reduction goals. ICT could help to “elaborate ways for a smooth transition from nuclear and coal-based energy production to more environmental-friendly and sustainable ones” (Helbing, 2010, p. 10)

²³¹ In this context he refers to UNESCO’s virtual university (<http://www.unesco.org/iiep/virtualuniversity/forums.php>) and other examples such as the Berkeley initiative ‘Research Now’ (<http://researchnow.bepress.com>) and the MIT OpenCourseWare (<http://ocw.mit.edu/index.html>).

Advances in modelling global dynamics

Since the 1990's a variety of new ICT-based tools and methods have been developed. These allow further accomplishments in modelling global dynamics. According to Helbing (2010, p. 15) the success of the FuturICT project - and this could be true for other attempts in modelling global dynamics (note of the author) - will be based on the following advances, which should be used in combination to be successful:

- ICT systems are becoming powerful enough to perform global scale simulations.
- Further data required for substantial simulations are becoming available through multi-source massive social data mining (e.g. reality mining with mobile phones, sensors, and on the Web).
- Geographic information systems support the visualization and interpretation of spatio-temporal patterns of global change.
- Environmental science is providing a much more accurate understanding of global and regional scale processes over a large range of time scales and is giving increasingly accurate projections of environmental change.
- Statistical physics, in particular the theory of critical phenomena, phase transitions, and extreme events make it possible to theoretically understand surprising behaviours of complex systems.
- Non-equilibrium statistical mechanics is providing new conceptual tools for studying the response of non-equilibrium systems to malfunctions.
- The theory of complex networks and networks of networks allows one to grasp complex systems, particularly the coupling of structure and dynamics, of function and form etc.
- A "Hilbert program" of grand fundamental challenges in socio-economic research has been worked out.
- A quickly growing community of interdisciplinarily working researchers from the social, natural, engineering, and computer sciences is available to perform large-scale integrative systemic analyses, combining the best of all knowledge.
- In view of global challenges like the financial crisis, the need for systemic, multi-disciplinary approaches is now widely recognized. (Helbing, 2010)

They can transform the society due to: „empowerment“²³², new dialogical practises, combined identities²³³, enhancing possibilities of societal participation, rapidly planned social activities (initiating demonstrations and flash mobs utilizing social media like Facebook or Twitter), and user driven governance (keeping an „eye on decision makers“ through new technologies²³⁴).

They can affect economy and business due to: a rising role of communities in working live²³⁵, encouragement of a culture of open innovation (Singh et al., 2009)²³⁶, open collaboration models, intellectual property²³⁷, and modular professions²³⁸.

Lastly, they can transform local environments by means of new communication options and efficient spreading of information.²³⁹

Surveillance of users

Within their analysis Friedewald and his colleagues (2007) examine, among other issues, privacy and surveillances aspects of ambient intelligence. They point out that “privacy is generally considered to be an indispensable ingredient for democratic societies. This is because it is seen to foster the plurality of ideas and critical debate necessary in such societies.” (Friedewald et al., 2007, p. 16) Their starting point is to introduce several aspects of privacy. Here, the authors refer to Bohn and colleagues²⁴⁰ (Bohn et al., 2004) and remark

²³² Empowerment is understood here as reflexive, usually based on some substance or issue and on temporary coalitions that engage the dialogue on the topic, e.g. Beck et al. (1994).

²³³ This refers to building up and reconstructing one’s social connections and societal linkages in a more non-local fashion in choosing communities, where one wants to have an impact or to network on specific topics

²³⁴ In this context, low participation rates, elite-only participation, excessive transparency and loss of control, and the erosion of trust may become possible bottlenecks

²³⁵ Communities serve as a knowledge pool for companies, which can seek the best “manpower” for their projects.

²³⁶ Work swarms or open collaboration models promote new ways of outsourced project modes. For example, firms allocate tasks to the general public in order to utilize their mass of creativity and ideas. This could pose threats on corporate culture through a higher probability and frequency of failures. Innovation activity doesn’t easily fit with annual corporate plans, some internal experts seem to be resistant towards open innovation (Lakhani and Panetta, 2007):

²³⁷ New forms of licensing are considered: Copyleft and Creative Commons Copyleft: free use of codes (software), as expressed in the GNU General Public license (see <http://www.gnu.org/licenses/licenses.html>) Creative Commons licences <http://creativecommons.org/>: the copyrights owner can define various aspects of how other people may use creative work including derivative work, attribution and commercial use.

²³⁸ People work in several project modules for several companies with light and flexible working contracts, like self-employee contracts.

²³⁹ For example warning, access points and interfaces to virtual communities in everyday physical space, communities of change. (Brown, 2007)

²⁴⁰ Bohn et al. refer to Lawrence Lessig, who, in terms of democratic ingredients “distinguishes between a number of motives for the protection of privacy in today’s law and standards” (Lessig, 1999) (p. 772)

different aspects of privacy in context of ICT: Privacy as empowerment, utility, dignity and regulating agent.²⁴¹

According to the risks possibly arising from new technologies Friedewald and his colleagues point at governments tempted to collect data concerning their citizens for reasons of “administering their welfare systems, in law enforcement and the fight against terrorism.” (Friedewald et al., 2007) (p. 25) According to ambient intelligence, the authors remark potential risks to the core of privacy²⁴². As they consider, it can prove particularly problematic for citizens according to insurance or employment, as “[t]he disclosure of health details, personal preferences, habits and lifestyle to an insurance company or to an employer can easily lead to discrimination (higher insurance contributions, reduced career prospects, even denial of insurance coverage and job lay-off), blackmailing and problems in human relations.” (Friedewald et al., 2007) (p. 25) Friedewald et al. conclude that new technologies are changing already and will continue to change our privacy expectations as personal (spatial and temporal) borders shift.²⁴³

Digital divide²⁴⁴

Bélanger and Carter stress the need for more digital literacy, as internet is increasing steadily and digital participation and making use of offers (e-government), in terms of democratic rights, is of growing importance. They point out that the so called digital divide subsumes to major divides, namely access divide and skills divide. (Bélanger and Carter, 2009) (p. 132) In terms of access they identified ethnicity, income, education and age as the major factors hindering digital access. In turn, computer experience, general internet use, online purchases and online information search are crucial competencies. The pervasiveness of ambient

²⁴¹ **Empowerment** relates to informational aspects such as “the power to control the publication and distribution of personal information. Referring to **utility** the authors point out “the right to be left alone” (Bohn et al., 2004) (p. 772) from nuisances. Dignity is detailed not only as “being free from unsubstantiated suspicion [...] but also focuses on the equilibrium of information available between to people.” (Bohn et al., 2004) (p.772) Lastly, the argument, defining privacy as a regulating agent, points out that “privacy laws and moral norms can be seen as a tool for keeping checks and balances on the powers of a decision-making elite.” (Bohn et al., 2004) (p.772)

²⁴² Friedewald et al. reflect on several spheres of life accentuating that, according to privacy, one’s home is considered to be sacrosanct. (Friedewald et al., 2007) (p. 25)

²⁴³ “Spatial or temporal borders. Most people expect that parts of their lives can exist in isolation from other parts, both temporally and spatially. For example, a previous wild adolescent phase should not have a lasting influence on an adult’s life, nor should an evening with friends in a bar influence his coexistence with work colleagues.” (Friedewald et al., 2007) (p. 16f)

²⁴⁴ Referring to Bertot: “The digital divide is long documented and broadly defined as the gap between those who have access to technologies and those who do not. However, there are in fact multiple divides that can exist, of which access to the ICTs is but one.” (Bertot et al., 2010) (p.268); cf. (Bertot, 2003; Barzilai-Nahon, 2006; National Telecommunication and Information Administration, 1995; National Telecommunication and Information Administration, 2004)

intelligence applications in almost every sphere of life poses the threat of social pressure and digital divide. (Bélanger and Carter, 2009) (p. 133)

Friedewald et al. also point out that individuals might be put under pressure “to use AmI technology.” (Friedewald et al., 2007) (p.26) In conjunction with health issues, insurances could frame rules forcing clients to use monitoring systems. Apart from expected limitation of freedom, the authors accentuate financial aspects in this case. (Friedewald et al., 2007) (p. 26f)²⁴⁵ Concluding, they outline financial aspects of growing divide are “especially relevant in the field of education where society could be divided more sharply into well-educated and less well-educated people.” (Friedewald et al., 2007) (p. 27)

²⁴⁵ Friedewald and his colleagues argues that ambient intelligence “applications and services will probably not be free of charge with the result that not all citizens will enjoy all of the benefits that AmI can offer - even in fields that have been regarded as having public utility.”(p.27)

B3.4 Key Assumptions

As described in the previous chapters opportunities and risks related to ICT are manifold in short term and almost unimaginable in long run. ICT-based processes can be as much supporting as harming such as creating high dependency. New ways of accumulating information and of learning as well as new communication technologies might pave the way for transparent governance and emancipated citizenship. However, there is a risk that transparency moves in a diametrically opposed direction resulting in a transparent citizen as privacy standards forfeit gradually.

The following table seeks to provide a comprehensive synopsis of the aforementioned areas of discussion.

	friendly	tough
2025	Societal Level <ul style="list-style-type: none"> • Open governance (High openness and transparency, high integrated and participatory policy intelligence) • Managing complex systems (smart grids, modelling global dynamics, smart energy production and consumption) • Information and knowledge (open collaboration, learning management systems) 	Societal Level <ul style="list-style-type: none"> • Privatised governance (low openness and transparency, low integration and participation) • Managing complex systems (increased dependency and systems' vulnerability, costs above and benefits below expectations) • Information and knowledge (high and successful efforts in securing information monopolies)
	Individual Level <ul style="list-style-type: none"> • Privacy (right to privacy, power to control distribution of personal information) • Ambient intelligence/ ubiquitous computing (supporting daily living) • New literacy (technology literacy, customized information services, personalized education) • Social inclusion (right to internet and digital inclusion) 	Individual level <ul style="list-style-type: none"> • Surveillance (disclosure of personal information, threat of social pressure) • Ambient intelligence/ ubiquitous computing (dependency and surveillance) • New illiteracy (financial dependence, fragmentation of education) • Social exclusion (limited access and digital divide)

Table B3.1 Key global scenario assumptions for ICT by 2025

B3.5 References

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ABOUT NEUJOBS

"Creating and adapting jobs in Europe in the context of a socio-ecological transition"

NEUJOBS is a research project financed by the European Commission under the 7th Framework Programme. Its objective is to analyse likely future developments in the European labour market(s), in view of four major transitions that will impact employment - particularly certain sectors of the labour force and the economy - and European societies in general. What are these transitions? The first is the **socio-ecological transition**: a comprehensive change in the patterns of social organisation and culture, production and consumption that will drive humanity beyond the current industrial model towards a more sustainable future. The second is the **societal transition**, produced by a combination of population ageing, low fertility rates, changing family structures, urbanisation and growing female employment. The third transition concerns **new territorial dynamics** and the balance between agglomeration and dispersion forces. The fourth is a **skills (upgrading)** transition and its likely consequences for employment and (in)equality.

Research Areas

NEUJOBS consists of 23 work packages organised in six groups:

- **Group 1** provides a conceptualisation of the **socio-ecological transition** that constitutes the basis for the other work-packages.
- **Group 2** considers in detail the main drivers for change and the resulting relevant policies. Regarding the drivers we analyse the discourse on **job quality**, **educational** needs, changes in the organisation of production and in the employment structure. Regarding relevant policies, research in this group assesses the impact of changes in **family composition**, the effect of **labour relations** and the issue of financing transition in an era of budget constraints. The regional dimension is taken into account, also in relation to **migration** flows.
- **Group 3** models economic and employment development on the basis of the inputs provided in the previous work packages.
- **Group 4** examines possible employment trends in key sectors of the economy in the light of the transition processes: energy, health care and goods/services for the **ageing** population, **care services**, housing and transport.
- **Group 5** focuses on impact groups, namely those vital for employment growth in the EU: **women**, the **elderly**, immigrants and **Roma**.
- **Group 6** is composed of transversal work packages: implications NEUJOBS findings for EU policy-making, dissemination, management and coordination.

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