Assessment of global megatrends — an update

Global megatrend 7: Intensified global competition for resources

European Environment Agency

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Europe is bound to the rest of the world through an enormous number of systems — environmental, economic, social, political and others. Such networks enable complex flows of materials and ideas across the globe, producing uncertain feedbacks and knock-on effects over time. Greenhouse gas emissions in Europe today can affect the climate in distant locations and far into the future. Land management choices on the other side of the world can influence food and energy prices in Europe. Global communication and trade networks fuel innovation — sometimes boosting efficiency, sometimes creating new environmental pressures.

Most of these interactions are intimately linked and set to unfold over decades. All are likely to have important implications for living standards and well-being.

The European environment's status, trends and prospects have always depended in part on events outside its borders. Yet the growing importance of global networks and flows has augmented this interdependence, creating complex challenges for traditional governance systems framed within national or regional territories. To design effective ways to manage the environmental changes ahead, societies and governments need to understand the global drivers at work and their potential implications.

With this challenge in mind, the European Environment Agency in 2010 produced its first assessment of emerging global trends as part of its five-yearly flagship report on the European environment's state and outlook (SOER 2010). The exploratory analysis summarised 11 global megatrends grouped into five clusters — social, technological, economic, environmental and governance. Introducing the issues succinctly, it sought to trigger a discussion about how Europe should monitor and assess future changes in order to better inform environmental policymaking.

In preparation for its next report on the European environment's state and outlook (SOER 2015), the EEA has initiated an update of the assessment of global megatrends, analysing each of these drivers in a little more detail than previously in terms of their impacts on the European environment and well-being. During the second half of 2013 and early-2014, the EEA is reassessing the 11 megatrends and publishing the updates separately on its website. In 2014 the chapters will be consolidated into a single EEA technical report and will provide the basis for the analysis of megatrends included in SOER 2015. The present chapter addresses megatrend 7: 'Intensified global competition for resources'.

Again, it needs to be emphasised that the complexity of highly interconnected human and natural systems introduces considerable uncertainty into projections and forecasts. As much as anything, the assessment of megatrends aims to encourage readers to acknowledge this interdependence and uncertainty. In so doing, it may help point the way towards systems of planning and governance better adapted to meeting the challenges ahead.

Global megatrend 7
Intensified global competition for resources

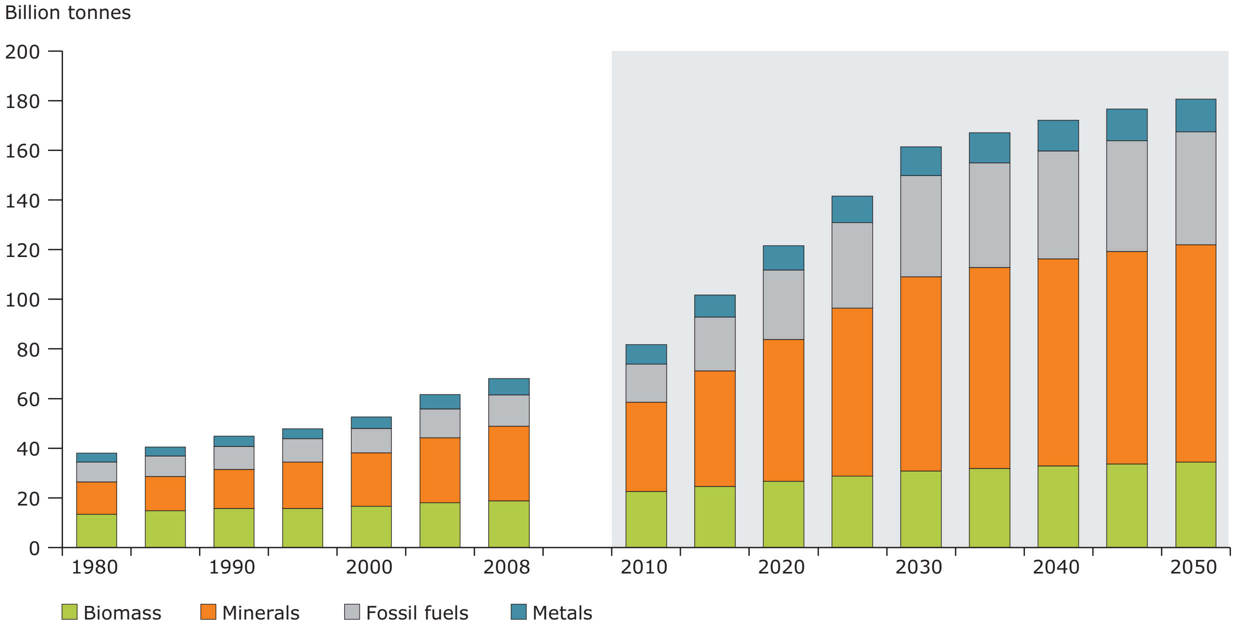
As they grow, economies tend to use more resources — both renewable biological resources (see GMT 8) and non-renewable stocks of minerals, metals and fossil fuels (addressed in this chapter). Industrial and technological developments, and changing consumption patterns associated with growing prosperity all contribute to this increase in demand.

While the rising living standards that drive these trends are unquestionably welcome, they create obvious risks. The world is a closed material system, implying finite limits on the amounts of resources available. Even if they are not scarce in absolute terms, resources may be unevenly distributed globally, making access uncertain and potentially fostering conflict. Such concerns are particularly apparent with respect to a range of resources designated as 'critical raw materials'.

Innovation plays a complex role in shaping the demand for and supply of resources. Ground-breaking technologies can create new uses for resources and new ways to locate and exploit deposits, potentially increasing the burden on the environment. But innovation can also enable societies to reduce their use of finite and polluting resources and shift towards more sustainable alternatives. The impacts of intensifying global competition for resources will therefore depend greatly on whether technological development can be steered towards establishing more resource-efficient ways of meeting society's needs.

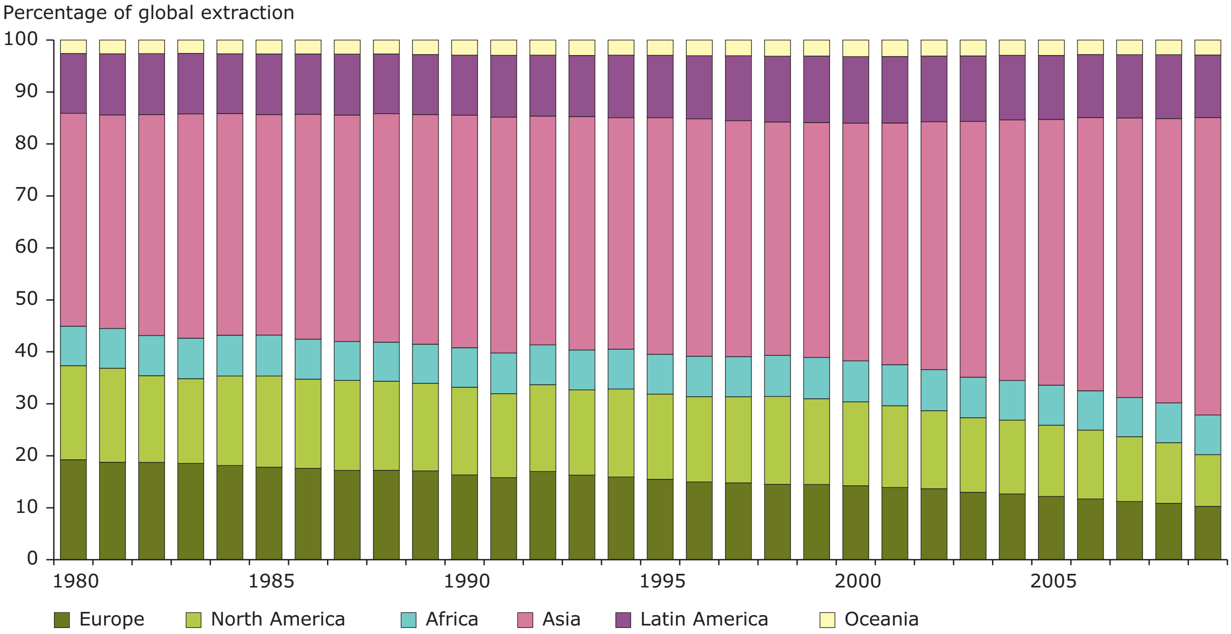
Global resource extraction has increased steadily since 1980 and is projected to continue rising in the decades ahead (Figure 7.1), driven by continuing economic growth (GMT 5) and related expansion of the middle- and high-income consumer classes (GMT 2). Industrial and technological developments further augment demand for minerals and metals. As illustrated in Figure 7.2, emerging economies account for an ever greater proportion of total extraction, and their expanding role in the global economy (GMT 6) and growing populations (GMT 1) are likely to sustain this trend.

Figure 7.1 Global resource extraction by material category, 1980–2008 and projections for 2010–2050



Source: SERI, 2011.

Figure 7.2 Percentage of global resource extraction by world regions



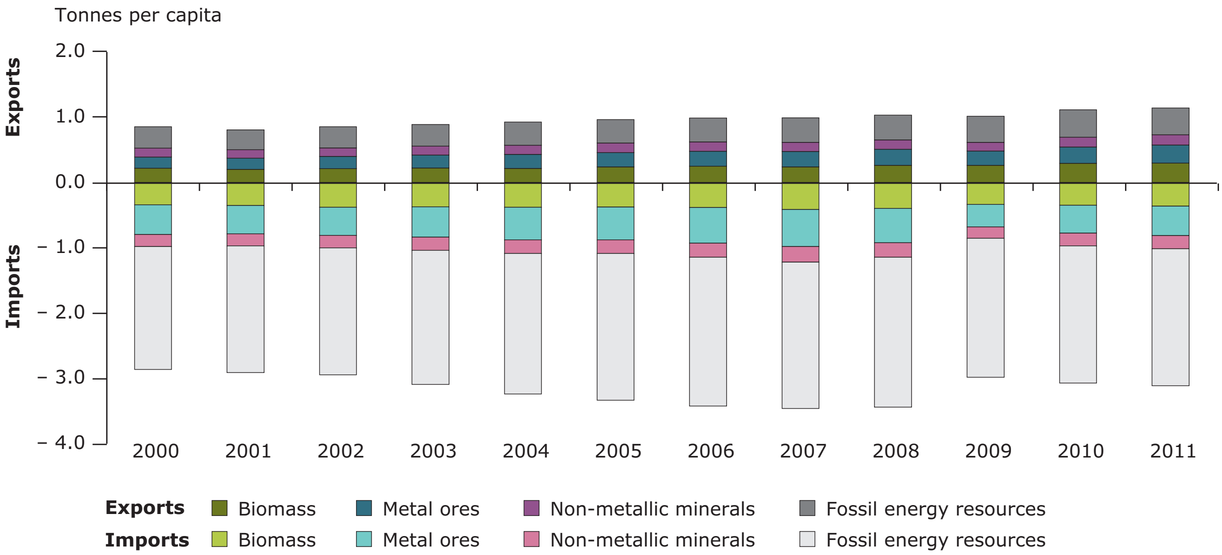
Note: Global resource extraction is calculated by aggregating commodities based on weight. The projected data are calculated by assuming that all countries have the material consumption patterns of OECD countries from 2030 onwards.

Source: SERI, 2011.

For Europe, the risks of growing competition for resources are clear: the European economy is structurally dependent on imported resources. Imports from outside the EU accounted for 58 % of EU-27 consumption of metal ores and products in 2011 and 57 % of fossil energy materials (Eurostat, 2012). This dependence, which increased steadily prior to the financial crisis (Figure 7.3), appears as a major vulnerability in the context of accelerating global demand for commodities and resulting price impacts and threats to security of supply.

Global competition for resources depends significantly on the interplay of demand and

Figure 7.3 Direct physical imports and exports by main material categories, EU-27, 2000–2011



Source: Eurostat, 2012.

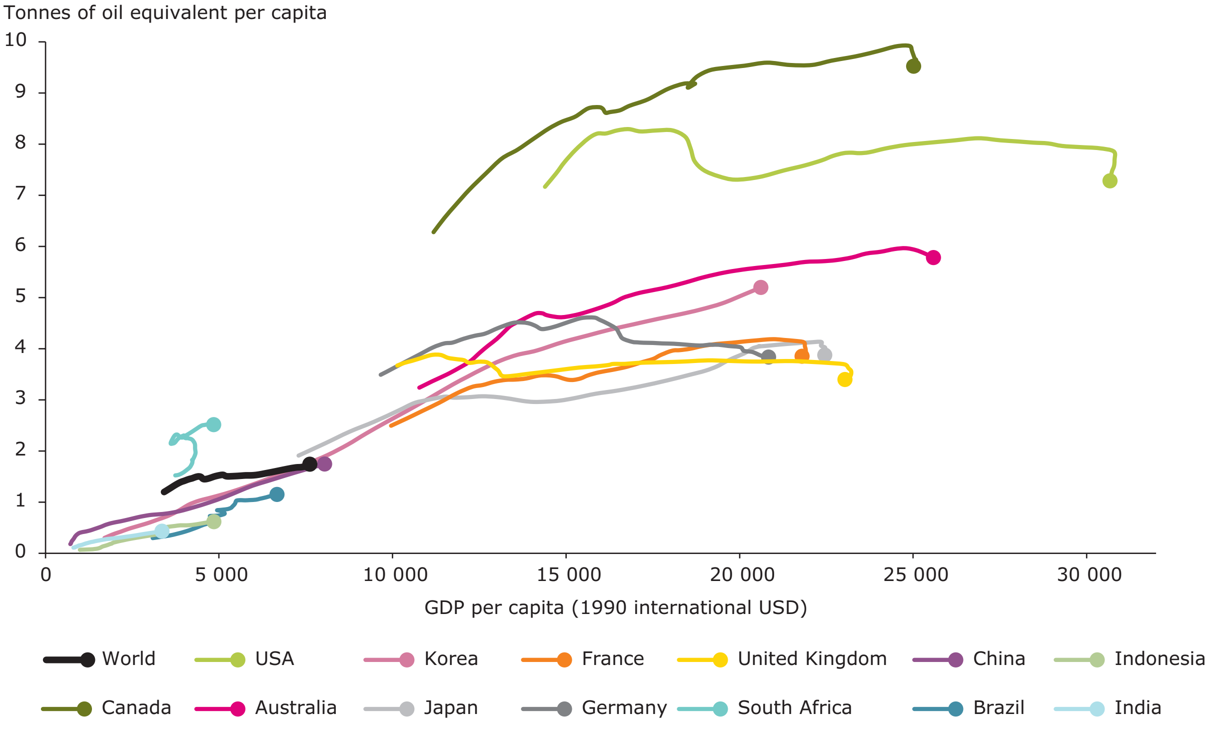
supply. The next two sections will look at each in turn, addressing the example of fossil fuels rather than all resource types. Focusing on a single group of resources is useful because resource types vary hugely in terms of their characteristics and scarcity, the quantities used and associated environmental impacts, making it hard to draw conclusions from data that aggregate different resources. Moreover, energy resources represent a key concern in terms of their importance for economic output and worries about scarcity (EC President, 2013), and also benefit from considerable historic data.

7.1 Demand: increasing consumption but some decoupling from economic growth

Like other major resource categories, consumption of fossil fuels has increased markedly in recent decades. As illustrated in Figure 7.4, energy consumption per capita is correlated with GDP per capita. Focusing on the national average data for 2008–2012 (designated with dots in Figure 7.4), it is apparent that individuals in countries with the lowest per capita GDP (India, Indonesia) use the least energy and that consumption increases steadily up to the countries with the highest per capita GDP (USA, Australia).

Figure 7.4 also conveys several other relevant messages regarding resource demand, with varying implications for future competition for resources. For example, the time series data for the period 1965–2012 (designated with lines in Figure 7.4) indicate that Korea has recorded a remarkable increase from among the poorest of the countries shown in 1965 to firmly among the advanced economies in 2012 — in terms of both per capita GDP and per capita energy consumption. Its record is particularly interesting because the BRIICS ([1]) economies (notably China) may be following a similar trajectory. The difference, of course, is that whereas Korea's population stood at just under 50 million in 2012, the combined total for Brazil,

Figure 7.4 Annual per capita energy consumption and GDP in selected advanced and BRIICS economies, 1965–2012



Note: The data cover the period from 1965 to 2012 and are presented here as five-year rolling averages (in order to smooth inter-annual variations). The final data point, representing the data for 2008–2012, is designated with a dot.

Source: Maddison, 2013; BP, 2013a; OECD, 2013 and EEA calculations.

([1]) 'BRIICS' denotes Brazil, Russia, India, Indonesia, China and South Africa.

China, India and Indonesia was approximately 3 billion. The implications for future global energy consumption are therefore enormously greater.

In the period 1965–2012, world per capita energy consumption (designated with a black line in Figure 7.4) increased by 45 % despite per capita GDP growth of more than 120 %. This relatively modest rise reflects the fact that the advanced economies that have dominated global GDP have recorded relatively little growth in energy use per capita during the last half century. The global trend appears likely to shift to a steeper upward trajectory in coming years as the major emerging economies come to play a larger role in the world economy and global energy consumption in coming decades.

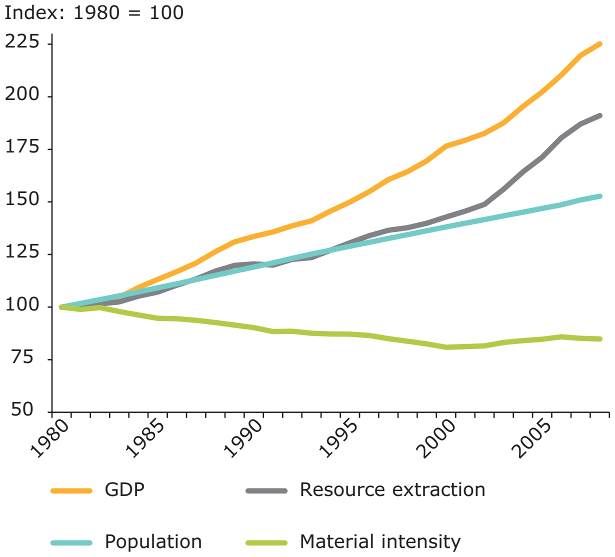
There is some evidence of energy consumption decoupling from economic growth in several advanced economies, albeit at very high levels by global standards. Several countries (France, Germany, Japan, United Kingdom, USA) have recorded little increase in per capita energy consumption since GDP per capita reached a level of USD 15 000–20 000 (in 1990 PPP dollars). Elsewhere (Australia, Korea) consumption continued to increase beyond this point, although less rapidly than previously.

These trends in energy use in advanced economies have clear implications for the related consumption of fuel resources. For example, the 2 % decline in EU-27 consumption of energy in the period 2000–2011 was matched by a 6 % drop in consumption of fossil fuel materials to 1.32 billion tonnes during the same period (Eurostat, 2012).

International Monetary Fund research (IMF, 2006) suggests that consumption of base metals and steel may be correlated to economic development in similar manner to energy resources. During the initial stage of economic development, per capita consumption of these metals rises in step with per capita GDP. However, saturation appears to occur at the USD 15 000–20 000 point, except in countries (e.g. Korea) where industrial production and construction continue to play a major role in economic growth.

At the global level, there are some indications of decoupling of resource extraction from economic output. While it is difficult to interpret aggregated measures of material resource use (because resources differ so greatly in their characteristics), Figure 7.5 shows that, despite almost doubling, global resource extraction has partially decoupled from economic growth since 1980.

Figure 7.5 Global GDP, resource extraction, population and material intensity, 1980–2008



Source: SERI, 2011.

7.2 Supply: risks of scarcity but innovation in extraction technologies

Increasing global demand for resources is complemented by constrictions and uncertainties in the supply of some commodities. In some instances, the geographic concentration of reserves of resources can result in oligopolistic and cartel behaviour (apparent, for example, in the influence of the Organization of Petroleum Exporting Countries over global oil prices). And uncertainty regarding access to commodities is likely to be augmented if reserves are concentrated in politically unstable regions. Such restrictions can create strong incentives for importing countries to identify alternative ways to meet their resources needs, either by locating new sources of traditional resources or finding ways to exploit substitutes.

Again, the energy sector illustrates many of these trends. Fossil fuel reserves are concentrated in a small number of countries. Just three countries — Venezuela, Saudi Arabia and Canada — accounting for more than 44 % of proved global oil reserves. Similarly, Iran, Russia and Qatar hold 49 % of natural gas reserves, while the US, Russia and China hold 59 % of coal reserves (BP, 2013b). The EU is heavily dependent on imports, which provided for 91 % of its gross inland consumption of oil in 2010, 62 % of natural gas and 39 % of solid fuels.

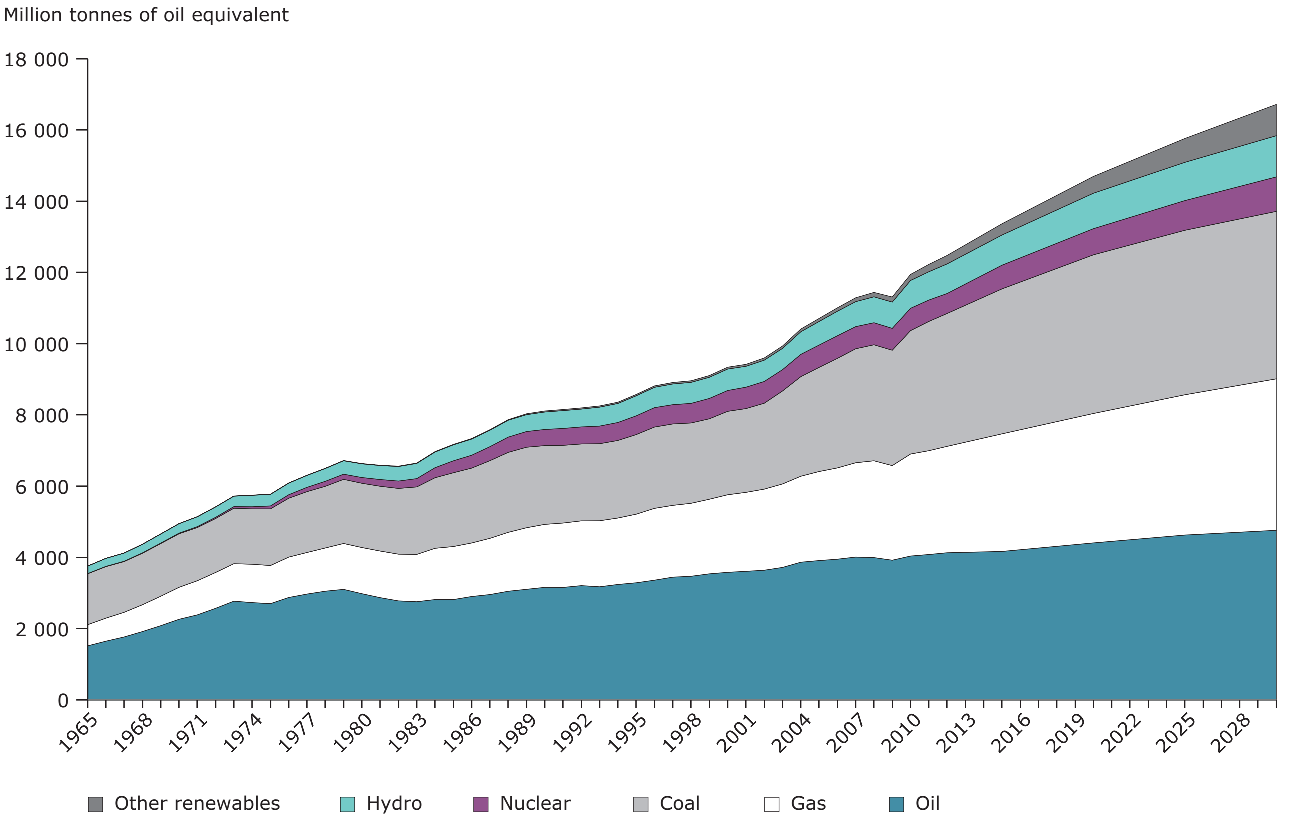
In the context of concerns about rising oil prices and energy security, the use of alternative energy sources has expanded rapidly in recent years. Global output of energy from renewable sources (excluding hydropower) increased by 460 % in the period 2000–2012 (REN21, 2013). Investment has increased correspondingly, from USD 40 billion in 2004 to USD 244 billion in 2012. Of this total, developing countries accounted for 46 % in 2012, which represented a sharp increase from the 34 % contribution in 2011 (REN21, 2013).

Despite rapid growth in recent years, however, renewable technologies have yet to reduce the relative contribution of fossil fuels to total energy supply. Together, coal, gas and oil accounted for 87 % of global energy output in 2010 — the same level as in 2000. Their contribution is projected to decline only slightly to 82 % in 2030, with each fossil fuel accounting for approximately a third of that total (Figure 7.6).

As well as facilitating a move towards alternative energy sources, technological advances have also boosted access to fossil fuels. Estimates of reserves evolve rapidly as new deposits are discovered (e.g. North Sea oil and gas) and innovation allows previously unreachable or unusable sources to be exploited (e.g. deep water drilling and mining of tar sands), with potentially greater environmental risks. These factors mean that proved global reserves of oil and gas have increased substantially since 1980 — faster, indeed, than consumption of either resource (Figure 7.7, left). As a result, the number of years that proved reserves would last at current consumption rates has increased in the last three decades (Figure 7.7, right). In the case of oil, the increase was considerable: from approximately 30 years to more than 50.

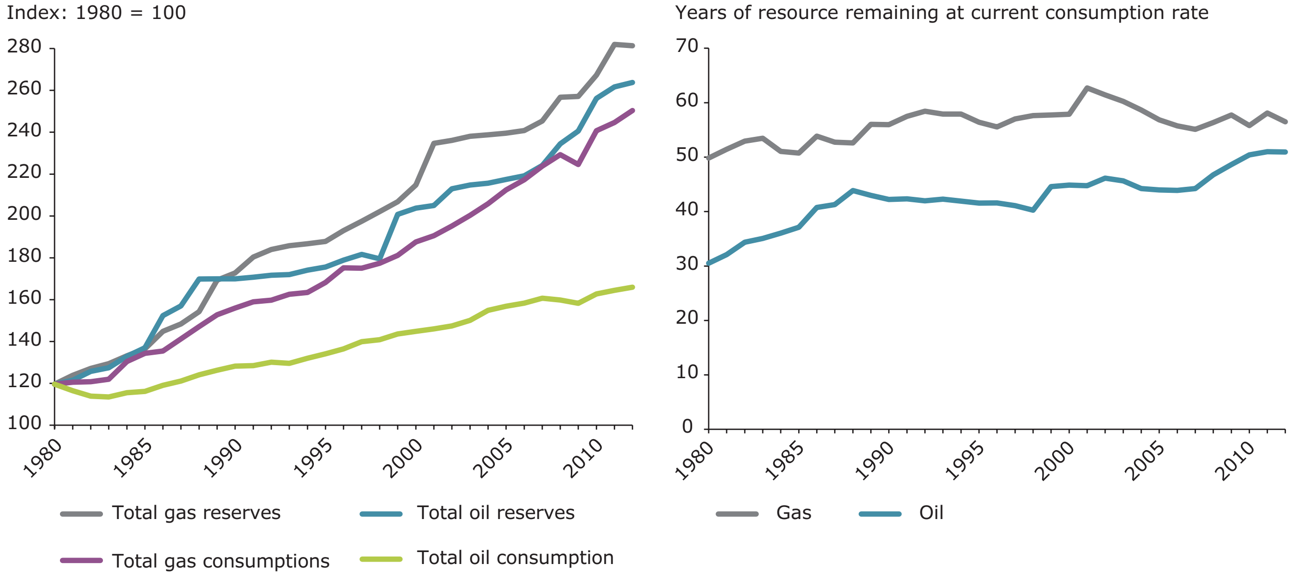
In the last decade, technological advances have facilitated a huge growth in extraction of shale gas and oil. The boom initiated in the US where shale oil and gas production shifted from minimal quantities at the start of the 2000s to account for 29 % of US crude oil production and 40 % of natural gas production in 2012. A US government report estimates that proved and unproved shale oil and gas could augment total world technically recoverable resource significantly, with total crude oil resources increasing by 10 % and natural gas resources by 47 % (EIA, 2013). The same

Figure 7.6 Past and projected world energy consumption by fuel (Mtoe), 1965–2030



Source: BP, 2013a, 2013b; and EEA calculations.

Figure 7.7 **Oil and gas: proved reserves and consumption, 1980–2012 (left) and implied years of reserves remaining at current consumption rates (right)**



Note: BP estimates of proved oil reserves are compiled using a combination of primary official sources, third-party data from the OPEC Secretariat, World Oil, Oil & Gas Journal and an independent estimate of Russian and Chinese reserves based on information in the public domain. Canadian oil sands 'under active development' are an official estimate. Venezuelan Orinoco Belt reserves are based on the OPEC Secretariat and government announcements. BP estimates of proved natural gas reserves are compiled using a combination of primary official sources and third party data from Cedigaz and the OPEC Secretariat.

Source: BP, 2013b.

Box 7.1 **Key uncertainties**

While continuing economic and population growth appear likely to drive a continued increase in humanity's demand for resources in coming decades, estimating the future demand for specific resources is subject to significant uncertainties. Much depends on the interaction of three related strands of technological innovation (for details see GMT 4).

The first consists of finding ways to exploit alternative resources that are more abundant or (ideally) non-depletable, for example wind and solar energy. Alternatives vary in their net benefits relative to traditional resources. For example, generating energy from combusting biomass may be less polluting than using fossil fuels but it can also reduce the land available for agriculture or forestry, with implications for food availability and prices and carbon sequestration. Even exploiting wind and solar energy requires significant material resource inputs (including rare earth metals).

The second focus of innovation involves developing technologies and approaches (for example recycling, supply chain management or industrial ecology), that enable society to extract more value from resources before they are returned to natural systems as emissions and waste. Such shifts can also take the form of behavioural change.

The third type of innovation is oriented towards findings new ways to locate and exploit traditional resources — a process illustrated by the steady growth in proved oil and gas reserves in recent decades. Such activities may be at odds with the other two forms of innovation, in the sense that increased access to traditional resources reduces incentives to find alternatives and boost efficiency.

Boxes 7.2 and 7.3, relating to shale gas and phosphorus, illustrate how advances in technology and price incentives can lead to very swift and radical changes in estimates of reserves. The direction of technological change and the implications for resource competition are also likely to be influenced by political and social choices that are hard to anticipate. For example, global progress in environmental agreements (e.g. on strict preservation of the Arctic environment) could exclude or reduce the availability of resources.

study estimates that Russia may have the largest technically recoverable shale oil resources, while China may hold the most shale gas.

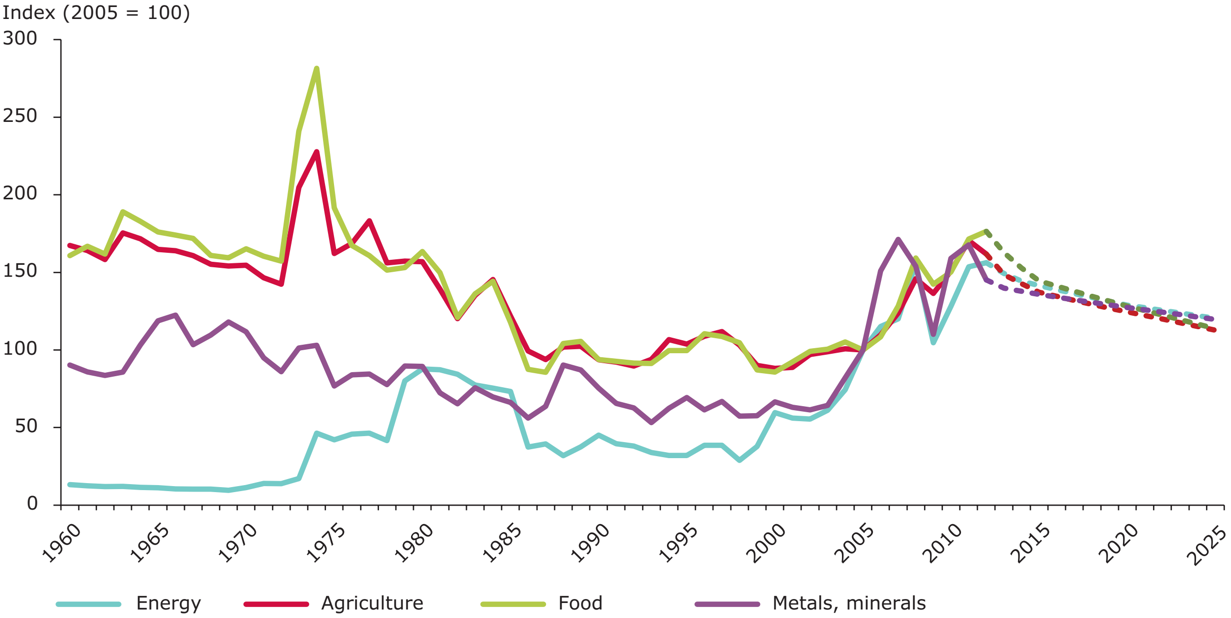
These recent developments are projected to have wide-ranging impacts on the global energy market, thereby affecting economic development. According to International Energy Agency projections, the USA will become the largest oil producer by around 2020 and a net oil exporter by 2030 (IEA, 2012). While this has important implications for the cost and security of energy supplies in many regions, several European countries are scrutinising the environmental impacts of hydraulic fracturing ('fracking'), which include air and water pollution. Such concerns prompted France to ban the practice in 2011. Beyond environmental concerns, the IEA has identified a range of other potential constraints to developing fracking, including adverse fiscal and regulatory frameworks, limited access to pipelines and markets, and shortages of expertise, technology and water, which is used in large quantities for extracting gas (IEA, 2012).

7.3 Commodity price developments

Commodity markets provide further insights into the interaction of global resource demand and supply. The prices of major resources categories (energy, minerals and metals, agricultural commodities) followed contrasting paths until about 2000 (Figure 7.8). Price indices for food and agricultural commodities (including food and beverages, as well as e.g. timber, cotton and tobacco) peaked in the mid-1970s, when a combination of bad harvests, currency adjustments and a surge in energy prices induced by major oil producers brought about the 'world food crisis' (FAO, 2000). Since 2000, however, the price trends have been more similar. Prices more than doubled in real terms in the period 2000–2012, suggesting that growing global resource demand outpaced increases in supply during the last decade.

Looking ahead, the UNEP International Resource Panel notes that commodity prices are hard to anticipate (UNEP, 2011). Uncertainties regarding future resource demand and supply are reflected in diverging commodity price projections from different sources. Whereas the World Bank foresees a slight reduction in commodity prices in real terms up to 2025 (Figure 7.8), recent OECD and FAO projections suggest that real prices for agricultural products will remain relatively stable in the period 2013–2022 (OECD, 2013). In contrast, the European Commission expects that resource prices will increase in coming decades (EC, 2011).

Figure 7.8 Global commodity prices 1960–2012 and projections 2013–2025 (real 2005 USD)



Source: World Bank Commodity Price Data and EEA calculations (interpolation of projections for 2021–2024).

Box 7.2 Uncertainties around demand and supply: the case of shale gas

Recent price developments provide an illustration of the capacity for technological change to alter very quickly the equilibrium in markets, with implications for the competitiveness of alternative resources. The development of shale gas in the US is apparent in the recent divergence of natural gas prices in the USA and Europe (Figure 7.9). Since 2005 price developments have followed contrasting courses, with US prices standing at less than a quarter of European prices in 2012.

European industries have voiced significant concern about how the disparity in energy prices will affect their competitiveness in global markets. In some instances they have elected to relocate production to the US (e.g. FT, 2013; NY Times, 2012). World Bank projections anticipate a reduction in the price gap in coming years, although European prices are still expected to exceed those in the USA by about 30 % in 2025.

Figure 7.9 US and EU natural gas prices 1990–2012 and projections 2013–2025

Source: World Bank Commodity Price Data and EEA calculations (interpolation of projections for 2021–2024).

7.4 Critical raw materials: high demand and uncertain supply

Certain non-renewable resources deserve particular attention because of their economic relevance, including their role in green energy technologies. In 2010, the European Commission identified fourteen 'critical raw materials' — resources associated with a high risk of supply shortage over the next ten years and of key importance for the European value chain. The EU's selection of critical raw materials was based on three core criteria (EC, 2010):

- economic importance, which is measured by identifying the main uses of the material and quantifying the value added by those sectors;
- supply risk, which is measured in terms of the degree of corporate concentration of worldwide production, the political and economic stability of the producing countries, the potential to use substitute raw materials, and recycling rates;
- environmental country risk (i.e. the risk that a country might implement environmental measures that restrain access to raw materials),

which is quantified by combining data on national environmental performance and on full life cycle impacts of raw materials on the environment.

As shown in Figure 7.10, global production of the fourteen critical raw materials is quite monopolistic in character, conferring a great deal of market power to a limited number of price-setting suppliers. China emerges as a key player as it holds more than 50 % of the known global reserves of nine of the fourteen materials and shows a particular dominance in the area of rare earth metals. Other important suppliers include the Brazil, the Congo, Mozambique, South Africa and the USA.

While the direction of future innovation is very hard to anticipate, projections suggest that demand for some of these critical raw materials is likely to expand substantially. Since mining output often cannot easily respond to changes in demand (EC, 2012), this implies potential risks in terms of security of supply and price volatility.

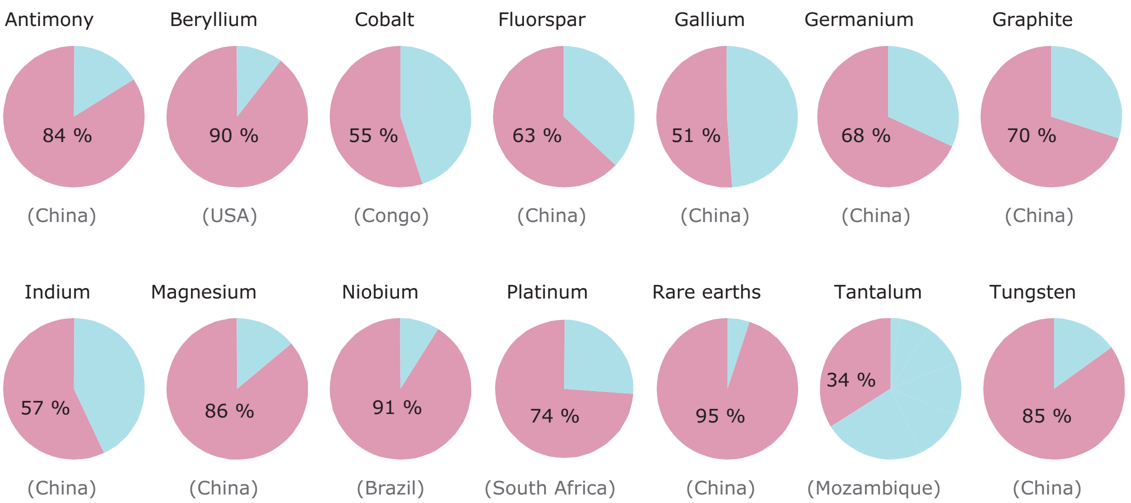
Figure 7.11 shows the potential increases in global demand for five out of the fourteen key materials that are crucial because of their importance in fast growing technologies (IZT and Fraunhofer, 2009; EC, 2010). For example, strategic low-carbon energy technologies such as the high performance magnets used in wind turbines or electric vehicles rely on neodymium (included among the rare earths group), while photovoltaic systems depend on gallium and indium. Tantalum is used in computers and mobile phones. The potential growth in global demand for these resources up to 2030 represents a concern for the EU, which has limited reserves (if any) of most of these materials and is heavily dependent on imports.

As with fossil fuels, growing awareness of the vulnerability of supply chains for critical raw materials has created strong economic incentives for countries to locate new reserves. There is evidence that these activities are beginning to pay off, potentially bringing a diversification of global supplies (New Scientist, 2013). As with fossil fuels, however, the rush to identify new deposits of resources presents environmental burdens alongside economic opportunities. In the case of rare earth metals, these include the toxic and radioactive waste generated by mines and processing plants (Schüler et al., 2011).

7.5 Why is intensified global competition for resources important for Europe?

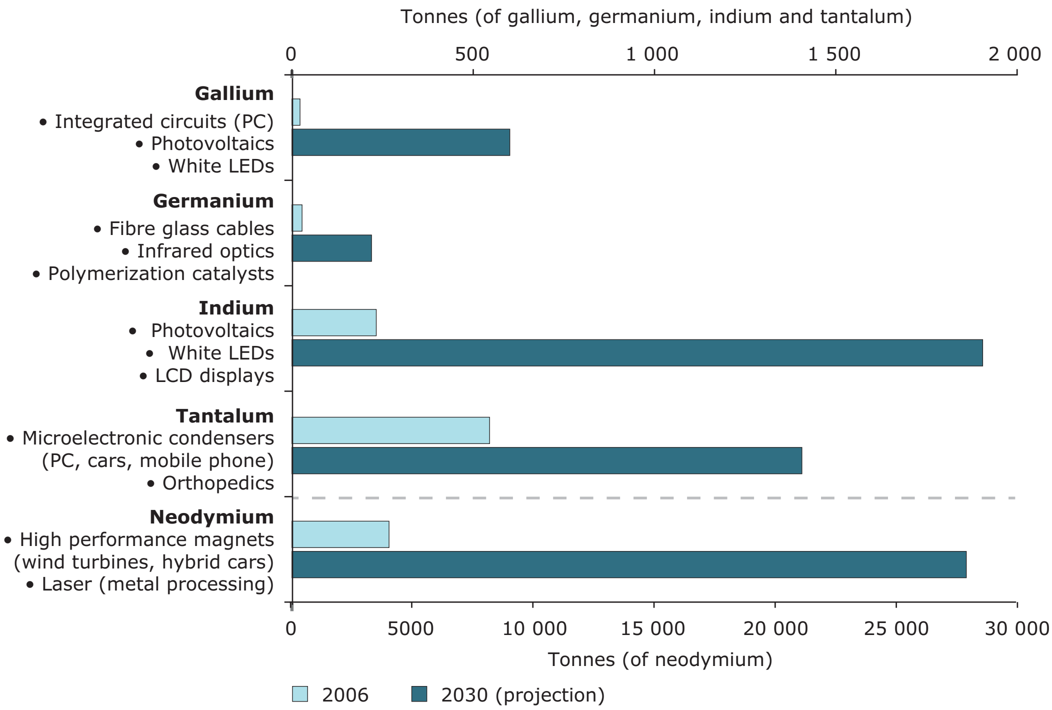
Intensifying global competition for resources is likely to affect Europe both directly and indirectly. For example, Europe's reliance on resource imports means that growing competition will directly influence whether businesses and consumers have access to commodities at affordable prices. But indirect environmental impacts are likely to follow as a result of growing extraction and exploitation of resources.

Figure 7.10 Percentage of global production of EU critical raw materials within a single country, 2011



Source: USGS, 2013, except for gallium, which is from Reichl et al., 2013.

Figure 7.11 World use of selected critical raw materials in emerging technologies, 2006 and 2030



Note: The bullet points provide examples of key uses for the materials.

Source: IZT and Fraunhofer, 2009.

The precise nature of these effects on Europe seems likely to depend significantly on how resource supplies respond to surging global demand, with technological development playing a key role. Europe's relative resource poverty could give it especially sharp incentives to innovate and identify market niches that reduce the continent's overall need for minerals and metals. As global competition for resources intensifies, such specialisation could provide an important focus of economic growth.

Cheaper, more secure supplies of fossil fuel reserves from shale oil and gas could likewise

Box 7.3 Uncertainties around demand and supply: the case of phosphorous

The finite character of non-renewable resources, combined with supply chain vulnerabilities and technological advances contribute to continued changes in estimates of remaining resource reserves and their geographical distribution.

Concerns about the longevity of phosphate reserves, which provide most of the phosphorus used in agriculture, have eased in recent years following a four-fold increase in estimated reserves between 2010 and 2011 (Van Kauwenbergh, 2010). Although projections for demand still suggest that phosphate stocks in the USA and China may be exhausted by 2060–2070, it is estimated that global reserves will last more than 300 years at current extraction rates, compared to previous estimates of less than 100 years.

Nevertheless, the heavy concentration of newly identified deposits in one country, Morocco, implies that concerns persist about security of supplies. According to one estimate, Morocco's share in world phosphorous production might increase from 15 % today to about 80 % in 2100 (Cooper et al., 2011).

create economic opportunities in Europe. But they also raise significant concerns in terms of their environmental impacts in Europe and elsewhere, including impacts of global warming (GMT 9) and pollutant emissions (GMT 10). Similarly, growing long-term scarcity of minerals and metals may induce Europe to turn to sources previously deemed uneconomic. Expanding mining has several environmental effects, including altering landscapes, polluting water and generating waste.

Facing competition in global markets, businesses may favour further exploitation of fossil fuels rather than expanding renewable energy supplies. Such a move would be unlikely to benefit society in the long term, since fossil fuel-based energy only appears cheap if the resulting environmental and human costs are ignored. Under pressure from firms and consumers, however, European governments may find it difficult to correct market prices and pursue ambitious greenhouse gas mitigation efforts — indeed they may have little incentive to do so if they cannot persuade other regions to implement similar measures.

As such, the emergence of new sources of fossil fuels could significantly weaken the momentum behind global efforts to mitigate climate, delaying the shift to cleaner alternatives and causing massive pollution in the meantime.

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