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COMMISSION STAFF WORKING PAPER

Analysis associated with the Roadmap to a Resource Efficient Europe
Part II

Accompanying the document

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF REGIONS

Roadmap to a Resource Efficient Europe

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This identifies changes needed to reach a prosperous world in 2050, in 9 inter-related areas. Vision 2050: The new agenda for business (2010)

Annex 2: Summary of the Resource Efficiency Public Consultation and other Stakeholders inputs

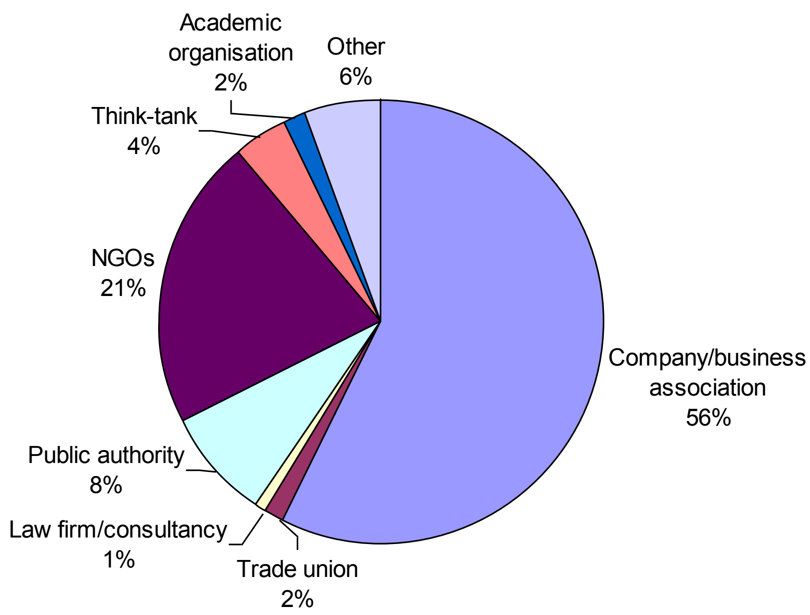
On 26 January 2011 the European Commission adopted a Communication on a resource-efficient Europe, a Flagship initiative of the Europe 2020 Strategy which sets the framework for a series of initiatives to be adopted in 2011 and 2012.

The planned 'Roadmap for a resource-efficient Europe' will be one of the main initiatives proposed. A public online consultation was launched with a press release and an announcement on Your Voice in Europe website on 22 February 2011, with a closing date of 22 April 2011. The online consultation asked for informed opinions and suggestions on how to best achieve the transition towards a resource-efficient Europe.

1. PUBLIC ONLINE QUESTIONNAIRE

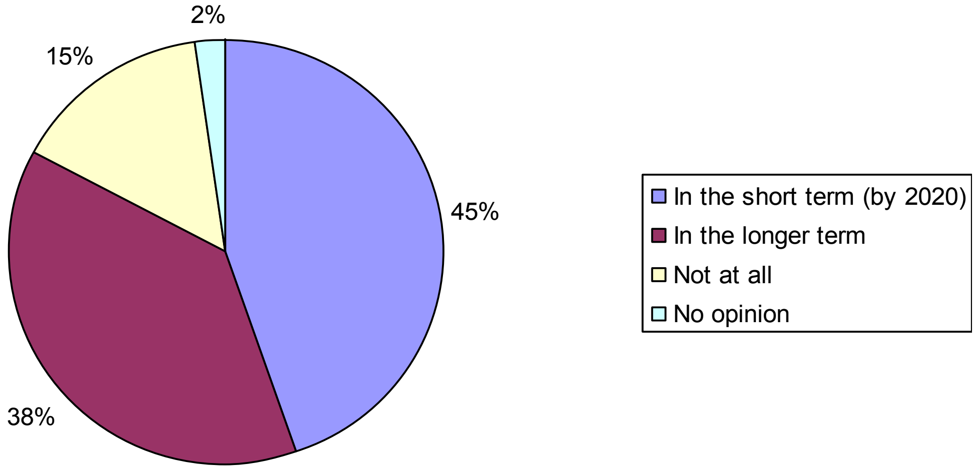
Out of the total 126 responses on behalf of organisations, the majority came from companies/business associations (72), followed by NGOs (27), public authorities (10), "others" (7), think-tanks (5), academic organisations (2) and one response from a consultancy (see Figure 1).

Figure 1: Breakdown of respondent organisations



Most of the respondents felt that impacts of resource consumption will affect us both in the short and in the long-term (see figure 2). They felt strongly that unsustainable natural resource consumption will only affect us in the long-term (76% thought so) but that the price of materials will affect us significantly in the short-term (76% also thought so).

Figure 2: We will consume natural resources at an unsustainable rate and sustainability limits of natural resources will be exceeded



54% of respondents believe resource efficiency has the potential to help in the long-term. 62% believe it will help creating jobs in the short-term with fewer respondents believing it will relieve pressures on environmental resources in the short term.

Overall, the current use of resources was rated not efficient (food, fossil fuels, water, biotic materials, ecosystem services and energy), or only more or less efficient (metals and minerals, construction materials and chemicals).

Responses reflect that the policies with the highest potential to help make the European economy more resource efficient were in the fields of agriculture and rural development, climate change, energy policy, environmental policy, industrial policy, maritime and fisheries policy, regional policy, research and innovation policy and transport policy. Consumers and health policy, employment policy, and trade policy were rated as having some potential as well.

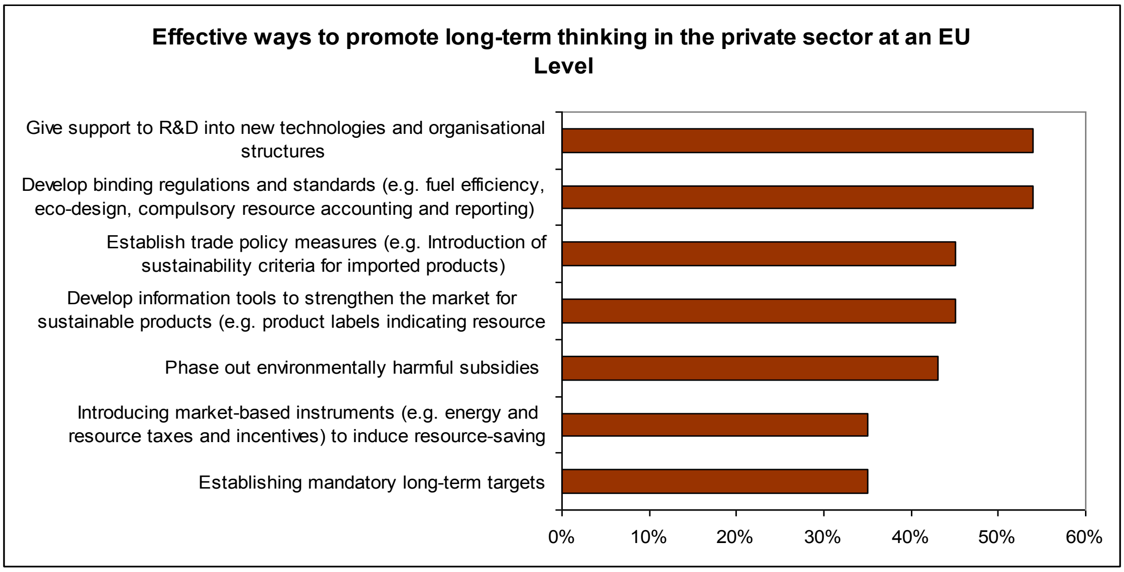
In terms of barriers preventing us from developing a more resource efficient economy, there were differing perspectives towards where these were relevant. They felt strongly that inadequate market signals for RE had a global significance for them as well as consumers purchasing decisions not reflection long term sustainability. They felt that there is a lack of information (on alternative options) and this affects institutions also at a global level.

Other issues of global importance are lack of long-term thinking in decision making (for example these could be awareness of new technologies, working methods and processes among managerial staff), a large dependence on existing technologies and the current business models.

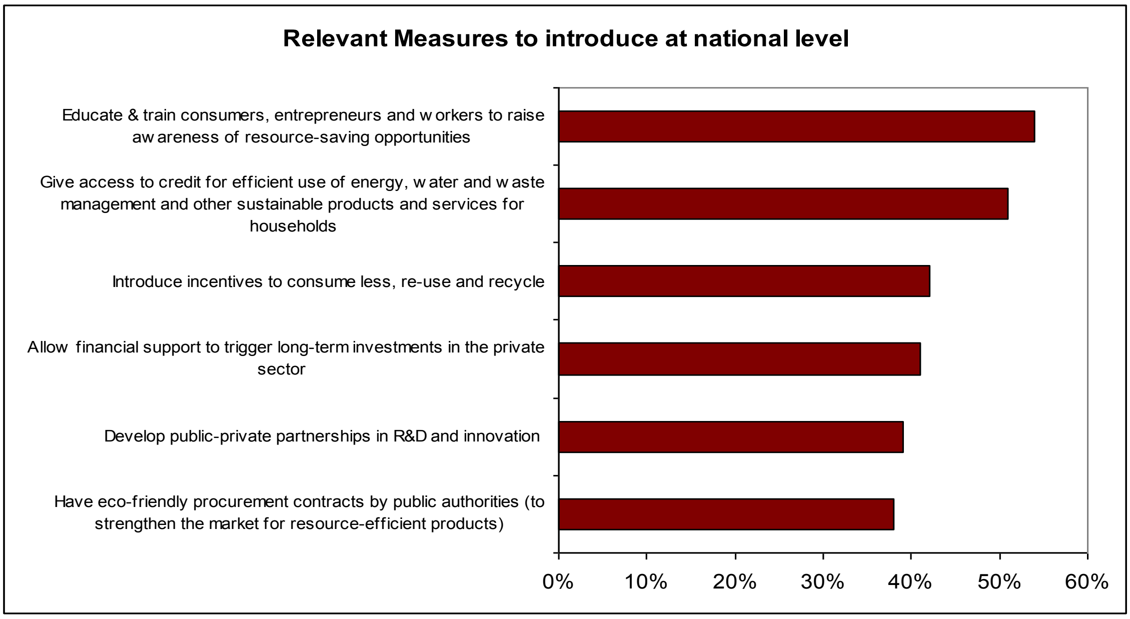
Of EU level importance are the feeling that there is insufficient public funding/incentives for investment and innovation promoting resource efficiency, limits in existing infrastructure (e.g. energy, transport and communication), unhelpful existing EU regulation and lack of targets and indicators at EU level (and to some extent at a global level too). It is also felt that there is a lack of prioritisation at EU level and that there is insufficient R&D funding and investment. Skills gaps in the workforce and sub-optimal functioning of the labour market were only perceived to have national relevance.

2. PUBLIC POLICY – INSTRUMENTS TO OVERCOME BARRIERS TOWARDS A MORE RESOURCE EFFICIENT ECONOMY

Respondents concluded that the most effective ways to promote long-term thinking and planning in the private sector would be, at a European level to focus on a mix of policies, from R&D support to binding targets.



A similar mix of policy tools should be employed also at national level.



When looking at ways of boosting investment in innovation for resource efficiency and what measures would be the most effective, respondents felt that most measures could and should be adopted at a European level (as opposed to nationally or globally).

In responding to how effective different measures would be in ensuring private investment in a resource-efficiency infrastructure, the respondents felt that measures would be effective at either national or European level. For example, market-based instruments and subsidies were seen as something relevant at a national level by the majority of institutions. Of national relevance were also the development of demand-side management strategies in parallel with any major infrastructure projects, and public-private partnerships.

Cap and trade-type quotas combined with economic incentives were seen as something relevant to EU level by approximately 40% of the institutions, even though an equal percentage felt that they were not effective.

Current Business Models

The factors seen as very significant barriers to adopting new business models/organisational innovation by private companies that could contribute to more resource efficiency were the excessive perceived risks, lack of funds and long payback periods for investments compared to short term investors' expectations, as well as uncertain market demand. They also felt that regulations do not proved the right incentives, that there is a lack of qualified personnel and a lack of adequate infrastructure.

More or less significant are limited access to information, and knowledge, lack of suitable business partners and a lack of technological and management capabilities. Market domination by established firms was seen as not being significant.

Shifting Business Behaviour

In order to shift business behaviour to resource efficient business models, respondents felt that market-based instruments (e.g. energy and resource taxes/incentives in support of resource efficient business models) would be very effective. Education and training of employees and binding technical regulations and standards would also be very effective.

Enabling access to investment/R&D and innovation funding, trade measures, as well as introducing a requirement for public procurement to comply with sustainability and ecological standards were seen to be potentially very effective. Cap and trade quotas were seen to not be effective.

3. POSITION PAPERS AND WRITTEN CONTRIBUTIONS

In addition to the responses to the online questionnaire, the Commission received also some more extensive contributions and 34 position papers: 25 from industry groups or companies, 6 from NGOs or think-thanks and the 4 from governmental organisation.

3.1. Companies/business associations

The points raised by companies and business associations can be organised along three broad lines: 1) Creating the right framework conditions, 2) Improving governance and 3) Competitiveness concerns related to resource efficiency.

3.1.1. Creating the right framework conditions

Many companies and business associations highlighted the importance of investing in R&D. One association considered that Europe's main weak point is the commercialising of innovations, whereas some others also insisted on the importance of more public funding for R&D and innovation policy. One business association stated that boosting innovation is also about creating new business models and targeting the key stages of the value chain simultaneously. Finally some companies also suggested putting more effort into researching substitution materials and recycling technologies.

Other points raised were the need to ensure access to finance, designing SME-friendly support instruments and setting up SME research networks that would enhance research cooperation.

3.1.2. Improving governance

One concern that is widely resonated by business is that the Roadmap to a resource efficient Europe should introduce an integrated approach to policy making to ensure improved policy coherence. Some industry stakeholders raised the point that there is still room for improvement with regard to reducing bureaucracy.

Many companies and industry associations also find that, with regard to resource efficiency, it is important to consider the entire value chain and to adopt a life-cycle perspective to avoid that policy measures would just shift the environmental impacts from one phase to another.

With respect to regulation not all views were unanimous. Whereas most contributions suggested that more regulation is not necessary or desirable, two companies argued for more regulation, arguing that this would increase policy certainty and hence a climate favourable to investments and the creation of new markets. In general, many respondents invite the Roadmap to a resource efficient Europe to set out a long-term vision of resource efficiency and to present a cost-effective step-wise approach towards this long-term objective.

A majority of business organisations pointed to the need for developing a sound knowledge base, and some also suggested that this would include the development of appropriate resource efficiency indicators. Two representative organisations argued against binding numerical targets.

3.1.3. Competitiveness concerns

Many of the contributions received also insist on the importance of ensuring access to raw materials. Better management of both primary and secondary materials as well as ensuring free trade and avoiding monopolistic or oligopolistic market structures are considered to be key in this regard. A significant number of business associations also expressed their concern about the recent volatility of resource prices.

One business association also expressed its concern about the fact that there is limited consumer awareness about resource efficiency issues.

Many in the business sector expressed the need to have regard to short-term competitiveness. In particular, some business and industry associations express concern that resource taxation – if applied only at the EU level – would negatively affect industry's competitiveness in the short or even mid-term. One stakeholder stated that there is a need for more tax harmonisation at the global level.

3.2. NGOs and think tanks

Nearly all respondents from think tank and non-commercial interest groups called for Commission proposals for resource efficiency indicators in its Roadmap, with some demanding that these indicators would lead to binding resource efficiency targets. Many respondents called for more effective waste policies.

A couple of NGOs found that the EU's product policy needs to be strengthened as to ensure that our production and consumption does not negatively affect Europe's resource base. One association adds that both the supply and the demand side should be equally addressed. It also points to the importance of taking into account the findings from research on consumer behaviour. Another association further suggests that green consumer choices should be made more affordable.

One NGO specifically pointed to investment related issues of resource efficiency policies, such as avoiding lock-in in large infrastructure works, urban planning and cohesion policy. One think tank insisted that the Roadmap would address the underlying drivers of increasing resource use. It also pointed to the importance of policy integration and developing a better understanding of the links between the different resources and the environmental impacts.

3.3. Governmental organisation

The Commission also received 4 position papers from governmental (national or international) organisations. Several of them stressed the need for global governance, addressing the geopolitical and development dimensions of resource use. Other points raised are the need for a coherent and integrated approach, the need to involve MS and private actors and the need of addressing the rebound effect.

Annex 3. Target Areas for Removing Barriers to Resource Efficiency

Introduction

This Annex provides the rationale for actions in particular areas of the economy, their application to particular resources and governance problems.

1. Transforming the Economy

1.1. Improving products and changing consumption patterns

1.1.1. Specific barriers to transition

Behavioural studies show that people often stick to their previous behaviours and purchasing habits. They are influenced by social conventions, lock-in to existing, familiar technology and the set of information available to them.

As consumption is the prime driver of production patterns and some innovation, these issues slow response to changing conditions. It weakens markets for innovations and traps consumers and organisations into inefficient resource use (e.g. in energy consumption in buildings) even if prices rise. New business models such as car-sharing or 'product service systems' can be slow to expand.

Many of the barriers come from the way people are influenced by marketing information on products, much of which fails to accurately convey the fully life-cycle costs of production and consumption. This can partly be attributed to knowledge gaps on the life-cycle impacts, and partly to the way that purchasers wrongly interpret the information is presented (e.g. getting confused by green claims).

1.1.2. Policy Actions

- Practically applicable knowledge of full life-cycle impacts can come from creating agreed methodologies for life-cycle impacts (or environmental footprint) and increasing applied research. This can be used for consumer information, supply chain improvements and policy.

- Markets for products or services with lower life-cycle impacts can be increased through changes to labelling and marketing that, in practice, help consumers choose. Bearing in mind that issues of trust and image are often more influential than information, greater diffusion of scientific research into drivers of consumer choice would support this. Other options to increase market rewards for these products include incentives.

- Incorporating life-cycle considerations into public procurement can increase markets and stimulate innovation. Joint public and private procurement can be used to cost-effectively buy innovations that would not otherwise be able to break quickly into commercial markets.

- Setting minimum environmental performance standards for products as part of integrated policy – under the Eco-Design Directive – can boost diffusion and markets for more resource efficient products, by removing the least resource efficient.

Including a wider range of products and looking at recycled content and durability of products could reduce the market demand for resource-heavy products, promoting recycling markets. New business models for products that promote recycling could be promoted by extension of producer-responsibility.

1.1.3. Analysis of strengths and weaknesses

Strengths

- Consumption is a very significant driver for change (or lock-in)[1] because it is the fundamental driver of up-stream production activities and the resulting resource use[2]. 54% of income is spent in final consumption; public procurement accounts for roughly 17% of the EU's GDP. It can change firms' behaviour.
- Greener public and private procurement can create markets and greater rewards for innovative products and production changes. For example, actions on private, public or joint procurement can remove blocks to investment in innovation by creating market certainty, reducing technological lock-in. This can overcome barriers to innovation. Removing least efficient products from the market increases the market rewards for innovation in more efficient products and services.
- Actions encouraging broader lifestyle changes can bring significant benefits only be encouraging less-resource intensive patterns of consumption[3].
- Changing purchasing and behaviours has significant cost saving potential for consumers and public authorities through life-cycle efficiency gains, often with short payback periods. For example:
  - A 2011 report of the Dutch Ministry of Infrastructure and the Environment[4] concludes public sector energy consumption would be reduced by 10% and 3 million tonnes of CO2 would be saved if all Dutch public authorities applied the national sustainable public procurement criteria. NOx and fine particle pollution would drop 1%. The UK found it would save £40.7 million (€47.2 million) if proposed Green Public Procurement furniture criteria are applied[5].
  - A 2009 study found that using a Life Cycle Costing approach for procurement reduced costs by 1 %, even if initial costs were higher[6].
- These actions would be able to overcome some of the policy and market failures that can not be tackled by measures affecting price. For example, many of the resource impacts of consumption happen outside the EU, during production. (Annex 4 shows

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1 Policy Studies Institute, 2009. Designing policy to influence consumers: Consumer behaviour relating to the purchasing of environmentally preferable goods [online]. London: Policy Studies Institute. Available from: http://ec.europa.eu/environment/enveco/pdf/RealWorldConsumerBehaviour.pdf.

2 EEA, The European Environment – State and Outlook 2010: Consumption and environment, 2010

3 EEA, The European Environment – State and Outlook 2010: Consumption and environment, 2010

4 De impact van het programma duurzaam inkopen anno 2011 - Vervolgonderzoek naar de effecten van duurzaam inkopen op markt en milieu (The impact of the programme bying sustainably 2011 – Follow-up research about the effects on the market and the environment)

5 http://archive.defra.gov.uk/sustainable/government/advice/public/buying/products/furniture/spec/furniture.htm

6 Price Waterhouse Coopers, Collection of statistical information on Green Public Procurement in the EU Report on data collection results, report to DG Environment, 2009, http://ec.europa.eu/environment/gpp/pdf/statistical_information.pdf, page 69

the Ecological Footprint, a measure of global resource impacts of EU consumption.) Change in consumption would also bring changes in global supply chains, bringing benefits outside the EU's usual policy scope[7].

- Using evidence from behavioural science, policy on consumer choice can counter lock-in biases with more effective policies, and can boost markets for green products by applying this knowledge to limit any green claims that wrongly mislead consumers.

Weaknesses

- The rebound effect may offset benefits if not tackled: as efficiency of a technology improves (and thus lowers the life-cycle cost), then usually consumers respond to that saving by consuming more (as seen with energy use). Annex 5 discusses this more.
- Adequate life-cycle information on resource impacts on many products and services is not yet available, and will require additional resources for development on top of existing EU, MS and private sector programmes. Decisions will only be able to be taken on the basis of these estimates, ignoring some of the diversity.
- Knowledge of how consumers actually respond to alternative policy measures (like billing information or forms of marketing, e.g. labelling) is limited.
- Changing government procurement practices – even to promote choices that save public money will in many cases involve change in procedures and practices (for example in single-year budgeting) and therefore training and understanding of the benefits of change.

1.2. Boosting efficient production

1.2.1. Specific barriers to transition

(a) Lock-ins to existing areas of business focus

Scarcity of both management time and accessible expertise holds back efficiency. This particularly applies where resource use is not the core business area, even though it may be an essential part of the process. There is an opportunity cost of engaging in efficiency. However, the judgement on where to spend management time is often based on past behaviour and current norms, even where external conditions or resource scarcity are changing[8].

(b) Suboptimal exchange of information on efficiency potentials

Firms in one part of a supply chain may not be able to improve the resource efficiency of their production without the co-operation of other parts of the supply chain[9]. However, inter-actions along the supply chains to find mutually beneficial efficiency savings, though frequent, are not the norm. Firms with wastes that could be inputs for other firms tend not to have the means to find buyers.

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7 EEA, The European Environment – State and Outlook 2010: Consumption and environment,2010

8 "Lags in the EU economy's response to change", Ecorys, 2011 for the European Commission

9 Ecorys 2011 Study on the Competitiveness of European Companies and Resource Efficiency

(c) Difficulty of comparing resource impacts between firms

The range of different methodologies for reporting resource impacts makes comparison between firms difficult – and this holds back the usefulness of resource measures as guides for firms looking to improve, or investors.

(d) Short-term focus at the expense of long-term competitiveness

Many companies fail to economise on longer-term resource use because of a short-term horizon encouraged by current corporate reporting practices and investor pressure. Access to finance and lack of knowledge and information on opportunities are further barriers. This holds back success of resource-efficient innovation, in turn weakening investment in development of beneficial innovations.

1.2.2. Actions

Firms can become more aware of change and savings possibilities, for them and in their supply chain. Member States and the Commission can assist by: improving the availability of expert advice for SMEs and helping companies work together to realise synergies, for instance in the sale of waste and by-products as inputs for others – 'industrial symbiosis'.

A methodological guide for corporate resource footprints, coupled with good incentives for suitable reporting of resource use (eg. specific measures to get prices right) could increase comparability on efficiency between firms. Establishing benchmarks of good performance would increase managers and investors ability to compare relative performance.

Avoiding, wherever possible, the use of dangerous chemicals can help protect key resources like soil and water, and make others, like materials, safer, easier and less costly to recycle and reuse. For example, the approach to chemicals management promoted by REACH will help identify opportunities for improvement, particularly in the substitution of dangerous chemicals with safer and technologically and economically viable alternatives.

New innovative technologies and solutions for sustainable raw materials supply can increase the options for businesses. The candidate Innovation Partnership Raw Materials for a Modern Society can stimulate commercial development of these technologies.

1.2.3. Analysis of strengths and weaknesses

Strengths

- Businesses will find it easier to seize the short-term efficiency savings that present easy win-wins, within their operations and across their value chains. This will create the conditions that facilitate innovation. Business consultants report that even providing nothing more than technical advice to companies in the processing sector could bring savings of around 20% of material costs[10].
- Putting in place market and policy incentives that reward business investments in efficiency by 2020 will stimulate the spread of new innovations in resource efficient production methods.

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10 Fischer et al. 2004; ADL et al. 2005; also Aldersgate Group, 2010

- A number of schemes show the benefits of increased information flows, and the pay-back from providing advice or bringing firms together in National Industrial Symbiosis Platforms:

  - Based on the performance of the UK Industrial Symbiosis Programme, improving the re-use of raw materials through greater 'industrial symbiosis' (where the waste of some firms is used as a resource for others) across the EU could save €1.4bn a year and generate €1.6bn in sales[11].

  - **Vienna Ecobusinessplan**, sent resource-efficiency advisors to 680 enterprises. These saved about €47.1 million, 114 912 tonnes reduction of solid waste output, 1 214 tonnes reduction of toxic wastes, 175.3m kWh energy savings, 51 470 tonnes of GHG emissions avoided, 85.8 m km reduction of total transport mileage.

  - **EnWorks** (A scheme in NW England) has delivered, on average: 9% reduction in energy costs, 16% reduction in water costs, 20% reduction in waste management costs. For every £1 spent in the scheme, there are 920 kilograms of materials, 40 kilograms of carbon dioxide and 450 litres of water saved, and the business saves £11.25.

  - €1 spent on the resource-efficiency advice scheme **'Stimular'** in the Netherlands can save €13.50 in costs (energy etc) for the SMEs[12].

- Improving interactions along supply chains is one of the most effective ways to create further improvements in resource efficiency[13]. It also helps avoid lock-in to existing patterns of production. It allows producers lower in the supply chain to innovate and reduce resource use with support for firms closer to the consumer, who can better influence consumer demand.

- Use of information tools, like reporting, have the power to bring about change in firms' investments and processes without heavy handed regulation, facilitating light-touch change. By coupling these with the provision of information to the financial markets, providing comparable standards for resource use impacts will allow financial market to better support investments in resource efficiency.

- EU level supporting actions can be particularly valuable where supply chains are international, with resource impacts and risks outside the EU. Co-ordinated action by firms active across the Single Market coupled with EU-led discussions on international agreements can facilitate change where national initiatives may not have sufficient leverage. The EU's action here will support the Rio+20 Summit in June 2012.

- These actions would complement the actions to get prices right and help consumers factor in (and reward) efficient resource use in purchasing decisions, increasing the mutual effectiveness of all the actions.

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11 The Economic Benefits of Resource Efficiency Policy, COWI 2011, forthcoming

12 EIM, 1996. Stimular naar het jaar 2000, een evaluatie van 5 jaar Stimular [Stimular to the year 2000, an evaluation of 5 years of Stimular]

13 Ecorys 2011 Study on the Competitiveness of European Companies and Resource Efficiency

Weaknesses

- The scale of benefit depends significantly on the scale of Member State action in assisting firms. To set the level of action at the right level, the benefits to growth and employment of these interventions need to be compared to other public expenditure and subsidies on business.
- Benefits also depend on business mindsets. An important route for change in business norms around resource management is through peer networks. Business action on improving their supply chains will depend on how sectoral and cross-sectoral initiatives are formed by business themselves and business organisations.
- At EU level, discussions between representative organisations from EU sectors or multi-national corporations can only provide one part of the story. Representation by companies promoting faster rates of innovation and SMEs needs particular attention. For full effectiveness, transition platforms need to be set up at Member State level and must include small, innovative businesses.
- These actions will work best when combined with changes to the relative prices facing firms, as these draw attention to the savings opportunities.

1.3. Treating Waste as a Resource

1.3.1. Specific barriers

'Waste' is already a resource in many sectors, particularly easily recyclable metals. Industrial structures exist for the collection and reprocessing of waste. Yet, barriers prevent much of the EU economy from expanding the re-use, recycling and recovery of the valuable materials in the 3 billion tonnes of waste that is thrown away each year[14]. Much of the value of which is lost overseas.

On average only 40% of our solid waste is re-used or recycled, the rest going to landfill or incineration. These materials are available from municipal waste, construction and demolition waste, to sewage sludge. Our waste streams are increasing[15]. Yet, in some Member States more than 80% of waste is recycled, indicating the possibilities of securing EU materials. Also, in many cases valuable raw materials are lost due to low quality 'downcycling' of waste. Those barriers arise from:

Mixed waste streams: valuable material is lost to recycling and re-use through mixing with other waste in general waste collection and disposal (rather than being collected as separate streams), from retention in homes even at end of life (eg. mobile phones), or from illegal trade in waste taking the end-of-life products and scrap waste outside the EU. The EU recycling and manufacturing industries view this as a significant loss of resources for the EU – particularly in those metals where the EU faces insecurity of supplies, for instance the elements defined as critical to the EU economy, including rare earth metals, where the level of recycling remains low[16].

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[14] EEA, The European Environment – State and Outlook 2010: Material resources and waste (p. 22), 2010

[15] http://www.eea.europa.eu/soer/synthesis p.79

[16] Critical Raw Materials, Ad hoc group of the EU Raw Materials Supply Group (2010)

Limits to the recycling ability and capacity in Member States: cost-effective recycling depends on technological facilities for the separation of different valuable elements out of waste streams and processing to obtain clean material. Whilst technology has improved to make this possible for many elements and waste streams in the past decades (for example, for plastics), many Member States do not have access to modern facilities and technologies for some waste streams remain unavailable or costly. Separate collection often depends on either market actors or public authorities offering the service, and the current limits and incentives of both authorities and market actors hold back collection.

Incomplete markets for secondary materials: weak demand for some recycled resources limits the investment in innovation, collection and diffusion in a 'chicken and egg' problem – lack of investment in supply can leave potential buyers uncertain of secure high-quality supplies, weakening demand for those considering investments.

Environmental harm from waste treatment: the recycling of some waste streams (for example waste electrical and electronic equipment containing greenhouse gas refrigerants) can have environmental impacts if not recycled to good standards, as required by EU legislation. These requirements save costs for society (from environmental damage) but raise costs for recycling. In some cases, avoidance of the legislative requirements is frequent, distorting markets and disadvantaging legal businesses.

Implementation of waste legislation: Legislation plays a key role in market creation and technology diffusion. However, waste policies are not well implemented in all EU Member States — 19 % of all new environmental infringement cases in 2006 and 2007 were registered in the area of waste policies (Zamparutti et al., 2009) — and better implementation of current waste policies is needed to fully capture the benefits that could result from them[17].

1.3.2. Actions

Resolving these will need a combination of policies, such as product design integrating a life-cycle approach, better cooperation along all market actors along the value chain, better collection processes, and incentives for waste prevention and recycling.

Shortage of supply of material for recycling can be boosted by facilitating the exchange of best practice on collection and treatment of waste among Member States. Member States can set minimum targets through their national waste prevention and management strategies and work in the EU and with international partners to eradicate illegal waste shipments would boost the legal market.

Legislation on the various waste streams could be aligned to improve coherence and support good implementation, as could measures to combat more effectively breaches of EU waste rules. The existing prevention, re-use, recycling, recovery and landfill diversion targets can provide the push for the move towards an economy based on re-use and recycling, with residual waste close to zero, if properly reviewed.

The introduction of minimum recycled material rates, durability and re-usability criteria and extensions of producer responsibility for key products could be one action, amongst others,

[17] EEA, The European Environment – State and Outlook 2010: Material resources and waste (p. 41), 2010

that stimulated the secondary materials market and demand for recycled materials. Economic incentives and developing end-of-waste criteria would also support the markets.

Public funding, including the EU budget, can play a key role through public investments in modern facilities for waste treatment and high quality recycling, boosting innovation by giving priority to recycling plants over waste disposal.

1.3.3. Analysis of strengths and Weaknesses

Strengths

- Waste reduction remains the optimal way to increase resource efficiency, and deliver the greatest economic and environmental savings. Improving waste management makes better use of resources and can open up new markets and jobs, as well as encourage less dependence on imports of raw materials and lower impacts on the environment.
- The potential opportunities are very large, particularly if innovation in recycling methods is considered.
- It is estimated that 6-12% of all material consumption (including fossil fuels) is currently saved or avoided due to recycling, waste prevention and eco-design policies – with a maximum potential with existing technology estimated between 10 to 17%[18]. Doing so would have an estimated CO2eq saving potential of 148 million tonnes (equivalent to taking around 47 million cars off the road per year), and a monetary value of €5 billion[19].
- Within waste are materials that constitute a significant loss of resources for the EU – particularly in those metals where the EU faces insecurity of supplies, for instance the elements defined as critical to the EU economy, including rare earth metals, where the level of recycling remains low[20]. This resource can be 'mined'.
- For example, the EU produces around 24kg of electrical and electronic waste per citizen per year. This waste contains many needed metals for the high tech industries, like Gold, Copper, Indium, Lithium, Palladium. It is increasingly clear that through improved recycling we can satisfy at least part of the demand for such important metals. Waste electrical and electronic equipment alone is expected increase by roughly 11% between 2008 and 2014.
- To show the possibilities, China has many 'city mines' - its largest is capable of producing 1 million tonnes of copper each year, twice as much as the largest primary mine.

18 Bio Intelligence Service 2011, Analysis of the Key Contributions to Material Efficiency

19 Friends of the Earth Europe, Gone to Waste: The valuable resources that European countries bury and burn, 2009

20 Critical Raw Materials, Ad hoc group of the EU Raw Materials Supply Group (2010)

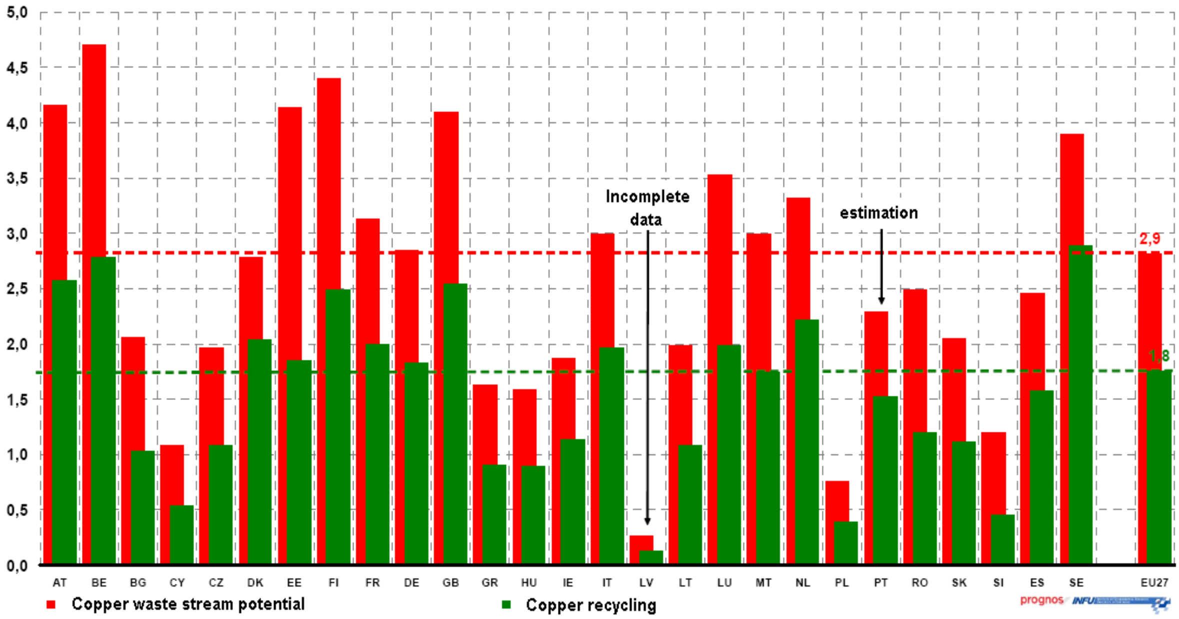

Figure: Copper waste recycling potentials (in kg/capita, 2004) (Source: Prognos, European atlas of secondary raw material – 2004 status quo and potentials, 2004)

- By working with markets, these actions have the potential to stimulate much greater investment in innovation and uptake of new practices than legislation alone. By aligning market incentives for recycling, including the costs of harm to other (particularly environmental resources) within the calculations of private actors has the potential to stimulate much faster rates of innovation, and hence secure a greater share of material flows for EU supply.
- Recycling has significant potential for reducing environmental impacts and harm to other resources – mainly from the avoidance of the life-cycle impacts (eg. in extraction and refining) of the virgin materials that are substituted by recycled materials. Benefits also come from avoidance of impacts from alternative treatment or disposal routes, e.g. avoided methane emissions from landfilled biodegradable waste.
- The EU is one of the world leaders in recycling technologies. Further stimulation of the market for recycling, together with public R&D support can drive innovation in this area to position EU producers even more favourably in growing world markets.
- Targets for recycling and waste prevention (for example for specific waste streams) have been effective at stimulating changes in collection and partnerships for recycling. Reviewed targets are also likely to stimulate organisation change and new technological development.
- The spread of best-practice in waste implementation and enforcement across the EU should assist Member States to achieve more and at lower cost.

Weaknesses

- For success, by 2020, waste must be seen and used as a resource. This requires a mind-shift in business and local authorities, in addition to the creation of economically attractive functional markets for secondary raw materials.

- Given the rate of global increase in demand for materials, recycling – even at much higher rates – is not a sufficient strategy to solve predicted problems of relative scarcity or security of supply. Taking steel as an example, between 2000 and 2020 China will produce as much steel as the US did during the last 120 years. If aggregate global production continues at its average growth rate over the period 1950-2007, i.e. 3.5% annually, in 135 years production would have increased by 100 times, so that even high recycling rates of existing stocks would be marginal compared with new production[21].
- This option requires significant public action – for instance in public, or publicly funded capacity for knowledge in recycling markets and collection. Whilst that is an opportunity for job creation in sectors of the future, public spending may be constrained due to the results of the financial crisis. Policy will be needed that uses the market to provide sources of finance whilst fairly distributing costs and benefits between consumers, producers and recyclers - for example through well-designed producer take-back schemes.
- Equally, the maintenance of strong market signals requires a belief in effective enforcement and the avoidance of illegal free-riding from operators working in the grey or black markets. This will require capacity in Member States authorities.

1.4. Supporting research and innovation

The ability of the economy to adapt is closely related to its rate of innovation. This change can be made by developing new technological and non-technological solutions, new approaches to the way we run business or the way we consume and use goods and services.

1.4.1. Specific Barriers

The current rate of eco-innovation is suboptimal because of certain barriers. Both radical and incremental innovations would be needed, and, as they work together, behavioural, organisational and systemic innovation would be as important as technological[22].

(a) Path dependency in areas for investment

Investors and entrepreneurs have started realizing the business potential of eco-innovation in the area of resource efficiency, but there is more to be done. Path dependency from the current dominance of certain technologies and systems can make commercial success of innovations very difficult[23].

Greater innovation would particularly be needed in: environmentally friendly material extraction, recycling, re-use potentials, substitution of environmental impacting material, technologies and design for less material and energy use, green chemistry (reducing the use of other resources) and improved and biodegradable plastics. Diffusion of innovation in water conservation and sustainable agriculture would also be required.

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21 F. Grosse, 'Is recycling "part of the solution"? The role of recycling in an expanding society and a world of finite resources', Institut Veolia Environnement, 2010.

22 OECD, 2004, The Economic Impact of ICT

23 OECD, Green Growth Synthesis (2011)

Innovation does not only rely on technologies but also on "softer" innovations such as those related to new business models or new process for example. Although the understanding and policy support to such types of innovation are less developed, they also have a significant potential, for example in delivery of the circular economy, as testified by the successful case of the National Industrial Symbiosis Programme[24].

(b) Lack of certainty about future markets

A particular challenge comes in creating market certainty about the demand for innovation by bringing together the stakeholders across value chains within the economy. Co-ordination must also allow the design and application of integrated policy mixes based on an appropriate understanding of innovation trends in the areas of resource efficiency identified as strategic (given the very horizontal and heterogeneous nature of the resource efficiency concept). Developing such knowledge base often represents a challenge.

(c) Under-investment in the relevant areas of knowledge

There is a mismatch between the areas of need highlighted in the Roadmap and the research funding in these areas, particularly around: so

- innovative solutions for environmentally friendly material extraction, for recycling or re-use, and for substitution of environmental impacting material, for example on smarter design, green chemistry and improved and biodegradable plastics;
- knowledge on the natural tipping points and ecosystems' resilience thresholds;
- knowledge on changing consumption behaviour for delivering resource efficiency and on the likely economy-wide rebound effects from policy interventions.

At European level, this knowledge gathering would build on the work of the EEA, Research Framework Programmes, as well as Earth observation policies (GMES, Galileo, INSPIRE, SEIS). Additional research would mainly take place under the cooperation specific programmes of the Research Framework Programmes, which are already paying growing attention to eco-innovation, for example, through public-private partnerships for 'Energy efficient buildings' and 'Green cars'. From 2014 onwards, resource efficiency would become a main theme, a "grand societal challenge" of the next framework programme.

1.4.2. Actions

Action will be needed to overcome the barriers by bringing together the actors, the policy framework and the incentives to boost innovation in the key areas for resource efficiency. The Innovation Partnerships and Joint Technology Initiatives under the EU's Innovation Union Strategy can do this, if designed to meet resource efficiency goals. EU research funding can be focused on the key resource efficiency objectives through its funding instruments - in

[24] Industrial symbiosis brings together traditionally separate industries and organisations from all business sectors with the aim of improving cross industry resource efficiency and sustainability; involving the physical exchange of materials, energy, water and/or by-products together with the shared use of assets, logistics and expertise. See http://www.nisp.org.uk/what_is.aspx

particular, Horizon 2020 These actions provide specific funding "windows" for eco-innovation and tackle some of the specific problems holding back eco-innovation, both on the supply and demand side. The Eco-Innovation Action Plan can help with by reducing the barriers to innovation, in technologies and behaviours.

1.4.3. Analysis of strengths and weaknesses

Strengths

- Scientific breakthroughs and sustained innovation efforts could bring about by 2020 dramatic improvements in efforts to reduce, reuse, recycle, safeguard and value resources.
- The actions set out in the Roadmap will provide a coherent framework for policy action in these areas of innovation, to develop a strategic, long-term plan to accelerate the development and deployment of solutions. A wide range of policies will contribute, including the Innovation Union, the Eco-Innovation Action Plan, the Strategic Energy Technology Plan (SET Plan) and assistance with EU-wide technology verification[25].
- 'Innovation Partnerships' can provide the interactions between potential innovators and policy makers that facilitate the policy framework, funding and clarity of direction needed to meet resource efficiency goals. These are being developed on water, raw materials, ecosystem services, smart cities, agricultural productivity and sustainability, sustainable fisheries, and green chemistry.
- Joint Technology Initiatives designed to pool national research efforts into key areas can provide the critical mass of research and investments that enhances the rate and success of innovation in different Member States and markets.

Weaknesses

- The drivers of innovation are complex, and a wide range of supply and demand side measures are needed to respond. Whilst the Innovation Union and the actions set out above will contribute, they will need careful co-ordination and to be complemented by other measures (such as price signals).
- The allocation of clean technologies venture capital to resource efficient technologies has increased from 17% in 2006 to 45% in 2010[26]. The percentage can be taken, even if very roughly, as a proxy indicator of the type of eco-innovation that is being marketed and that might become mainstream in the near future. Even if the figure looks reassuring it has to be noted that energy efficiency plays the lion share in such trends while only a marginal role is played by technologies in areas such as bio-materials, water conservation, smart production and sustainable agriculture.
- The current levels of R&D in the EU fall well below the headline target of 3% set in the context of Europe 2020. Reaching this target and making sure that resource efficiency issues are mainstreamed into the resulting innovation push, will be necessary to successfully deliver the desired eco-innovation boost.

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25 Environmental Technology Verification Impact Assessment

26 2010, "Understanding the state of play in financing eco-innovation in the EU", Cleantech Group http://ec.europa.eu/environment/ecoinnovation2010/2nd_forum/presentations_en.htm

1.5. Phasing out inefficient subsidies

1.5.1. Specific Barriers

Distorting price signals, hiding future change

Subsidies for resources that lead the economy away from greater resource productivity are those which artificially lower the costs of using resources. Subsidies deter firms and consumers from adopting efficiency behaviours and technologies that would be cost-effective in the absence of subsidies. For example, in fishing, subsidies have led to the creation of global fishing capacity twice as large as current fish stock's ability to reproduce, resulting in lost global economic benefits of US$50bn/year (around half the value of the global seafood trade)[27].

These distorted price signals make it difficult for firms and consumers to predict future resource scarcities and adapt accordingly[28].

Holding back the pace of change

The size of this kind of inefficient subsidy greatly reduces the incentives for innovation and so retards the EU's pace of change. It also leads to reduction in the capital assets – including environmental resources - that the EU relies on, reducing our growth potential. The table below illustrates the scale of the barrier[29]:

Table: Aggregate subsidy estimates for selected economic sectors [30]

Sector / Region	Region
Agriculture OECD:	US$ 261 billion/year (2006-8) (OECD 2009)
Biofuels:	US, EU and Canada US$ 11 billion in 2006 (GSI 2007; OECD 2008b)
Fisheries World:	US$ 15-35 billion (UNEP 2008)
Energy World:	US$ 500 billion/year (GSI 2009a) US$ 310 billion in the 20 largest non-OECD countries in 2007 (IEA 2008)
Transport World:	US$ 238-306 billion/year – of which EHS US$173-233 billion (EEA 2005)
Water World:	US$ 67 billion – of which EHS US$ 50 billion (Myers and Kent 2002)

The cost of the subsidies to the public budget exacerbates macro-economic imbalances, increasing tax burdens or preventing investment in alternative investments that would have a greater growth and innovation benefits or social effects. EHS lead to higher levels of waste, emissions, resource extraction, or to negative impacts on biodiversity[31].

27 World Bank/FAO 2009: The sunken billions – the economic justification for fisheries reform.

28 OECD, Environmentally harmful subsidies: challenges for reform, 2005

29 The table should be treated only as an illustration as estimates are subject to uncertainty, the definition of an EHS is not always clear, and figures are not available at the EU level in most cases.

30 TEEB – The Economics of Ecosystems and Biodiversity for National and International Policy Makers, Chapter 6: Reforming subsidies, 2009

31 OECD, Environmentally harmful subsidies: challenges for reform, 2005

Hindering the economy's flexibility

Short-term, individual or sectoral interests in preserving subsidies lock-in past policy decisions, holding back the economy from responding to change. Fears of sudden losses of competitiveness of firms and job losses from the abrupt removing of subsidies without mitigating measures block discussion of appropriate reforms. Political and bureaucratic interests can also be an internal governmental barrier to reform, whilst our frequent sectoral approach to policy making does not prioritise the indirect benefits and longer-term from subsidy reform.

1.5.2. Actions

Member States are invited to prepare plans and timetables to phase EHS out as part of their National Reform Programmes.

The Commission will monitor the phasing out of EHS in the European Semester as of 2012; organise exchange of best practices on the reform of EHS between the Member States as of 2012; and will assess in the future revision of the environmental State aid rules as of 2013 how measures aiming at increasing resource efficiency have been implemented and to what extent aid for resource efficiency objectives is necessary.

1.5.3. Analysis of strengths and weaknesses

Strengths

- The potential economic pay-off of reform is very high, corresponding to the level of these subsidies. A study by the OECD found that ending fossil fuel subsidies could reduce GHG emissions by 10% by 2050[32]. At their September 2009 summit in Pittsburgh, the Leaders of the G-20 officially recognized the harmful effects of fossil fuel subsidies. They agreed to "phase out and rationalize over the medium term inefficient fossil fuel subsidies while providing targeted support for the poorest"[33].
- The direct savings and long term economic gains from subsidy reform can be significant. An example of the possible direct impacts comes from estimates that reforming subsidies for company cars could save up to 0.5% of GDP/year[34].
- Phasing out environmentally harmful subsidies by 2020 will deliver public budget savings at a time of public spending pressure, at the same time as improved productivity and, in the long run, economic, social and environmental benefits.
- The social goals behind these subsidies can often be achieved more cost-effectively by other measures that do not run counter to resource efficiency.
- Where subsidies affect internationally traded goods and services, worries of cross-border competition often need mitigation through co-ordination between Member States, which the EU can support.

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32 OECD, Mitigation potential of removing fossil fuel subsidies - A general equilibrium assessment, 2011

33 G20, Leader's Statement: The Pittsburgh Summit, (Preamble, para 24), 2009

34 S. Naess-Schmidt and M. Winiarczyk (Copenhagen Economics),Company car taxation: Subsidies, welfare and environment, Report to DG TAXUD, 2009

- Many EHS are off-budget, and require investigation to identify and quantify. Assessment of the harmfulness of subsidies is sometimes not unambiguous. EU action can support Member States in carrying out investigation.

Weaknesses

- Reform of the subsidies has been identified as part of the reforms under the Europe 2020 Strategy. The OECD has developed an integrated assessment approach on the assumption that better policies will result when there is an explicit understanding of the distribution of costs and benefits, and when this information is made available. This requires systematic analysis of all costs and benefits, winners and losers, intended and unintended effects (environmental, economic, social) and highlighting where trade-offs exist. However, despite much rhetorical support, significant resistance to change remains.
- Successful reform needs to either review the initial purpose of the subsidy or find ways to deliver that goal in an economically more efficient way. The lack of co-ordination between Member States gives rise to perceived short-term competitiveness concerns for those who act first. The arguments that reform boosts competitiveness need more advocacy.
- Progress on reform will depend on Member State willingness to tackle political resistance. Distributional and short-tem sectoral competitiveness concerns are the major factors withholding member states from introducing market based instruments[35]. Mitigating arrangements may be necessary for the most affected regions, economic sectors or social groups within policy packages that ease transition by creating market rewards for greater efficiency.

1.6. Getting prices right

1.6.1. Specific Barriers

Distorting price signals, preventing the market's prediction of future conditions

Markets can only bring about efficient use of resources where the prices match the true cost of the resources used. Prices that do not match true costs lock in inefficient technologies and business structures, and hinder investment in clean energy and other green technologies.

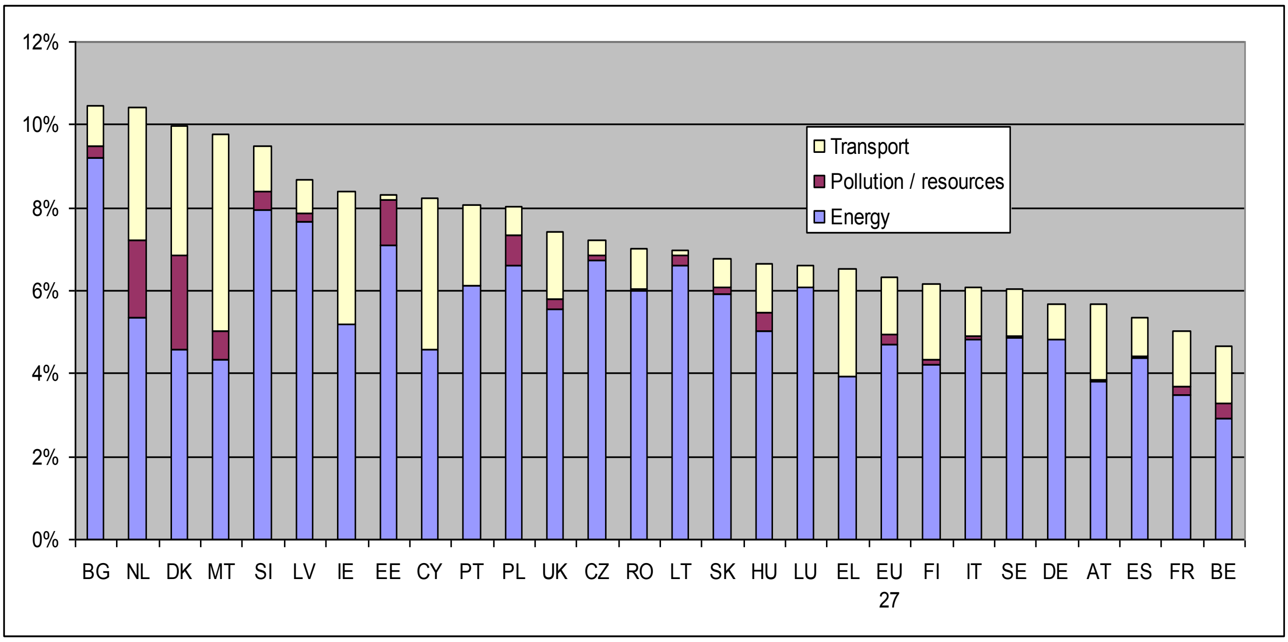
In macroeconomic terms, resources and labour are often substitutes – and if resources are relatively cheap compared to labour prices, decisions are made to use more resources in place of labour. The incidence of the burden of taxation significantly affects these relative prices – and so frequently current tax policy distorts market prices away from resource efficiency. In microeconomic terms, the cost of externalities can still remain unreflected in prices, which leads to unsustainable exploitation of some resources.

[35] SEC(2009)53 final

Reduced flexibility through slow-moving tax policy

Mainstream tax policy often does not consider the effects of the burden of taxation on the nature of innovation in the economy, and this slows the ability of policy to match changing conditions. For example, the trend in the proportion of environmental tax revenues is not promising: broadly on the decline in the EU27[36]. The potential to reverse this trend and for further rebalancing by Member States is shown in the figure below by the considerable variation in taxes on pollution and resources with Denmark generating 2.3% of its tax take through these (and almost 10% from environmental taxes more widely).

Figure: Environmental taxes as a percentage of total tax revenue (2009)[37]



1.6.2. Actions

- The Commission will facilitate greater exchange and co-operation at EU level between the Member States on taxation issues: in particular, through engagement with Member State Ministries responsible for taxation reform for resource efficiency, for example under the Market Based Instruments Forum.
- Member States can assess the relative burden of taxation on labour compared to resources, making this ratio an analytical tool for policy effectiveness.

1.6.3. Analysis of strengths and weaknesses

Strengths

- Well designed tax shifts can be extremely effective at inducing behavioural change. Shifting the average share of environmental taxation in public revenues to more than 10% (in line with the best performing Member States) by 2020 would create a level

[36] As a percentage of GDP, environmental taxes accounted for 2.4% in 2008 as against 2.9% in 1999, when they reached their peak level (Eurostat data)

[37] Taxation Trends in the European union, 2011, European Commission

playing field and support the economy to achieve greater resource efficiency. There is evidence[38] that raising energy taxation could drive forward substantial increases in innovation. Some positive examples of environmental tax reform:

- Sweden's introduction of a NOx emission tax led to a dramatic increase in firms using existing abatement technology – from 7% to 62% in the year following the tax and a large number of patents for new technical solutions[39].

- Modelling of a Norwegian tax of 15% on plastic and paper virgin materials, (far below the external effects) pointed to a reduction in the use of these materials of 11%[40].

- Experience in the UK shows that heavier taxation of virgin materials improves recycling levels for construction and demolition waste so that virgin resources are saved.

- Properly taxing resources (including pollution) should provide revenues that can either be used to cut labour taxes, and so generate higher employment; or to relieve pressure on public budgets. The OECD has estimated that a permanent one-percent reduction in average burden on labour may increase the employment rate by 0.4% over the long run[41]. Another option is recycling revenues to industry to invest in innovation.
- Currently, most environmental tax revenue comes from energy (particularly petrol and diesel transport fuels), with significant potential for taxes on pollution and resources. Revenues from carbon pricing alone may raise 1-3% of GDP by 2020 depending on the circumstances of each country[42].
- The highlighting of these reforms within the European Semester monitoring of Member State reforms will help strengthen co-operation between Member States, likely to facilitate more policy change.
- Improving discussion and analysis will help to overcome this perceived barrier, and so the Commission will bring together experts and representatives of Member States to discuss and share best practice (at minimal administrative cost) in particular areas.

Weaknesses

- Progress on reform will depend on Member State action, but this will be subject to political resistance. Distributional and short-term sectoral competitiveness concerns are the major factors withholding member states from introducing market based instruments[43]. Attention therefore needs to be paid to anticipate and mitigate against any negative impacts on growth, employment and competitiveness. Success will depend on compensatory measures for socially disadvantaged groups and the use of

38 Innovation of energy technologies: the role of taxes, Copenhagen Economics, 2010
39 Taxation, Innovation and the Environment, OECD (2010)
40 ibid
41 OECD 2006 Boosting Jobs and Incomes, Policy lessons from Reassessing the OECD Jobs Strategy
42 OECD. Green Growth Synthesis, based on OECD, ENV-linkages model
43 SEC(2009)53 final

fiscal reform within packages of policy that ease transition by creating market rewards for greater efficiency.

- Those concerns were also raised during a symposium on "Growth and green tax shifting in an era of fiscal consolidation" organised in 2010 by the Belgian Presidency, where Hungary and Belgium explicitly said that resource taxes would harm their countries competitiveness, given their existing economic structures. They stated that coordination among EU-Member States and potentially beyond would be crucial to avoid relocation and competitiveness concerns, deal with cross-border policy issues and to avoid distortions of the internal market.
- Before any reform, worries are voiced about putting a greater burden on existing industry, e.g. the risk of 'carbon leakage' to countries outside the EU, and the uncertainty that market based instruments could create for businesses, and the uncertainty about the strength of the new industry created (as is the case of carbon price in ETS). Without strong analysis of the positive effects of change and the transition costs for the structure of the economy, these arguments can block progress.

2. KEY NATURAL RESOURCES

The resources below all play an important role in economic growth and determining the environmental impacts of our resource use. They form a part of the EU's 'natural capital'. This section describes some of the particular problems which slow our adaptation to managing the resources efficiently. This indicates where the actions above to transform the economy should be prioritised or complemented. These resources are part of the economic and environmental system, with use of one linked to use of others. Increasing efficiency in one can have multiplier effects. Climate is a key resource: specific challenges of progressing to a low-carbon economy are addressed in detail in the Commission's Roadmap for moving to a competitive low carbon economy[44] and the forthcoming Energy Roadmap 2050.

2.1. Ecosystem services

2.1.1. Interlinkages, Significance, Risks

Ecosystems provide a number of services that contribute directly and indirectly to human well-being, including provisioning services (e.g. food, water, fuel), regulating services (e.g. flood and disease control), supporting/habitat services (e.g. nutrient cycling) and cultural services (e.g. recreation). These services are of benefit locally, nationally or globally[45]. The magnitude of global business opportunities related to natural resources is estimated to be up to $2-6 trillion by 2050[46].

Depending on the spatial scale of ecosystem services, it can affect people in the neighbourhood of ecosystems, as well as local authorities and businesses, affect EU citizens as a whole, or have global consequences. Some business sectors are particularly affected, as

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44 COM(2011)112 and SEC(2011)288, in particular sections 2.3 and 5.2.3

45 The Economics of Ecosystems and Biodiversity. Mainstreaming the economics of nature. A synthesis of the approach, conclusions and recommendations of TEEB

46 WBCSD(2010) Vision 2050: New Agenda for Business. World Business Council for Sustainable Development

they depend on ecosystem services, either directly or indirectly, including fisheries, forestry (wood products), agriculture (dependent on services such as pollination, biological control, soil formation, water availability and genetic diversity), water supply, pharmaceuticals and cosmetics, chemicals, agro-food, and growing parts of the tourism sector.

Nature-based solutions (green infrastructure) can be more cost-effective than purely man-made infrastructures for delivering public and private benefits – for example, green spaces providing cooling in cities enhancing resilience, for instance by using forest and wetland ecosystems for flood control and water purification. This investment in Green Infrastructure and the 'restoration economy' offers enhanced growth potential.

Yet, 60% of the Earth's ecosystems have been degraded in the last 50 years[47]. In the EU, only 11% of protected ecosystems are in a favourable state[48]. 88% of fish stocks, for example, are fished beyond maximum sustainable yields[49].

2.1.2. Specific Barriers

The TEEB report[50] highlights some of the key barriers holding-back resource efficiency:

- Often the benefits of ecosystems accrue to a wide range of stakeholders over a wide geographical area. These wider benefits are hard to integrate into decisions taken by individuals or localities, which tend to focus on immediate, direct winners and losers.
- Economic incentives – e.g. prices – play a major role in influencing the use of natural capital but in most cases prices do not take account of the full value of ecosystem services.
- Conventional measures of national or businesses' economic performance and wealth fail to reflect natural capital stocks or flows of ecosystem services that they rely on. So these are often not factored into decision making – leading to policy, production and investment decisions that degrade or ignore eco-system services.
- There is often a lack of familiarity with investment in maintaining, restoring or enhancing services provided by ecosystems, as alternatives to man-made infrastructure (such as wastewater treatment plants or dykes). This holds back financing and investment decisions.

2.1.3. Actions

Member States, regions and firms can better factor in the value of ecosystems by mapping and valuing the ecosystems they rely on. Changes in these values can be included within accounting and reporting to allow the assessment of wealth, risks and facilitate investment.

The use of innovative financial instruments can be developed, including payments for ecosystems services and other market based instruments: at national, EU and international level. The EIB and public private partnerships can usefully be involved. Giving those services

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[47] http://bankofnaturalcapital.com/category/ecosystem-services

[48] EU 2010 Biodiversity baseline.

[49] European Commission's Green Paper on the Reform of the Common Fisheries Policy

[50] The Economics of Ecosystems and Biodiversity. Mainstreaming the economics of nature. A synthesis of the approach, conclusions and recommendations of TEEB.

their appropriate value would induce economic actors to integrate the external impacts of their activities on the ecosystems. Public authorities can create policy frameworks that promote investments in natural capital.

2.2. Biodiversity

2.2.1. Interlinkages, Significance, Risks

Beyond ethical arguments for protecting biodiversity for its intrinsic value, there are also economic arguments. Biodiversity underpins many of our ecosystems and is vital to their resilience. Its loss can weaken an ecosystem, compromising the delivery of ecosystem services and making it more vulnerable to environmental shocks.

It has been estimated that by 2050, the global business opportunities dependent on biodiversity and the ecosystem services it underpins, could have a value of between $800-2.300 billion per year. However, 30% of species are threatened by overexploitation[51] The EU has failed to meet its previous target of halting biodiversity loss by 2010.

2.2.2. Specific Barriers

- Many of the barriers for ecosystem services are also present for biodiversity management. The true value of biodiversity is only starting to be taken into account in decisions.
- Biodiversity is often damaged by the result of the accumulation of many small indirect, harmful acts. So action to halt biodiversity loss will need to cover a wide range of policy areas, and a high degree of complexity will be unavoidable. The demands on integration and mainstreaming place a heavy burden on policy making and institutions, and explain many of the difficulties in meeting the earlier target of halting the loss of biodiversity by 2010.

2.2.3. Actions

The EU has agreed a target of halting the loss of biodiversity and restoring them as far as feasible to preserve and increase its value. The 2020 EU Biodiversity Strategy summarises the key actions to be taken to reach the target, many of them implementing EU commitments under the Convention on Biological Diversity (CBD).

2.3. Minerals and metals

2.3.1. Interlinkages, Significance, Risks

Global trends appear to indicate that an era of declining resource prices may be over, driven by increasing demand. On the supply side easily accessible high-grade ore deposits tend to be depleted, leaving less accessible, lower-grade ore, that requires more energy and risk to extract. Depending on the resource, the impacts on supply prices are mitigated by increasing innovation in extraction technology.

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[51] International Union for Conservation of Nature (IUCN) quoted at http://www.eea.europa.eu/themes/biodiversity/where-we-stand/threats

Volatility of market prices – for those materials that are internationally traded has increased for some resources and presents an economic risk. Stocks, availability and market volatility of minerals and metals differ greatly between each other, even within groups of related elements, like 'rare earth metals'. The volatility may increase from increasing contractual arrangements between states and between monopolistic mineral supply markets that limit the size of the traded market – with this 'shallowness' leaving markets more susceptible to shocks. Some aggregate trends and indications of recycling rates are given in the separate Annex 7.

In general, there are only a few elements with geological scarcity. However, there can be scarcity (in the sense of reduced availability) for other reasons. The supply risk is linked to the concentration of production in a handful of countries, often with low political or economic stability. This risk is in many cases compounded by low substitutability and low recycling rates. For instance, the Commission has identified 14 critical raw materials at EU level that display a particularly high risk of supply shortage in the next 10 years and which are particularly important for the value chain.

In many cases, a stable supply is important for manufacturing competitiveness, and often for climate policy objectives and for technological innovation. For example, rare earths are essential for high performance permanent magnets in wind turbines or electric vehicles, catalytic converters for cars, printed circuit boards, optical fibres, electronic and photonic components, LED lighting products and high temperature superconductors. The EU is completely dependent on imports, with China accounting for 97% of world production in 2009.

2.3.2. Specific Barriers

There is significant lock-in to existing ways of using materials, for example in construction, where the introduction of more resource-efficient building elements may require new knowledge by architects and builders.

Declining price trends in the past have led to weak innovation in ways to use materials more efficiently, and in recovering valuable material from mixed waste streams. Recycling of some metals and minerals increases, but global economic growth is now so large that recycling can only make a small, though significant impact on demand.

2.3.3. Actions

The actions mentioned in Section 4 to promote greater innovation in materials, substitution, efficiency of design and increased values of recycling can mitigate the barriers to optimal use and management of minerals and resources.

2.4. Water

2.4.1. Interlinkages, Significance, Risks

Water is an essential resource for many sectors, such as agriculture, tourism, industry, energy and transport, as well as a fundamental need for citizens. Reduced water availability has a direct negative impact on citizens and economic sectors. For instance, water is needed in power stations for cooling, as well as hydropower.

By 2020, Europe's water should be of good quality, efficiently used and available in sufficient quantity but with water abstraction, as a rule, below 20% of available renewable water resources. While water is generally abundant in Europe, demand for water can exceed availability. When water is scarce, meeting human demands can mean reducing availability to ecosystems. Where this over-abstraction occurs, it is causing low river flows, lowered groundwater levels and the drying-up of wetlands, with detrimental impacts on freshwater ecosystems[52]. This erodes the natural capital and the services (e.g. recreational fishing) that are provided. Many European river basins and waters have been altered by water abstraction, land drainage and dams, leading often to major adverse ecological effects, poor quality water and limited space for natural habitats[53].

Water availability varies hugely between regions, and over time. At least 11% of the European population and 17% of its territory have been affected by water scarcity to date, particularly in the south with its relative lack of, and high demand for, water. A comparison of the impacts of droughts in the EU between 1976–1990 and 1991–2006 shows a doubling in both area and population affected[54]. Similarly, global groundwater depletion has increased from 126 (±32) km^3/year in 1960 to 283 (±40) km^3/year. In Europe, the main groundwater depletion hotspots are south-east Spain and the lower Danube[55].

Under a "business-as-usual" development, water withdrawals could increase by more than 40%. Climate change is also projected to exacerbate these impacts, with more frequent and severe droughts projected for many parts of Europe. In addition, demand for electricity increases during hot, dry periods, when air conditioning is used – and this corresponds to the time of increased risks of water scarcity or increased river temperature, leading to risks of black-out.

As well as water quantity, water quality remains an issue across Europe, with implications for public health and bio-diversity. Pollution remains a concern for water users and the need to supply clean water in sufficient quantity and at a reasonable cost remains a challenge EU wide.

For many European countries much of the 'water footprint' of its consumption is indirect, occurring in use wherever production takes place (virtual water), causing potential water stress abroad.

2.4.2. Specific Barriers

Policy simulations show a water saving potential of 65%, and that an ambitious environmental policy could keep the vast majority of EU river basins out of water stress[56]. 20% to 40% of Europe's water is wasted and water efficiency could be improved by 40% through technological improvements alone[57]. Changes in land use, in production and water

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52 EEA, The European Environment – State and Outlook 2010: Water, 2010

53 EEA 2010 State of the Environment Report (SOER), Water, key messages.

54 EEA, The European Environment – State and Outlook 2010: Water, 2010

55 Source Wada et al. (2010) *Global depletion of groundwater resources* (http://tenaya.ucsd.edu/~tdas/data/review_iitkgp/2010GL044571.pdf)

56 ClimWatAdapt project

57 T. Dvorak et al.(Ecologic - Institute for International and European Environmental Policy), EU Water saving potential, Report for DG Environment, 2007 (http://ec.europa.eu/environment/water/quantity/pdf/water_saving_1.pdf)

consumption patterns could increase savings further in a cost-effective way and contribute to ensure both water quality and availability.

There are several reasons why this potential has not yet been achieved by policy or markets:

- Water resource management in Europe has tended to focus investment on ensuring availability through supply side measures[58]. Demand management requires change of more actors, with more coordination.
- Water scarcity, droughts, floods and water quality problems affect most European river basins, the most important of which – like the Danube and the Rhine – are transboundary and cover the majority of the European territory. Solutions need to take the entire water cycle into consideration often needing transboundary action.
- True costs of water are often not reflected in prices, reducing the benefits of investment in water efficiency. One user does not naturally take into account the impacts of his use on the availability of water for others. Even where prices are right, water costs can be a small part of total costs for any individual, and outside of core business activities, so not taken into account.
- Sustainable management of water resources would require integration into agriculture, transport and energy policies; and the application of fair water pricing policies. (For example, water pricing in agriculture should be closely related to actual volume of water consumption rather than a fixed amount per irrigated hectare.)
- Water leakages from distribution networks are as high as 50% in certain areas of Europe, with big differences across Member States. However, in some parts of Europe, for example, Germany and Denmark, leakage rates are less than 10 % and close to what is technically and economically feasible[59]. The difference is partly explained by lack of prioritisation of investment, due to under-pricing of the true costs of water.

2.4.3. Actions

These costs and benefits of economic activities and water resources management need to be reflected in prices to allow water users to make the right choices about efficiency. Further implementation of the cost-recovery principle, enshrined in the Water Framework Directive and highlighted in Water Scarcity and Droughts strategy, will be essential.

Fostering the integration of water and other policies and managing trade-offs covering both water quantity and quality are needed to give clear signals for changing behaviours. Life-cycle measurement of water use (within and outside the EU) by companies for the products they produce can identify water risks and opportunities. Labelling and certification schemes can enhance market rewards for reduced life-cycle consumption. Member States can also aim at estimating the right balance between market instruments and public funding to finance the recovery of environmental and resource costs.

Water efficiency can be improved by properly examining the allocation of water resources in the medium and longer term. There is a great potential for increasing the availability of water

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58 EEA, The European Environment – State and Outlook 2010: Synthesis, 2010
59 BDEW, 2010 and Statistics Denmark, 2006

in a basin through reuse and recycling of water through land use change that restore water cycles. Leakage reduction programs, and setting cost-effective targets for leakage reduction can direct investment to where the costs/benefit ratio is strong.

The River Basin Management Plans under the Water Framework Directive offer a process to better understand the costs and benefits of both economic activities and water resources management, and so manage trade-offs. Multi-purpose natural water retention measures, a component of Green Infrastructure, are under-exploited. They could also provide cost-efficient responses to extreme events. Redundancies, overlaps and gaps in legislation can be addressed to give the right frameworks.

Additional analysis will provide a more accurate picture of the vulnerability of water resources in the medium and long term and the pollution of surface and groundwater. On the basis of new information on estimated future gaps between water demand and supply for 2020 and 2050, indicative targets could be set at EU, Member State and river basin level that would help change policy, behaviours and technology.

2.5. Air

2.5.1. Interlinkages, Significance, Risks

The quality of air is a key factor in quality of life and in lowering economic costs. The EEA SOER estimates that current concentrations of fine particles cause 500,000 premature deaths in Europe a year and that exposure to particulate matter and ozone is linked to other significant effects such as acute and chronic respiratory and cardiovascular effects, impaired lung development in children and reduced birth weight[60].

These concerns were echoed in the latest World Health Organisation health and environment progress report for Europe which states that "*urban air pollution, especially particulate matter, causes significant health problems throughout the region, reducing the life expectancy of residents of more polluted areas by over one year*"[61].

Other studies have shown that the number of working days lost due to air pollution induced illnesses is higher than the working days required to pay for additional pollutant abatement measures.

Significantly, ecosystems and agriculture also suffer damage from airborne impacts such as acidification, eutrophication and ozone damage to vegetation. The annual economic cost in 2020 has been estimated at €537 bn. Whilst the EU is well on track to resolving the problem of ecosystems damage due to acid deposition, biodiversity remains under threat due to excess nutrient deposition (eutrophication) or high levels of ground-level ozone.

There are very strong synergies, and some trade-offs, between air pollution and climate change policies[62]. Certain measures (e.g. those reducing black carbon), may also yield

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60 European Environment Agency, 2010. The European environment – State and outlook 2010: Synthesis pp. 96-100

61 WHO –Health and Environment in Europe: Progress Assessment (2010), ISBN 978 92 890 4198 0

62 COM(2010) 265 final

important short-term benefits for climate change[63]. For example, future large scale uptake of electric vehicles could lead to significant benefits from the displacement of air pollutants from urban to rural areas (where fossil-fuelled power stations often are) so lowering population exposure. Electricity sourced from non-combustion renewable sources would lead to further benefits.

Up to 62% of Europe's urban population remains potentially exposed to ambient air concentrations of fine particle matter (PM 10) in excess of the EU limit value set for the protection of human health. Several air quality standards are widely exceeded in the EU[64]. Even though, since the nineties, air emissions have been reduced significantly for almost all pollutants identified at the time as problematic. For example, compared to 1990 emission levels, sulphur dioxide emissions came down by almost 80%, those of heavy metals by between 60-90%, and nitrous oxides by almost 40%.

Cost-effective options to move beyond the present objectives agreed for 2020 as contained in the 2005 Thematic Strategy on Air Pollution have been identified. Preliminary analysis suggests a revision of the National Emission Ceilings (NEC) Directive[65] aiming at meeting the 2020 objectives of the Thematic Strategy on Air Pollution would deliver major health and environment benefits, with the monetised health benefits 12 to 37 times larger than the costs.

Many Member States will likely miss at least some of their emissions obligations for 2010 under the national emissions ceilings directive. Meeting the EU's interim air quality standards by 2020, including in urban hot spots, will contribute to achieving levels of air quality that do not cause significant impacts on health and the environment.

2.5.2. Specific Barriers

- Clean air is a shared 'public' good, without ownership or a market. So it can not be managed effectively by the market and legislation is needed to optimise the health and economic benefits. However such policy, even where it has net economic benefits in addition to health benefits is often held-back by distinct political groups who may suffer short-term costs. This retards the predictability of change and the market economy's flexibility, holding back innovations.
- Thanks to policy, the EU has held a leading position in developing and marketing "green technologies" to control air pollution, a growing global market. This position is increasingly under pressure from such countries as Japan and Brazil. Whilst this may reduce competitiveness of EU air pollution control technologies firms, it should allow for more cost-efficient policy[66].
- Ongoing evaluation suggests that many compliance problems in Member States are related to a number of factors such as the overestimation of the expected emission

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63 See UNEP (2010) "Measures to Limit Near-Term Climate Change and Improve Air Climate: An Integrated Assessment of Black Carbon and Tropospheric Ozone" which is the first assessment that actually shows this in a quantitative way.

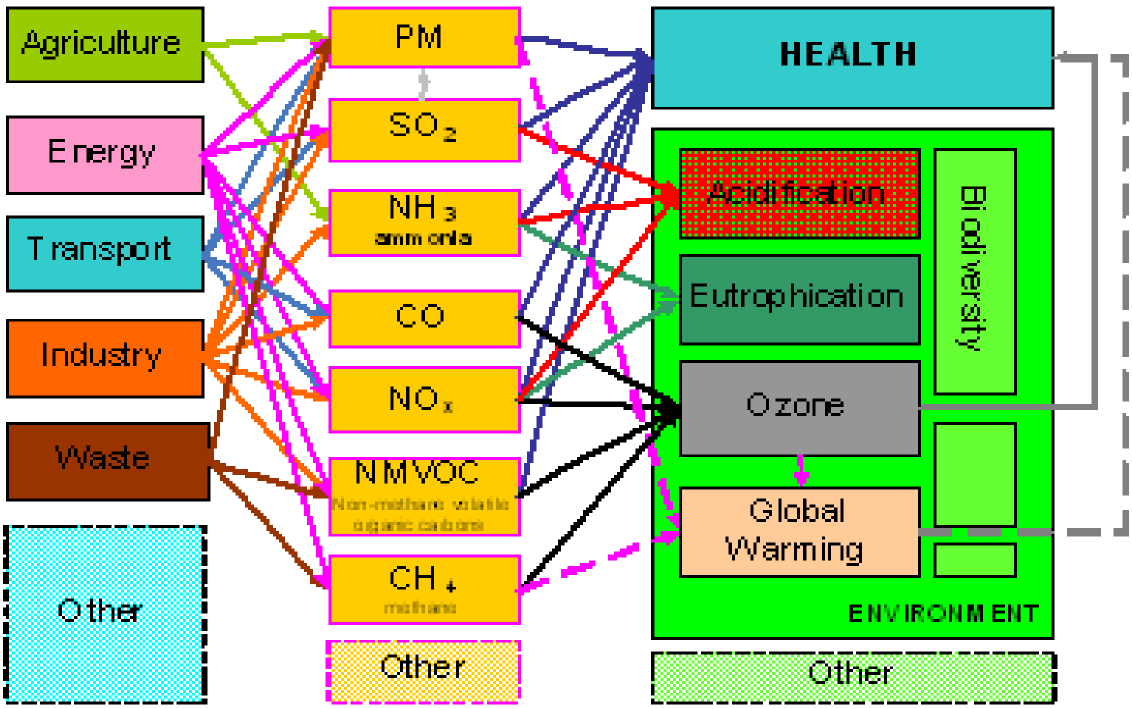
64 European Environment Agency, 2010. The European environment – State and outlook 2010. Synthesis pp. 96-100. Copenhagen. Via http://www.eea.europa.eu/soer.

65 Directive 2001/81/EC

66 Study on the Competitiveness of the EU eco-industry –Within the Framework Contract of Sectoral Competitiveness Studies – ENTR/06/054. Available at http://ec.europa.eu/environment/enveco/eco_industry/pdf/report%20_2009_competitiveness_part1.pdf

reduction of EU-wide measures (e.g. EURO standards for vehicles) or the misjudgement of the effectiveness of national measures. Other important factors are the late development and/or implementation of the Member States' national programmes.

- Complexity hinders evaluation of harm and potential benefits from any individual reduction measure. The figure below shows how several pollutants contribute to the same environmental impact, and how a broad range of sectors are responsible for the emissions of atmospheric pollutants, except for ammonia, whose agricultural activities are the predominant source (94%).



2.5.3. Actions

Better implementation of existing legislation and new, science-based standards would help address these problems and steer innovation. With appropriate lead-times, these can ensure air quality benefits from transition to a low-carbon economy, and by other actions in this Roadmap, for example through reductions in waste, through more efficient production methods, as well as action in agricultural policy and the transport sector. Air pollution policy can be reviewed to find the synergies with other benefits.

Model-based scenario analysis has shown that reducing GHG emissions in 2020, 2030 and 2050 will further reduce emissions of $PM_{2.5}$, SO_2 and NO_X in the EU compared to the reference case. An effective decarbonisation can reduce air pollution cost (of both damage and air pollution control) by some €11 billion in 2020, €29 billion in 2030 and €85 billion in 2050[67].

[67] For a detailed analysis see SEC(2011)288, in particular section 5.2.14.

2.6. Using land and preserving soils

2.6.1. Interlinkages, Significance, Risks

Land

Available productive land is itself a natural resource, whether used to deliver agricultural produce or eco-system services. Changes in land-use may be the best use of the land. However, for this to be the case, the current and future public and private benefits of alternative uses of the land need to be taken into account.

Current EU land cover is 4.2 million km² of which roughly is 40% forests, 44% agriculture, and 4% built up areas[68]. The SOER notes that "land-use specialisation (urbanisation, agricultural intensification and abandonment plus natural afforestation) is still a very strong trend and is expected to continue in the future".

On urbanisation, more than 1,000 km² are taken every year for housing, industry, roads or recreational purposes. About half of this surface is actually 'sealed'[69], meaning that, at this pace, every ten years we pave over a surface area equal to Cyprus. Much of the land being converted is highly agriculturally productive, due the historical location of cities at the centre of agriculturally productive areas. Current land take results in a potential food production loss of 440,000 tonnes of wheat per year[70].

The loss of joined up habitat through fragmentation is also serious.

Intensification is problematic where the impacts of high stocking numbers, inadequate crop rotation and high water use are not controlled – inputs of nitrates and pesticides into water, ammonia into air and water stress can result.

Agricultural abandonment is also an issue: potentially 12 million hectares[71], with 8.6% abandoned by 2020[72]. This can have undesirable consequences for biodiversity, especially related to the loss of extensively grazed grasslands.

Some of these land use risks vary between regions, and here subsidiarity is important. However, issues such as pressure on agricultural land or soil sealing are present in all but the most isolated parts of the EU, and the policy drivers are often from the EU if not international level.

EU policy also has an impact worldwide. The ongoing work on Indirect Land Use Change in the context of biofuels suggests a relatively responsive model whereby additional demands on

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68 Land Use/Cover Area frame Survey (LUCAS), conducted in 2009. Land was surveyed in 23 EU Member States, where both the physical cover of the land and its visible socio-economic use were recorded

69 Prokop et al (2011)

70 Gardi, Ciro, Claudio Bosco, and Ezio Rusco (2009), Urbanizzazione e sicurezza alimentare, *Estimo e Territorio*, 11:44-47.

71 Eurostat Farm Structure Survey 2007

72 JRC IPTS AGLINK study

agricultural output translate into undesirable land use change mainly outside of the EU (deforestation, ploughing up of grassland).

Soil

Soil provides us with food, biomass and raw materials. It serves as a platform for human activities and landscape and as an archive of heritage and plays a central role as a habitat and gene pool. It stores, filters and transforms many substances, including water, nutrients and carbon.

Soil captures about 20% of the world's manmade carbon dioxide emissions, giving good soil management significant cost-effective potential for mitigating climate change. Europe's soils contain an estimated 73 to 79 billion tonnes of carbon in the form of organic matter. Even a tiny loss of 0.1% of that carbon emitted into the atmosphere is the equivalent to the carbon emission of 100 million extra cars on our roads – an increase of about half of the existing car fleet. Conversely, an increase in soil carbon of the same small amount would be worth some €1.6 billion[73]. It is important to note that about 20% of the European soil carbon stock is in peatlands, despite the fact that they only cover 8% of the EU-27 surface area[74].

Soil quality and water issues are linked – soil organic matter can hold 3-5 times its weight in water, when it is preserved.[75] In addition, a fully functioning soil reduces the risk of floods and protects underground water supplies by neutralising or filtering out potential pollutants and storing as much as 3,750 tonnes of water per hectare[76].

In 2006, the Commission evaluated that soil degradation in EU-25 was costing the EU economy some €38 billion per year[77], with the EEA estimating a cost of agricultural land loss of €53/ha/year.

Europe has a problem of soil contamination, particularly historical contamination. It is estimated that 3.5 million sites may be contaminated, with 500,000 sites being really contaminated and needing remediation[78], at a cost of €17.3 billion per year[79]. Once contaminated, soil functions may be impaired and human as well as ecological health and food quality may also be prejudiced.

17.5% of the soil is at risk from water erosion of more than 1 t/ha/y80; Economic effects due to erosion-induced on-site income losses (e.g. tourism, land abandonment) have been estimated at 10 – 90 €/ha/y (2006 value)81.

The Commission's 2050 vision foresees that the soil resource is sustainably managed. One measure of the health of soils is the level of organic matter. To make the most of the potential

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73 (based on 2009 CO2 price, i.e. €20/tCO2).

74 Peatlands in EU-27: 318,000 km²; EU-27 surface area: 4.2 million km². See also Schils et al. (2008), Review of existing information on the interrelations between soil and climate change (CLIMSOIL), Final report to DG Environment (http://ec.europa.eu/environment/soil/review_en.htm), p. 71.

75 Reflection paper p. 14

76 Soil – a key resource for the EU (http://ec.europa.eu/environment/pubs/pdf/factsheets/soil2.pdf).

77 SEC(2006) 620.

78 SEC(2006) 1165.

79 SEC(2006) 620.

80 PESERA (Pan–European Soil Erosion Risk Assessment) model, covers 21 Member States

81 SEC (2006) 620

of this resource, degraded EU soils would have to increase their levels of soil organic matter. Soils which have lost organic matter to a large degree have the greatest potential gains for fertility, erosion reduction and carbon sequestration from increasing organic matter. The Commission has already indicated that around 45% of soils in Europe have a low or very low organic matter content, taken to be less than 2% organic carbon, or 3.5% organic matter. Thus, by 2020, soil organic matter levels should not be decreasing overall and should increase for soils with currently less than 3.5% organic matter.

2.6.2. Specific Barriers

Land

As land-use change is frequently long-term, and often practically irreversible, or costly to reverse (e.g. conversion of natural/agricultural land into transport infrastructure), decisions made now may not be optimal over time.

The use of land is nearly always a compromise between social, economic and environmental needs including additional housing to deal with an aging population and improved infrastructure to facilitate economic development.

Yet many individual decisions often do not consider the cumulative effects of land-take and longer-term, strategic goals. Most land is in private ownership and owners, within planning and other legal limits, and decisions do not consider the indirect or public benefits of land-use. One of the challenges for land use policies is successful engagement of the interested parties.

For example, if we are to reach a state of no net land take by 2050, following a linear path, we would need to reduce land take to an average of 800 km² per year in the period 2000-2020.

Although identification of contaminated sites and their subsequent remediation would facilitate land use, only a minority of Member States has a proactive policy in this field. Even with significant increases in activity, only a fraction of the identified sites will be remediated by 2020.

Some land use risks vary strongly from region to region, and here subsidiarity is important. With regards to fragmentation and sealing of land, significant infrastructure decisions are increasingly being taken at the EU level, which means that EU level checks and balances are required. Much land use change is being driven by EU legislation - mainly the Renewable Energy Directive.

Soil

Natural soil formation is very slow: it can take more than 500 years to form two centimetres, so soil losses over 1-2 t/ha/year are in practice irreversible.

Longer-term and public benefits from soil are often not factored into to private decision making.

Member States have a key role in taking action on soils. However, very few Member States have soil monitoring schemes in place allowing a quantified evaluation of soil conditions changes in time[82]. Partially as a result, there is unequal progress among Member States in addressing soil contamination.

2.6.3. Actions

Developing the knowledge-base on biotic material, land-use trends and spatial planning can inform decisions. Research can discover where high erosion rates take place, as this can identify the most cost-effective measures. (For example, the EU Strategy for the Danube Region[83], looks to reduce the surface area where erosion exceeds 10 t/ha/y, by 2020.) The EU can gather estimates of Europe's consumption globally, including impacts at global level, and highlight best policy practices in the Member States.

The Innovation Partnership on Agricultural Productivity and Sustainability can help halt the loss of soil functionality, for example, by ensuring that EU agricultural land susceptible to water and wind erosion is managed by practices of conservation farming. It can assist Member States in the development of organisational and behavioural innovation on soils, by improving the information flow.

EU level checks and balances can integrate strategic, long-term and environmental aspects into EU decisions affecting land. This includes indirect land use change from renewable energy, TEN-Ts, TEN-Es, regional initiatives such as the Danube Strategy and specific projects. Ongoing CAP reform will continue to play a key role in supporting the sustainable management of land.

The EU and Member States can improve consideration of land as a resource in policy and planning processes, including the operation of the Environmental Impact Assessment Directive. Changes in trading arrangements, such as the proposed MERCOSUR agreement can have a very large influence on indirect land.

Setting goals that accelerate the current downward trend in per capita land take would support an evolution of national policies in this direction. This would respect subsidiarity whilst assisting in reducing the pressures from the EU level. The identification of contaminated sites and their subsequent remediation would enhance resources at risk from contamination and facilitate land use.

2.7. Marine resources

2.7.1. Interlinkages, Significance, Risks

Marine ecosystems have an important natural regulatory function and constitute the resource base that underpins the economic prosperity of many coastal regions. Overexploitation of natural resources reduces the economic yield that could be derived, e.g. from fisheries. The European Union represents about 4.6% of global fisheries and aquaculture production[84], and fisheries, aquaculture and food processing account for around 0.5 million jobs with a turnover

[82] EEA, The European Environment – State and Outlook 2010: Thematic Assessment - Soil, 2010
[83] COM(2010) 715.
[84] European Commission, Facts and Figures on the Common Fisheries Policy. Basic Statistical Data. ISSN 1830-91192010 edition.

of 32 billion Euros per year[85]. Achieving good environmental status of all EU marine waters by 2020, and by 2015 fishing within maximum sustainable yields would put the EU fishing industry on a sustainable basis, and ensuring that marine resources are managed effectively and are not left at risk.

In addition to sustainable fisheries, the marine environment holds many economic opportunities stemming from living resources -e.g. in pharmaceuticals and biotechnology - from mineral resources and both renewable (wave, wind, ocean energy) and fossil energies (oil, gas). A recent report[86] underlines the economic importance, assessing the sustainable benefits related to marine ecosystems in the Mediterranean in 2005. The benefits assessed fall into three groups of ecosystem services: production services (production of food resources of marine origin), cultural services (amenities and support for recreational activities) and regulatory services (climate regulation, mitigation of natural hazards (coastal erosion) and waste processing). At regional level, the benefits are assessed at over 26 billion Euros for 2005, more than 68% of which comes from the provision of amenities and recreational supports. The benefits relating to the production of food resources account for only 11% of the overall estimated benefit.

The global market for Marine Biotechnology products and processes is currently estimated at € 2.8 billion with annual growth of 4-5%. Some estimates predict that annual growth in the sector could exceed 10 in the coming years, revealing the huge potential, if properly encouraged and facilitated[87].

2.7.2. Specific Barriers

There is sub-optimal management of marine resources. The depletion of fish stocks has severe economic and social consequences for coastal zones and contributes to biodiversity loss by disrupting systems.

(a) Fish stocks below maximum sustainable yield

In the EU, about 1/3 of the assessed stocks are being fished outside their safe biological limits[88]: of the assessed commercial stocks in the NE Atlantic, 8% (Baltic Sea) to 80 % (Irish Sea) are outside safe biological limits. For the other areas in the NE Atlantic the percentages of stocks outside safe biological limits vary between 25% and 55%. In the Mediterranean the percentage of stocks outside safe biological limits ranges from 44% to 73%[89].

EU catches have declined since 1993 at an average rate of 2 per cent per year. The lower productivity of EU stocks means that fishing is becoming an increasingly costly enterprise. The amount of effort and fuel needed to land one tonne of fish is higher than it needs to be,

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85 European Commission, Facts and Figures on the Common Fisheries Policy. Basic Statistical Data. ISSN 1830-91192010 edition.

86 The economic value of sustainable benefits from the Mediterranean marine ecosystems, Blue Plan. Sophia Antipolis, May 2010

87 Marine Biotechnology: Marine Board, A New Vision and Strategy for Europe, September 2010, http://www.esf.org/marineboard

88 European Commission (2008) Directorate-General for Maritime Affairs and Fisheries ‘CFP Reform’. Green Paper: Reform of the Common Fisheries Policy, COM (2009)163.

89 EEA. Status of marine fish stocks (CSI 032) - Assessment published Feb 2009.

and higher than it would be if stocks were at a sustainable level. It is estimated that UK trawlers invest 17 times more effort than they did 118 years ago to land an equivalent catch[90].

Fishery discard practices constitute a waste of valuable living resources, which plays an important role in the depletion of marine populations. Based on Eurostat data, it can be estimated that in European fisheries 1.7 million tonnes of all species are discarded annually, corresponding to 23% of total catches.

On a global level, the United Nations Food and Agriculture Organization (FAO) reports that around 28 per cent of stocks are overexploited or depleted, with another 52 per cent fully exploited[91]. Around the world 27 per cent of fisheries were judged to have collapsed by 2003, meaning that their annual harvests had fallen to less than 90 per cent of their historical maximum yields[92].

(b) Increasing reliance on imports

The EU is one of the world's top three importers of fishery and aquaculture products, importing US$23 billion worth of fish and fisheries products in 2007[93]. Imports account for around 60 to 70 per cent of the EU's consumption of fish.[94] The EU is increasingly reliant on imports, as domestic production is falling, and has reduced its self-sufficiency for fish by 12 per cent compared to the year 2000[95].

(c) Under-exploitation of other marine resources

Beyond fisheries and marine ecosystems, the oceans hold a host of valuable resources. Sand and gravel, oil and gas have been extracted from the sea for many years. In addition, minerals transported by erosion are mined from the shallow shelf and beach areas. These are increasingly attractive economically to exploit.

Until now, the expansion of renewable energies, such as wind and solar power, has mainly taken place onshore. However, now the production of environmentally friendly energy from the oceans is being promoted worldwide: it is hoped that wind, waves and ocean currents will meet a substantial share of the world's electricity needs. Experts estimate that offshore wind power could in future supply about 5000 terawatt-hours (TWh) of electricity a year worldwide – approximately a third of the world's current annual electricity consumption. Offshore wind energy plants (WEPs) in Europe alone should supply about 340 terawatt-hours a year by 2015[96].

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90 Thurstan, R.H., Brockington, S. & Roberts, C.M. (2010) The effects of 118 years of industrial fishing on UK bottom trawl fisheries. *Nature Communications*, 1(2) p15.

91 The State of World Fisheries and Aquaculture 2008. FAO Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Rome, 2009.

92 Worm, B., Barbier, E.B., Beaumont, N., Duffy, E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J. & Watson, R. (2006) Impacts of biodiversity loss on ocean ecosystem services. *Science*, 314 (5800), p787.

93 FAO Newsroom (2008) Half of world fish trade sourced from developing countries.

94 Eurostat – includes EU aquaculture production. Eurostat statistics © European Communities (1990–2006).

95 Fish dependence, Ocean2012 p.16-18

96 World Ocean review : Marine minerals and energy http://worldoceanreview.com/wp-content/downloads/WOR_chapter_7.pdf

Marine Biotechnology, which involves marine bioresources, either as the source or the target of biotechnology applications, is also becoming an important component of the global biotechnology sector.

(d) Pollution

Challenges posed by pollution and climate change (e.g. acidification), are threatening marine resources. For example, over 1 million birds and 100,000 marine mammals and sea turtles die each year as a result of plastic waste[97]. Factors such as marine litter and urban waste water treatment seriously aggravate pollution in some seas around Europe. Nearly 1 in 10 fish collected in the Pacific Ocean during a recent study contained plastic debris, as one sign of the significant amount of plastic entering the global food chain[98].

(e) Inertia in policy and decision making

Management of EU fishing, whilst generally supported, is seen as threatening fishing communities. This can slow down or block reform, for example, of subsidies, as there are concerns over the concentrated impact of changes in local communities that do not have easy access to other jobs.

The difficulties of managing EU fish stocks in a sustainable way indicate the size of the challenge for the global fish stocks that the EU increasingly relies on, and which are a significant source of income and food for coastal communities in many developing countries.

2.7.3. Actions

The reform of the Common Fisheries Policy to eliminate all fisheries subsidies which do not improve the sustainable management of marine resources would help align economic incentives with sustainable fishing. Greater use of consumer sustainability labelling, and the use of sustainably caught fish by food producers could also create greater rewards for sustainable fishing, providing incentives for stock management. The creation of more protected marine areas can provide the biodiversity needed for strong sustainable fish stocks.

Good implementation of the Marine Strategy Framework Directive by Member States through policy measures on management and planning as well as support for knowledge and demonstration projects would safeguard natural coastal and marine capital. Member States can promote eco-system based strategies and integration of climate risk into maritime activities, whilst collaboration between Member States bring measures that tackle marine litter.

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97 UNEP, Ecosystems and Biodiversity in Deep Waters and High Seas, 2006

98 "Plastic ingestion by mesopelagic fishes in the North Pacific Subtropical Gyre", Peter Davison, Rebecca G. Asch, 2011

3. KEY SECTORS

Much of the potential for resource efficiency comes from interactions through the value chains that links consumers to raw materials, which are best addressed through a focus on key sectors of the economy. Analysis by EIPRO[99] identified food, mobility and consumption as the final services that are responsible for 70 to 80 per cent of environmental impacts.

3.1. Addressing food

3.1.1. Significance

The food and drink industry has a turnover of €917bn[100]. It employs more than 4 million people in around 310 000 companies. Judged by consumer expenditure, purchases of food and catering services are the most important items for consumers[101]. The EU's production and consumption of food and drink has global resource implications through trade. In 2007, trade in both raw and processed agricultural products accounted for approximately 6% of total EU trade with non-EU countries[102].

It is dependent on the resources which are subject to the greatest risks. For its inputs it is dependent on natural systems (including clean water, fertile soil, ecosystem services from biodiversity), petrochemicals and other mineral inputs (eg. phosphates). Problems with these resources can send ripples through global markets that have particularly high impacts on people in developing countries and lower income groups.

It is also one of the largest contributors to unsustainable use of natural resources, in the EU and in our global footprint. The relationship between consumption and food and drink and resource use and depletion is described in the Figure below, looking along the life-cycle. Resource depletion includes eutrophication, habitat change, climate change, water use, soil erosion and pollution[103]. The size of these impacts is on an upward trend. Along the whole life-cycle, consumption of food and drink in the EU causes 18% of the EU's material use[104].

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99 Tukker, A. et al. (2006). Environmental Impact of Products (EIPRO). EC Joint Research Centre - IPTS

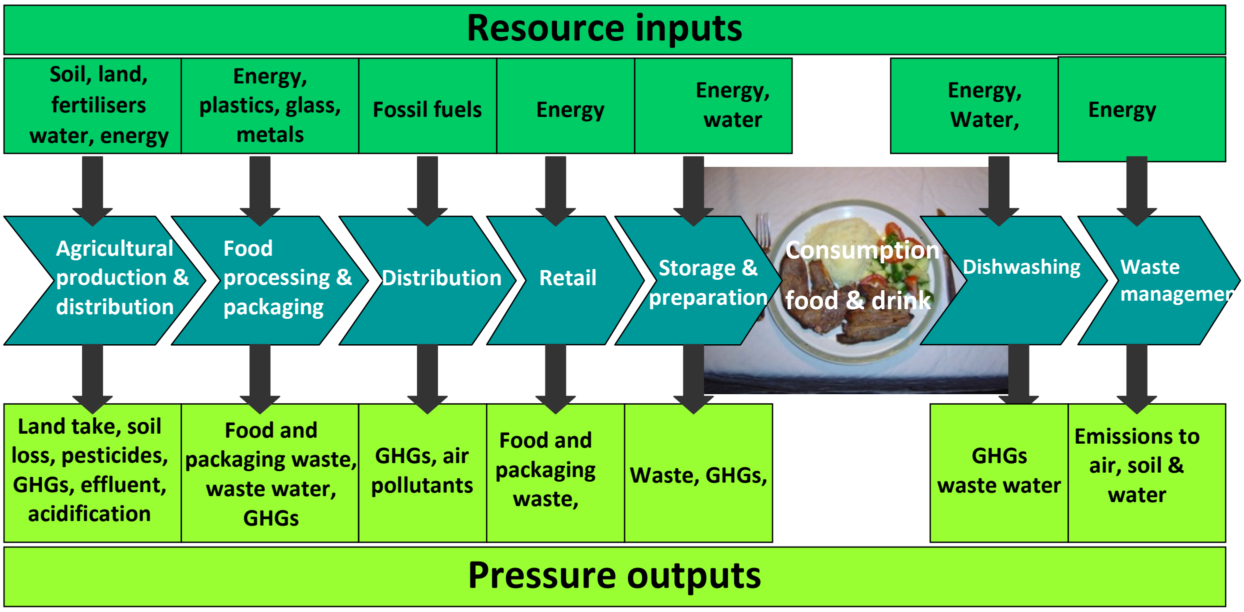
100 http://ec.europa.eu/enterprise/sectors/index_en.htm

101 Eurostat Household Budget Survey

102 European Commission, (2009) publication Trade and agriculture – an overview of EU imports and exports based on EUROSTAT COM, 2008. Available at: trade.ec.europa.eu/doclib/cfm/doclib_section.cfm?sec=175&langId=en

103 UNEP (2010) Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials, A Report of the Working Group on the Environmental Impacts of Products and Materials to the International Panel for Sustainable Resource Management. Hertwich, E., van der Voet, E., Suh, S., Tukker, A., Huijbregts M., Kazmierczyk, P., Lenzen, M., McNeely, J., Moriguchi, Y.

104 EEA, The European Environment – State and Outlook 2010: Synthesis, 2010



Estimates of impacts on environmental resources vary, but are consistently high:

- One estimate is that around half of all environmental impacts are attributable to food and drink[105]. This includes 18% of our greenhouse gas emissions[106] or approximately 2 tonnes CO2- equivalents of greenhouse gases per capita. (equivalent to the quantity which Europeans will need to budget for *all* their activities in the long term if we are to meet the European Commission's 2050 target of an 80% reduction in GHGs)[107].
- According to a study by the European Topic Center[108] some 15-30% of all key environmental pressures can be allocated to eating & drinking.

EU consumption has impacts elsewhere, through the global markets. For example, EU meat production, which equals about 15-18 % of global meat production and which is almost exclusively consumed within EU, requires large amounts of high quality protein feed. With only a minor domestic production, the major share of this feed is based on soybeans and soybean cake which imported from countries like Brazil and the United States. The imported amount corresponds to an area of more than 20 million ha of cropland and shows how European consumption patterns contribute to land use change elsewhere[109].

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105 Van der Voer et al, 2005

106 EEA, The European Environment – State and Outlook 2010: Synthesis, 2010

107 S. Moll, D. Watson et al., Environmental pressures from European consumption and production: A study in integrated environmental and economic analysis, ETC/SCP working paper 1/2009

108 S. Moll, D. Watson et al., Environmental pressures from European consumption and production: A study in integrated environmental and economic analysis, ETC/SCP working paper 1/2009

109 Preparatory study for the review of the thematic strategy on the sustainable use of natural resources, Bio Intelligence Services, 2010, http://ec.europa.eu/environment/natres/pdf/BIO_TSR_FinalReport.pdf

Globally, agricultural production accounts for 70% of global freshwater consumption, 38% of the total land use, and 14% of the world's greenhouse gas emissions[110]. The fossil energy embedded in food is significant.

3.1.2. Opportunities for Resource Efficiency

The value brought by food and drink can be realised with lower resource inputs and resource depletion if steps are taken along the value chain on: food waste, food choices, production techniques and phosphorous management.

Food Waste

According to FAO figures, roughly one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year[111]. Annual food waste generation in the EU-27 is approximately 89 million tonnes representing 179 kg per capita[112].

Reductions in the wastage of food can allow the EU economy to meet citizens' desires for food and drink with significantly fewer inputs. These cost savings for producers and manufacturers could either boost their profits or be passed on to consumers. Reduction in food waste would also cut the resource impacts of unnecessary production and costs of collection, treatment and elimination of waste food. To illustrate the scale of potential benefits - food waste represents about 3% of the GHG emissions of the EU-27, i.e. 170 Mt CO2 eq./year, in which households contribute 45%.

Food waste occurs at different stages of the supply chain, not only during final consumption. It is affected by interactions along the supply chain – for example, contractual relations, timings of delivery, or labelling by retailers. Policy actions that promote interactions in the supply chain to reduce food waste can manage resources more efficiently[113]. Catering and retail sectors, responsible for part of food waste (14% and 5% respectively) could often avoid this wastage relatively easily.

Considerable improvements can be achieved through prompting behavioural change for all the actors of the food chain. A study carried out in the UK[114] shows that 60% of the food wasted by households could be avoided, saving more than €500 per year per household. Significant benefits could come from small, smart changes many of which can be realised at low costs through awareness and nudges to behavioural change. For instance, the UKstudy found out that poor comprehension of date labelling, notably the difference between "use-by" and "best before" dates, is responsible for about 20% of the avoidable food waste.

The UN has pointed to a target of reducing avoidable food waste by half by 2020[115].

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110 UNEP (2010) Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials, A Report of the Working Group on the Environmental Impacts of Products and Materials to the International Panel for Sustainable Resource Management.

111 J. Gustavsson et al., Global food losses and food waste, FAO, 2011

112 BIO Intelligence Service (2010) Preparatory study on food waste across EU27

113 WRAP, Waste arisings in the supply of food and drink to households in the UK, 2010

114 WRAP, Waste arisings in the supply of food and drink to households in the UK, 2010

115 UNEP, The Enviornmental Food crises: Environment's role in averting future food crises, 2009

Food Choices

People's selection of the food and drink they consume has a significant effect on resource use. Different products have considerably different impacts on resources. In particular, consuming animal products has much higher impacts than a similar nutritional level of plant based products. Diets that are high in meat, eggs, milk and cheese has a relatively large life-cycle impact on resources. The selection of fish also impacts on sustainability of fish stocks.

The greater impacts of animal products come from:

- Land degradation: The production of 1 kilogram of meat requires several kilograms of vegetable products, depending on the livestock product. As a result, the livestock sector accounts for 70 percent of all agricultural land and 30 percent of the land surface of the planet[116]. This magnifies agricultural impacts. In addition, the livestock sector may be the leading player in the reduction of global biodiversity through its demand on land, for example, as the major driver of deforestation, as well as of climate change. Its resource demand also leads to overfishing, sedimentation of coastal areas and facilitation of invasions by alien species[117]. In Europe, pastures are a location of diverse long-established types of ecosystem, many of which are now threatened by pasture abandonment or intensification[118].
- Greenhouse Gas emissions: The livestock sector contributes 18 percent of greenhouse gas emissions measured in CO2 equivalent looking at life-cycle impacts[119].
- Higher Water Footprint: The livestock sector accounts for over 8 percent of global human water use, mostly for the irrigation of feedcrops. It is probably the largest sectoral source of water pollution, contributing to eutrophication, “dead” zones in coastal areas, degradation of coral reefs, human health problems, emergence of antibiotic resistance[120].
- The consumption of meat and dairy products contributes on average 24% of the global environmental impacts from the total final consumption in EU-27[121].

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116 FAO, Livestock's long shadow, Livestock Environment And Development (LEAD) Initiative, 2006

117 FAO, Livestock's long shadow, Livestock Environment And Development (LEAD) Initiative, 2006

118 Some 306 of the 825 terrestrial ecoregions identified by the Worldwide Fund for Nature (WWF) reported livestock as one of the current threats. In addition 23 out of 35 global hotspots – identified by Conservation International – are reported to be affected by livestock production. According to the International Union for Conservation of Nature (IUCN) most of the world's threatened species are suffering habitat loss where livestock are. (FAO, Livestock's long shadow, Livestock Environment And Development (LEAD) Initiative, 2006)

119 FAO, Livestock's long shadow, Livestock Environment And Development (LEAD) Initiative, 2006

120 FAO, Livestock's long shadow, Livestock Environment And Development (LEAD) Initiative, 2006

121 B.P. Weidema et al., Environmental Improvement Potentials of Meat and Dairy Products (IMPRO), JRC, 2008

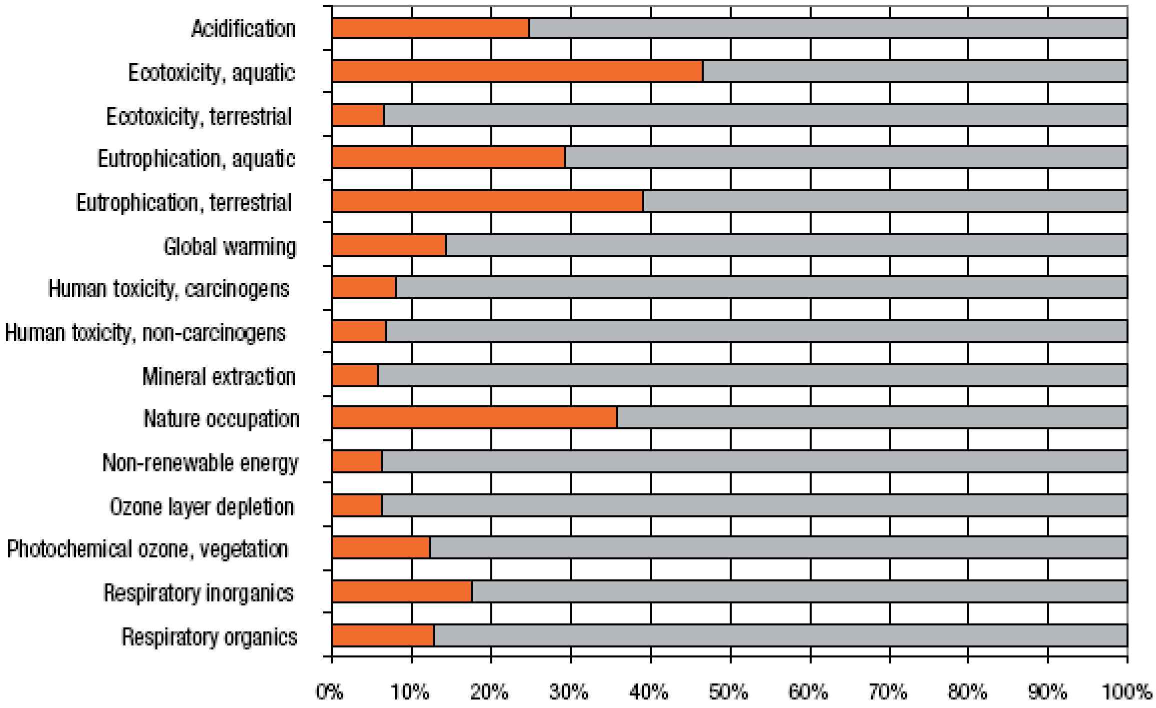


Figure : Percentage contribution of meat and dairy products to the environmental impacts of EU-27 total consumption (Source: B.P. Weidema et al., Environmental Improvement Potentials of Meat and Dairy Products (IMPRO), JRC, 2008)

The Figure presents the percentage contribution of meat and dairy products to the environmental impacts of EU-27 total consumption.

However, given current levels of environmental impact from animal products, these consumption levels are not sustainable in the face of global trends. Growing global populations, with increasing dietary intakes and changing food preferences, are rapidly increasing demand for livestock products. Production of meat and milk is projected to more than double from 1999/01 to 2050. These consumption trends are not sustainable.

In the EU animal product consumption are increasing, as incomes grow although EU citizens consume more meat than necessary from a health point of view (in 2007 the average protein consumption in the EU-27 (FAO 2010) was 70% more than WHO standards[122] [123]).

Having widespread incentives to healthier and more sustainable food production and consumption by 2020 would drive a 20% reduction in the food chain's resource inputs.

Production Techniques

The same food and drink can be produced using different methods, using more or less resources, during agricultural production, manufacturing processes or as waste treatment. The

122 WHO 2007

123 See also the Lancet paper of 12th September 2007 "*Slash global meat consumption to tackle climate change*" stating that not more than 50 g per day should come from red meat provided by cattle, sheep, goats and other ruminants.

selection of agricultural impacts can be significantly influenced by the market – through consumer preferences either acting directly or through influencing intermediary buyers (e.g. wholesalers and retailers). Co-operation along the value chain can bring innovation in farming practices that otherwise wouldn't take place, through the diffusion of information and provision of incentives. These market incentives can be supported by development of a methodology for sustainability criteria for key food commodities, which increases information along the value chain.

In the EU, the Common Agriculture Policy has a very significant effect on choices and value chain impacts. Ensuring that agricultural production in the EU lowers environmental resource impacts may sometimes conflict with the other objectives (such as increasing production). The reform Communication of December 2010 sets out the potential for environmental improvements in a number of areas, notably in terms of water consumption and pollution, soil and habitat conservation, preservation of ecosystem services. Changes made under the new Multiannual Financial Framework should help improve agricultural production.

Changes in the EU are also only part of the issue, given the impacts on global agriculture and land use. Working to shape incentives along value chains can reach beyond the EU.

Phosphorus Management

Phosphorus is one of the essential nutrients for plants. There are also numerous animal illnesses associated with inadequate phosphorus intake, including milk fever in high yielding cows. Between 120 and 170 million tonnes of phosphate rock are used every year. Nearly 90 % of phosphorus use is in agriculture, mainly as fertilizers[124]. There are two major opportunities from efficiency gains in phosphorus use:

- Reducing risks from security of supply - most of the world's current known and accessible phosphate resource is under Moroccan control in the Western Sahara. Two thirds of the current mining comes from 3 countries (Morocco, China and the US). There are additional known resources in areas with difficult access (e.g. Alaska, Amazon forest)[125]. There has been some evidence of recent short term scarcity – very high capacity utilisation rates in existing facilities, price spikes etc. In 2007–2008, phosphate rock and fertilizer demand exceeded supply and prices increased by 700% in a 14-month period[126]. Against this, the demand for phosphorus is predicted to increase by 50–100% by 2050.
- Reducing pollution of soils and water - Phosphorus is, along with nitrogen, a major contributor to eutrophication due to over use leading to runoff from agricultural land. Also, as cheap and cleaner resources of phosphate rock are used up, dirtier sources with higher cadmium contents will be accessed, which will risk cadmium pollution of soils.

124 D. Cordell et al., The story of phosphorus: Global food security and food for thought, Global Environmental Change vol. 19 p. 292-305, 2009

125 PBL Netherlands Environment Agency, Scarcity in a Sea of Plenty? Global Resource Scarcities and Policies in the European Union and the Netherlands, 2011

126 Minemakers Limited, 2008 quoted in D. Cordell et al., The story of phosphorus: Global food security and food for thought, Global Environmental Change vol. 19 p. 292-305, 2009

Globally, we are mining five times the amount of phosphorus that humans are actually consuming in food, showing scope for efficiency gains. Estimates suggest that through resource efficiency, global fertilizer phosphorus use from primary sources can be reduced by 18%, compared to currently envisaged policies. Total global phosphorus demand could reduce an additional 8% by banning its use in detergents[127].

There is no single ‘quick fix’ solution to phosphorus issues, but there are a number of technologies and policy options that exist today at various stages of development that together could make a significant difference and deliver other environmental co-benefits on water quality. These include more efficient use of P-fertilizers and manure in agriculture.

3.2. Improving buildings

3.2.1. Significance

By improving resource efficiency in constructing and use of infrastructure and buildings, the EU can influence 42%[128] of its final energy consumption, about 35% of its greenhouse gas emissions and more than 50% of all extracted materials, and save up to 30% water.

Economically, construction is one of Europe’s largest industrial sectors, with an annual turnover exceeding 1200 billion Euros, and activities that account for 10.4% of the EU GDP. 7.2% of the EU workforce is directly in the building and construction sector[129].

The aggregated impacts of housing and infrastructure account for around 15-30% of all environmental pressures of European consumption. Housing and infrastructure contributes approximately 2.5 tonnes of CO2 equivalent of greenhouse gasses per capita per year. 40% of these GHG emissions are directly associated with heating and hot water for private households. The construction of buildings and other infrastructures contributes another 30% of the total emissions[130].

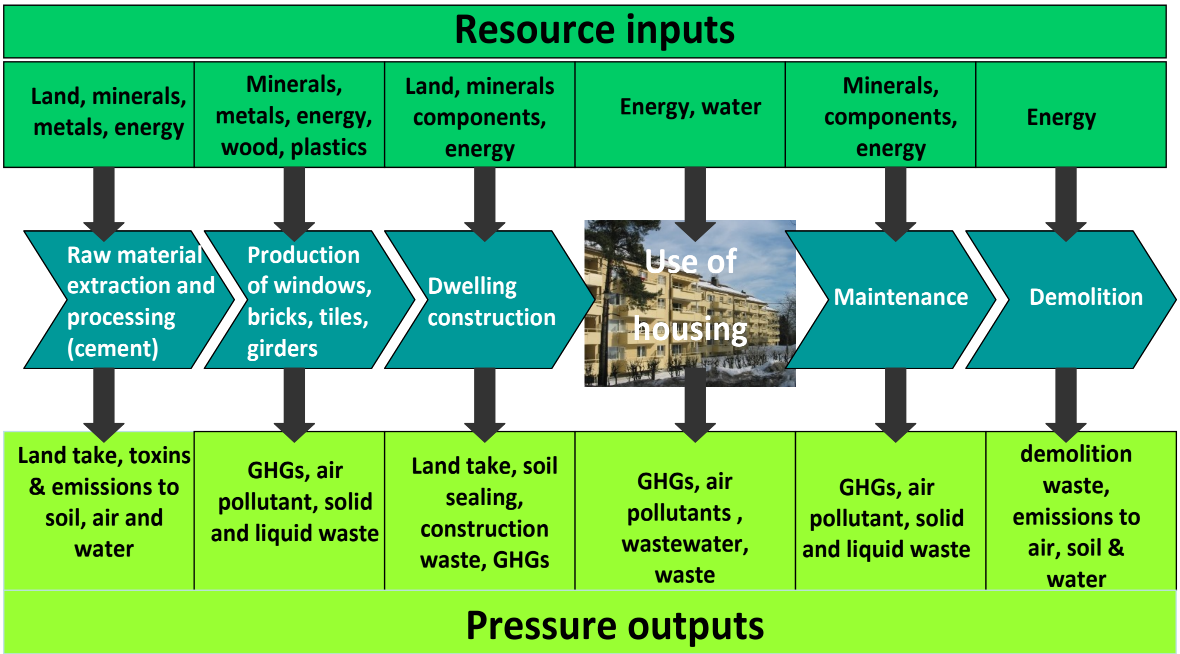
The resources used along the value chain of construction are shown in the figure below.

127 PBL (2011) EU Resource Efficiency Perspectives in a Global Context: A fast track analysis. Forthcoming (will be available at: http://ec.europa.eu/environment/enveco/studies.htm)

128 European Construction Industries Federation

129 ETAP, 2007; BUILD-NOVA, 2006a quoted in S. Jofre (Technical University of Denmark), The challenge of a greener European construction sector: Views on technology-driven (eco)innovation, 2011

130 S. Moll, D. Watson et al., Environmental pressures from European consumption and production: A study in integrated environmental and economic analysis, ETC/SCP working paper 1/2009



3.2.2. Opportunities for Resource Efficiency

If buildings and infrastructure are renovated and constructed to high resource efficiency standard, then the resource impacts could be significantly reduced. The economic value of the resource savings over the life-time of the building can be captured by the construction sector, with increased demand and greater value added. Improvements in buildings (particularly energy efficiency) have a very large potential for cost savings with simultaneous reductions of fossil fuel use and greenhouse gas emissions[131], estimated at around 40% cost-effective savings to 2020.

Whilst the sector has been hard hit in some Member States during the financial crisis, this could provide an opportunity for re-orientation of construction: for example, the Commission estimates that 2 million jobs could be created in renovation of existing building stock.

These opportunities exist because the building sector has particular characteristics which act as barriers to greater resource efficiency:

- Buildings are one of the most long-lived products, meaning that decisions made now lock-in consumption patterns (e.g. of energy) for decades to come, with adjustment of the initial choices carrying additional costs.
- Consumers and investors frequently discount future pay-offs from investment choices, and focus on the short-term, sometimes because of uncertainty of future returns. This means that investments in efficiency with positive net benefits do not get made.

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131 Action in line with the Energy Performance of Buildings Directive alone would reduce direct CO2 emissions by 160 to 210 Mt per year (IA of the EPBD)

- Blocks to the flow of information between constructors, sellers or buyers/renter prevent the market from delivering investments in efficiency and uptake of available innovation. For consumers, housing choices are rarely taken, and knowledge about the relative performance of buildings or components are low.
- In renovation, consumers frequently rely on the advice of professionals. However, the building sector is characterised by SMEs, many of whom do not have the resource to innovate and keep up with innovation. 99.9% of construction enterprises are SMEs, 92% have less than 10 employees[132]. Both in construction and renovation this slows the adoption of new technologies and processes[133].
- Investments in efficiency are also hindered by the principal-agent problem. In rented buildings, often investment in efficiency measures must be done by landlords, who cannot recover savings from tenants, and vice versa. Data from the UK found that 31% of owner-occupied dwellings were in the top efficiency quartile, only 8% of dwellings with private tenants indicate a similar performance[134].

Significant improvements in resource and energy use are possible during construction and demolition, through use of existing techniques, and greater investment and diffusion of innovation. For example, changes delivering water are estimated to be able to deliver savings of a potential greenhouse gas emission saving of 1% of the EU's total. Whilst, research and development is taking place into new forms of concrete, which can deliver the same or improved properties with greatly reduced life-cycle greenhouse gas impacts.

Policy already points the way to some improvements, with, for example, all new and renovated buildings to be nearly zero-energy[135], the existing building stock to be refurbished[136] at a rate of 2% per year; and 70% of non-hazardous construction and demolition waste will be recycled[137].

Further policy measures can reach more SMEs, by using market signals as a driver for innovation. This would require a life-cycle approach to be widely applied. Such demand facilitates increased investment in innovation by building firms (if other blocks are removed). For instance:

- Creating increased market demand for more efficient ‘greener’ buildings. This can be done through public procurement, in particular through the uptake of life-cycle costing methodologies by public procurers that take better account of future running and maintenance costs.
- The convergence of building codes across the EU (where appropriate) can increase the market rewards for innovation, both in products and process.
- Similarly, ensuring market prices of building materials and energy reflect their real costs, relative to labour, will act as a stimulus to innovation. A shifting of taxation from labour as part of this realignment would be likely to increase employment.

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132 Sustainable Competitiveness of the Construction Sector (2010) Ecorys

133 OECD, Environmentally sustainable buildings: Challenges and policies, 2003

134 Bell *et al.*, 1996 quoted in OECD, Environmentally sustainable buildings: Challenges and policies, 2003

135 Directive 2010/31/EU

136 In line with Art. 9 of Directive 2010/31/EU of 19 May 2010 on the energy performance of buildings

137 In line with Art 11 of Directive 2008/98/EC of 19 November 2010 on waste.

An important part of stimulating demand is freeing up financing for more resource-efficient new buildings and renovation of existing buildings. This can be helped by the formation of financial vehicles that increase the awareness of steady returns from resource savings in buildings.

Best practice from Member States indicates that bringing together firms and policy makers across the value chain of construction, will facilitate change in practices and technology that is otherwise locked in to existing patterns[138]. This can be supported by increasing the availability of information on the resource efficiency of building components and alternative construction processes.

Increasing investment, both at EU and Member State and regional level, in training in the skills needed for creation and renovation of more resource efficient buildings, would remove current skills gaps and so lower costs.

Facilitating growth of innovations in the use of 'green infrastructures', as part of integrated spatial planning, increases the performance of buildings, infrastructure and urban environments. For example, the use of green roofs has been shown to reduce temperatures in cities. Measures to increasing awareness, skills and acceptance would reduce barriers to diffusion of these techniques.

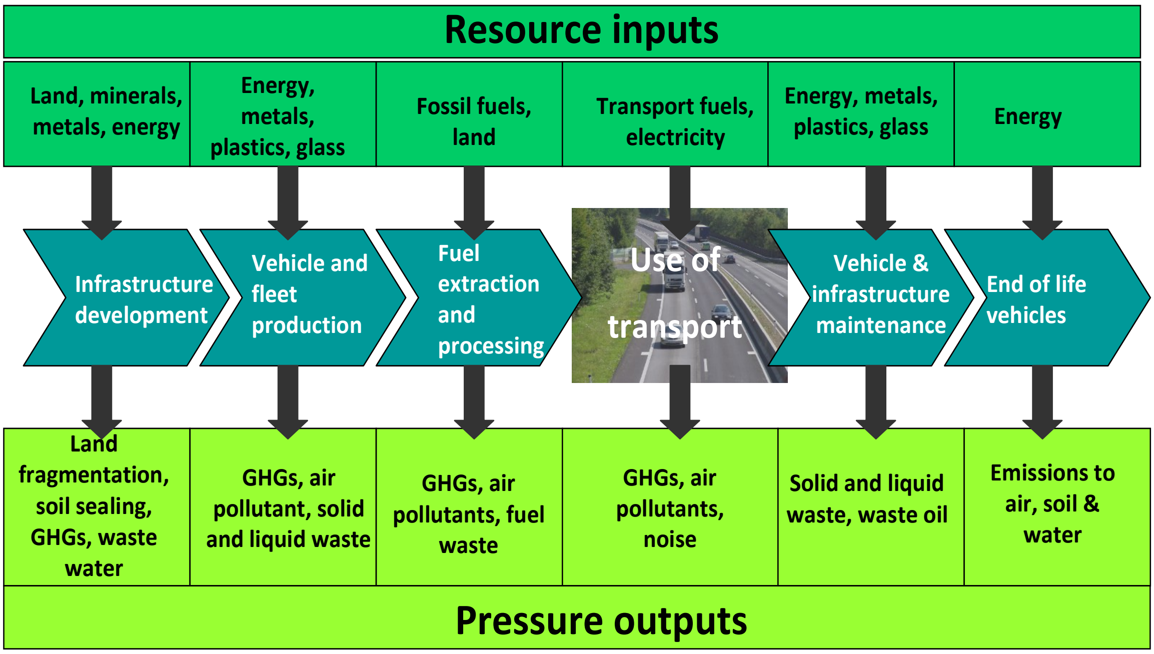
3.3. Ensuring efficient mobility

3.3.1. Significance

A modern, resource efficient mobility system, serving both passengers and freight can contribute to competitiveness and sustainability through reduced resource dependency, and reduced impacts from pollution, land use, and noise on climate change, biodiversity and ecosystems, health and safety. Increasing efficiency in the transport sector by 2020 could deliver greater value with significantly reduced needs for resources like raw materials, energy, land use, and impacts such as climate change, air pollution, noise, accidents, and ecosystem degradation.

The Figure below shows the relationship between resource depletion and transport.

[138] E.g. the European Re-Building Forum, run by the Resource Efficiency Alliance.



Exploitation of these synergies can offer additional routes to the achievement of goals given the extent of resource efficiency and decarbonisation needed by 2050. These interactions appear likely to reduce costs of achievement of those goals, compared to existing scenarios.

3.3.2. Opportunities from Resource Efficiency

The Transport White Paper[139] aims to increase mobility, dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050. This involves moving to more resource efficient transport system in Europe, notably:

- Developing and deploying new and sustainable fuels and propulsion systems, for example, halving the use of 'conventionally-fuelled' cars in urban transport by 2030; phasing them out in cities by 2050 and achieving essentially CO2-free city logistics in major urban centres by 2030[140].
- Optimising the performance of multimodal logistic chains, including by making greater use of more energy-efficient modes.
- Increasing the efficiency of transport and of infrastructure use with information systems and market-based incentives, including: (a) the deployment of the modernised air traffic management infrastructure (SESAR12) in Europe by 2020 deployment of equivalent land and water transport management systems and (b) moving towards full application of "user pays" and "polluter pays" principles.

139 COM(2011)144, White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system

140 This would also substantially reduce other harmful emissions

The Commission will seek to ensure that the initiatives under the Transport White Paper are implemented consistently with resource efficiency objectives including by moving towards particular through internalisation of external costs.

The OECD points to the complexity of this area, particularly the indirect effects as a cause for low levels of integration. This also leads to difficulties of modelling the complex interactions between all the aspects of the economy, which also has a tendency to exclude examination of these aspects within model-driven climate, energy and transport policy.

Whether synergies are fully realised depends on the extent of integration and policy co-ordination, at EU, Member State, value chain and company level. The structures for co-ordination, information flow and governance contained in this Roadmap should facilitate this integration.

4. APPLICATION OF GOVERNANCE TO OTHER KEY AREAS

4.1. Investing in the transition

UNEP estimates that the annual financing needs for making the world economy more resource efficient are between US$1.05-2.59 trillion - around 10% of annual global capital investment[141]. In the EU, and elsewhere, this financing will need to come mainly from private sources[142]. This will require a combination of well-designed policies creating the right market conditions and an evolution of the perspectives on opportunities held by private investors.

The startling growth of global financing for clean energy shows how this shift in mindset is possible. In 2010, annual clean energy investment exceeded investment in traditional energy sources for the first time, exceeding US$230bn. These flows are still small compared to the volumes required, but show how the right policy mix (for example emissions trading) can stimulate change. For the investments in the medium term transition, greater flows of assets will be needed from public and private institutions that can invest in the long term, whose liabilities are not due for short-term payment, including pension funds, development banks, sovereign wealth funds and insurance funds.

These institutions are increasingly seeing the advantages of investments that reduce future environmental, social and governance risks and moving some of their assets into portfolios that deliver these profiles. One key element of successful mobilisation of finance is the development of comparable measures of corporate resource efficiency and exposure to resource scarcity to assist institutions. Regulation of investments and accounting may, in some cases, need to be changed to facilitate greater long-term market investment.

Yet, for the level of financing necessary, the current financial systems bias towards the short-term would have to be reversed. Investment in the infrastructure needed for transition can offer the long-term yields with weak correlation to other economic sectors that could form greater shares of the portfolio of e.g. pension funds (who currently, in most countries, invest 1% in infrastructure)[143]. The Commission estimates annual EU investment needs for a move

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141 UNEP Green Economy Synthesis 2010
142 OECD Green Growth Synthesis 2010
143 OECD Green Growth Synthesis 2011

to a low-carbon economy to be around €200 billion over the longer-term, with both the building/infrastructure/construction and the transport sector comparatively accounting for the highest investment needs[144].

Eco-innovation needs also to be supported, in particular as lots of SMEs are active in this field. A faster pace of eco-innovation and market penetration is hampered by the lack of risk finance and support for demonstration. Support is needed for the development of innovative solutions and new technologies, for testing, but also for entering these technologies in implementation and use phases.

Finance for resource-efficient product innovation and investment in efficiency savings should become available on equal or better terms than comparable investments. SMEs in particular need to have better access to finance for resource-efficient innovation.

Public funding has an important role in assisting SMEs, particularly as market signals are not fully aligned with resource efficiency. However, access to private funds is essential for the scale of investment. The combination of public and private action needed to open up private investment opportunities in resource efficiency can be identified by suitably focussed discussions between policy makers and financiers.

A Resource Efficiency Finance Round Table, including representatives from private and institutional banks (such as the EIB, EBRD), insurance companies and venture capital companies may serve this purpose and to identify opportunities to develop adapted finance for resource-efficiency.

4.2. Supporting resource efficiency internationally

The EU is affected by global resource scarcity through economic and environmental interactions. It also has significant direct and indirect effects on global resources through its consumption (and the drivers that provides for global resource use), its wastes, its pollution, the activities of EU firms overseas and its international policy interactions.

In a globalised economy, a more globalised view of products and markets is increasingly necessary. Recent model calculations, quoted by the UN's International Resource Panel suggest that CO2 emissions embedded in internationally traded products accounted for 27% of global energy-related CO2 emissions in 2005, up from 22% ten years earlier.

In addition, unsustainable resource use also leads to security risks as the competition for scarce resources becomes more intense. Water, food and soils are essential for basic subsistence and poverty eradication, with evident links to EU development goals.

The use of international policy tools is one of the key routes to influence resource use outside the EU that matters for EU objectives. This complements the EU's impact through supply chains and leadership in innovation (in technology, policy and consumption behaviours). The EU has a window of opportunity to take the lead in a number of areas, by leading by example in environmental performance and know-how, and by promoting a level playing field among competitors for resources. A number of EU environmental policies and standards are already

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[144] Roadmap to a Low Carbon Economy (2011)

being taken up around the world: electrical/electronic waste and hazardous substances (e.g. China WEEE, China RoHs, Brazil RoHs).

A number of countries are re-orientating their policies towards resource efficiency; the United States, China, Korea and some developing countries. The EU can learn from this experience and help influence their path. As developing countries grow economically, they have to address a range of resource management issues (e.g. better waste and water management) and can learn from European know-how in design and implementation of policy.

There are a wide range of actions open to the EU, including: direct support to and joint initiatives; strengthening the implementation of existing agreements; using our own consumer power and trade agreements to influence global consumption and production patterns; using development aid; cooperating in research and innovation; and working towards stronger multilateral mechanisms for a global governance of public goods. Progress in other countries' resource efficiency in partner countries will not only enable them to develop sustainably, but will also in turn make it easier for the EU to reduce its own global footprint.

If resource efficiency could become a shared objective of the international community, it could form the basis of co-operation in many different fields, including development, trade and technology co-operation.

The EU can make increasing resource efficiency in global supply chains a key part of the EU's approach to the Rio+20 Summit in June 2012, where business and global governments can set goals and pathways to international efficiency providing strong market signals and tackling international barriers. The Commission has proposed a wide range of actions, including new international initiatives on agriculture, land use, forests, chemicals and marine resources, helping mobilise private and public financing and investment, as well as help with progress towards a more effective global, multilateral governance system[145].

To bring this about resource efficiency considerations would need to be more systematically factored into our external policies.

4.3. Removing skills bottlenecks and mitigating social costs

The issue of skills is a key issue. A key factor affecting transition costs is the number of skill shortages and the potential exclusion from work of people with obsolete skills. Already there are some reports of green skill bottlenecks For example, recent OECD work has confirmed that SMEs face particular challenges in upgrading or adjusting the skills of their workforce[146].

In order to build a sustainable future growth, employment needs to be of high quality and move away from precarious and low-paid working conditions. Jobs created in sectors linked to sustainable growth are often more secure, with high potential for exports and economic value creation

The European Employment Strategy already offers range of tools based on principle of flexicurity including anticipation, social support to restructuring, active labour market policies

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145 COM (2011) 363

146 OECD, 2010 Leveraging training and skill development activities in SMEs – Cross country analysis of the TSME survey, CFE/LEED

(ALMP), skills provision and social dialogue. There is a need to build on the existing range of programmes trying to fill this gap[147].

As announced in the 'Agenda for new skills and jobs', the Commission will develop an EU skills Panorama to improve transparency and mobility for jobseekers, workers, companies and/or public institutions by providing information, in the short and medium term, on current and future skills needs, skills supply and mismatches. The Panorama will contain updated forecasting of skills supply and labour market needs up to 2020. As part of this skills panorama, the green skills for a low carbon a resource efficient economy will be analysed in detail.

The Commission will continue to support the establishment of European Sector Skills Councils. A European Sector Council on skills for green and greener jobs could, for example, facilitate the exchange of information between Member States on skills profiles, training programmes and emerging skills gaps mismatches. Skills and employment strategies can be developed for promising areas, e.g. the construction of zero-carbon homes.

Closely linked to this, the European Social Fund is used for green skills promotion, but not to a great extent and hardly at all in some countries. There is scope to expand the targeting on green jobs and share best practice in this respect. The vast majority of this support does and will need to come at Member State and regional level. Social dialogue is an important part of measures to anticipate skills and design and provide the right responses.

4.4. Improving implementation of EU legislation

Poor implementation brings economic costs: the costs of implementation gaps in relation to currently legally binding targets are estimated at around €50 billion per year[148].

Poor implementation also signals uncertainty, which puts business off investing in resource efficiency. It also impacts on the single market through different conditions in Member States which can reduce the rewards for innovation, and so slow the pace of efficiency gains. Good implementation of EU legislation is crucial for creating clear market signals. It helps create a single market for innovation that is sufficiently large to encourage R&D and commercialisation. It also prevents free-riders causing damage to resources that others use as inputs. At present there are gaps in compliance and implementation. Correcting these fully by 2020 would support the transition to resource efficiency.

Actions to support implementation will need to be taken by a wide range of stakeholders working together. The Commission has a role to play in facilitating action, though the action is ultimately for Member States.

The impacts depend on design and enforcement in implementation, where the record of Member States is mixed, varying depending on political priority and capacity. For example, implementation by Member States of recycling policy or the Water Framework Directive (which calls for many measures promoting efficient use of water) has been mixed.

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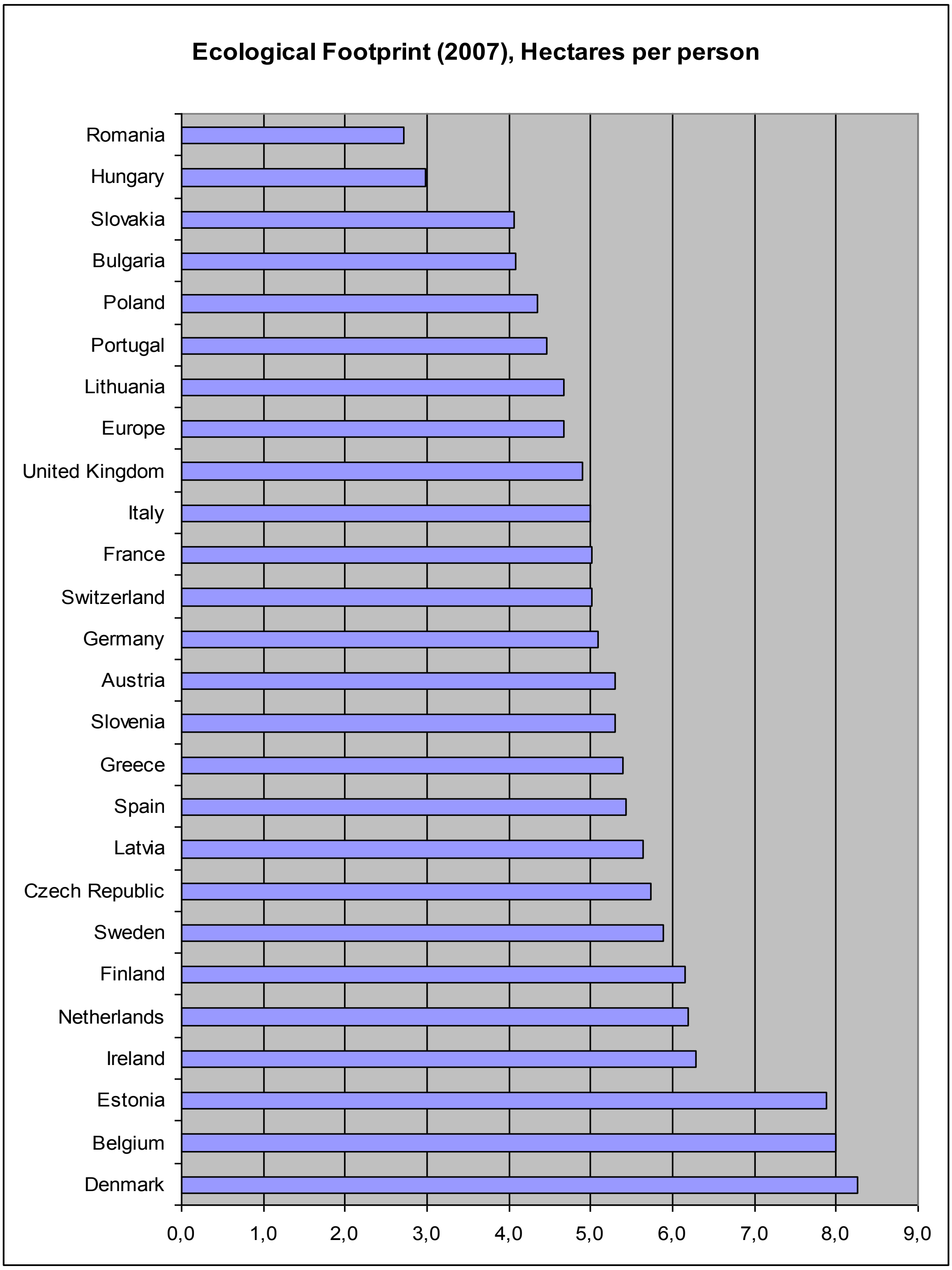
147 Programmes to promote environmental skills (2010) , Ecorys

148 COWI (2011) 'The costs of not implementing the environmental acquis'

Annex 4: Representative European Ecological Footprints

This annex shows the 'ecological footprint' of some EU Member States consumption (not available for all countries) plus Switzerland – an assumption and data based assessment of the natural resources consumed by a Member State, measured in hectares/capita[149].



[149] Data from from National Footprint Accounts 2010 edition, WWF and Global Footprint Network., retrievable at www.footprintnetwork.org

Annex 5: The rebound effect and odd price effects

This annex summarises a study by Bio Intelligence Service on the rebound effect[150]. The study provides an overview of the main findings from a review of the literature.

1. DEFINITION

Although in the literature there are many definitions of the rebound effect, in general it can be defined as *'increases in consumption due to environmental efficiency interventions'*. These increases in consumption can occur through:

- **behavioural effects** – when a feel good perception of being 'green' encourages increased consumption for certain products where 'greener' options are readily available.
- **price effects** – there are three types of price induced rebound effect:

  (1) Direct Rebound Effect – where increased efficiency and associated cost reduction for a product/service results in its increased consumption because it is cheaper.

  (2) Indirect Rebound Effect – where savings from efficiency cost reductions enable more income to be spent on other products and services.

  (3) Economy wide Rebound Effect – where more efficiency drives economic productivity overall resulting in more economic growth and consumption at a macroeconomic level.

2. EVIDENCE AND SIGNIFICANCE

Evidence on the existence of direct rebound effects is robust…

The existence of the rebound effect is recognised on the basis of evidence from many credible sources including United Nations Environment Programme, International Energy Agency, UK Dept of Environment, Food and Rural Affairs, European Environment Agency, UK Dept for Energy and Climate Change and the EEA State of the Environment and Outlook Report[151].

… but the exact size is hard to measure and extrapolate…

Whilst widely accepted, the size of the rebound effect is still a widely debated subject. The rebound effect is both hard to measure and varies depending on the intervention (policy, technology, practice), the type of products/services/resources investigated (energy, food, transport, etc.), as well as other related factors e.g. income level, productivity, price elasticity, saturation, location and time[152]. Therefore the evidence is clear that generalising the available direct rebound effect estimates to all types of rebound effect from all types of energy efficiency improvement is not appropriate.

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150 Bio Intelligences Service, Addressing the rebound effect, April 2011 (for the European Commission)

151 UNEP, 2002; IEA, 2005; 4CMR, 2006; EEA, 2009; DECC, 2010; EEA, 2010

152 Sorrell, 2007; UKERC, 2007

Even harder to measure are indirect and economy wide rebound effects, which are difficult to define and distinguished from other micro- and macro-economic effects[153].

... we have a number of examples…

In general, examples relate to the direct rebound effect associated with interventions relevant to energy efficiency, with a smaller number focusing on water, materials and waste. This is a reflection of the status of the rebound effect topic which has been mostly measured for energy efficiency as rather than wider resource related impacts. Examples include:

– direct rebound effects for household energy efficiency for space heating/ cooling, personal transport, white goods and lighting are estimated in the range 10- 30% for developed countries[154].

– direct rebound effects of 30-80% for fuel efficiency in commercial road transport[155].

– for policies to reduce the environmental impacts of meat and dairy consumption in the EU[156] found negative rebound effects of -10 to -100%[157].

– for industry sectors, estimates for rebound effects for energy efficiency in the UK are 15%[158].

– a recent USA study investigating 30 industry sectors shows long term direct rebound effects of 20-60% with energy intensive sectors e.g. utilities, chemicals and agriculture having the highest effects[159].

3. IMPLICATIONS FOR POLICY

The rebound effect can lead us to miss targets

Understanding the size of the reduction in anticipated environmental savings from the rebound effect is important when developing policy as it affects the environmental effectiveness. Rebound effects can be assessed e.g. in Regulatory Impact Assessment (RIA) though, to date, only the UK government has accounted for 'take back' in energy savings in its policy evaluation. This could relatively easily be done in the short term for specific policies where direct rebound effects are known to occur e.g. energy efficiency interventions for energy services, transport, household heating/cooling heating, appliances and lighting. It could also be considered in the evaluation and performance monitoring of policy.

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153 Estimates of indirect and economy wide rebound were only found for energy efficiency improvements, and are limited due to few published studies with weaknesses in the measurement approach (Sorrell, 2007; Allan et al, 2006; Barker, 2005).

154 Greening et al, 2000; Schipper and Grubb, 2000; UKERC, 2007; Sorrell, 2007; Small and van Dender, 2007

155 Gately 1990, Graham & Glaister 2002, Anson & Turner 2009

156 Environmental Improvement Potentials of Meat and Dairy Products, JRC, 2008

157 This negative rebound effect means that the net environmental benefit would be greater than planned. It occurs because the policy measure increases the production and consumption costs.

158 4CMR, 2006

159 Saunders, 2010

Need a policy mix to respond to rebound effects

Where the rebound effect is significant, it is clear that efficiency measures alone will not be sufficient and that other measures will also be required[160]. The evidence shows that a policy mix, incorporating technology, fiscal and behavioural aspects, is best suited to addressing direct rebound effects. For example, awareness raising through the provision of information on consumption via SMART metering (or real time displays) gives the consumer the opportunity to think about their consumption and then reduce it. The use of a mixture of instruments is already found in the EU Sustainable Consumption and Production policy, which has both demand and supply facing measures.

160 Sorrell, 2007; EEA, 2010

Annex 6: Resource efficiency indicators and targets

1. INTRODUCTION

Indicators and targets are important tools to measure and foster progress towards the vision and objectives of the resource efficiency flagship initiative. This annex on indicators and targets presents in more detail the approach on indicators. The section on theme and action specific indicators is organised according to the chapters of the Resource Efficiency Roadmap Communication and includes related targets or milestones. It complements the already existing and agreed indicators and targets on climate change, energy and energy efficiency.

This annex presents the indicators that are now ready for use, discusses their scope and limitations and gives information on ongoing work to improve or develop further indicators. The targets or milestones mentioned are in various stages of development: some are already in place, others are presented here as a basis for further discussion and evaluation. As a whole, further progress and development is needed to better incorporate the monitoring of resource efficiency in policy making.

2. The approach

To orient decisions, assess state of play and communicate progress towards the objectives of this roadmap, the Commission will use a lead indicator, accompanied by a dashboard of complementary macro indicators. A complementary set of theme specific indicators will be used to measure progress towards the specific thematic objectives and actions set out in the roadmap.

3. LEAD INDICATOR AND DASHBOARD OF COMPLEMENTARY MACRO INDICATORS

3.1. The Lead Indicator

For the near future, while recognising that it only captures the material resources aspects of resource efficiency, the Commission will use "Resource Productivity" (GDP/DMC[161] expressed in euro/tonne) as the lead indicator. To compensate for the limitation in scope of DMC, the lead indicator will be complemented by a dashboard of macro indicators on water, land and carbon. New indicators on natural ecological capital[162] and on environmental impacts of resource use[163] will be added as soon as possible.

The lead indicator and the dashboard are closely linked and should normally be used in combination. This is because the scope of the lead indicator does not cover all relevant natural resources, it has a national rather than a supply chain perspective (thus not covering shifts of material use from EU to abroad) and, furthermore, economic value, scarcity and environmental impacts of a resource are only partially correlated to its weight. Therefore, there might be situations in which an improvement of the lead indicator hides some overall unfavourable development. Such a highly aggregated indicator needs to be complemented by

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[161] DMC is defined as Domestic Material Consumption.

[162] E.g. Landscape Ecosystem Potential or Ecosystem Degradation under development by the EEA

[163] The life cycle based resource-efficiency indicators under development by the Commission's JRC is one key option the Commission will consider

a small set of additional indicators and this follows the recommendations from the Commission's "Beyond GDP" initiative[164] and the work of the Stiglitz-Sen-Fitoussi-Commission[165]. Monitoring evolution of the lead indicator together with the dashboard of macro indicators on land, water and carbon can help to disclose potential unfavourable trends that are hidden by the Resource Productivity indicator. A disaggregation of the material use in main categories such as biomass, fossil energy carriers (linking with energy and energy efficiency), industrial minerals and ores and construction minerals will also be necessary.

The proposal described above is based on an analysis of existing, readily available indicators, indicators that have been developed and produced but are discontinued, and indicators under development that are likely to be finalised before 2013 (see Appendix 1). The selection of a single lead indicator has taken careful account of its quality profile, purpose and key message.

Resource Productivity indicator (GDP/DMC) relates an important part of the resource input into the economic production process to the output of economic activity. GDP, as a measure of monetary values, does not cover non-market goods and services, it focuses on current economic activities rather than on the developments in natural, social and economic assets important from a longer term perspective, and it has no concern for inequality. Despite all its limitations, GDP is still considered as the best available indicator accounting for the output of economic activity. The Commission is working under its "Beyond GDP" initiative towards a more comprehensive measure of prosperity or wealth that might be used in the long-term.

3.2. The dashboard

As mentioned, DMC covers only material resources and has a national production perspective, which means that it does not include material resources used overseas to produce our imports. Thus, it would not register or 'indicate' if improvements of domestic resource efficiency are made by delocalisation of resource intensive or less resource efficient steps in the production chain to countries outside the EU. Indicators that have a life cycle or value chain perspective are needed to trace such potential effects. Therefore, the dashboard complementing the lead indicator needs to comprise both perspectives.

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164 COM (2009) 433 "GDP and beyond" and www.beyond-gdp.eu

165 Report of the Commission on the Measurement of Economic Performance et Social Progress (CMEPSP), see http://www.stiglitz-sen-fitoussi.fr/en/index.htm

The Commission intends to use, improve or develop the following concrete indicators:

	Production / territory perspective	*Consumption / global supply chain perspective*
Land	Artificial land or built-up area (km²) – available with restrictions in time series	Indirect land use / embodied land for agricultural and forestry products (km²) – to be developed
Water	Water exploitation index[166] (WEI, %) – available with restrictions on completeness of data and regional/temporal resolution (river basin/intra-annual variations)	Water footprint – to be updated and improved or Embodied water – to be developed
Carbon	GHG emissions (t) – available	Carbon footprint – estimates available from scientific sources

This dashboard of indicators – in conjunction with the lead indicator – has the advantage that it focuses on clear stocks or flows of main resources: materials, land, water and carbon. As such it can be easily understood, measured and communicated.

3.3. Baselines, latest values and trends[167]

Resource productivity: Resource productivity in 2007 has increased with 7.4% in comparison with 2000. However, in order to achieve absolute decoupling of economic growth from resource use, resource productivity needs to grow equally to or faster than GDP, which has not been the case. GDP has grown with 16.2% over the same period while DMC has grown 7.9%. An absolute decoupling would mean that DMC should remain constant or decrease.

Land: Artificial land has continued to expand; in the period 2000-2006 at a rate of 920 km² per year. To reach a state of no net land take by 2050 and assuming a linear reduction from now until then, the average annual land take needs to decease to maximum 800 km² per year in the period 2010-2020.

Water: Trends in EU average values of the water exploitation index (WEI) have been stagnating around 13% for the past 20 years. However WEI national values vary from 64% to less than 1% and decreases of WEI are rare. Values above 20% are considered unsustainable.

GHG emissions: After an initial decline starting from the baseline in 1990, GHG emissions were for almost stable for a decade. Recently a further decline was observed, reaching 17.4% reduction (compared to 1990) in 2009 (the Kyoto Protocol requires the EU to reduce greenhouse gas emissions by 8% below 1990 levels by 2008-2012).

166 This indicator has limitations; e.g. it aggregates different water resources, it does not take into account the nature of the water use after abstraction, the commonly used threshold values are under discussion. The Commission is exploring alternatives, which are however not yet fully available. Awaiting improvements, the WEI will be further used.

167 The relevant data is provided in an appendix to this document.

The challenge will be to keep this trend also in the period of economic recovery as the EU target for 2020 is a 20% reduction (30% if the conditions are right).

3.4. Further developments

An indicator on natural ecological capital and an indicator on environmental impacts of resource use will be added as soon as possible. Indicators on natural ecological capital are under development by the EEA as part of their activities to set up comprehensive eco-system accounts to complement the existing approach on environmental economic accounting. For example, Landscape Ecosystem Potential and Ecosystem Degradation are indicators that will be developed and evaluated for inclusion into the dashboard. Also the life cycle based environmental impact indicators under development by the Commission's Joint Research Centre will be considered.

A further important development underway is the integration of indirect or embodied material consumption into material flow accounts in order to reflect the life cycle or value chain perspective. The indicator that will come out of this improvement is Raw Material Consumption (RMC). In contrast to DMC, but similarly to the life cycle based indicators, it will also include the indirect effects outside the EU.

In addition, the Commission will continue working on improving indicators on:

- Resource availability and consumption, thereby clearly distinguishing renewable and non renewable resources;
- Resource productivity, including sustainable management patterns;
- Policy instruments, such as environmental taxes or Green Public Procurement;
- Benefits of resource efficiency along the production chain, such as innovation and green jobs;

all above listed aspects measured appropriately at:

- industry,
- product,
- national and European level.

4. THEME SPECIFIC INDICATORS

This section presents specific thematic indicators – and where appropriate also milestones and existing targets – that the Commission intends to use to define existing or potential levels of ambition and to assess the state of play, the progress towards objectives and the implementation of actions of the Resource Efficiency Roadmap. The presented indicators, targets and milestones are related to both 'objectives' and 'actions' from the Roadmap, depending on availability of data or "measurability".

For each indicator a short rationale is given, including information on any other indicators that have been considered but rejected. This annex presents the best indicators currently available, some of which are still under development. For some parts no good indicators exists; they still need to be developed and produced. As new or improved indicators, besides the ones suggested, become available, they will be used to replace or complement those laid out below. As such this will be a continuous process of improvement. These new and improved indicators could also be used in iGrowGreen, since there are strong synergies between indicators, areas and domains covered by iGrowGreen and the indicators considered below.

4.1. Transforming the economy

4.1.1. Improving products and changing consumption patterns

4.1.1.1 Supporting Green Public Procurement (GPP)

The Commission will consider developing the following indicators in 2012:

- Proposed indicator:
  - Percentage of the value, and number, of public procurement contracts that include GPP criteria.
- A milestone or target will be considered.

Rationale

Public authorities are major consumers in Europe with a large purchasing power: they spend annually the equivalent of around 17% of the EU's GDP. By greening their purchases, they can make an important contribution to environmental protection, energy and resource efficiency, the fight against climate change and the development of eco-innovation industries. This contributes to achieving a critical mass for producing and consuming green products and services (products with a low environmental impact over the life-cycle). A higher uptake of GPP therefore indicates an overall improvement in resource efficiency.

4.1.1.2 Promoting green buying

The Commission will consider developing the indicators on green products (products with a low environmental impact over the life-cycle) bought by households, or on the output of green products by 2012. This includes also further clarification of the definition of 'green products'.

- Proposed indicator:
  - Number and value of green products purchased by households;
  - Alternatively: output or share of green products in total output;
  - A milestone or target will be considered.

Rationale

Households in Europe are major contributors to environmental problems such as climate change, air pollution, water pollution, land use and waste. The proportion (number and value) of green products bought by households is an indicator not only of the change in environmental performance of products on the market, but also in attitudes towards resource efficiency. Based on work on environmental footprint of products, products sold in the EU market should communicate their environmental impact to final consumers.

4.1.2 Boosting efficient production

4.1.2.1. Measuring, managing and improving European companies' resource efficiency

The Commission will consider developing the following indicators in 2012:

- Proposed indicators:
  - Proportion of companies using environmental footprint, by sector and size class, within priority sectors, for:
    - measuring,
    - managing,
    - meeting benchmarks,
  - Number of companies, by sector and size class, benefiting from advisory assistance from Member States or regional government on improving their environmental performance.
- A milestone or target will be considered for the share of companies within the priority sectors, which measure their environmental footprint, to be achieved by 2020.

Rationale

Based on work on corporate environmental footprint, and to help European companies become more resource efficient and lower their environmental impacts, companies need to measure and monitor their performance (based on an harmonised 'environmental footprint' methodology), and to improve it against agreed benchmarks. In the long-term and to reduce significantly their environmental impacts, all companies should measure and improve the environmental footprint of their operations. In order to set benchmarks and start trends, by 2020 most of the companies in sectors where environmental impacts are the highest, should do so. Assistance is essential especially for SMEs in taking the first steps in managing resource efficiency aspects of their operations. The availability of such services is uneven across the EU. The indicator would show progress on this issue.

4.1.2.2. Phasing out the most harmful chemicals

- Proposed indicators:
  - Number of known 'substances of very high concern' (SVHC) included on the REACH Candidate list.
- Targets and milestones:
  - Currently there are 53 SVHCs on the REACH Candidate List. The aim is to have 136 on the Candidate list by 2012 (existing target), and to include all relevant SVHC by 2020.

Rationale

REACH has a number of mechanisms (notably, authorisation/restriction) for dealing with substances of very high concern (SVHC.) These are substances that are for example carcinogenic, mutagenic or toxic for reproduction (CMRs) or persistent, bio accumulative and toxic (PBTs). Substances that are subject to authorisation may not be used in the EU, unless a company (and their registered users) have been authorised to do so. This will mean that eventually these substances are phased out of all non-essential uses. In other words, the more SVHC substances there are under REACH, the higher control is of their use. Our aim is to achieve the '2020 Chemical Goal' of the World Summit on Sustainable Development (WSSD). This commitment aims, by 2020, to use and produce chemicals in ways that do not lead to significant adverse effects on human health and the environment. REACH generates pressure to substitute hazardous chemicals of very high concern leading to a reduction in the number of CMRs and Endocrine Disruptors in the environment.

4.1.3. Turning waste into a resource

4.1.3.1. Ensuring full implementation of waste legislation, in line with the waste hierarchy

- Proposed indicators:
  - Total waste generation;
  - Overall recycling rate;
  - Landfill rate;
  - Proportion of secondary raw material used in the EU economy compared to primary raw material (to be developed based on existing information).
- Targets and milestones:
  - Waste prevention – a milestone or target will be considered for the reduction of waste generated by 2020;
  - Reuse and recycling – the existing targets of 50% of reuse/recycling of municipal waste and 70% of reuse/recycling/recovery of construction and demolition waste by 2020 will be reviewed and potentially raised to their maximum feasible level. New targets for other waste streams will likely be proposed in 2014;
  - Existing landfill diversion target for biodegradable waste will be reviewed and new targets for other waste streams will likely be proposed in 2014.

Rationale

Increasing waste prevention and re-use/recycling in line with the principles of the 'waste hierarchy' will contribute directly to improving resource and material efficiency. First, overall waste generation will be monitored, with a view to progressively decouple it from economic growth as well as to reduce the absolute quantities generated. Member States have to draw up waste prevention programmes by 2013 according to the revised Waste Framework Directive, and the experience from the most advanced Member States has shown that a reduction target of 7% in 7 years is achievable, although there are still considerable differences between the waste management performances between Member States. Second, to secure access to raw materials in the EU, to create new job opportunities and to ensure a sustainable management of materials, the recycling/reuse targets should be reviewed and driven to their maximum feasible levels when they are reviewed in 2014, further to an Impact Assessment. The proposed indicators, for example on overall recycling rate, can be segmented by stream and material type, if needed. The landfill diversion rates, notably for biodegradable waste, should be reviewed accordingly to progressively and drastically limit land-filling to non-recoverable/compostable waste and energy recovery to not recyclable/compostable waste.

4.1.4. Supporting research and innovation

4.1.4.1. Increasing investment in research and innovation on resource efficiency

- Proposed indicator:
  - Number and value of funding (€/year) of research and innovation projects promoting mainly resource efficiency and sustainable environmental management, allocated through European financial support programmes.
- Milestone:
  - A milestone or target has not been set yet. The aim is to significantly increase funding compared to the sum of (1) funding for environmental research under FP7 (environment theme), and (2) funding for research in all other themes of FP7 contributing to the environmental knowledge base (which is approximately on the order of 5 times the environment theme in terms of funding).

Rationale

To mobilize innovation policy to be more resource efficient, we need to provide sufficient, targeted funding for relevant research and innovation projects. The amount of financial support for such projects would be a good indicator, together with the indicator of the number of such projects supported. However, investments in research and innovation from the private sector are evenly important. Related data and indicators are difficult to be set up, but will be considered as well.

4.1.5. Phasing out inefficient subsidies

4.1.4.1. Phasing out Environmentally Harmful Subsidies (EHS)

- Proposed indicators:
  - Annual value of all EHS provided (to be developed);
  - The value of EHS removed measured by last year's or last years' average annual spending, including tax exemptions where appropriate.
- Milestone:
  - EHS phased out completely by 2020.

Rationale

EHS have a negative impact on the levels of waste, emissions, resource extraction and biodiversity. As such, they prevent the economy from shifting to greater productivity. The key action is to remove all EHS, although replacing the social benefits of EHS can sometimes be challenging. The indicators should measure the value of EHS actually phased out, as well as the value of EHS still provided (and their share of total subsidies). A good proxy for the value is the previous year's total spending including tax exemptions where appropriate on EHS. The decrease in annual spending would represent the amount the public budget and consumers are directly saving in a given year. It will include both on-budget and off-budget subsidies (such as tax exemptions) as appropriate. This indicator should be complemented by a broader indicator on the annual value of EHS provided which requires to find objective, statistical criteria to distinguish EHS from non-harmful subsidies and standardization of different EHS methodologies.

4.1.6. Getting the prices right

4.1.6.1. Increasing the share of environmental taxation

- Proposed indicators:
  - Environmental taxes as share of total taxes and social contributions;
  - Total value of environmental taxes paid.
- Milestone:
  - By 2020 the share of environmental taxation in public revenues will have been increased to an EU average of more than 10%.

Rationale

Getting the prices of resources right will create incentives to use them more efficiently and sustainably. These indicators will provide information about the value of public revenue brought in by environmental taxes and show their relative weight in the tax system, thereby showing if the objective of shifting taxation from labour or capital to environment and resources is being met. The milestone suggests putting the EU average in line with what is now the level in the best performing Member States.

Note: The indicator 'environmental taxes as share of GDP' is not suitable to answer this question, as it measures the share of environmental taxes compared to total economic activity, not in relation to total taxation. Comparing environmental tax to GDP provides insights into the tax burden on products damaging the environment, rather than insights into assessing whether "green" taxes account for an increasing share of the tax burden.

4.2. Natural capital and ecosystem services

4.2.1. Ecosystem services

4.2.3.1. Mapping and assessing the state and value of ecosystems and their services

- Proposed indicators:
  - Based on the EU 2010 Biodiversity Baseline, measurable milestones and indicators will be developed within the EU Biodiversity Strategy to 2020. They will be available by mid 2012.

- Milestones:

  – Map and assess the state of ecosystems and their services in Member States territory by 2014.

  – Assess the economic value of such services, and integrate these values into accounting and reporting systems at EU and national level by 2020.

Rationale

The benefits from ecosystem services or the costs imposed by their loss are usually not accounted for in the decision making process. As a result, degradation of these services and depletion of natural capital continue unnoticed. Mapping and assessing the state of ecosystems and their services is necessary to establish a baseline and to develop a prioritisation framework for protection, restoration and sustainable management. These milestones have been defined in the EU Biodiversity Strategy to 2020.

4.2.3.2. Maintaining and enhancing ecosystems and their services

- Proposed indicators:

  – Based on the EU 2010 Biodiversity Baseline, measurable milestones and indicators will be developed within the EU Biodiversity Strategy to 2020. They will be available by mid 2012.

- Milestone:

  – Establishing sufficient functional green infrastructure in all MS for maintaining and enhancing ecosystems and their services.

Rationale

Biodiversity and ecosystems are crucial resources to support societal and individual well-being and economic prosperity. Solutions relying on natural capital and ecosystem services are in many cases more cost-effective than engineering options, e.g. for flood protection and water purification. Such green infrastructure, thanks to its multi-purpose character, makes most efficient use of the multiple ecosystem services the same piece of land offers to people. The milestone reflects Target 2 of the EU Biodiversity Strategy to 2020. It translates the global Aichi Biodiversity Targets 14 and 15 of the Strategic Plan[168] agreed under the Convention on Biological Diversity in Nagoya in October 2010, where the restoration of at least 15% of degraded ecosystems is seen as a means of contributing to climate change mitigation and adaptation. These have been defined in the EU Biodiversity Strategy to 2020.

168 http://www.cbd.int/sp/

4.2.2. Biodiversity

4.2.3.1. Halting the loss of biodiversity and ecosystem services in the EU and restoring them as far as possible

- Proposed indicators:

  – Based on the EU 2010 Biodiversity Baseline and the Aichi Biodiversity targets, measurable milestones and indicators will be developed within the EU Biodiversity Strategy to 2020. They will be available by mid 2012.

- Target:

  – Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible (at least 15% of degraded ecosystems by 2020), while stepping up the EU contribution to averting global biodiversity loss.

Rationale

Biodiversity underpins our ecosystems and is vital to their resilience and is thus a crucial resource to support societal and individual well-being and economic prosperity. The Biodiversity Strategy is aimed at reversing biodiversity loss and speeding up the EU's transition towards a resource efficient and green economy. It is an integral part of the Europe 2020 Strategy, and in particular the resource efficient Europe flagship. The target reflects the 6 targets of the EU Biodiversity Strategy to 2020[169]. It translates the global Aichi Biodiversity Targets of the Strategic Plan agreed under the Convention on Biological Diversity in Nagoya in October 2010, where the restoration of at least 15% of degraded ecosystems is seen as a means of contributing to climate change mitigation and adaptation. These targets have been set in the EU Biodiversity Strategy to 2020.

4.2.3. Minerals and metals

- Proposed indicators:

  – Resource productivity of minerals and metals (GDP/DMC minerals+metals)

- A milestone or target will be considered.

Rationale

The lead indicator (resource productivity measured as GDP/DMC) takes into account all materials, but can be decomposed in the main material streams such as minerals and metals.. The indicators mentioned in the section "Turning waste into a resource" are also closely related to this field as they point out how the material loops could be closed and as they often refer to minerals and metals.

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[169] "Our life insurance, our natural capital: an EU biodiversity strategy to 2020". COM(2011)244. http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm

4.2.4. Water

4.2.4.1. Ensuring good quality and quantities of water

- Proposed indicators:
  - Indicators will be presented as part of the 2012 Blueprint[170], accompanied by a rationale for their choice.
  - In the meanwhile, the Water Exploitation Index could be used.
- Milestones and targets:
  - All Water Framework Directive River Basin Management Plans (RBMPs) are implemented by 2012, good status of waters is attained in all EU river basins in 2015, and good quality and quantities of water will be ensured by 2020.
  - By 2020, water abstraction stays, as a rule, below 20% of available renewable water resources.

Rationale

Water is a key resource necessary for life – it needs to be preserved and used efficiently. The milestones reflect the need to integrate resource efficiency actions into EU policies relevant for water as competing demands for fresh water is putting pressure on the availability and quality of fresh water. Climate change is another important factor affecting availability and quality of fresh water and is projected to have even more severe impacts in the future. Member States are expected to set water efficiency targets for 2020 at River Basin level, based on a common EU methodology that takes into account the great variety of situations across economic sectors and geographic areas. The 2012 Blueprint will also provide indicative water efficiency targets. These targets will be subject to full cost-benefit and feasibility studies and developed with full stakeholder involvement to ensure their credibility amongst those stakeholders that may bear costs of meeting them. The choice of indicators will be linked to these specific targets. On the Water Exploitation Index, the warning threshold to distinguish a non-stressed to a stressed area is around 20%.

4.2.5. Safeguarding clean air

4.2.5.1. Achieving air quality with no significant negative impact on health and the environment

- Proposed indicator:
  - Concentrations of Particulate Matter (PM10) in ambient air;
  - Percentage of urban population in areas with PM10 concentrations exceeding daily limit values.
- Target:
  - Concentrations of Particulate Matter (PM10) in ambient air, not exceeding 50µg/m3 per 24 hours more than 35 times a year.

[170] The Commission will publish a Blueprint for Safeguarding Europe's Waters (2012).

Rationale

Air quality and related emission control policies have been in place for decades. Legislation required setting up of a comprehensive monitoring and evaluation system. In addition, impact and sector specific indicators have been developed and reported annually[171]. Particulate matter is one of the pollutants with the largest impact on human health and therefore on quality of life (cardiovascular/ lung diseases, effects on central nervous system etc.). There is no known threshold for PM10 under which there is no effect on human health. Hence, besides measuring the concentrations of PM10 in ambient air, an additional indicator referring to the percentage of urban population in areas with PM10 concentrations exceeding daily limit values would measure the proportion of urban population exposed to this risk.

4.2.6. Land and soils

4.2.6.1. Reducing the anthropogenic pressure on ecosystems from land take

- Proposed indicator:
  - Average annual land take on the basis of the EEA Core Set Indicator 14 "Land take"[172].
- Milestone:
  - Annual land take (i.e. the increase of artificial land) does not exceed 800 km² per year at the EU level by 2020.

Rationale

Land take is used in this context as a proxy for soil sealing. Land take, i.e. increase of artificial land, covers increase of urban, industrial, commercial or transport land, mainly coming from agricultural land. It thus indicates the total amount of land converted to urban and commercial, etc purposes in a given time period. Soil sealing causes adverse effects on, or complete loss of, practically all soil functions. For example, fluxes of gas, water and energy are cut off; soil biodiversity is affected and the water retention capacity and groundwater recharge of soil are reduced. This in turn results in several negative impacts such as a higher risk of floods. There are also indirect effects, including habitat fragmentation and indirect land use changes with losses in biodiversity and food production capacity. To reach a state of no net land take by 2050 and assuming a linear reduction from now until then, we would need to decrease the average annual land take from 920 km² per year in the period 2000-2006 to 800 km² per year in the period 2010-2020.

4.2.6.2. Reducing soil erosion

- Proposed indicator:
  - Soil erosion on the basis of the EEA indicator "Soil erosion by water"[173] and the PESERA and/or RUSLE models of the JRC[174].

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171 http://www.eea.europa.eu/data-and-maps/indicators/.

172 http://www.eea.europa.eu/data-and-maps/indicators/land-take-2/assessment.

173 http://www.eea.europa.eu/data-and-maps/indicators/soil-erosion-by-water/soil-erosion-by-water-assessment.

174 http://eusoils.jrc.ec.europa.eu/library/themes/erosion/.

- Milestone:

  – The area of land in the EU that is subject to soil erosion of more than 10 tonnes per hectare per year should be reduced by at least 25% by 2020.

Rationale

Erosion is a natural process, which can however be significantly accelerated by human activities. It is a serious problem throughout Europe, from the Mediterranean zone to Scandinavia (snowmelt erosion) and Central and Western Europe (wind erosion). As natural soil formation is extremely slow, losses of over 1 or 2 tonnes/ha/year are considered irreversible for most soils. In the context of the EU Strategy for the Danube Region (COM(2010)715), the Commission has proposed to reduce by 25% the area affected by soil erosion exceeding 10 tonnes per hectare by 2020. On the basis of existing estimates, there are 100,000 km² where soil erosion (by water) is higher than that value over the 21 Member States considered in the PESERA model. This milestone is a first step to decrease erosion in the most affected areas.

4.2.6.3. Maintaining soil organic matter levels

- Proposed indicator:

  – Soil organic matter levels, e.g. on the basis of LUCAS results[175].

- Milestone:

  – By 2020 soil organic matter levels do not decrease overall and increase for soils currently with less than 3.5% organic matter.

Rationale

Soil organic matter plays a very important role, not only for soil fertility, but also for soil structure, buffering and water retention capacity and is crucial for soil biodiversity. It also has a major role in the global carbon cycle, as soil can at the same time be both an emitter of greenhouse gases and a major store of carbon. Around 45% of soils in Europe have low or very low organic matter content (0-3.5% organic matter) and 45% have a medium content (3.5-9% organic matter). Besides climate reasons, various unsustainable human activities are the most relevant driving forces. By 2020 soil organic matter levels should not be decreasing overall and should increase for soils with currently low or very low organic matter content. The proposed indicator will provide relevant information as to the evolution of soil organic matter levels.

4.2.6.4. Identifying and remediating contaminated sites

- Proposed indicator:

  – Share of contaminated sites on which remediation actions have started in the previous year on the basis of the EEA Core Set Indicator 15 "Progress in management of contaminated sites"[176].

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[175] http://epp.eurostat.ec.europa.eu/portal/page/portal/lucas/introduction and http://eusoils.jrc.ec.europa.eu/projects/Lucas/.

[176] http://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites/progress-in-management-of-contaminated-1.

- Milestone:
  - Member States should have started undertaking remediation actions on identified contaminated sites by 2020.

Rationale

Available information indicates that the number of contaminated sites and surface covered across Europe is very large. There is a very unequal progress among Member States in addressing the issue. Soil contamination has far reaching consequences for environment, human health and sectors as agriculture. As a first step we need to monitor the identification of contaminated sites, followed by the monitoring of remediation actions. To allow for proper identification and remediation, all Member States should set up an inventory of contaminated sites in their territory by 2020 and should in parallel start remedial actions. This will ease the soil contamination problem and will also contribute to less land take by increasing the land bank available for urban and industrial development.

4.2.7. Marine resources

4.2.7.1. Ensuring fish and shellfish are within maximum sustainable yield

- Proposed indicator:
  - Share of fish and shellfish populations within safe biological limits.
- Target:
  - All fish and shellfish populations are exploited within maximum sustainable yield in all areas in which EU fishing fleets operate by 2015.

Rationale

The marine environment offers many economic opportunities in the use of its resources and it has an important natural regulatory function. Examples of vital resources are fish and shellfish populations, which need to be sustained within safe biological limits. The aforementioned indicator is considered appropriate as it sums up in an easily understandable and measurable way (necessary data are already regularly collected) the various aspects which are key to sustainable management of stocks e.g. discard and by-catch practices and fleet overcapacity. The target is part of the Biodiversity Strategy[177] and also in line with the requirements of Common Fisheries' Policy and EU commitments under Regional Fisheries' Management Organizations (RFMOs).

4.2.7.2. Achieving good environmental status in all EU waters

- Proposed indicator:
  - The number and area of Marine Protected Areas (MPAs).
- Milestone:
  - At least 10% of the marine EU area is covered by a coherent network of MPAs.

Rationale

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[177] COM(2011)244

The coverage of MPAs is a good indicator in relation to the preservation of marine habitats and marine biodiversity more generally. MPAs will contribute to the achievement of Good Environmental Status under the Marine Strategy Framework Directive and foster regional cooperation within Regional Seas Conventions. Increasing coverage of MPAs will moreover facilitate the fulfilment of EU commitments under these Conventions but also those under the Convention for Biodiversity. The latter included in its strategic goals adopted in Nagoya in 2010 the target that, by 2020, at least 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

4.3. Key sectors

4.3.1. Addressing food

4.3.1.1. Making food consumption healthier and more sustainable

- Proposed indicator:
  - Development in consumption of different meat and dairy products per capita per year based on ETC/SCP Indicator 13.2 for the EEA[178].
- Milestone:
  - Amount of animal proteins (including meat and dairy products) consumed per person is in line with WHO recommendations.

Rationale

Food production and consumption, in particular of animal proteins, are responsible for a large part of environmental impacts, as highlighted, for example, in reports from the International Resource Panel[179] and PLB Netherlands Environmental Assessment Agency[180]. The planet's carrying capacity is limited while the population is increasing. As an increasing part of the population suffering from health problems due to unhealthy diets, following the WHO recommendation on the daily intake of animal proteins would make a significant contribution to ease this problem. The ideal indicator to measure this would be the 'amount of animal proteins consumed per person per year' but this is not yet available. Currently existing indicator, the 'development in consumption of different meat and dairy products per capita per year' covers large part of animal proteins.

4.3.1.2. Reducing food waste

- Proposed indicator:
  - Share of edible food waste in households, retailers and catering.
- Milestone:

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178 Developed by the ETC/SCP for the EEA, http://scp.eionet.europa.eu/announcements/ann1298365469, based on Eurostat data.

179 http://www.unep.org/resourcepanel/Publications/PriorityProducts/tabid/56053/Default.aspx

180 http://www.pbl.nl/sites/default/files/cms/publicaties/Protein_Puzzle_web_1.pdf

– Decrease of edible food waste in households, retailers and catering by 50% in the EU.

Rationale

Reducing our food waste is a clear first step towards more resource efficiency in the food value chain. To have a significant impact, we should at least halve our edible food waste. Households count for about 40 % of all food waste; the retail and catering sector add another 20%. If the same rate of edible food waste of households (60%) is applied to the retail and catering sector, halving our edible food waste results in a reduction of total food waste by approximately 18%[181].

After the results of ongoing studies will be available, expected in 2013/14, the Commission will, together with ESTAT's Working Group on Waste Statistics, develop proposals on how such an indicator can be developed and maintained.

4.3.2. Improving buildings

4.3.2.1. Promoting green buildings

- Proposed indicators:
  - The rate of nearly zero-energy new buildings (to be developed);
  - Energy consumption per m2 for space heating, per dwelling and for total housing stock alongside growth in m2 of living space per capita based on ETC/SCP Indicator 16.1 for the EEA (to be further developed)[182].
- Target:
  - Member States shall ensure that by 31 December 2020, all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are near zero-energy buildings[183].

Rationale

Energy consumption for building-related services accounts for approximately one third of total EU energy consumption. One way to reduce energy consumption is to improve energy efficiency. The proposal for a Directive on energy efficiency[184] strengthens the energy performance requirements. A target set in this Directive is to ensure that all new buildings are nearly zero-energy buildings by 2020. The indicator on the energy consumption per m^2 shows developments in energy use for heating in housing at different scales. It is based on the reasoning that developments in energy consumption per m^2 are directly influenced by technical improvements in building envelopes and in heating technology. Average per capita size of living space can offset or strengthen technological improvements. Increasing living

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181 Calculated based on data in the preparatory study on food waste in the EU27, http://ec.europa.eu/environment/eussd/reports.htm

182 Developed by the ETC/SCP for the EEA, http://scp.eionet.europa.eu/announcements/ann1298365469. The data is held by Enerdat Odyssee database and the indicator is available for 27 EU MS except of one trend line for growth in floor area available only for 19 EU MS.

183 Article 9 of the Directive 2010/31/EU on the energy performance of buildings (recast)

184 Repealing Directives 2004/8/EC and 2006/32/EC, see COM(2011) 370 final of 22.6.2011

space per capita will, in general, offset technical improvements[185]. Looking at these trends gives an indication on energy efficiency of new buildings.

4.3.3. Ensuring efficient mobility

4.3.3.1. Transforming transport

- Proposed indicators:
  - CO2 emissions in the transport sector;
  - Total energy consumption/km driven as a proxy for energy efficiency in transport;
  - Average CO2 emissions per km for new passenger cars;
  - Pollutant emissions (NOx, VOC, PM) from the transport sector (available from EEA / Reporting under NECD);
  - Energy consumption by fuel type.
- Milestones and targets:
  - The Transport White Paper proposes a target to decrease GHG by 60% in transport sector by 2050 (EU transport emissions should drop by 1% annually until 2030, afterwards by 5% annually until 2050).

Rationale

The decarbonisation of the economy and the transformation of the efficiency of the transport system are essential aspects of the move to a resource efficient economy. CO_2 is a reasonably good proxy for how efficiently conventional fossils are being used, because most emissions occur during the fossil fuel combustion phase, and hence lower levels of CO_2 emissions tend to correspond to reductions in fossil fuel energy use. Transport remains a significant contributor to persistent air quality problems, hence the environmental performance of transport with respect to other key pollutants (such as PM, NOx and VOCs) will be monitored. Energy consumption by fuel type is another indicator to monitor fuel shifts in the transport system, i.e. whether we are moving towards more sustainable fuel types.

4.4. Governance: New pathways to action on resource efficiency

4.4.1. Financing resource efficient innovation and investments

- Proposed indicators:
  - Share of total budget spent on the environmental and resource efficiency measures;

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185 2011 Progress Report prepared by ETC/SCP for the EEA, http://scp.eionet.europa.eu/announcements/ann1298365469

– Capitalisation of ‘Core’ and ‘broad’ Sustainable and Responsible Investments (SRI) in Europe (billion/€) based on ETC/SCP Indicator 24.1 for the EEA (to be further developed)[186].

- Milestone:

  – 30% of the EU Regional Budget (i.e. cohesion policy budget) allocated to environment related expenditure.

Rationale

The target is set according to the Sustainable Growth Communication of January 2011, which mentions, "approximately 30% of the total € 344 billion Regional funding over 2007-2013 is available for activities with a particular impact on sustainable growth. By the end of 2009, 22% of this funding for sustainable growth had been allocated to specific projects compared to 27% for the total of Regional funding." The 30% funding refers to the cohesion policy budget, and includes both direct and indirect expenditure covering environment, climate, resource efficiency, clean transport, and others. The indicator on public funding for the transition can directly track how much of the budget is spent on the environment and resource efficiency. The indicator on private funding for the transition shows how funds with social and environmental criteria are increasing/decreasing, i.e. it represents those financial assets selected by fund managers according to criteria about the social and environmental responsibility of emitters.

[186] The definitions of 'Core' and 'broad' SRI can be found in the 2011 Progress report on SCP prepared by ETC/SCP for the EEA. To date the indicator covers 14 EU MS (for 2010) and is based on the data from the Eurosif database. This indicator would need further processing but is a good proxy for private funding for the transition.

APPENDIX 1: CHOICE OF LEAD INDICATOR

Developing a set of resource efficiency indicators is a considerable challenge, as measuring the state of and changes in resource efficiency is much more complex than measuring, say, labour or energy productivity. Ideally, a set of indicators would cover (i) resource use, (ii) its efficiency, (iii) related policy measures and (iv) related societal and economic benefits – such as (green) jobs, free ecosystem services, (cost) savings and (eco-) innovation – along the full production chain from extraction to recycling or waste disposal. They should include *inter alia* information on availability, scarcity, location, economic value/prices and environmental and biodiversity impacts of resources. For renewable resources the sustainability of their management patterns is to be covered.

A substantial amount of base data is readily available, e.g. on mining, agriculture, waste and international trade. Other data sets, e.g. those on environmental impacts of production and consumption, are under development. On the other hand the conceptual work on how to aggregate these detailed statistics into meaningful macro indicators on resource use and efficiency is still underway.

First macro indicators such as Resource Productivity (GDP/domestic material consumption), Environmentally-weighted Material Consumption (EMC) or the Ecological Footprint have been developed and produced and are in principle ready for use. However all of them should be considered as "proxy" indicators, as all of them cover only part of the resource efficiency agenda.

There is currently no indicator measuring comprehensively the consumption of natural resources as defined in the roadmap – and there are considerable methodological challenges to aggregating resources as different as land, water, oil and ores into one single indicator. For the selection of the lead indicator the Commission looked at existing indicators on materials, such as the Domestic Material Consumption; indicators on land use, such as the Ecological Footprint; indicators related to carbon, such as carbon intensity; indicators on environmental impacts, such as Environmentally-weighted Material Consumption (EMC); and resource specific indicators, such as on water, land, soils and others.

The following assessment criteria have been used as appropriate:

- Political relevance;
- Coverage of all relevant categories of resources;
- Coherence and completeness;
- Transparency of trade-offs and negative side effects such as burden shifting;
- Link to a timeline for production of the data and calculation of the indicator;
- Applicability to different levels of economic activities (EU, Member States, sectors, firms, products);
- Support by data that can be aggregated and disaggregated across scales, from products to sectors and countries.

Below the key arguments are listed that led to the proposal to continue using Resource Productivity (GDP/DMC) as the lead indicator for efficient use of natural resources.

DMC

Aggregated weight of used domestic extraction of raw materials, plus direct weight of imports (raw materials and products), minus exports (raw materials and products) measured in tonnes.

Strengths

- Established indicator;
- Output of well established integrated environmental economic accounting methods;
- Official statistics;
- Statistical regulation for continuous production in place;
- Includes all materials: minerals, metals, carbon related fossil fuels and (renewable) biomass;
- Breakdown by materials and sectors and industries possible.

Limitations

- Material resources only;
- Economic value, resource scarcity and environmental impacts of resource use are only partially correlated to their weight;
- Statistically not fully consistent with GDP.

Ecological Footprint

Aggregates the land use caused by human consumption based on "bio-productive" land (and sea) areas and the land area theoretically necessary for carbon sequestration. Measured in 'global hectares'.

Strengths

- Powerful communication tool;
- Strong link to biodiversity and eco-system health;
- Strong link with the thresholds for use of the renewable resources, or carrying capacity of the planet;
- Includes renewable materials, land and carbon.
- Takes account of burden shift issues

Limitations

- Methodology under scientific and statistical scrutiny;
- Current version based on weak international data set while better EU data sets are available;
- Water and non-renewable materials only indirectly included.

Carbon Intensity

Relates economic output to aggregated emissions of greenhouse gases, measured in tonnes of CO_2 equivalent per euro of GDP.

Strengths

- Good data quality;
- Proxy for wider environmental impacts;
- Proxy for use of non-renewable materials;
- Proxy for unsustainable use of land based renewable resources (soil degradation, forest loss).

Limitations

- Duplication of information of the already agreed indicators on 20/20/20 targets;
- Mainly driven by energy consumption;
- Does not include consumption of renewable and nuclear energy;
- Does not include other resources.

EMC

Aggregates the contribution of resource use to specific (or the overall) environmental impacts, such as ground-level ozone or human toxicity, measured in percentage of total environmental impact.

Strengths

- Aggregates material consumption not only by weight (as DMC), but according to environmental impacts.

Limitations

- Weighting of environmental impacts cannot be done scientifically;
- Methodology under scientific and statistical scrutiny;
- Limited data availability and quality.

Resource specific indicators

Aggregate use or consumption of a specific resource, e.g. coal, land or water, using their physical unit of measurement.

Strengths

- Concrete;
- Easy to communicate;
- Indicate substitution effects / shift of burden.

Limitations

- No overview;
- Difficult to aggregate into one indicator or index.

Appendix 2: Trends for EU and Member States on lead and dashboard indicators

Table 1: Resource productivity GDP/DMC (EUR per kg)

GEO/TIME	2000	2001	2002	2003	2004	2005	2006	2007
EU	1,21	1,24	1,27	1,30	1,27	1,28	1,29	1,30
Austria	1,41	1,44	1,38	1,37	1,30	1,30	1,32	1,40
Belgium	1,32	1,29	1,36	1,41	1,43	1,43	1,43	1,47
Bulgaria	0,13	0,13	0,13	0,13	0,13	0,14	0,13	0,14
Cyprus	0,66	0,66	0,61	0,67	0,61	0,62	0,66	0,64
Czech Republic	0,33	0,34	0,37	0,37	0,36	0,39	0,40	0,42
Denmark	1,28	1,32	1,38	1,36	1,31	1,22	1,20	1,24
Estonia	0,32	0,34	0,32	0,25	0,28	0,31	0,31	0,27
Finland	0,76	0,76	0,78	0,76	0,79	0,80	0,78	0,79
France	1,64	1,73	1,74	1,87	1,74	1,83	1,83	1,80
Germany	1,41	1,52	1,55	1,58	1,58	1,64	1,65	1,71
Greece	0,88	0,86	0,86	0,83	0,87	0,90	0,94	0,98
Hungary	0,45	0,43	0,45	0,46	0,42	0,38	0,47	0,60
Ireland	0,63	0,63	0,67	0,67	0,68	0,68	0,66	0,66
Italy	1,25	1,36	1,46	1,62	1,52	1,49	1,52	1,60
Latvia	0,24	0,27	0,27	0,29	0,29	0,29	0,31	0,31
Lithuania	0,44	0,53	0,47	0,38	0,42	0,43	0,46	0,43
Luxembourg	2,78	3,01	2,95	3,01	3,33	3,33	3,04	4,32
Malta	3,00	3,26	3,04	2,81	2,32	2,42	2,18	2,14
Netherlands	2,16	2,14	2,35	2,44	2,42	2,45	2,59	2,60
Poland	0,32	0,35	0,38	0,38	0,37	0,38	0,40	0,38
Portugal	0,66	0,64	0,68	0,75	0,70	0,70	0,62	0,62
Romania	0,18	0,15	0,17	0,16	0,16	0,16	0,16	0,14
Slovakia	0,40	0,39	0,40	0,43	0,40	0,39	0,44	0,49
Slovenia	0,48	0,51	0,51	0,50	0,49	0,53	0,48	0,46
Spain	0,93	0,93	0,87	0,85	0,86	0,87	0,85	0,90
Sweden	1,71	1,82	1,81	1,83	1,85	1,69	1,95	1,79
United Kingdom	2,11	2,13	2,24	2,30	2,28	2,41	2,48	2,54

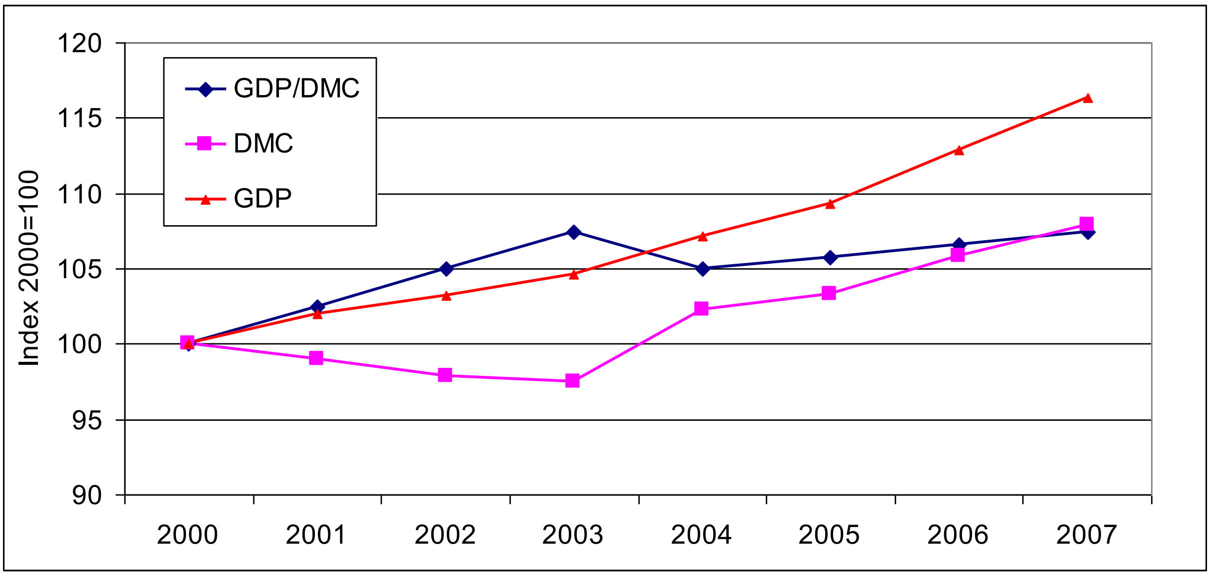


Figure 1: Resource productivity in the EU (index 2000 = 100)

Table 2: Artificial Surface (hectares)

GEO/TIME	1990	2000	2006	Total Surface
EU	17.614.704	18.621.100	19.173.193	432.080.477
Austria	392.958	401.408	409.181	8.392.463
Belgium	605.485	627.595	630.347	3.066.430
Bulgaria	549.815	553.385	557.529	11.096.372
Cyprus	67.544	68.870	79.103	925.971
Czech Republic	472.803	493.223	501.899	7.886.893
Denmark	301.465	315.255	324.745	4.289.089
Estonia	86.603	90.953	94.173	4.346.186
Finland	461.581	472.234	483.422	33.702.920
France	2.588.183	2.744.303	2.826.586	54.881.341
Germany	2.744.401	2.964.561	3.012.304	35.708.592
Greece	231.604	270.084	283.301	13.162.924
Hungary	532.595	546.685	561.572	9.300.074
Ireland	108.416	142.516	162.565	6.987.857
Italy	1.362.772	1.450.012	1.498.303	30.150.499
Latvia	85.011	85.241	86.224	6.461.353
Lithuania	209.948	212.818	215.648	6.497.798
Luxembourg	22.303	24.003	24.171	259.741
Malta	7.402	8.171	8.178	31.586
Netherlands	406.803	475.143	510.995	3.735.750
Poland	1.211.876	1.243.546	1.254.749	31.195.005
Portugal	237.586	287.976	315.507	9.196.404
Romania	1.490.431	1.502.611	1.511.699	23.845.069
Slovakia	257.984	265.604	268.718	4.901.397
Slovenia	53.795	55.155	56.215	2.027.724
Spain	759.205	893.455	1.030.762	50.672.957
Sweden	593.125	611.383	628.929	44.911.418
United Kingdom	1.773.010	1.814.910	1.836.368	24.446.664

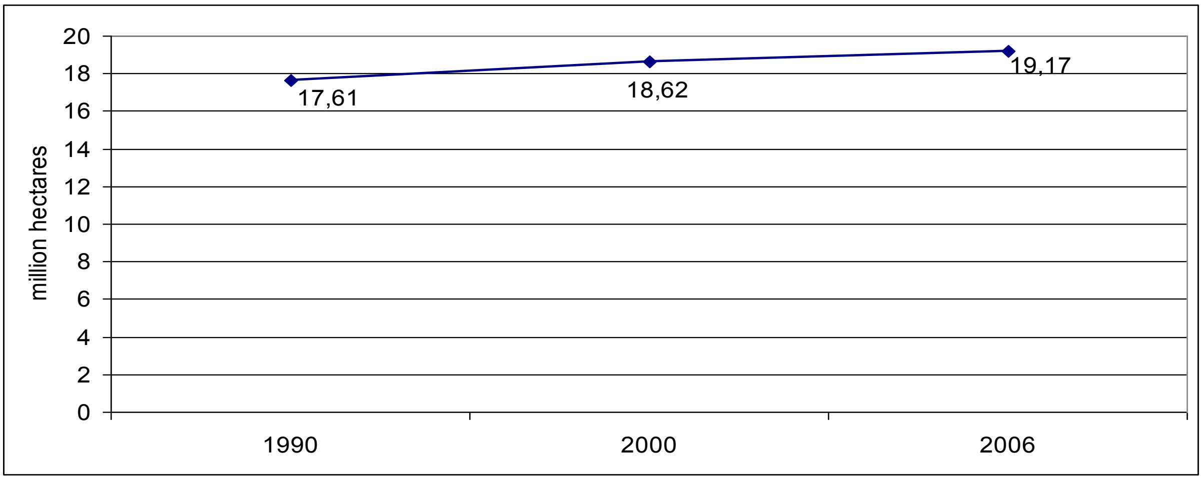


Figure 2: Artificial Surface in the EU (million hectares)

Table 3: Water Exploitation Index

GEO/TIME	1990	2002	2005	2007
EU	0,13[1]	0,132	0,13	0,13
Austria	0,05	0,04	0,04	0,04
Belgium	0,338		0,32	0,32
Bulgaria	0,10	0,06	0,06	0,06
Cyprus		0,63	0,45	0,64
Czech Republic	0,23	0,12	0,12	0,12
Denmark	0,08	0,04	0,04	0,04
Estonia	0,15	0,11	0,13	0,15
Finland	0,02	0,02	0,02	0,02
France	0,21	0,18	0,18	0,17
Germany[3]	0,25	0,20	0,20	0,19
Greece	0,11	0,12	0,12	0,13
Hungary	0,06	0,05	0,0545	0,0562
Ireland	0,026	:	0,02	0,02
Italy		0,24	0,24	0,24
Latvia	0,01	0,01	0,007	0,006
Lithuania	0,18	0,13	0,10	0,09
Luxembourg		0,04	0,04	0,04
Malta	0,32	0,24	0,21	0,21
Netherlands	0,09	0,10	0,12	0,11
Poland	0,24	0,19	0,18	0,18
Portugal	0,10	0,15	0,15	0,15
Romania	0,08	0,03	0,02	0,03
Slovakia	0,03	0,01	0,01	0,01
Slovenia	0,01	0,01	0,03	0,03
Spain	0,33	0,33	0,34	0,30
Sweden	0,02	0,01	0,01	0,01
United Kingdom[4]	0,204	:	0,22	0,13

Note:
(1) 1990 data are for average EU24, no data for CY, IT and LU
(2) 2002 data are for average EU24, no data for UK, BE, and IE
(3) Germany includes ex-GDR from 1991
(4) United Kingdom comprises of England and Wales data only

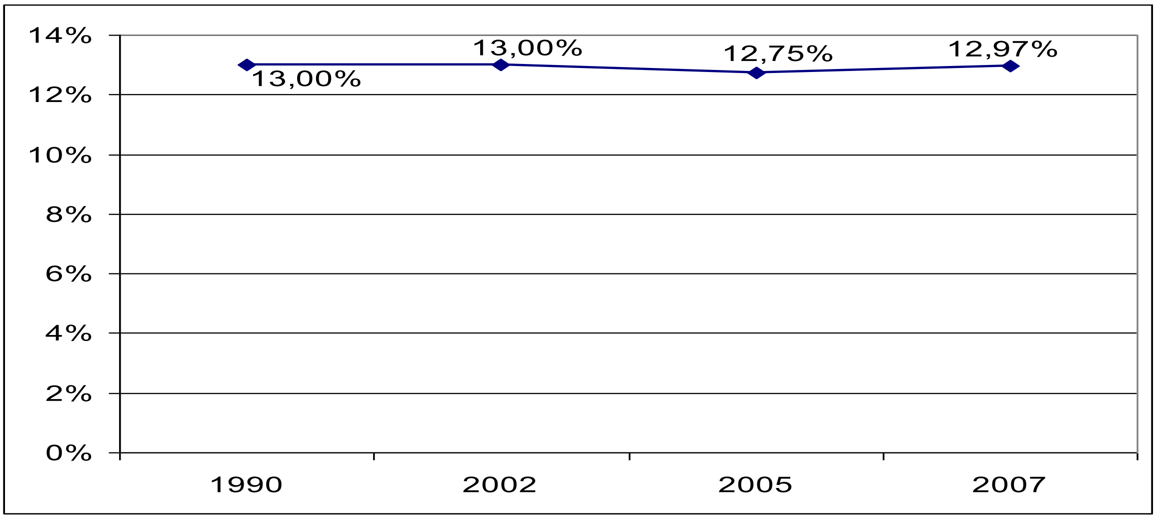


Figure 3: Water Exploitation Index in the EU

Table 4: Greenhouse Gas Emissions (CO_2 equivalent thousands of tonnes)

GEO/TIME	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
EU	5.588.798	5.231.962	5.085.820	5.145.129	5.104.918	5.177.396	5.181.206	5.148.753	5.128.892	5.071.328	4.969.052	4.614.526
Belgium	143.344	150.070	145.415	144.863	143.564	145.899	146.713	142.729	137.737	132.908	135.155	124.440
Bulgaria	111.401	80.814	63.344	66.359	63.052	68.300	67.560	67.110	68.297	71.763	69.029	59.493
Czech Republic	195.523	153.632	147.420	149.612	145.343	144.419	145.331	144.711	146.036	147.055	141.131	132.925
Denmark	68.007	75.655	67.847	69.524	68.859	73.599	67.897	63.634	71.556	66.927	63.654	60.985
Germany	1.247.901	1.119.906	1.042.071	1.056.941	1.036.680	1.030.603	1.021.218	999.776	1.002.257	979.873	981.112	919.698
Estonia	41.053	20.249	17.811	18.200	17.531	19.479	19.835	19.164	18.710	21.603	20.071	16.837
Ireland	54.820	58.490	67.865	69.701	67.870	67.842	67.683	69.221	68.683	68.035	67.817	62.395
Greece	104.365	108.983	126.003	127.444	127.161	130.876	131.383	134.356	130.746	133.395	128.550	122.543
Spain	283.168	314.839	379.563	379.820	396.775	403.731	419.511	433.847	426.023	437.130	404.771	367.548
France	562.886	559.672	566.838	569.147	563.708	565.719	566.462	568.972	552.969	544.501	539.178	517.248
Italy	519.157	529.951	551.640	557.476	558.668	573.477	576.600	574.893	563.911	554.569	541.749	491.120
Cyprus	5.273	6.666	9.112	9.079	9.100	9.115	9.296	9.590	9.705	9.855	10.182	9.401
Latvia	26.576	12.699	10.316	10.952	10.923	11.134	11.299	11.417	11.839	12.348	11.918	10.723
Lithuania	49.559	21.833	19.166	20.271	20.659	20.871	21.627	22.610	23.419	25.146	24.033	21.609
Luxembourg	12.827	10.104	9.766	10.275	11.044	11.486	12.900	13.152	13.018	12.398	12.260	11.684
Hungary	96.824	78.180	76.703	78.713	76.667	79.665	78.707	79.495	77.824	75.478	73.095	66.727
Malta	2.065	2.463	2.614	2.727	2.750	2.932	2.900	2.927	2.965	3.048	3.009	2.866
Netherlands	211.852	223.249	213.161	214.995	214.317	215.370	216.762	211.105	207.129	205.405	204.601	198.872
Austria	78.171	79.811	80.476	84.343	86.159	91.894	90.927	92.884	90.103	87.373	86.961	80.059
Poland	452.935	440.282	389.427	385.999	372.786	384.621	385.557	388.017	402.339	400.695	395.724	376.659
Portugal	59.417	69.499	81.225	82.337	86.897	81.703	84.078	85.984	81.272	79.107	77.935	74.583
Romania	250.087	187.882	142.117	147.844	154.573	161.227	160.118	155.738	160.404	156.215	153.419	130.828
Slovenia	18.478	18.458	18.821	19.682	19.955	19.635	19.898	20.237	20.455	20.567	21.286	19.339
Slovakia	74.112	53.311	49.203	50.590	49.754	50.983	50.751	50.087	49.864	47.836	48.166	43.404
Finland	70.364	70.783	69.162	74.383	76.524	84.278	80.269	68.477	79.711	78.144	70.420	66.336
Sweden	72.490	74.313	68.900	69.521	70.378	70.914	70.369	67.591	67.283	65.794	63.570	59.994
United Kingdom	776.142	710.168	669.832	674.330	653.223	657.625	655.557	651.027	644.637	634.159	620.257	566.210

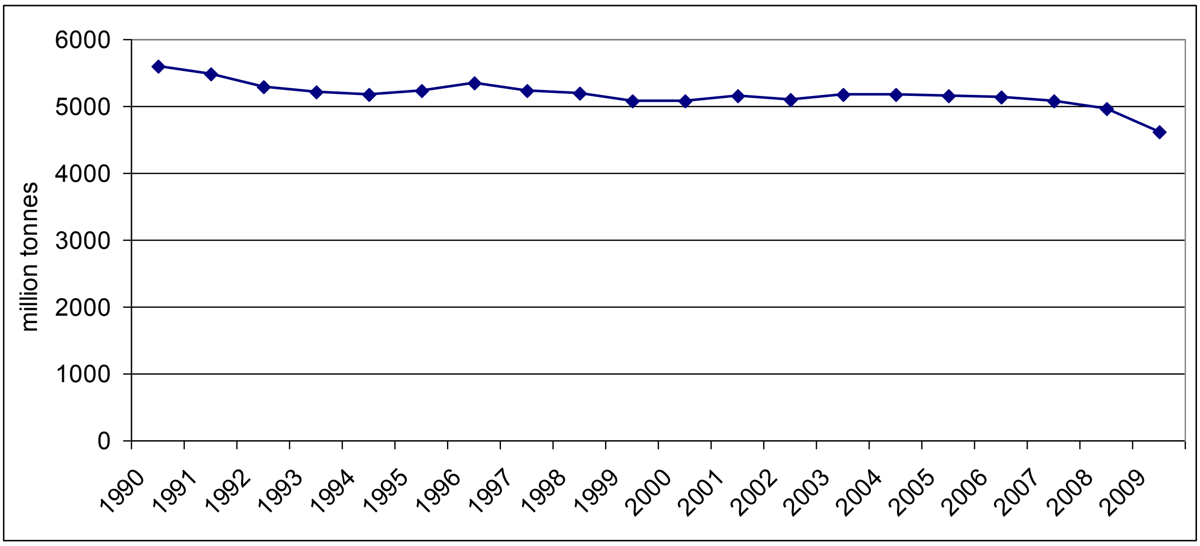


Figure 4: Greenhouse Gas Emissions in the EU (CO2 equivalent millions of tonnes)

Annex 7: Trends in Resource Use

1. INTRODUCTION

To describe trends in sustainable resource use, it is essential to monitor economic activity, use of natural resources and, finally, interdependance between natural resources, in particular how unsustainable use of some resources may lead to the depletion of others. While complete statistics exists for economic activity, monitoring is more complex for the use of natural resources and even more so for their interlinkages.

This Annex presents snapshots of information on resource trends, taken from various data sets. Given the breadth of different resources, it does not attempt to cover all trends for all relevant resources, but shows selected examples to give a representative picture. If focuses mainly on trends in material resources, but attempts also to present the most relevant data as regards other key natural resources. Next to that, in analyses some aspects of resource interdependence, referred to also as environmental impacts. Finally, it reflects briefly on the drivers of resource use. Wherever possible, EU and global trends are shown graphically, complementing the information in the two Staff Working Documents accompanying the Roadmap to a Resource Efficient Europe.

2. MATERIAL USE IN THE EU

2.1. Domestic Material Use and Import Dependency

The use of materials in Europe is closely connected with economic growth. Being a key driver of material use, it entails the changing structure of the economy with a growing share of services and a parallel increase of imports of resources including finished and semi-finished products as well as growing levels of household consumption. Contrary to most parts of the world, population growth in Europe has only a limited impact on the use of resources (see section 5).

In 2007, the domestic material consumption (DMC) in the EU amounted to 8.2 billion tonnes, equalling 13% of the global materials extraction. Minerals including metals accounted for half of EU consumption, while fossil fuels and biomass for about one quarter each. With an annual average per capita material consumption of about 16.5 tonnes/capita/year in 2007, the EU was more than 65 % above the global average. Having adopted a rigorous resource conservation policy, Japan was down to an average of 12 tonnes/capita/year; however, the USA reached a level of 27 tonnes/capita/year.

While material use has stabilised at a high level in the EU-15 (DMC slightly growing but a small decline for DMC per capita), it is still increasing substantially in the EU-12, which results in a slow growth in material use in EU-27 overall, at a similar pace as population. The important increase in EU-12 is probably due to large-scale infrastructure projects and the construction boom that started in the late 1990s and later on intensified when joining the EU.

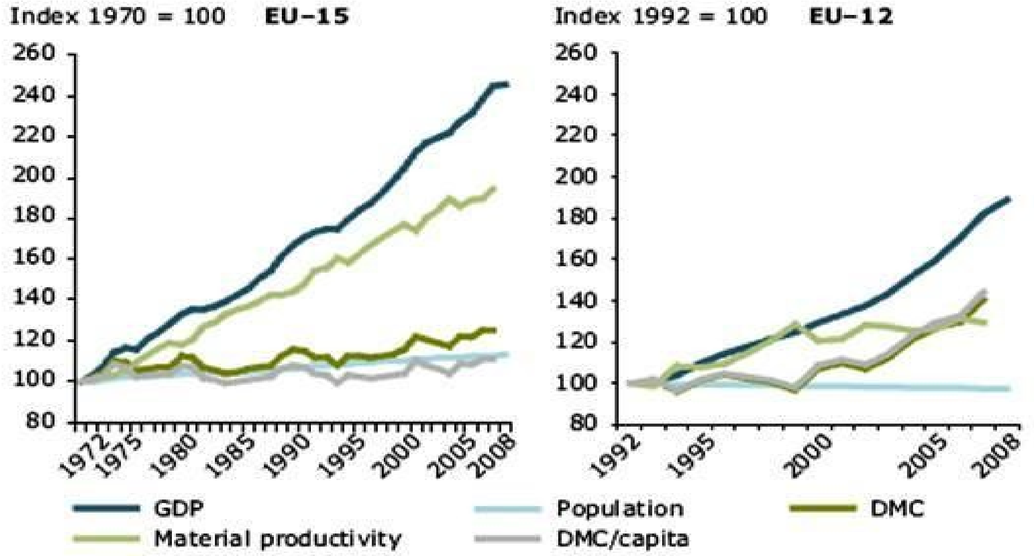


Figure 1: Trends in the use of material resources in EU15 and EU12, 1972-2008 (Source: EEA, 2010)

The overall trend of stabilisation of material consumption is based upon stable or even decreasing domestic material extraction. The latter is the case for metallic ores and fossil energy carriers, while domestic extraction of biomass and non-metallic minerals are stable at high levels. In contrast, in order to meet EU's material demand, trade is rapidly increasing and there is a high import dependency for many material categories, especially strategically important ones. Net imports of materials into the EU-27 are now 1.3 billion tonnes, reflecting an increase of over 25% in the period between 2000 and 2007 and currently between 20 and 30 % of the resources we use are imported. This means that care needs to be taken when interpreting the observed trends of stabilisation of material use as upstream material flows are not taken into consideration in import data.

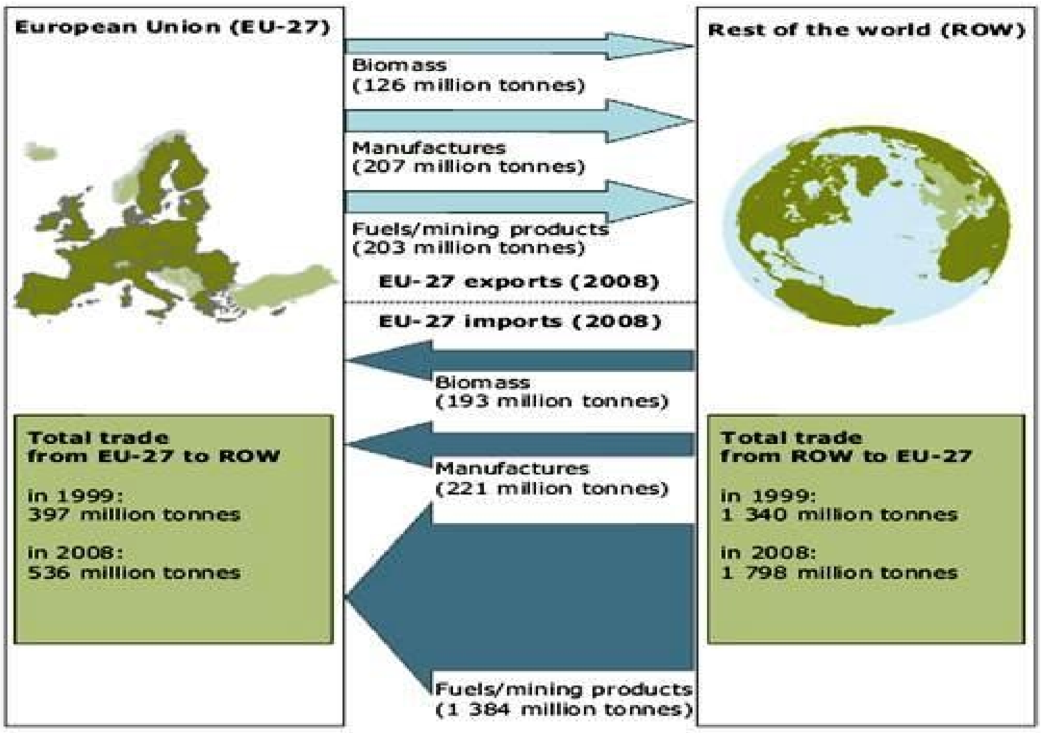


Figure 2: EU-27 physical trade balance with the rest of the world (Source: EEA, 2010)

Fossil Fuels Use

The current energy system is heavily dependent on fossil fuels and their share in the total energy consumption has declined only slightly, from 83 to 79 % between 1990 and 2005. Oil is still the biggest contributor with over 36 % of the gross inland consumption in 2007 while gas was up to almost 24 % and solid fuels reached above 18 %. Renewable energy made up 7.8 %. In this category, wind power remains dominant and represented 75 % of the total installed renewable capacity in 2006.

The gross inland consumption of energy in EU27 amounted to about 1800 Mtoe in 2007, having experienced an annual increase of final energy consumption by 0.6 % between 1990 and 2005. In the same period, the total energy intensity (total energy divided by GDP) in the EU-27 decreased by an estimated 1.3 % annually, with by far the fastest decrease taking place in the new Member States. The dependency on import is particularly high in this sector and over 53 % of all fuels are imported, showing one of the most dramatic increasing trends in recent years. As can be seen in Figure 3, oil import dependency in the EU was over 80% in 2006, and gas import dependency around 60%. Moreover, according to the Netherlands Environmental Assessment Agency these imports only stem from a limited number of countries. This restriction of the number of potential import countries is likely to increase further due to the concentration of world oil and gas reserves in some of them and the expected depletion of world oil and gas reserves in other countries[187].

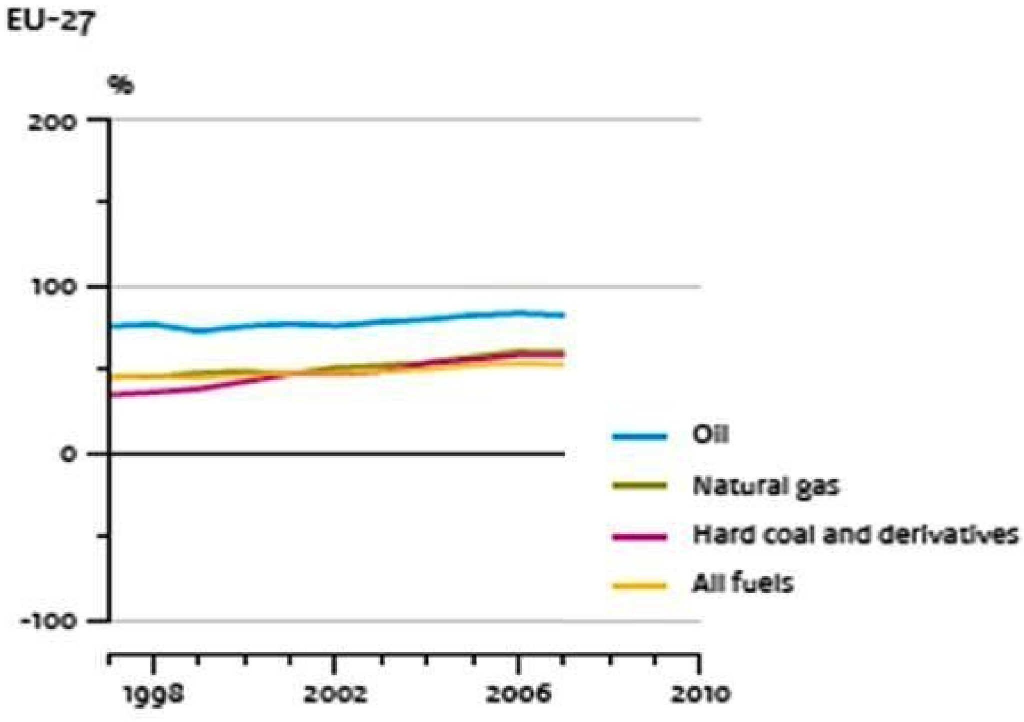


Figure 3: EU-27 Energy import dependency 1995-2006 (Source: Eurostat, 2010)

Biomass extraction

The EU has a highly productive land use system and biomass extraction amounted to 1.6 billion tonnes in 2005, corresponding roughly to 8 % of total global biomass extraction. Crop harvest accounted for the largest share of total extraction (42 %) followed by forage and

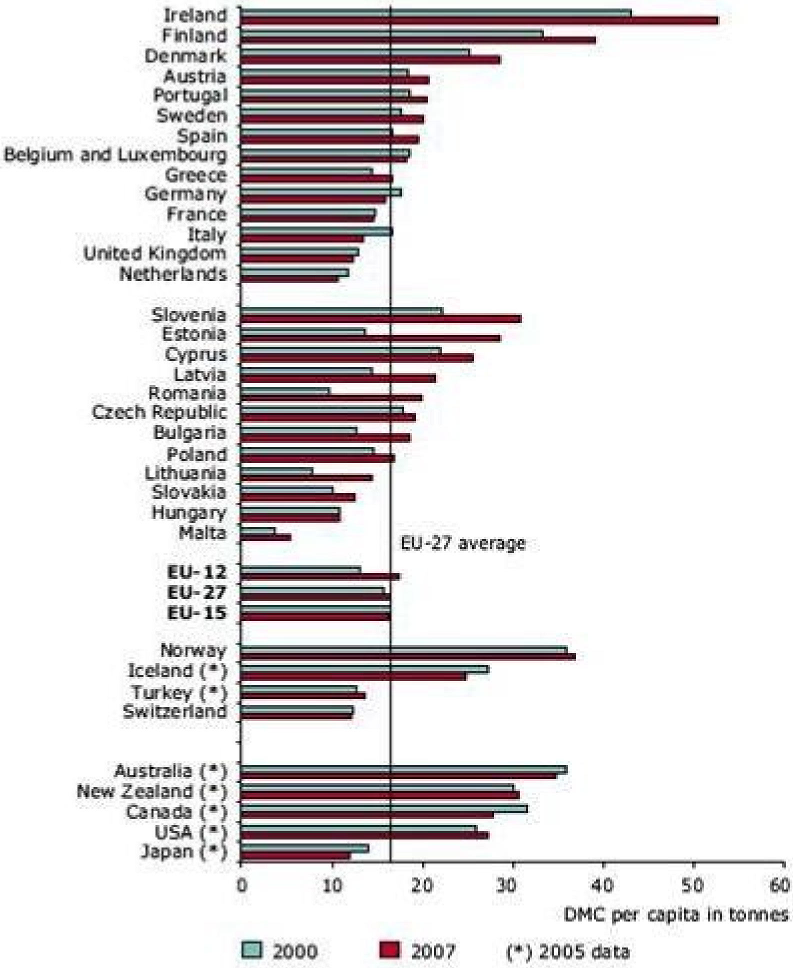
187 Netherlands Environmental Assessment Agency, Scarcity amidst a Sea of Plenty?, 2010

grazed biomass (31 %). The share of timber and fuel wood was 17 % and that of crop residues 10 %. The use of biomass is dominated by feeding livestock. Trade of biomass based products is very dynamic with both imports and exports growing rapidly. Here as well, the EU is an important net importer, with large imports of feed and animal products as well as wood and wood-based products. To a large extent, biomass consumption in the EU affects land use in third countries, where the import of soybean and soybean cake may serve as an example. The EU meat production, which equals about 15-18 % of global meat production and which is almost exclusively consumed within EU, requires large amounts of high quality protein feed. With only a minor domestic production, the major share of this feed is based on soybeans and soybean cake which is imported from countries like Brazil and the United States. The imported amount corresponds to an area of more than 20 mio ha of cropland and this illustrates how European imports are demanding large areas of fertile cropland in distant regions of the world, with European consumption patterns contributing to land use change elsewhere. Several studies have attempted to estimate the drawing of global land use and results vary from about 50% of domestic HANPP (2000) and upwards. The implementation of the European biofuel strategy will drastically increase this demand and is likely to further increase EUs draw on global land resources, with its associated environmental impacts.

Decoupling economic growth from material resources use

The general trend is of relative decoupling between economic growth and use of material resources. An absolute decoupling only took place under very limited periods and was always linked to recession or at least very low economic growth. Absolute decoupling of material use during economic growth, as has been observed in Japan since 1990, has not been achieved in the EU.

Varying trends can however be seen across member states with most countries achieving relatively stable DMC and relative dematerialisation. A few Member States have reached absolute decoupling also in the long run. This has generally been the result of fuel shifts and deindustrialisation with the fading out of intensive and heavy industries or mining activities, a process which is often related to the externalisation of material use and corresponding environmental impacts to third countries. If taking these aspects into account, the absolute decoupling may no longer be obvious. At the same time, certain Member States, often with low level of per capita income but with high economic growth, have seen particularly the development of built infrastructure contribute to a high increase in material use and, thus, not even reaching a relative decoupling. The overall improved resource productivity during the last two decades in the EU is largely based on more resource-efficient technologies, the transition to service-based economies but at the same time an increased share of imports in EU economies, outsourcing early phases in the life cycle which generally have a lower economic value/weight. Figure 4 shows resource use per person in 2000 and 2007.



Note: Domestic material consumption (DMC) is an aggregate of materials (excluding water and air) which are actually consumed by a national economy. It includes used domestic extraction and physical imports (mass weight of imported goods) minus exports (mass weight of exported goods).

Figure 4: Resource use per person, by country, 2000 and 2007 (Source: EEA, 2010)

Limitations of DMC measurement

Current material flow accounts only consider direct material flows and do not take into account indirect or hidden resource flows associated with used material extraction which do not enter the economy (such as overburden from mining operations, eroded soil or earthen materials displaced during construction). Hidden flows can be large and can moreover give rise to considerable environmental pressures. The increasing dependency on imported materials thus risks hiding increasing material flows and their associated environmental pressures and impacts taking place beyond the EU. In terms of weight, the EU imports over six times more materials than it exports, and this ratio is fairly stable. Considering how overall trade is growing, this means most Member States are increasingly consuming products for which the majority of the resource use has taken place elsewhere. In fact, Europe has the highest net imports of resources per person in the world. Thus, behind a significant part of the improved figures in EU material productivity lays the increasing dependency on import for which upstream flows, hidden flows, never enter the material flow accounts and the statistics of the EU. Pilot studies which quantify these upstream flows indicate that, for highly industrialised countries, the so called Raw Material Equivalents are three to six times larger than the direct import flows.

2.2. Global Stocks and Imports of Materials

Europe is highly dependent on imports for many raw materials which are increasingly affected by growing demand pressure from emerging economies and by an increasing number of national policy measures that disrupt the normal operation of global markets[188]. Import dependency holds for several minerals and metals. 95% of global 'rare earth' elements production is thought to be located in China, which has imposed export restrictions on of some of them. Likewise phosphate, an essential raw material in fertilizer and thus in agricultural production is only extracted in a limited number of countries: three quarters of total known world reserves are in China, with the rest coming from Morocco and the Western Sahara, and minor fractions from the US and South-Africa[189].

There is a particular concern about the availability of 14 minerals. Figure 5 depicts the economic importance and supply risk of 41 materials. The minerals in the upper-right quadrant are labelled as critical because their importance for the economy is high and they run the risk of supply shortage. An overview of the sources of these minerals, their producers, substitutability and recycling rate as well as the EU's import dependency rate[190] can be found in Figure 6.

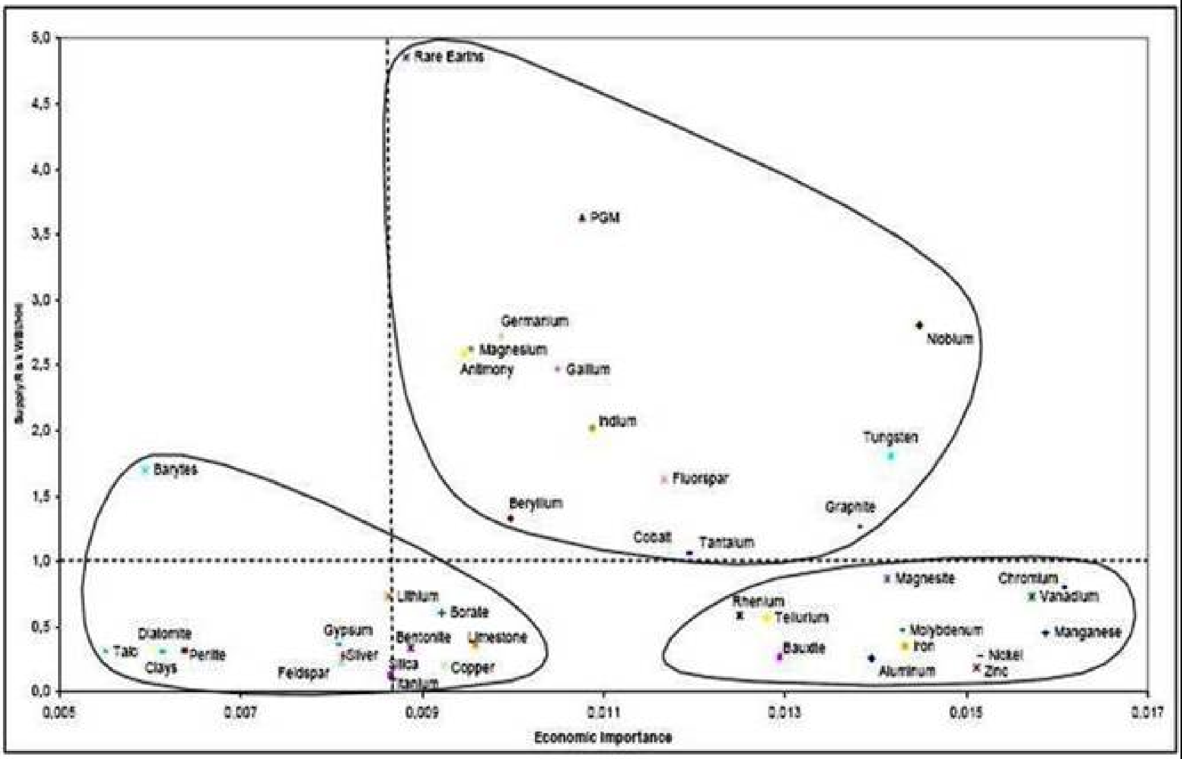


Figure 5: Economic importance and supply risk of 41 materials (Source: European Commission – DG Enterprise and Industry, 2010)

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188 European Commission – DG Enterprise and Industry, Critical raw materials for the EU, 2010

189 Netherlands Environmental Assessment Agency, Scarcity amidst a Sea of Plenty?, 2010

190 "Import dependence is calculated as “net imports / (net imports + production in EU)" European Commission – DG Enterprise and Industry, Critical raw materials for the EU, 2010

Raw materials	Main producers (2008, 2009)	Main sources of imports into EU (2007, or 2006)	Import dependency rate	Substitutability	Recycling rate
Antimony	China 91%	Bolivia 77%	100%	0,64	11%
	Bolivia 2%	China 15%			
	Russia 2%	Peru 6%			
	South Africa 2%				
Beryllium	USA 85%	USA, Canada, China, Brazil (*)	100%		
	China 14%				
	Mozambique 1%				
Cobalt	DRC 41%	DRC 71%	100%	0,9	16%
	Canada 11%	Russia 19%			
	Zambia 9%	Tanzania 5%			
Fluorspar	China 59%	China 27%	69%	0,9	0%
	Mexico 18%	South Africa 25%			
	Mongolia 6%	Mexico 24%			
Gallium	NA	USA, Russia (*)	(*)	0,74	0%
Germanium	China 72%	China 72%	100%	0,8	0%
	Russia 4%	USA 19%			
	USA 3%	Hong Kong 7%			
Graphite	China 72%	China 75%	95%	0,5	0%
	India 13%	Brazil 8%			NA
	Brazil 7%	Madagascar 3%			
		Canada 3%			
Indium	China 58%	China 81%	100%	0,9	0,30%
	Japan 11%	Hong Kong 4%			
	Korea 9%	USA 4%			
	Canada 9%	Singapore 4%			
Magnesium	China 56%	China 82%	100%	0,82	14%
	Turkey 12%	Israel 9%			
	Russia 7%	Norway 3%			
		Russia 3%			
Niobium	Brazil 92%	Brazil 84%	100%	0,7	11%
	Canada 7%	Canada 16%			
Platinum group metals	South Africa 79%	South Africa 60%	100%	0,75	35%
	Russia 11%	Russia 32%			
	Zimbabwe 3%	Norway 4%			
Rare earths	China 97%	China 90%	100%	0,87	1%
	India 2%	Russia 9%			
	Brazil 1%	Kazakhstan 1%			
Tantalum	Australia 48%	China 46%	100%	0,4	4%
	Brazil 16%	Japan 40%			
	Rwanda 9%	Kazakhstan 14%			
	DRC 9%				
Tungsten	China 78% (6,1)	Russia 76%	73%	0,77	37%
	Russia 5% (6,5)	Bolivia 7%			
	Canada 4%	Ruanda 13%			

(*) subject to strong fluctuations

Figure 6: Main producers, main sources of imports into EU-27, import dependency rate, substitutability and recycling rate (Source: Tackling the challenges in the commodity markets and on raw materials – European Commission, 2011)

Geological data on global metals stocks is scarce, and if available, it is only relevant when used to generate scenarios for the future, which include use intensity, discard, reuse, etc. Such data and scenarios are now beginning to appear[191]. From Figure 7 for example it can be seen that there are only scarcities for a couple of minerals that are defined as critical by the EU[192].

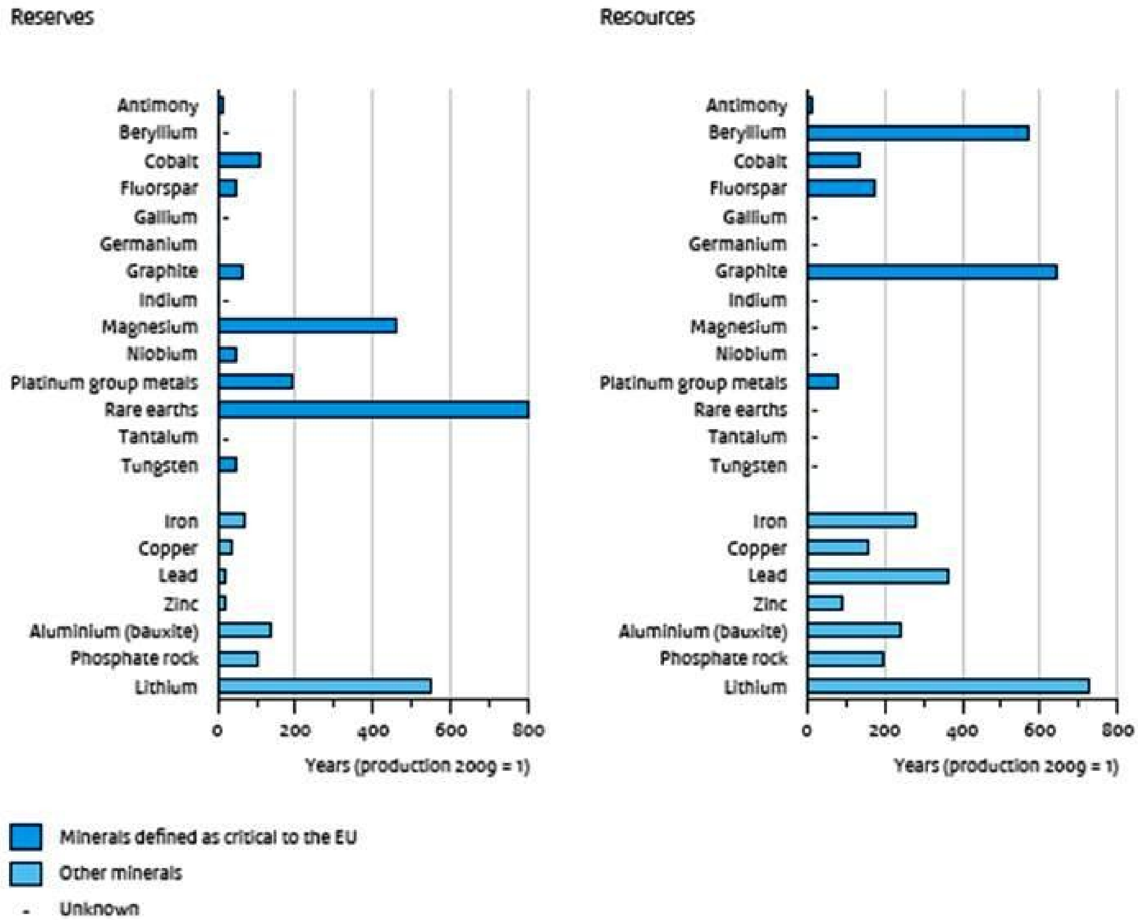

Figure 7: Global reserves and resources of minerals (2009) (Source: Dutch Environmental Assessment Agency, 2010)

2.3. Waste and recycling

In 2006, EU-27 Member States produced some 3 billion tonnes of waste – an average of 6 tonnes per person[193]. About two thirds (62 %) of the waste generated in EU-27 is mineral waste, stemming from construction and demolition activities (25-30 %) and from mining and quarrying 25 %. The rest is from manufacturing (12%), households (7%) and other activities[194]. Of all the resources consumed in the EU a significant part ends up as waste.

Recycling rates[195] are above 50% for 18 of 60 metals and the share of old scrap in the total flow is above 50% only for thirteen metals. End-of-life recycling rates are still globally low due to the relative abundance of primary material and due to the absence of performing collection and processing of old metals.

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191 International Resource Panel,, Metal Stocks in Society – Scientific Synthesis, 2010

192 Dutch Environmental Assessment Agency, Scarcities in a sea of plenty: Global resource scarcities and policies in the EU and the Netherlands, 2010

193 EEA, The European Environment – State and Outlook 2010: Synthesis, 2010

194 Staff Working Document with the Thematic strategy on the prevention and recycling of waste (2005)

195 Recycling Rates of Metals : A Status Report, International Resource Panel, 2011

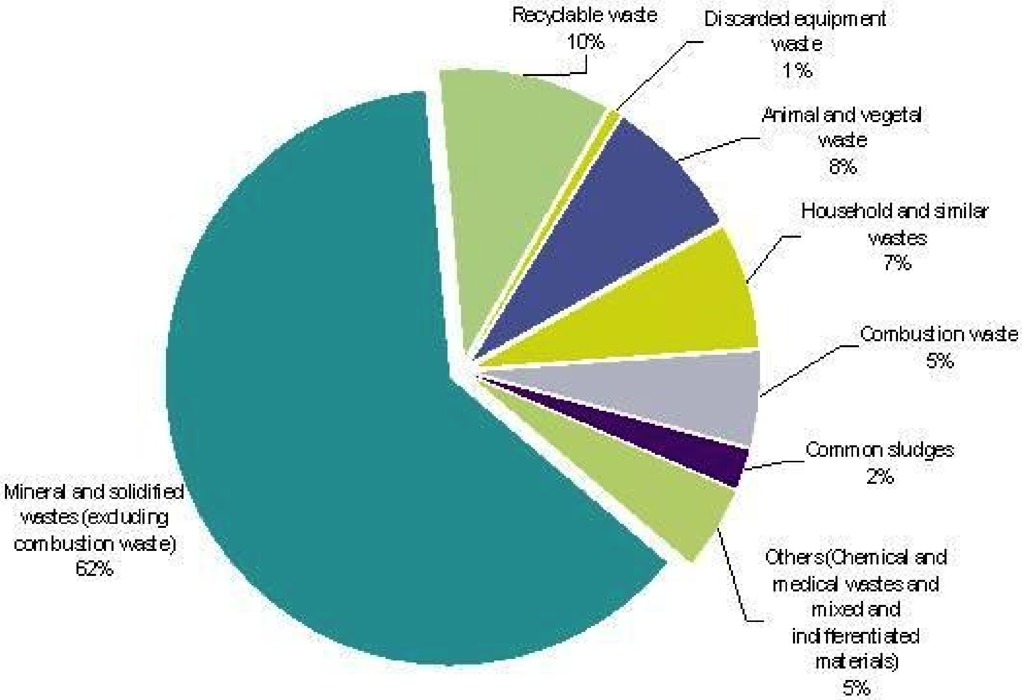

Figure 8: Composition of waste EU-27, 2006 (by weight) (Source: European Commission – Review of the thematic strategy on waste prevention and recycling, 2011)

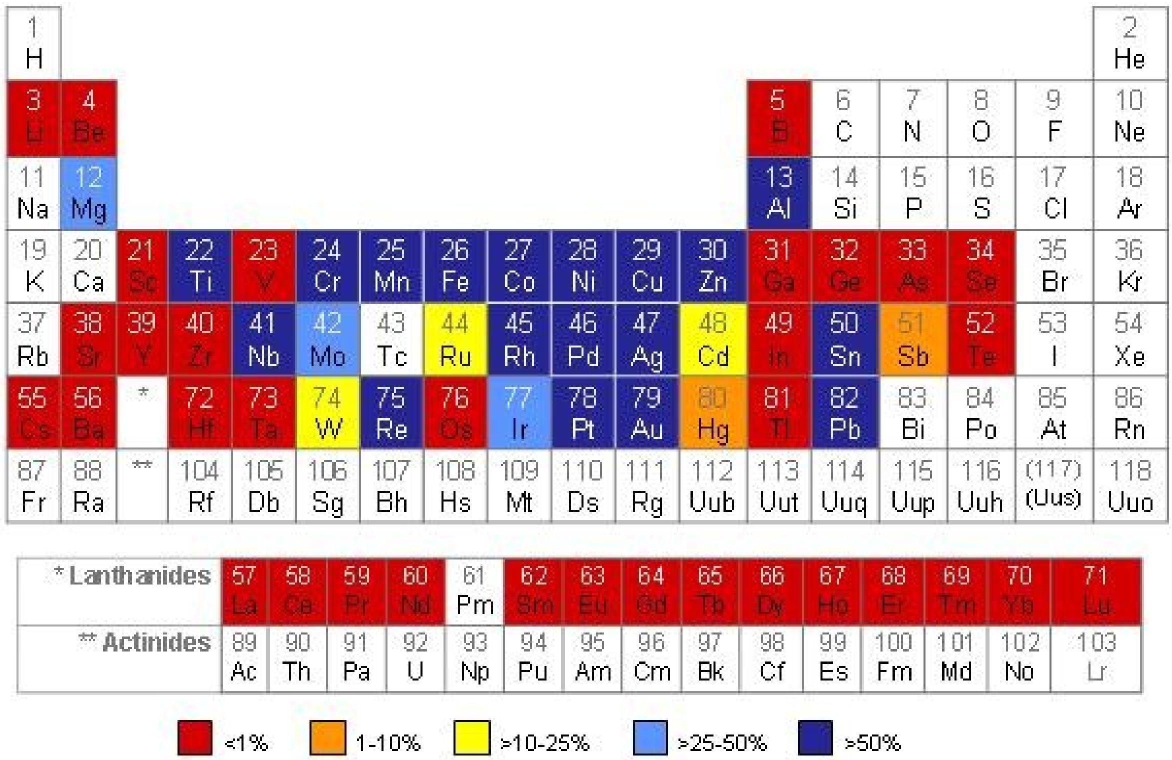

Figure 9: Average end-of-life functional recycling (Source: UNEP – International Resource Panel (2011)

3. KEY NATURAL RESOURCES

Resource efficiency policies build on a broad concept of resources, including not only raw materials but also environmental media such as air, water and soil, flow resources as well as space in the form of land area. Past trends in resource use have led to changes in the available stocks of resources, with very different results between resources and regions, depending on the nature of the resource and varying social and economic conditions.

3.1. Water

Water is a resource on which increasing stress has been observed in recent years, with an increasing number of severe draughts as well as floods. In both cases, climate change is projected to aggravate this even further.

As regards water quantitiy, a comparison of the impacts of draughts in the EU between 1976-1990 and 1991-2006 shows doubling in both areas and population affected. In many locations in Europe, water used by agriculture, industry, public water supply and tourism puts considerable stress on Europe's water resources, and demand often exceeds local availability[196]. Figure 10 shows the Water Exploitation Index (WEI) in the late 1980s / early 1990s (WEI-90) compared to the latest years available (1997-2005). The WEI is a measure of the annual total water abstraction as a percentage of available long-term freshwater resources. The warning threshold, which distinguishes a non-stressed from a water scarce region, is around 20%, with severe scarcity occurring where the WEI exceeds 40%[197].

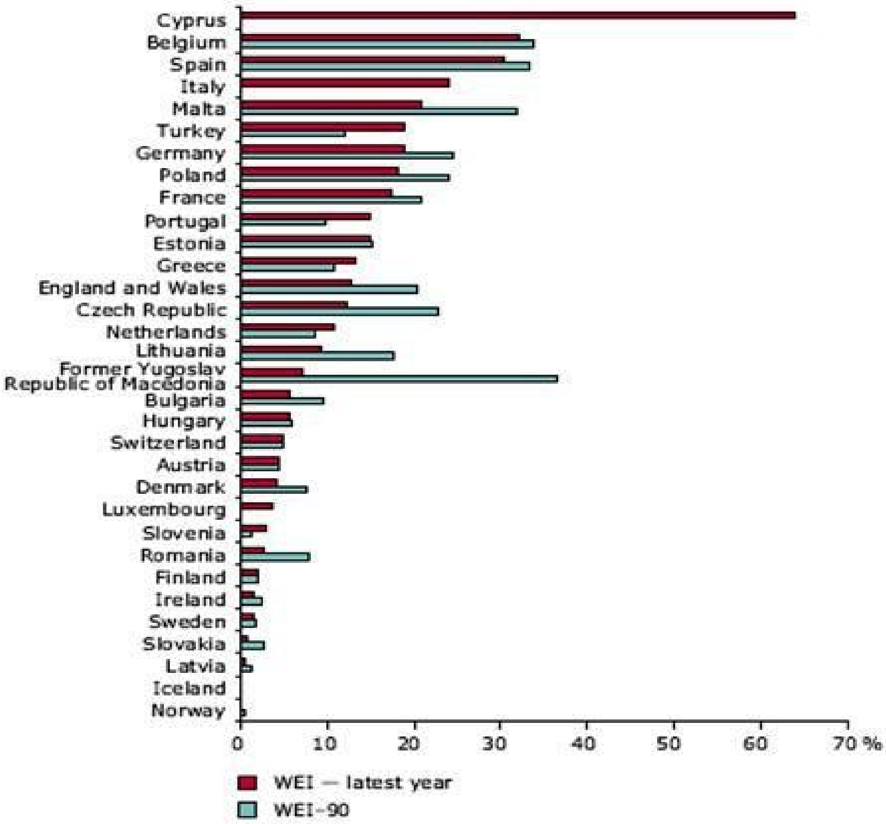

Figure 10: Water exploitation index (WEI)) in late 1980s / early 1990s (WEI-90) compared to latest years available (1997-2005) (Source: EEA, 2010)

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196 EEA, The European Environment – State and Outlook 2010: Synthesis, 2010

197 EEA, The European Environment – State and Outlook 2010: Synthesis, 2010

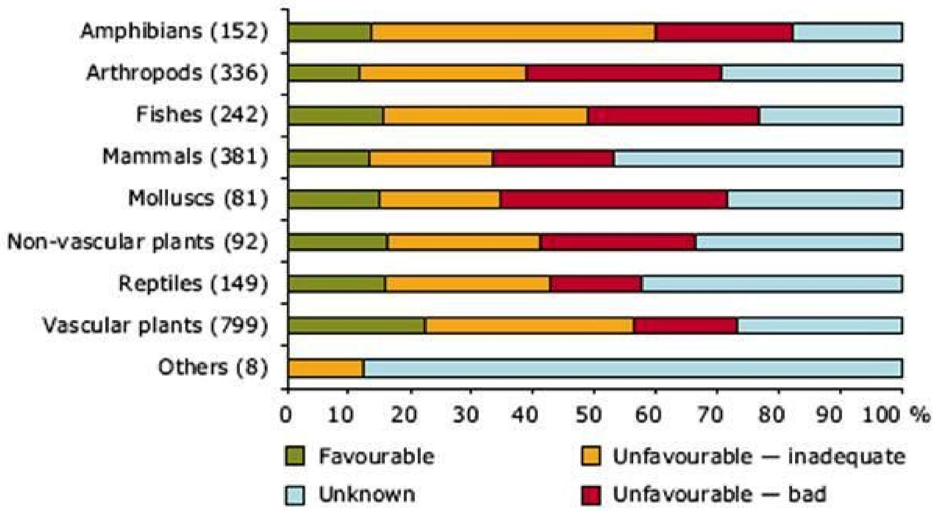
As regards water quality, despite improvements in some regions, pollution from agriculture remains a major pressure on Europe's freshwater with nitrogen and phosphorus being washed to waterways. Improved wastewater treatments and bans on phosphates in detergents have resulted in a decline of phosphorus levels in freshwater in recent years, but with this trend slowing down, diffuse sources need to be targeted for further improvements. Nitrate concentrations are also declining, but the situation in many rivers is often such that eutrophication is likely to occur in receiving costal waters with the subsequent depletion of oxygen and loss of life in bottom waters. Even with measures implemented to reduce this trend, measurement stations show no change in nitrogen and phosphorus concentrations in 85% and 80 % of the cases respectively. Oxygen depletion is particularly serious in the Baltic and Black seas.

Just as for material and land, many European countries have an important share of their water footprint (an indicator for direct and indirect water use) imported from wherever production takes place, causing potential water stress abroad.

3.2. Biodiversity

Changes in habitat impose the greatest impacts on species in Europe. With grassland and wetland in decline, urban sprawl and infrastructure fragmenting the landscape, only a small share of the forest being undisturbed and agro-ecosystems being characterised by agricultural intensification and abandoned land, biodiversity is affected negatively. Introducing biofuel crops may further worsen the situation. Monitoring the status and trends of biodiversity is a challenge and there are significant gaps in our understanding. As can be seen from Figure 11, detailed bio-geographical evaluations of the species listed in the EU Habitats Directive show a favourable conservation status for only 17 %, an unfavourable status for 52 % and an unknown status for 31 %. Linked to this, only 17 % of the assessments of the European habitat types were favourable[198].

Moreover, climate change has started to take its toll and is increasing the ecosystem vulnerability. Sea surface temperature changes in Europe's regional seas have been up to six times greater than in the global oceans in the past 25 years. This leads to changes in the composition of plankton and some fish species, with consequences on fishing opportunities.



Note: Number of assessments in brackets. Geographical coverage: EU except Bulgaria and Romania.

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198 EEA, The European Environment – State and Outlook 2010: Synthesis, 2010

Figure 11: Conservation status of species of Community interest in 2008 (Source: EEA, 2010)

3.3. Fish

Overfishing is threatening the viability of both European and global fish stocks. In 2010, 70 % of commercial stocks were fished above the maximum sustainable yield.

Looking at the biological viability of stocks, only 8 % and 11 % of coastal habitats and species, and 10 % and 2 % of marine habitats and species, respectively, are in favourable conservation status. The remaining majority either have unfavourable status or are un-assessed. Figure 12 shows the proportion of fish stocks within and outside safe biological limits – so at risk of collapse. 21 % of the assessed commercial stocks in the Baltic Sea are outside safe biological limits. For the areas of the North-East Atlantic, the percentages of stocks outside safe biological limits vary between 25 % in the Arctic East and 62 % in the Bay of Biscay. In the Mediterranean Sea, the percentage of stocks outside safe biological limits is about 60 %, with four out of six areas exceeding 60 %.

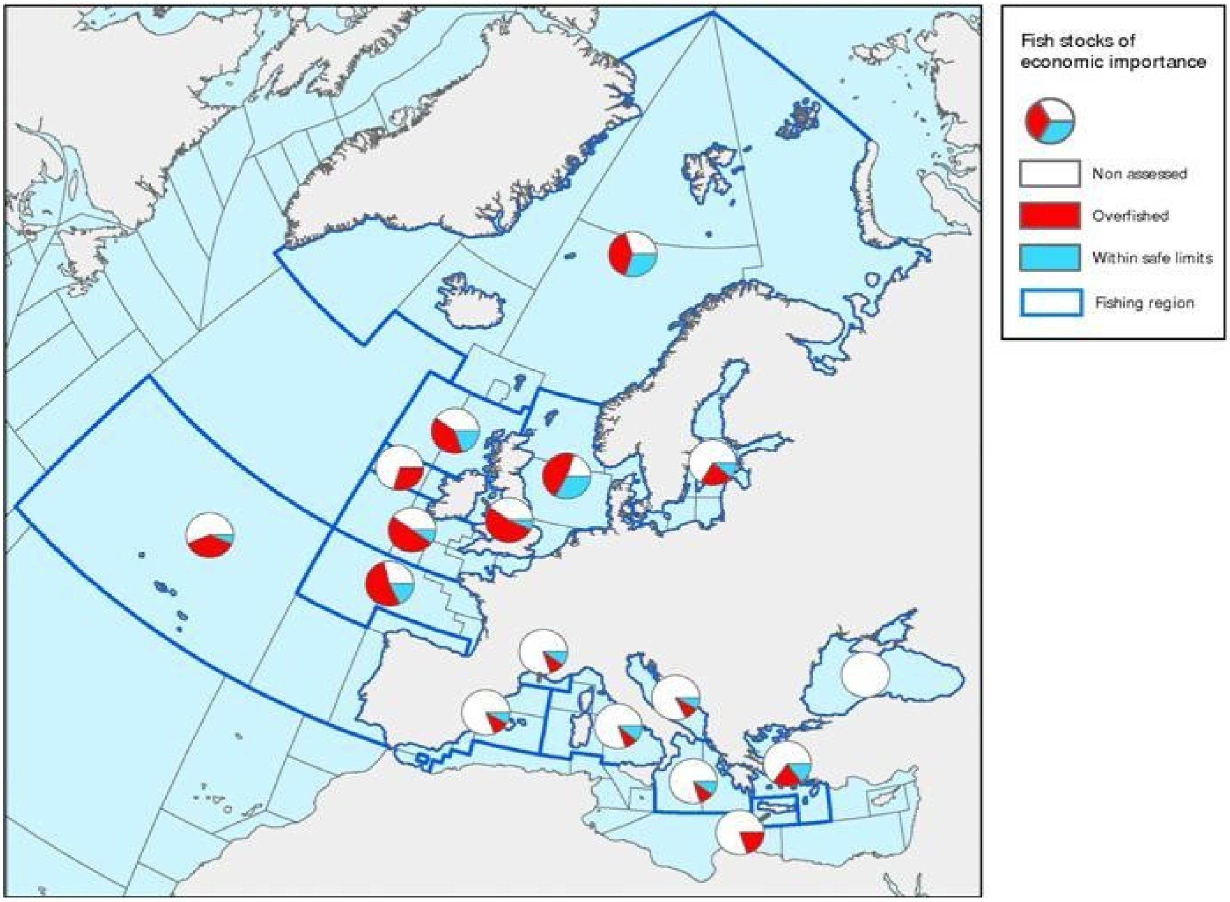

Figure 12: Status of commercial fish stocks in European Seas, 2003-2004 (Source: EEA, 2010)

At the global level the FAO (2007) reports that the proportion of over-exploited and depleted stocks has been rising during the last 40 years, e.g. from 10% in 1974 to 25% in 2005, although this trend has moderated in the last 10-15 years. Excess fishing pressure exerted on these stocks in the past leaves no possibilities in the short- or medium-term for further expansion, with an increased risk of further declines or even commercial extinction[199]. Figure 13 represents the status of world fish stocks in 2005.

[199] OECD, Environmental Outlook to 2030, 2008

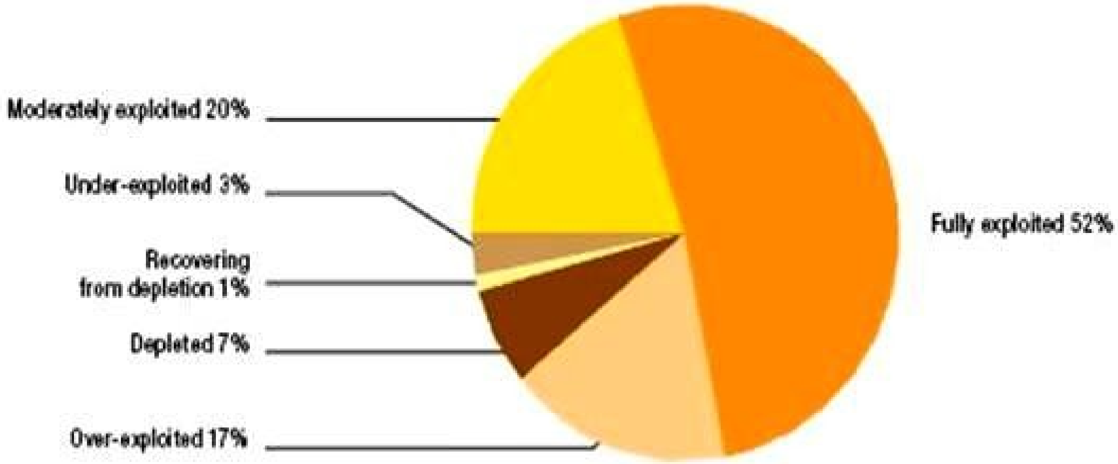

Figure 13: Status of world fish stocks (2005) (Source: FAO, 2007)

3.4. Land use

There has been a change in land-cover type on 1.3 % of the total land stock (68 353 km^2 of 5.42 million km^2) from 2000 to 2006 across 36 European countries. Although the rate of these changes has slowed down compared to the period 1990 to 2000, the trend of land use specialisation (urbanisation, agricultural intensification and abandonment, together with natural afforestation) is still very strong and is expected to continue.

The largest relative increase was of artificial surfaces: they grew with more than 3 % from 2000 to 2006, mainly due to conversions for economic sites and infrastructures. Internal conversion has been relatively large for forestry, but total forest area increased only slightly. It has been noted, however, that due to steadily growing demand for wood and wood products, the ratio of felling over net annual increment (utilisation rate) could temporarily increase in some European countries to over 100 %, causing a decline in growing stock after 2020. A temporary high utilisation rate is not necessarily unsustainable, but given that much of the forest is relatively old in many Member States, this could turn forests from a carbon sink into a temporary source. A high utilisation rate could however at the same time help decreasing instability of aging stands, reducing saturation effects in old forests and vulnerability to forest fires, storms and pests and, thereby, counteracting the risk that EU forests turn into a carbon source.

As in many other industrialised regions, the EU is experiencing a long-term trend of decline in agricultural areas, which are either reforested or developed as urban or infrastructure land. Arable land and permanent crops as well as pastures and mosaics decreased with 0.2 and 0.3 % respectively during 2000-2006. Although land change rate in Europe has slowed down since the 1990s, biodiversity-rich natural and semi-natural areas continue to decline, mainly due to conversion to forest but also because of intensification in agriculture.

Land use has impacts on climate with increasing releases of carbon dioxide when soils and natural vegetation are disturbed, which has direct impacts on biodiversity and ecosystem services. Unsustainable use of land is furthermore leading to increased soil degradation and thereby a loss of a fundamental resource. Several other factors with a negative impact on the soil quality and biodiversity are working in parallel; organic matter decline, compaction in agriculture, salinisation, contamination and sealing.

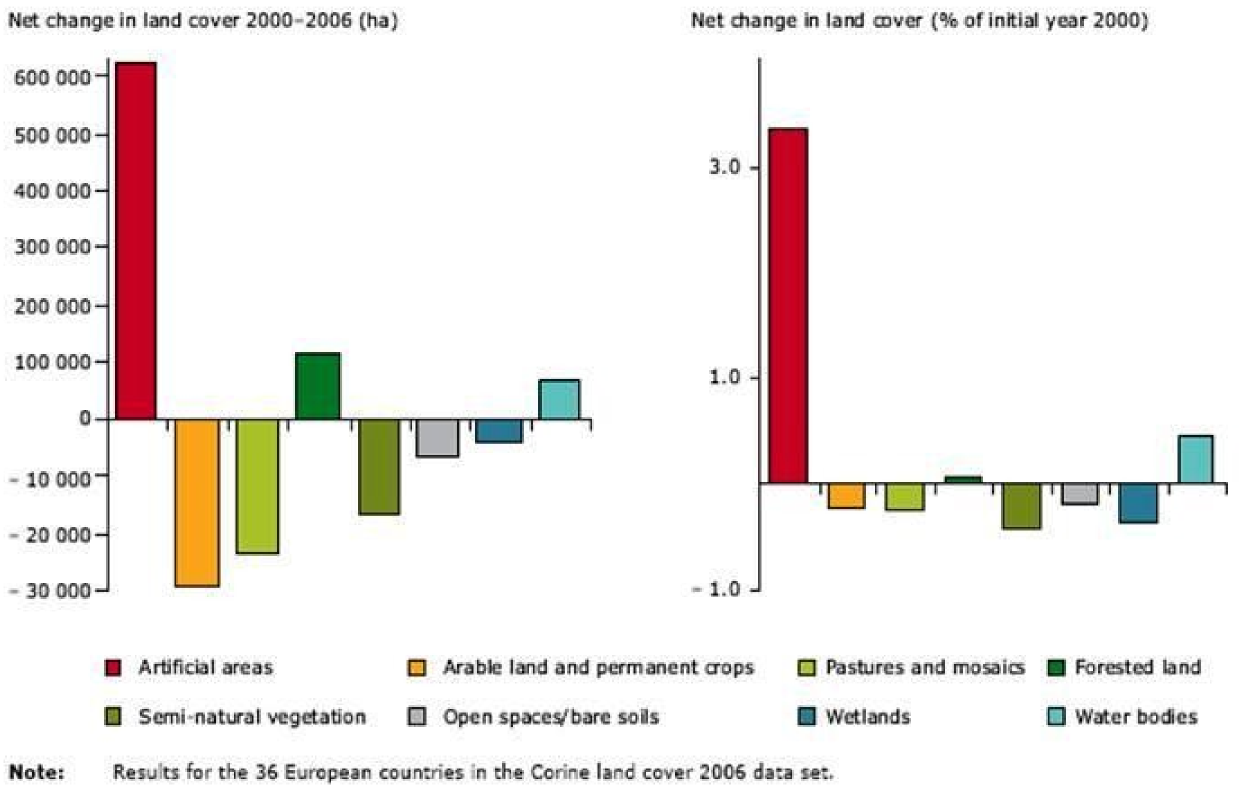

Figure 14: Net land-cover changes 2000–2006 in Europe: total area in hectares (left) and percentage change from 2000 (right) (Source: EEA, 2010)

3.5. Air

Air pollutants make their way to soil and water and thus deplete ecosystems and biodiversity. Major sources of air pollution are still the energy sector and road transport. Emissions of the main air pollutants in Europe have however declined significantly in recent decades. For example, in 2008 SOx emissions were 72 % below 1990 levels and emissions of particulate matter decreased by 13 % since 2000. Primarily SO_2 mitigation measures have succeeded in considerably reducing the ecosystems area affected by acidification.

However, in terms of controlling emissions, only 14 European countries expect to comply with all four pollutant-specific emission ceilings set under EU and international legislation for 2010. The limit for NOx is the most challenging, which 12 countries expect to exceed. This is e.g. reflected in the fact that nitrogen compounds, released as NOx and ammonia, are currently the main acidifying components. In addition, nitrogen contributes to nutrient oversupply in terrestrial as well as aquatic ecosystems, leading to changes in biodiversity. The area of sensitive ecosystems affected by excessive atmospheric nitrogen diminished only slightly between 1990 and 2010. Thus, despite major improvements, Europe still contributes significantly to global emissions of air pollutants and the complex links between emissions and ambient air quality moreover means that lower emissions have not always produced a corresponding drop in atmospheric concentrations.

4. INTERACTIONS BETWEEN RESOURCES

As described above, the use of resources for production and consumption not only impacts on the resource stock of the inputs, it drives impacts on other resources and their availability. For example:

- emissions from the use of fossil fuels lead to climate impacts that affect fish stocks, fresh water, soils and ecosystems;
- biomass use puts pressure on land and water resources and also contributes to climate change and biodiversity loss in ecosystems - any land-cover changes may have additional considerable effects on ecosystems;
- extraction of industrial minerals and ores uses significant amounts of fossil fuels and often releases toxins;
- transport and production of bulk construction materials (eg. cement) contribute to wastes and CO_2 emissions.

These interactions are taken into account by Life-Cycle Analysis of resources, products or services, where information on the impacts at different stages of the life-cycle from extraction to end-of-life/waste are brought together. The complexity of interactions and indirect effects makes it difficult to reach simple conclusions about direct linear causal links between resource input use (or product consumption) and inputs on other (eg. environmental) resources. This is possible for impacts directly related to global warming, acidification and health effects from fossil fuel consumption. But links get more complex the further consequent impacts are looked at (eg. consequent effects of the use of an extracted resource, or impacts on fresh water from climate change). There are 4 main reasons for this:

1) Each resource used has different impacts on other resources

The use of one resource has impacts of different strength on the other resources. Figure 15 indicates this. For example, oil use has a large impact on global warming and pollution damaging to health, but a relatively low impact on land use. The diagram shows the relative importance of the impacts of resources listed on the right viewed by certain metrics of impact. (It demonstrates that the mass of materials is not necessarily correlated to their impacts – so mass consumed is not always a good proxy for resource impacts.)

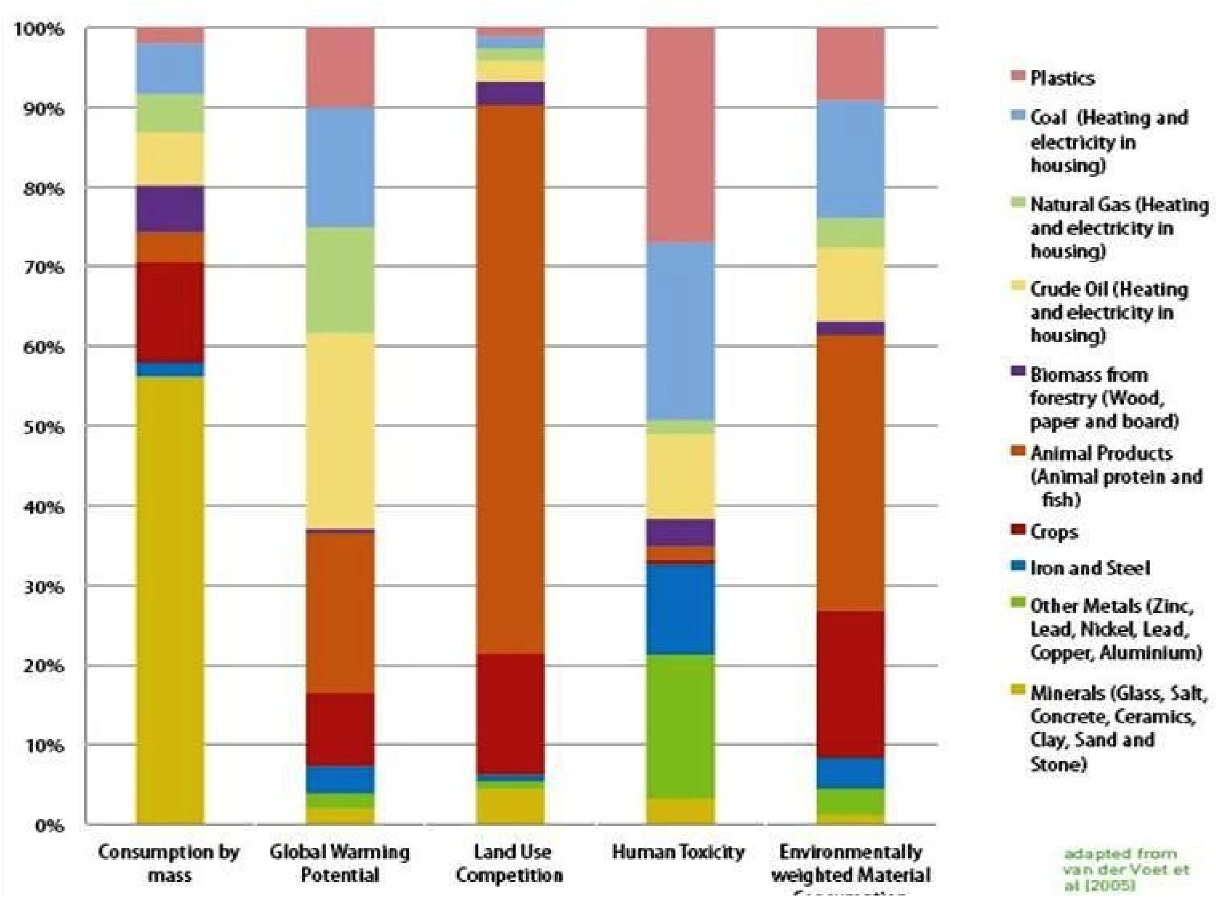

Figure 15: Environmental impact of materials (Source: International Resource Panel)

In the diagram, the left-hand column shows the impacts of resource use in the economy judged by mass, the next column the impacts of the same use of resources judged by impact on climate, the next on land, and the next on human health. The right hand column shows an amalgamated indicator of the impact of the use of resources on environmental resources as a whole.

2) Products are a combination of different resources, from different sources

Products made from many different materials have a correspondingly increased complexity of impacts.

In addition, resources can be used and produced in different ways or places that bring different impacts – for example a material can be produced with more or less material and energy efficient processes. Hydropower can be used for energy in one country, coal in another. The local geography (e.g. environmental vulnerability) also affects the impact a process can have.

Tracing impacts along supply chains is possible, but does require simplifications. This can be illustrated by Figure 16. Looking at only one resource – steel – it can be seen that products on the right are made from a mix of steels from various different processes. Considering that products are made up of many materials, each of which could come through various supply chains with different impacts, a complex product can have differing degrees of impact.

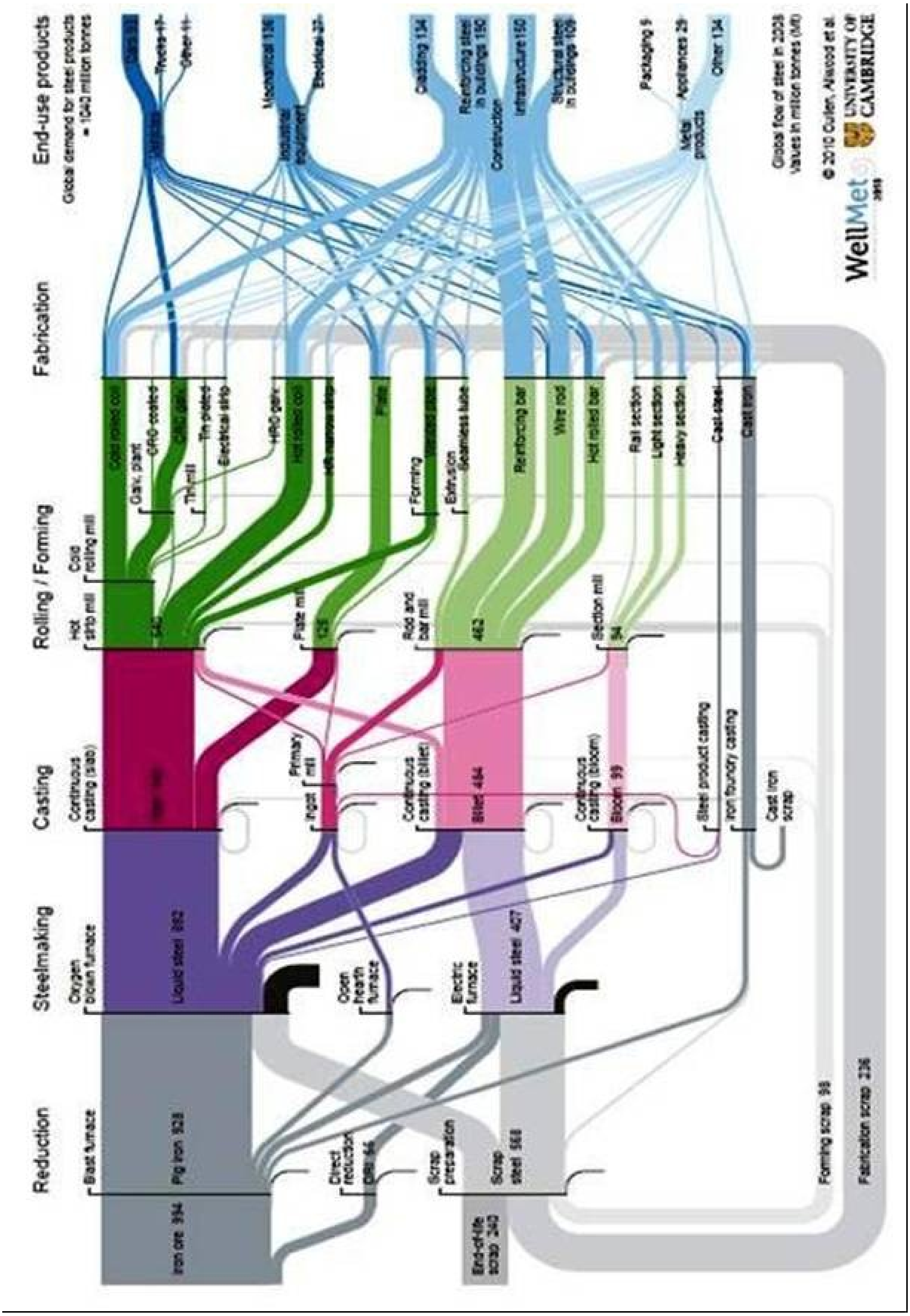

Figure 16: Global Steel Flows (Source: Cullen, Allwood et al., The efficient use of energy: Tracing the global flow of energy from fuel to service; Energy Policy38 (2010) 75–81

3) Including the full life-cycle: global impacts

Much of the EU resource base is now located outside the EU, with more than 20 % of resources used in Europe being imported. Often, only a relative minor part of the environmental pressures caused by consumption are emitted during the use phase, the majority is emitted during production, i.e. elsewhere in case of import. An important part of the impacts on resources from European consumption occurs in exporting regions. Although caused by European consumption, these pressures are less visible to European policy makers and will require different sets of measures than those that may have been adopted to tackle emissions from domestic production.

4) Aggregating trends in Resource Impacts

Given the complexity, it is not possible to present clear trends for the full impacts on environmental resources that use of natural resources inputs may have. This pushes the limits of scientific knowledge about indirect impacts, and resulting impacts of the combination of different pressures (on environmental systems, or health). This is an area needing more research to clarify the potential impacts.

However, sufficient attribution is possible to link certain consumption activities to major pressures on environmental resources. These areas are: eating and drinking, housing and infrastructure, and mobility.

It is also possible to create aggregate indicators that point to particular causes and important trends. Data for indicators such as EMC (environmentally-weighted material consumption) and EF (ecological footprint) exist, even though both are criticised for the methodological weaknesses mentioned. EMC data from 1992 to 2000 suggest that the impact on environmental resources in Europe has remained fairly constant per capita while it has decreased in relation to GDP, even though there are large differences across Member States.

EF data, which go back about 50 years, show the resources that are used expressed in global hectares per person. In the EU, EF has increased from 3.0 in 1961 to 4.7 in 2006. Such data allow us to identify the single largest contributor to eco-efficiency in Europe as the reduction in coal use. Investigations claim decoupled air emissions from growth in production with several related emissions either decreasing or remaining stable during times of continuous economic growth. A major reason for this decoupling was the shift towards a service-based economy. This again shows how apparent improvements in the EU may have been possible by increasing the pressure on environmental resources elsewhere. Few sources suggest that global impacts from Europe's resource use are going down.

5. DRIVERS

There are 3 key drivers of resource use: population, economic growth, and resource productivity, each of which will be described briefly below.

5.1. Global Trends and Drivers

Increasing materials use in the EU is part of a global trend. Figure 17 shows global material extraction for the period from 1900 to 2005 broken down by the four major material classes: biomass, fossil energy carriers, ores & industrial minerals and construction. Total material extraction has increased by a factor of 8. The strongest increase can be observed for construction minerals, which grew by a factor 34, ores & industrial minerals by a factor 27, and fossil energy carriers by a factor of 12. Biomass extraction increased 3.6 times[200].

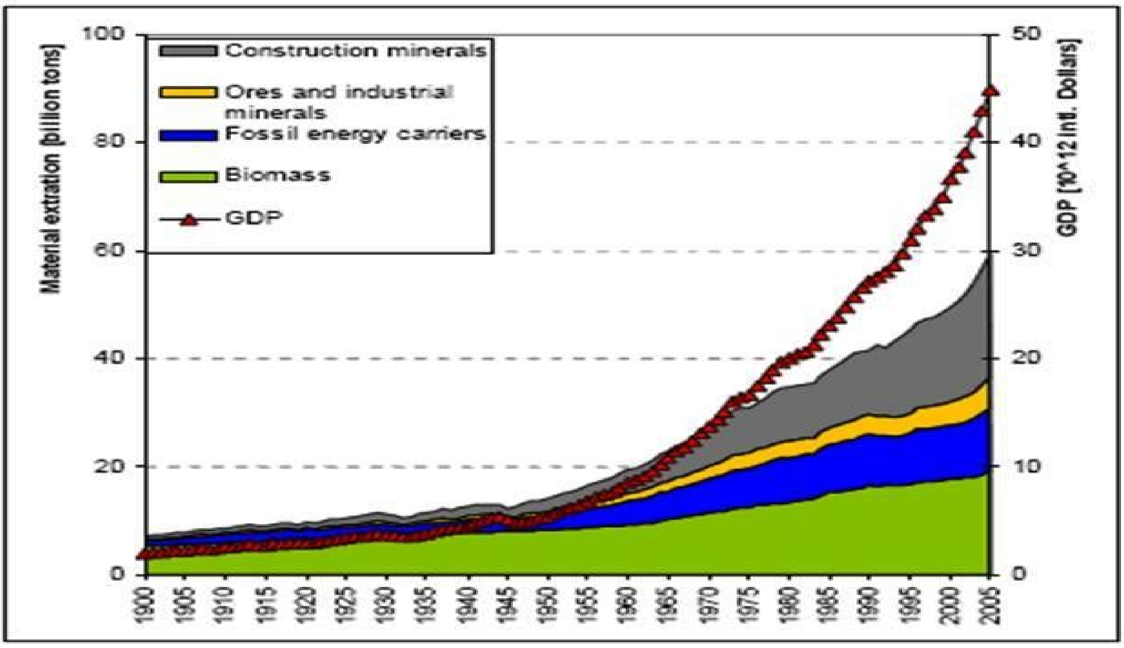

Figure 17: Global material extraction in billion tons, 1900-2005 (Source: Krausmann et al 2009)

5.2. Population Growth

During the 20th century, world population increased from 1.65 billion to 6 billion. The global population growth rate has fallen from its peak of 2 per cent per year to around 1.3 per cent today, but the annual growth in people is larger every year[201]. Figure 18 shows the evolution of world population during the last millennium. Figure 19 shows the evolution of EU-27 population.

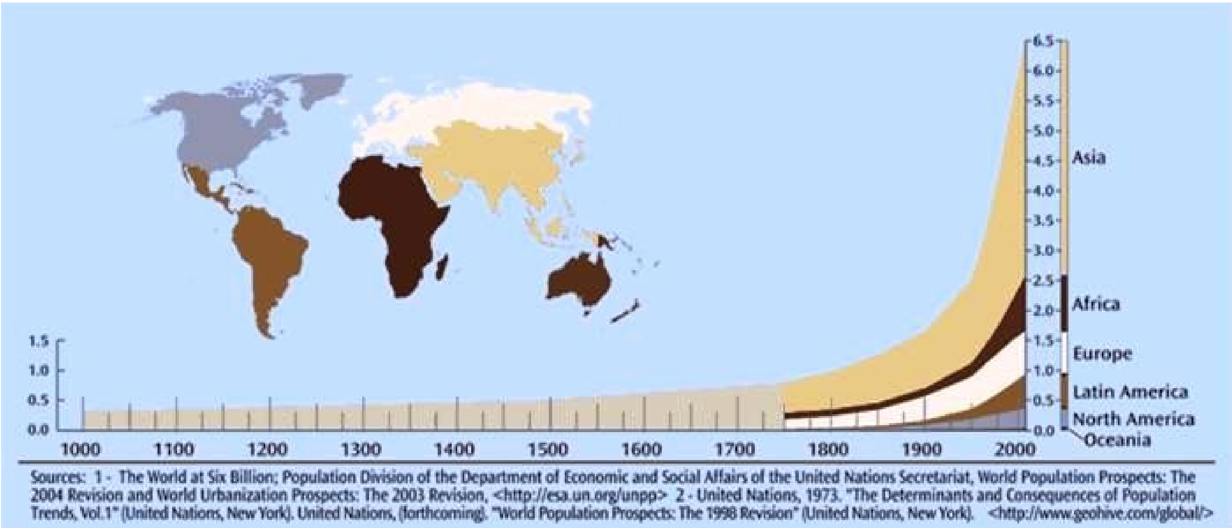

Figure 18: World population 1000-2000 (Source: http://www.theglobaleducationproject.org/earth/human-conditions.php)

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200 International Resource Panel, Decoupling the use of natural resources and environmental impacts from economic activity: Scoping the challenges, 2010

201 United Nations, The world at six billion, 1999

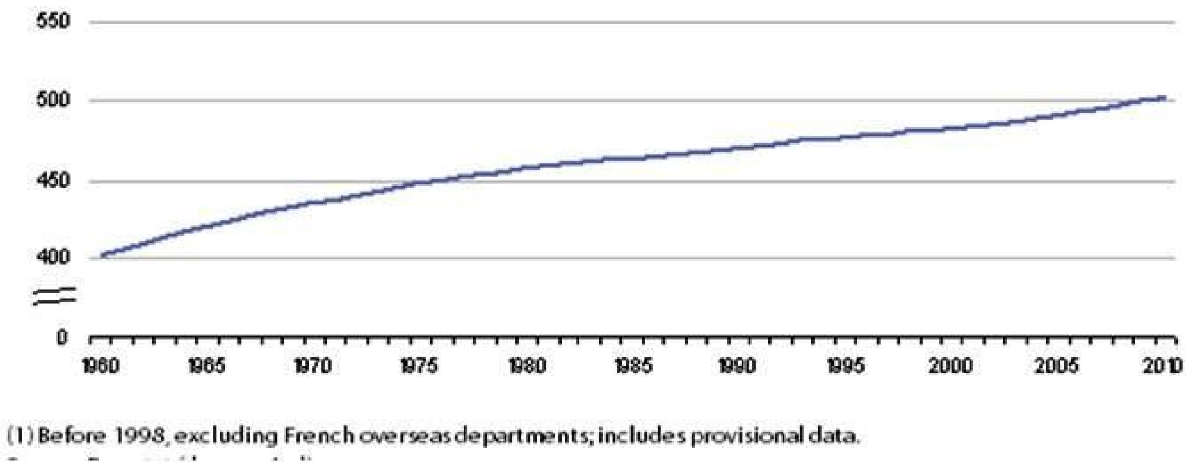

Figure 19: EU-27 population 1960-2010 (Source: Eurostat, 2011)

5.3. Economic Development

The world economy grew more in the last half century than at any time in the past. World GDP increased six–fold from 1950 to 1998 with an average growth of 3.9 per cent a year compared with 1.6 from 1820 to 1950, and 0.3 per cent from 1500 to 1820[202]. Figure 20 represents world GDP from 1960 until 2009, at current market prices.

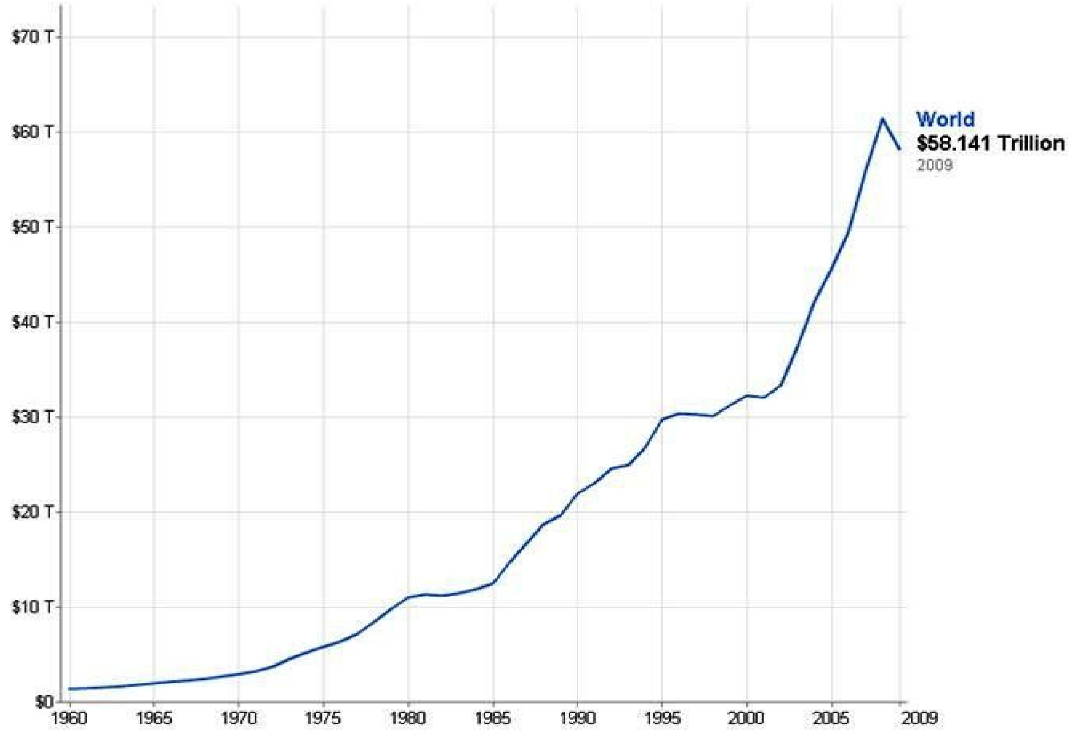

Figure 20: World GDP 1960-2009 at current market prices (left scale in units of $1.000 million) (Source: World Bank, 2009)

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202 OECD (A. Maddison), The World Economy: A millennial perspective, 2001

5.4. Productivity

European economies are creating more and more wealth from the resources that we use. Resource productivity in Europe has improved over the past two decades through the use of more eco-efficient technologies, the transition to service-based economies and an increased share of imports in EU economies[203]. Figure 21 shows the evolution of the growth in the productivity of labour, energy and materials from 1970 till 2008.

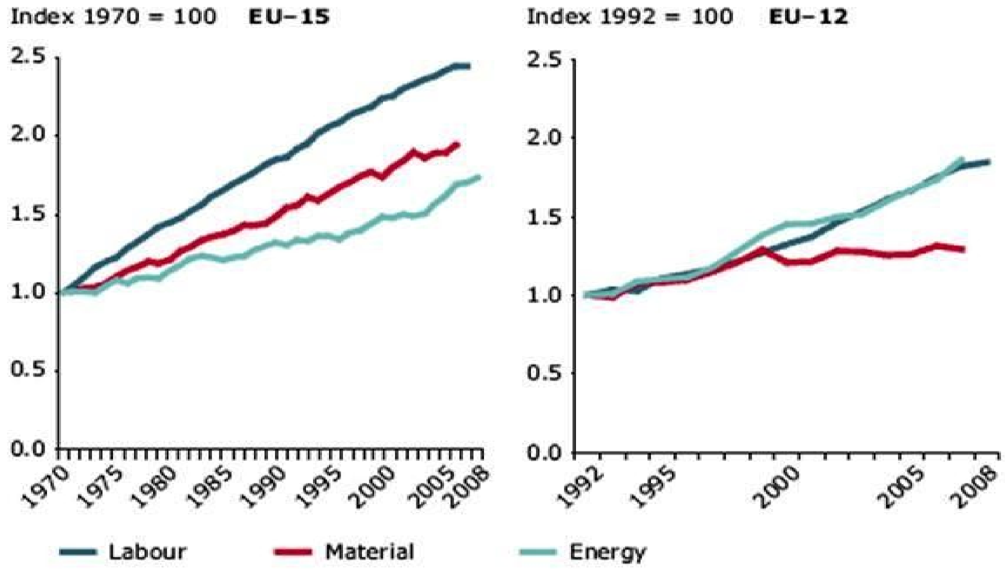

Figure 21: Growth in the productivity of labour, energy and materials in EU15 and EU12, 1970-2008 (Source: EEA, 2010)

203 EEA, The European Environment – State and Outlook 2010: Synthesis, 2010

Annex 8: Modelling for the Roadmap to a Resource Efficient Europe

1. EXISTING RESOURCE MODELLING – APPROACHES & TOOLS

The Communication on the Resource Efficiency Flagship introduced the ambition to: [...] *develop a set of tools to allow policy makers to drive forward and monitor progress. This will help build the clear support and involvement of national, regional and local authorities, stakeholders and citizens.*

A study was commissioned[204] to explore the possibility of developing a quantitative modelling framework that could be used to assess Resource Efficiency scenarios, and identify the policies needed. The study explored the different scenarios used by different sustainability exercises. It found that there are some aspects of the scenarios that cannot be quantified under the current knowledge base. However, the modelling capabilities to carry out the assessment exist and are reasonably well established.

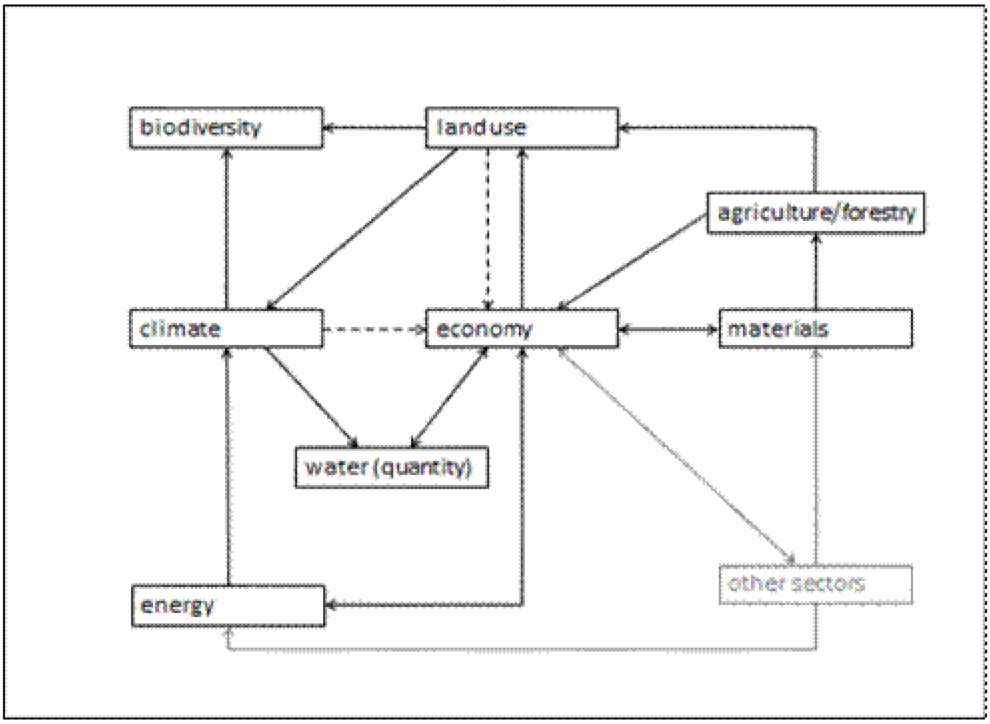

Figure 1: Overview of a Resource Efficiency Modelling Framework

Whilst for individual resources, there is often good modelling and data, the focus of future development should be to build on this and improve the linkages between resources within a single modelling framework (see Figure 1). Whilst there is already some modelling of interlinkages, this is the weak point of existing efforts. The new framework should cover both: the key linkages between different types of resources like materials, energy and climate, fresh water and land use, soil and biodiversity but also the link between the economy and the environment. The study concluded with **four recommendations**:

204 Cambridge Econometrics, Wuppertal Institute and SERI (2011). Sustainability Scenarios for a Resource Efficient Europe. Forthcoming, will be available at: http://ec.europa.eu/environment/enveco/studies.htm

(1) economic models should include materials by default;

(2) economic models should develop a modular framework to provide better detail of key sectors;

(3) a common interface should be developed for linking models;

(4) some further research is needed to deepen the understanding of the linkages from environment to economy.

As regards **including materials in economic models**, two macroeconomic models, E3ME and GINFORS, already include a treatment of material demands. Although both these models are econometric in structure, there is no reason that this development could not also be brought into Computable General Equilibrium (CGE) models.

2. DEVELOPING A NEW MODELLING FRAMEWORK

If a new modelling framework is to be developed along the lines set out above, then this is easiest to do if there is ***a methodology that is clearly documented and is generally adopted by model developers, with the underlying assumptions explored to provide good data***. The challenge is partially one of dissemination. There are 3 particular aspects to tackle:

1) To develop a modular framework for economic models: Previous examples of model linkages have been based on a modular approach, but this has not usually been generalised to a position where modules can easily be added or removed for a particular assessment. The academic literature has increasingly been moving in this direction although putting the recommendations into practice has in general been less successful.

This could be the subject of a research project, but the focus of the work and the research outputs must be on the methodology used rather than the results for particular scenarios. If these outputs defined a standard modular framework, other models could be adapted on this basis.

2) To design a common interface for linking models, there are some general principles that must be adhered to if the interface is to be widely accepted and used. For example:

– A system must be flexible so that different types of models can use it.
– The requirements of model operators from different backgrounds must be taken into account.
– Issues of differences between models in spatial and sectoral disaggregation and time steps should be addressed.

3) Understanding linkages from environment to economy. Work in this area is already going on for key linkages and involves determining the key sectors / regions where these occur, and then quantifying the linkages.

3. MODELLING EU RESOURCE EFFICIENCY

3.1. An Example of an integrated modelling of resource efficiency

There is already some modelling of complex resource efficiency questions. An example is modelling by PBL for the Commission[205], employing a suite of models that have also been used for the modelling associated with the OECD Environmental Outlook and OECD's Green Growth work. The study explores the implications of resource efficiency for five resource themes: energy, land, phosphorus, fresh water, and fish stocks.

The results of the study provide a global, model-based analysis of the impacts of current and projected resource use up to 2050, in the assumed absence of any additional, targeted policies.

The study provides evidence of the biophysical potential for boosting resource efficiency, in different contexts of global and EU coordinated action. It concludes that there is substantial potential to improve efficiency in the use of the resources analysed, compared to current policy. As examples of outputs, it illustrates that:

- Global energy use could be reduced by over 30% in 2050 (see figure 2), compared to policies continued in line with that envisaged by the EU. As a result, this would halve the gap between baseline greenhouse gas emissions and the 450 ppm CO2-eq mitigation scenario. It would require accelerated adoption of best available technologies in industry, new buildings, household appliances, power and transport sectors, but without major changes in consumer habits.
- Net global agricultural expansion between 2010 and 2050 can be halted, with expansion in Africa reduced by half.
- Global fertilizer phosphorus use from primary sources can be reduced by 18%, as compared to currently envisaged policies; total global phosphorus demand could reduce an additional 8% by banning its use in detergents.
- Water withdrawals can be reduced by 25%.
- Fish stocks can be recovered, and marine biodiversity improved, sustaining higher catches in the long-term.

[205] PBL (2011). EU Resource Efficiency Perspectives in a Global Context: A fast track analysis. Forthcoming, will be available at: http://ec.europa.eu/environment/enveco/studies.htm