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# Earnings, jobs and innovation: the role of recycling in a green economy

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# Acknowledgements

This report is based on a technical report prepared by the European Topic Centre on Sustainable Consumption and Production (ETC/SCP, 2011) for the European Environment Agency (EEA).

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# Key messages

The EU has introduced a variety of policies to increase recycling in the last 15 years. These include specific recycling targets for the waste materials and products in electrical and electronic equipment, end of life vehicles, packaging, batteries, household waste, and construction and demolition waste. Similarly, the Landfill Directive (EU, 1999) set targets for diverting waste away from landfills to either recycling or recovery. And the environmental requirements on landfills and incineration plants have been tightened, making these waste management options more expensive, and recycling more competitive.

These EU initiatives were primarily taken for environmental reasons. Recycling benefits the environment by diverting waste away from landfill, thereby avoiding pollutant emissions. It also helps meet the material demands of economic production, preventing the environmental impacts associated with extracting and refining virgin materials.

At the same time, promoting recycling offers other important economic and social benefits: generating economic growth, fostering innovation, boosting employment, and helping secure access to critical resources. Taken together, these characteristics mean that recycling has an essential role to play in achieving a major European and global policy priority: the shift to a green economy that generates prosperity while maintaining a healthy environment and social equity for current and future generations.

This short report explains the role of recycling in the green economy and examines the evidence of its contribution in Europe, focusing primarily on the economic benefits that recycling offers. The key findings are as follows:

- **Revenues from recycling are substantial and growing fast**. From 2004 to 2008 the turnover of seven main categories of recyclables increased by almost 100 %, to a minimum of EUR 60 billion. Due to the economic downturn the turnover of recycling declined sharply at the end of 2008 and in the first half of 2009 but seems to have recovered markedly since then.
- **Booming Asian economies and EU directives have boosted European recycling**. One driver for the increasing economic importance of recycling is the globally growing demand for materials, especially in booming Asian economies. But in addition to rising unit prices for metal and plastic waste until 2008 another important factor is the increasing amount of recyclables sorted and placed on the market. EU waste directives have contributed by creating obligations to recycle or recover increasing percentages of waste, and discouraging landfilling.
- **Recycling creates more jobs at higher income levels than landfilling or incinerating waste**. The overall employment related to the recycling of materials in European countries has increased steadily from 422 per million inhabitants in 2000 to 611 in 2007. This represents an increase of 45 % between 2000 and 2007, corresponding to an annual increase of 7 %.
- **Recycling can meet a large proportion of the economy's demand for resources, alleviating pressure on ecosystems to provide resources and assimilate waste**. Already recycling meets substantial proportions of demand for some resource groups, notably paper and cardboard, and iron and steel.
- **However, even maximum recycling cannot cover all EU demand for resources**. This is due to the accumulation of goods in a growing EU economy, for example in the construction sector, which acts as a long-term store for materials, making them unavailable for recycling for many years. Recycled plastics and waste from electronic and electrical equipment provide the lowest coverage of demand both currently and in a maximum recycling scenario. Increasing recycling can help create a resource secure economy but we need to accept that economic growth driven by ever increasing material consumption is unsustainable.

- **Recycling is particularly valuable in securing supplies of critical resources**. Recycling of rare metals is essential for the EU to pioneer new technologies, particularly in areas such as e-mobility, information and communication technologies and renewable energy. However, rare and precious metals are characterised by dissipative use, meaning that they are used in small amounts in a multitude of applications and products. The existing recycling infrastructure has not yet focused on this problem, meaning that many of these metals are lost. More analysis is therefore needed of rare metals (for example in WEEE) and possibilities to recycle them.

## Opportunities to support recycling and the green economy

Today three of the most important challenges facing Europe are reducing environmental burdens, creating new jobs and enhancing the resource base for the economy. Recycling can make a substantial contribution to addressing all three challenges, offering a win-win-win opportunity.

Decision-makers across society have clear opportunities to enhance recycling in the EU and thereby help create a green economy in Europe by:

- supporting demand for recyclables in industry within and outside the EU;
- ensuring that recyclable material is separated from waste for disposal and the quality of recyclables is improved because this increases the value of the recyclable waste material;
- improving product design to facilitate material separation;
- integrating the recycling of rare and precious metals into the existing recycling infrastructure, developing new recycling technologies and stimulating research on substitutes for these metals;
- phasing out landfilling for recyclable materials;
- building up recycling infrastructure and markets where they do not exist.

The development of recycling over the last decade is an interesting example of market forces and legislative demands working together to produce positive results. This integrated approach should be further strengthened within an EU sustainable raw material management strategy. Measures are also needed to broaden understanding of the role of recycling in realising a green economy in the EU and worldwide.

# 1 Recycling and the green economy

- A green economy balances economic goals with a focus on social equity and maintaining environmental systems.
- Recycling contributes to a green economy in numerous ways, including enhancing resource efficiency, reducing environmental impacts from raw material extraction, generating jobs and business opportunities and ensuring secure supplies of essential resources.
- Recycling also represents a key means of implementing the EU's Europe 2020 strategy, particularly the flagship initiative on shifting to a resource-efficient, low-carbon economy to achieve sustainable growth.

## 1.1 The green economy and the economic downturn

In recent years, the term 'green economy' has emerged in the context of policy discussions on recovering from the global economic downturn in 2008. The precise meaning of the term (and related concepts such as 'green growth' and 'green new deal') has been a matter for debate. However, the United Nations Environment Programme (UNEP) has recently helped structure and inform discussions by elaborating a working definition. According to UNEP (2011a):

> *A green economy is one that* ***results in improved human wellbeing*** *and* ***social equity****, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is* ***low carbon, resource efficient and socially inclusive****.*
>
> *In a green economy,* ***growth in income and employment*** *should be driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services. These investments need to be catalysed and supported by* ***targeted public expenditure, policy reforms and regulation changes****.*
>
> *The development path should maintain, enhance and, where necessary,* ***rebuild natural capital*** *as a critical economic asset and as a source of public benefits,* ***especially for poor people*** *whose livelihoods and security depend on nature.*

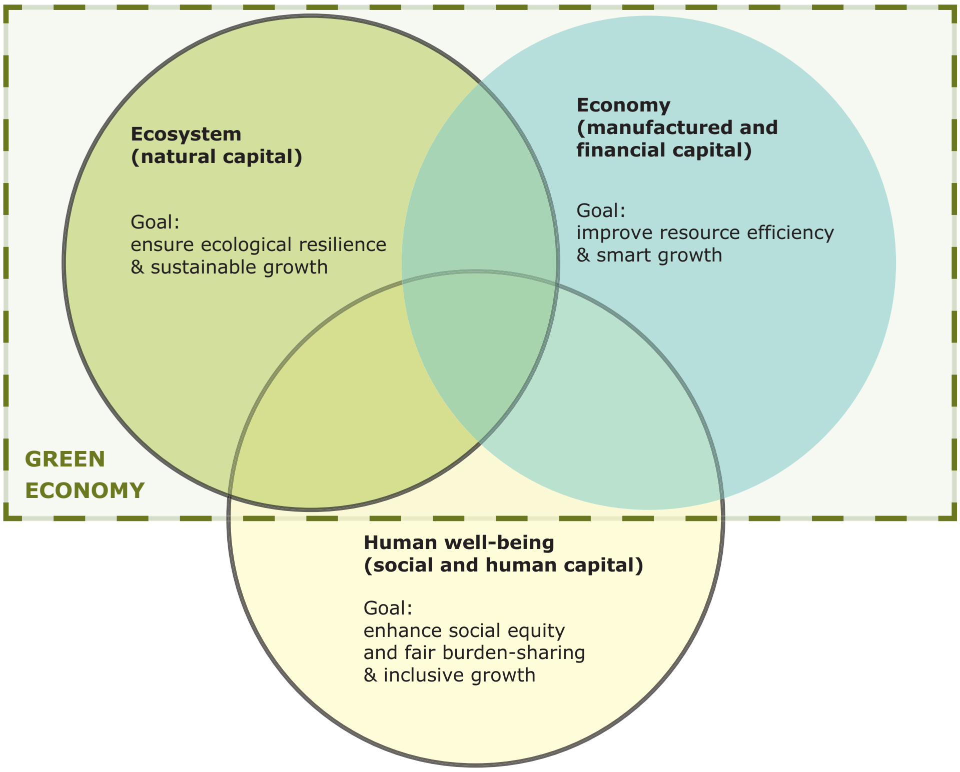
In the EU, the European Commission's response to the economic crisis includes the Europe 2020 strategy for smart, sustainable and inclusive growth (European Commission, 2010a). The strategy's links to the green economy concept are numerous, although arguably most evident in its 'Resource-efficient Europe flagship initiative', which aims to support the shift towards a resource-efficient, low-carbon economy to achieve sustainable growth (European Commission, 2011).

Despite the recent surge in interest, however, it is clear that 'green economy' is not an entirely new concept. The terms 'green economy', 'sustainable economy', 'green growth' and 'sustainable growth' started to appear in policy discourse at around the same time as 'sustainable development' — in the IUCN's World Conservation Strategy (IUCN, 1980), the Brundtland Report (WCED, 1987) and at the Earth Summit in Rio de Janeiro (1992).

In some of the earlier studies, the term 'green economy' was used as a synonym for sustainable development and as UNEP's definition above makes clear, the links are abundant. A green economy balances economic goals with a focus on social equity and maintaining environmental systems. It also recognises that an economy's potential to generate incomes is largely determined by various forms of capital, including (most fundamentally) natural capital — ecosystems that deliver a huge array of enormously valuable goods and services, if they are properly maintained (Figure 1.1).

An essential element in the green economy concept is the necessity of reflecting the environment's value in economic decision-making. Market prices can often provide misleading signals about the environmental and social impacts of economic activities, leading to systems of production and consumption that fail to maximise the wellbeing

**Figure 1.1 The 'green economy' concept in the context of sustainable development**




of current and future generations. Governments therefore have an important role to play in correcting incentives and helping shape socially optimal outcomes. An important aspect of this is catalysing a shift to a circular economy (in which waste is recognised as a valuable resource), thereby increasing resource efficiency and reducing the environmental impacts resulting from extracting raw materials and generating waste.

Policy documents from the last two decades indicate that different levels of government have recognised these goals. In the EU, the Lisbon Strategy aimed to make the EU 'the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion' by 2010 (European Council, 2000). In 2001 the Stockholm European Council decided that the EU sustainable development strategy should complete and build on the political commitment in the Lisbon Strategy by including an environmental dimension. The sustainable development strategy recognises that in the long term, economic growth, social cohesion and environmental protection must go hand in hand (European Commission, 2001).

The complementary nature of the EU's sustainable development strategy and its Lisbon Strategy has been highlighted in, for example, the Thematic strategy on the sustainable use of natural resources (European Commission, 2005) and the Renewed EU sustainable development strategy in 2006 (European Council, 2006).

## 1.2 Recycling's role in a green economy

In general, the definitions of the green economy proposed over the last two decades are strikingly similar. Key elements include:

- internalising externalities;
- improving material and energy efficiency and ultimately decoupling material and energy use from economic growth;
- shifting from a linear economy to a circular economy;
- shifting from non-renewable to renewable resources.

As described in more detail in subsequent chapters, recycling contributes in several ways to each of these four principles.

- As a promising eco-industry sub-sector ([1]), recycling is increasingly important for the European economy, contributing to total economic output (GDP) and Europe's internal and overseas trade.
- The growing recycling industry also helps to generate 'green jobs'.
- A large part of recycling is closely linked to non-renewable resources, above all metals. As such, recycling helps reduce virgin non-renewable resource use, directly helping decouple material use from economic growth.
- Recycling could help ensure that the EU has secure supplies of critical resources, especially rare metals. These are essential for producing a wide range of products and emerging technologies, notably renewable energy resources such as wind turbines and solar panels.
- Already, recycling of waste streams covers a reasonably large part of EU consumption of certain materials.
- Numerous opportunities exist for eco-innovation and development of new technologies in the recycling sector, potentially creating markets for new products and services.
- Recycling ensures that resources remain in the economy via a closed-loop process. It contributes to a shift to a circular economy and away from a linear economy model characterised by resource depletion and waste.
- In most cases recycling has lower environmental impacts compared to producing virgin materials. As such, recycling is ranked third in the waste hierarchy: it is less desirable than preventing and reusing waste but preferable to energy recovery and disposal.
- Recycling helps businesses, other organisations and communities avoid the costs associated with landfills and incinerators — both in terms of financial expenditures and environmental impacts.

The importance of recycling has been reiterated in a range of EU documents in recent years. For example, the European Commission's Action Plan on Sustainable Production and Consumption and Sustainable Industry (European Commission, 2008a) states the need to reduce dependence on raw materials and encourage optimal resource use and recycling. The Commission's 2008 communication on the Raw Material Initiative (European Commission, 2008b) likewise highlights recycling as an important measure to enhance sustainable supply of raw materials.

Most recently, the European Council has underlined the need to focus on 'steering the market towards recycling and waste reduction and recycling certificates' (European Council, 2010). Furthermore, many European countries have placed recycling at the heart of their policies to increase resource efficiency (EEA, 2011).

([1]) Ecorys (2009) specifies that the eco-industry comprises the following 10 sub-sectors: air pollution; biodiversity; noise and vibration; others; recycled materials; renewable energy; soil and groundwater; waste management; wastewater management; and water supply.

# 2 Recycling's economic importance in Europe

- The turnover of seven core groups of recyclables almost doubled from 2004 to 2008.
- European exports of recyclables are increasing due to the booming Asian economy, increased supply of recyclables in the market and implementation of EU waste directives.
- Recycling generates more jobs at higher income levels than other forms of waste management.
- EU employment related to the recycling of materials increased by 45 % between 2000 and 2007 — the second largest increase of all eco-industry sub-sectors.

## 2.1 Recycling sector turnover

While the environmental benefits of recycling are widely recognised, recycling's economic importance is less well known. By turning waste into valuable raw materials, recycling creates jobs, builds more competitive manufacturing industries and adds significantly to the European economy.

The recycling sector is growing and developing but it is currently dominated by seven core groups of materials:

- glass
- paper and cardboard
- plastic
- iron and steel
- copper, aluminium and nickel
- precious metals
- other metals

As shown in Figure 2.1, turnover of the seven recyclables almost doubled in current prices from EUR 32.5 billion in 2004 to EUR 60.3 billion in 2008. While the economic value of all recyclables increased, this trend is especially notable for metals. The economic downturn initially prompted a decline in turnover but it recovered significantly in the second half of 2009.

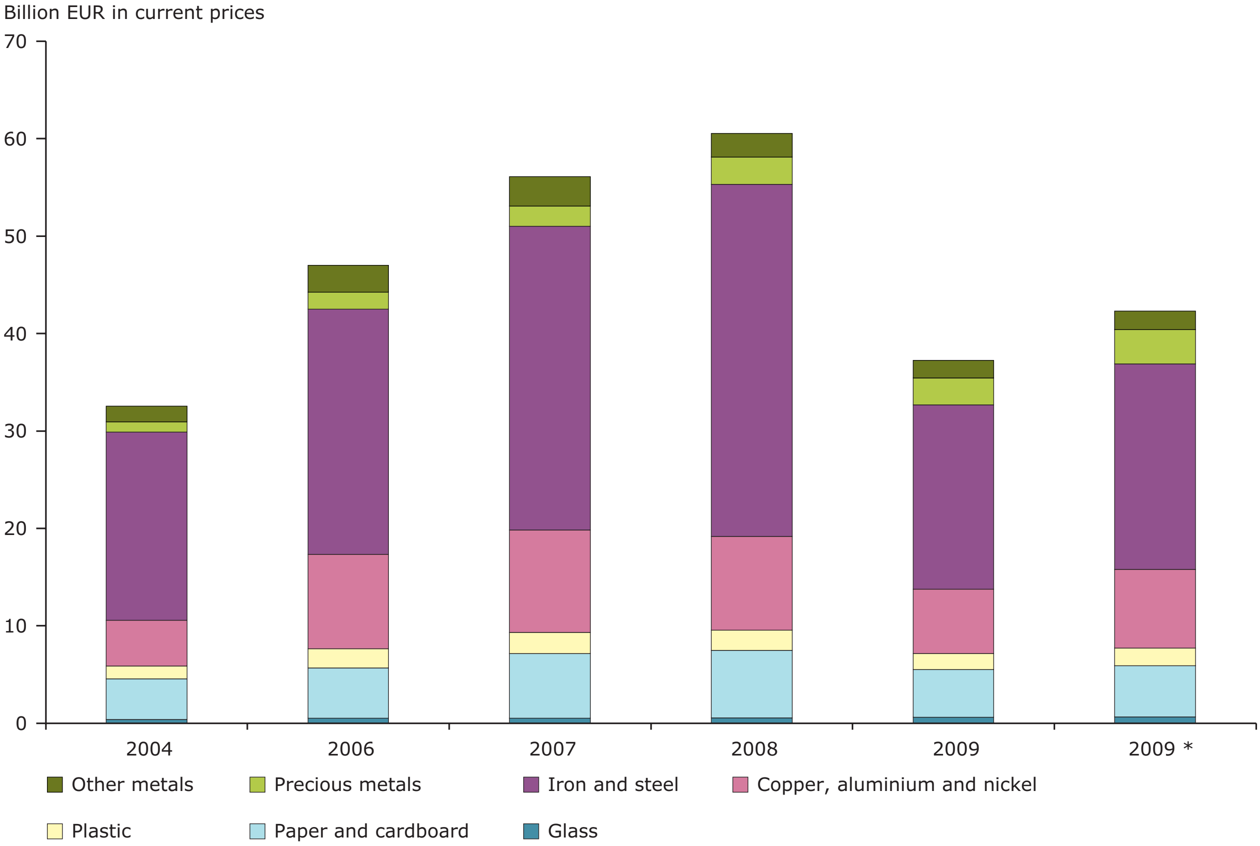
As a whole, the EU-27 eco-industry sector recorded turnover of EUR 232 billion in 2004 and EUR 319 billion in 2008 (at current prices), which translates into a compound annual growth rate in nominal terms of 8.3 % (Ecorys, 2009). Compared to total EU-27 economic output, eco-industry turnover increased from 2.2 % of GDP in 2004 to 2.5 % in 2008. Clearly, these turnover data do not imply that the eco-industry sector accounted for 2.5 % of EU economic output in 2008. However, in the absence of value added data for the eco-industry, they do at least provide a measure of the sector's scale and growth relative to the economy as a whole.

Recycling recorded the fastest growth rate among the largest eco-industry sub-sectors (recycling, waste supply, wastewater treatment and waste management). Admittedly, its annual growth rate could not match the renewable energy sub-sector, which expanded by 37 % per year in the period 2004–2008 (EREC, 2010). However, the annual increase of recycling's turnover was still very rapid at 17 %. Furthermore, not all economic activities related to the recycling of the seven material groups are included and not all recyclables themselves are included. The recycling sector's turnover figures cited above can therefore be considered as minimum values.

The growing importance of the recycling sub-sector is also apparent in its increasing scale relative to the economic output of key sectors. In the period 2004–2008 the value of recyclables relative to the gross value added of the manufacturing, electricity and waste management sectors increased from about 1.7 % to 2.7 %. Although the financial crisis has reduced this level, the importance of recycling for the economy is still greater in 2009 than five years earlier.

Table 2.1 presents the turnover of the EU recycling sector in the period 2004–2009 and relates it to the GVA of key sectors and aggregate economic outputs.

**Figure 2.1 Total turnover of recycling of seven key recyclables in the EU, 2004 and 2006–2009**




**Note:** The methodology for calculating the turnover is described in detail in ETC/SCP, 2011.

'Precious metals' include silver, gold and platinum. 'Other metals' include lead, zinc, tungsten, molybdenum, tantalum, magnesium, cobalt, bismuth, cadmium, titanium, antimony, manganese, beryllium, chromium, germanium, vanadium, niobium, rhenium, gallium, indium and cermets.

* The 2009 calculation is based on the values for only the second half of 2009. Despite the huge decline in commodity prices at the beginning of 2009 due to the economic downturn, the total turnover of recyclables recovered markedly in the second half of 2009.

**Source:** Based on Eurostat, 2010d; JRC, 2009 and Prognos, 2009.

**Table 2.1 Recycling sector turnover in 2004, 2006–2009** (*)

| | 2004 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|
| Turnover of recycling seven key recyclables in the EU (million EUR, current prices) | 32 535 | 47 008 | 56 082 | 60 524 | 37 229 |
| Total GVA of the EU manufacturing, electricity and the waste management sectors (million EUR, current prices) | 1 930 790 | 2 113 325 | 2 221 800 | 2 243 801 | 1 919 044 |
| Turnover of recycling seven key recyclables relative to the total GVA of the manufacturing, electricity and waste management industry in the EU (%) | 1.69 | 2.22 | 2.52 | 2.70 | 1.94 |
| Total EU GVA (million EUR, current prices) | 9 490 958 | 9 877 205 | 10 405 157 | 11 011 791 | 11 188 957 |
| Turnover of recycling seven key recyclables relative to total EU GVA (%) | 0.34 | 0.48 | 0.54 | 0.55 | 0.33 |

**Note:** (*) The material groups included here are glass waste; paper and cardboard waste; plastic waste; iron and steel scrap; aluminium, copper and nickel scrap; precious metals; and other metals.

**Sources:** Eurostat, 2010d and 2010f; and assumptions in ETC/SCP, 2011.

## 2.2 EU internal and overseas trade in recyclables

More and more recyclables were traded between EU Member States or exported from the EU in the period 2000–2009. During the same period, imports of recyclables into the EU were quite stable and at a much smaller scale than export flows. The only exception was the value of imports of precious metal waste, which increased by 50 % in this period.

Figure 2.2 shows developments in the value of trade for all recyclables except glass. For all six shown, the amount and value of exported recyclables out of the EU increased from 2000 until the economic downturn started in 2008. For some recyclables, the crisis even seems to have strengthened exports.

For plastic waste and precious metal waste, the value of recyclables exports is larger than the internal trade within the EU. Furthermore, for paper and cardboard, aluminium, copper and nickel waste, and iron and steel waste, the value of exports was higher in 2010 than in 2007. In other words, the EU is increasing its collection of recyclable waste but more and more is sent outside of the EU as secondary raw materials for final processing.

## 2.3 Drivers of the increasing value of recycling

One explanation for the increasing economic importance of recycling is growing demand for materials in the booming Asian economy and the related increase in resource prices. In addition to this, Asian recyclable-consuming industries have recovered quicker from the economic downturn than their European counterparts and manufacturing jobs have moved out of the EU since the crisis started.

However, the changes are not all demand driven. On the supply side, an increasing amount of recyclables are collected separately or sorted from mixed waste and marketed. In the period 2004–2009 the amount of the seven recyclable groups made available on the market increased by at least 15 %. This development is partly due to implementation of EU waste directives such as the Packaging and Packaging Waste Directive (EU, 2004), the End of Life Vehicle Directive (EU, 2000), the Waste Electrical and Electronic Equipment (WEEE) Directive (EU, 2003) and the Landfill Directive (EU, 1999). All these directives create an obligation to recycle or recover increasing proportions of waste.

## 2.4 Recycling and job creation

Recycling makes another important contribution to the green economy in terms of creating new jobs. The employment opportunities in the recycling sector include low-skilled work in particular, but also include medium- and high-skilled jobs, ranging from collection, materials handling and processing to manufacturing products.

**Box 2.1 Key drivers and constraints for increased recycling**

**Drivers**

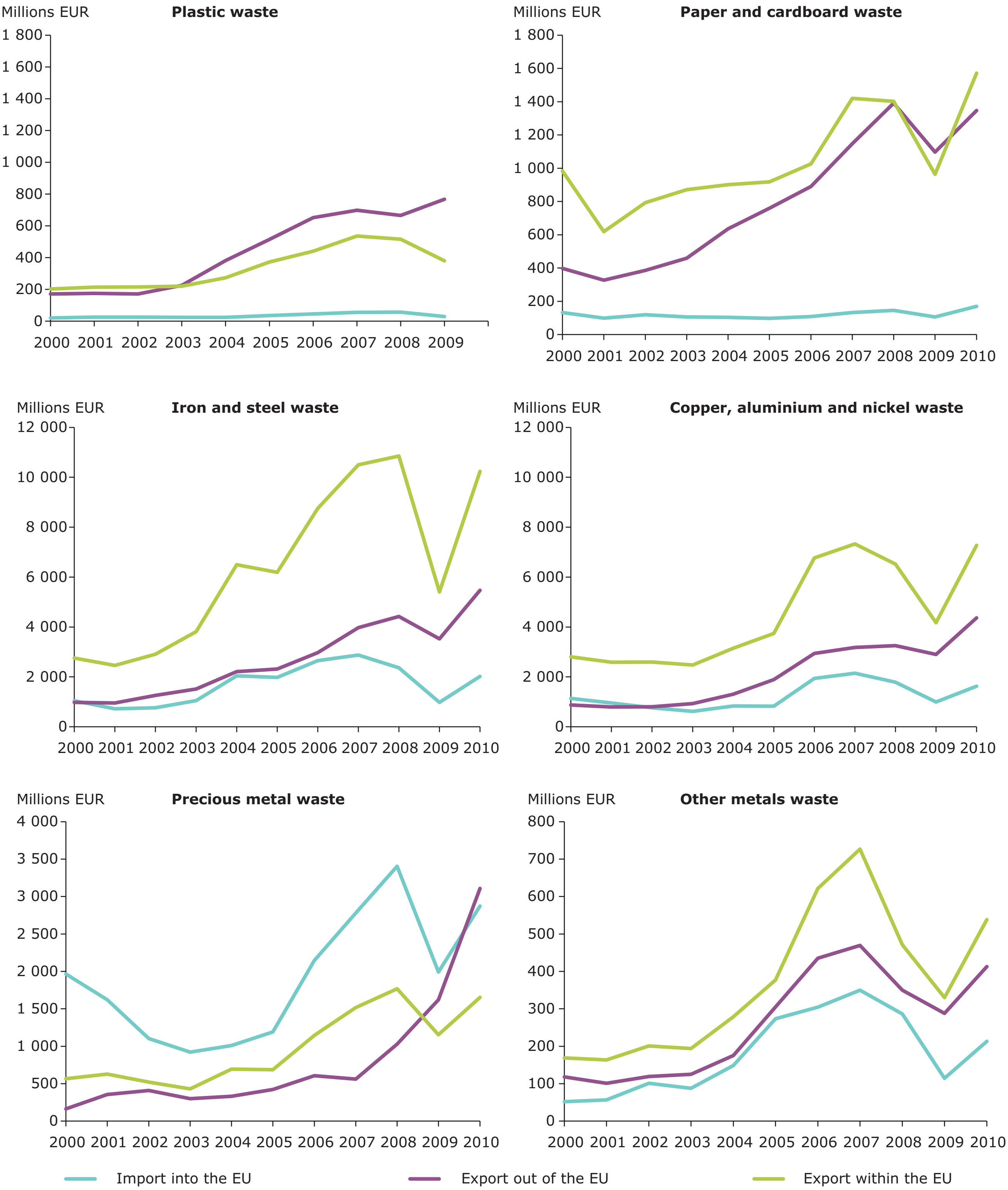
- increasing waste volumes demand efficient solutions
- improved regulatory implementation (EU waste directives, national legislation and policies)
- the shift away from landfill towards recycling and recovery
- regulatory pressures and legislative support for recycling
- growing public concern and the need for a clean image
- the economic value of recycling
- increasing demand for secondary raw materials (especially from the Asian economy)

**Constraints**

- varied interpretations of legislation
- weak implementation of legislation
- continued dependence on landfill
- recycling is expensive for certain types of waste
- economic downturn affects market prospects
- illegal waste dumping

**Source:** Frost and Sullivan, 2009.

**Figure 2.2 Value of EU internal and overseas trade in recyclables, 2000–2010** (*)




**Note:** The calculation methodology is described in detail in ETC/SCP, 2011.

(*) The 2010 values are based on amounts and values for only the first half of 2010 because figures for the second half of the year were not available at the time of writing. Precious metals include silver, gold and platinum. 'Other metals' includes lead, zinc, tungsten, molybdenum, tantalum, magnesium, cobalt, bismuth, cadmium, titanium, antimony, manganese, beryllium, chromium, germanium, vanadium, niobium, rhenium, gallium, indium and cermets.

**Source:** Based on Eurostat, 2010d.

Of course, other forms of waste disposal also offer job opportunities and contribute to national income. The crucial point is that a growing body of evidence indicates that the recycling industry generates more jobs at higher income levels than landfilling or incinerating waste. Recycling has roughly twice the economic impact of burying the same amount of materials in the ground. Specifically, recycling a tonne of waste will pay USD 101 more in salaries and wages than disposing of it in a landfill (CIWMB, 2003).

In general terms, these results convey a clear message to policymakers: moving up the waste hierarchy — from landfilling to recycling — creates jobs and boosts the economy. And as outlined below, European employment data underline the opportunities for job creation in the recycling sub-sector.

### *EU employment developments*

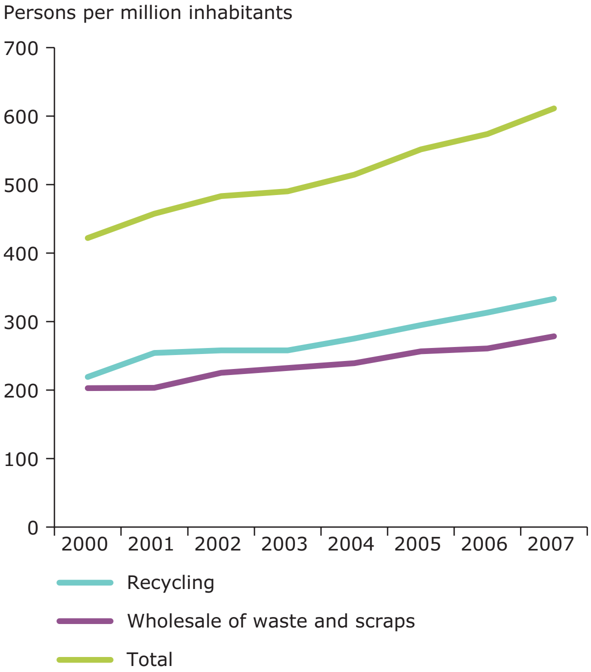
In Europe, information on employment in recycling is limited because Eurostat employment data are not structured with a focus on recycling. Data on some relevant activities (e.g. collecting recyclable materials, and activities enabling the use of recyclables in manufacturing) are aggregated with other activities. In addition, changes to classification methodologies mean that data gathered up to 2007 are not directly comparable with data from 2008 onwards.

Despite these shortcomings, existing data do provide a reasonable (albeit incomplete) picture of the overall trend for recycling-related employment. As Figure 2.3 shows, overall employment related to materials recovery in Europe has increased steadily, from 422 inhabitants per million in 2000 to 611 in 2007, which is an increase of 45 %. Moreover, these figures are conservative, as they do not include employment linked to processing materials at certain manufacturing facilities, such as manufacture of pulp or metals.

### *Employment in recycling compared to other EU eco-industries*

The EU-27 eco-industry is estimated to have directly employed some 2.8 million individuals in 2004, rising to 3.4 million in 2008. Employment grew 7.0 % in the years 2000–2008. In the same period, the annual growth in employment in the recycling sub-sector (11 %) was second only to the renewable energy sub-sector (17 %) (Table 2.2).

**Figure 2.3 Persons employed in recycling activities in the EU (*), Norway and Switzerland per million inhabitants, 2000–2007**




**Note:** The activities included are according to the NACE classification Rev.1.1 and consist of Division 37 (Recycling) and Division 51.57 (Wholesale of waste and scrap).

(*) Data are missing for some countries in years between 2000 and 2007. The countries whose data are missing are listed in ETC/SCP, 2011.

**Source:** Based on Eurostat, 2010a and 2010b.

**Table 2.2 Employment growth in EU eco-industry sub-sectors in the period 2000–2008**

| | Employment (2000) | Employment (2008) | Employment: annual growth rate (%) |
|---|---|---|---|
| Waste management | 844 766 | 1 466 673 | 7.14 |
| Water supply | 417 763 | 703 758 | 6.74 |
| Wastewater management | 253 554 | 302 958 | 2.25 |
| Recycled materials | 229 286 | 512 337 | 10.57 |
| Others | 129 313 | 193 854 | 5.19 |
| Renewable energy | 49 756 | 167 283 | 16.37 |
| Air pollution | 22 600 | 19 067 | 2.10 |
| Biodiversity | 39 667 | 49 196 | 2.73 |
| Soil and groundwater | 14 882 | 18 412 | 2.70 |
| Noise and vibration | 4 176 | 7 565 | 7.71 |
| **Total** | **2 005 764** | **3 441 102** | **6.98** |

**Source:** Ecorys, 2009.

# 3 Meeting Europe's resource needs via recycling

- Recycling activities provide material inputs to the economy, substituting for virgin raw materials and thereby improving the resource efficiency of production.
- Recycling currently covers only a small proportion of EU demand for many material resources.
- If all waste were recycled then it could meet the demands of a substantial part but not all of EU material consumption.

Recycling activities provide material inputs to the economy, substituting for virgin raw materials and thereby improving the resource efficiency of production. But how much of the EU economy's material demand can be satisfied through recycling? And what is the current share of recycled materials in resource consumption?

## 3.1 Recycling can increase greatly but cannot meet all demand

At present the EU consumes a huge amount of resources, with a significant proportion imported from abroad (EEA, 2010). Recycling is becoming an increasingly important source of material inputs but there is no clear correlation between increased material recovery through recycling and the reduction of resource imports. Recovered materials enter the free market like any other product and can be traded both within and outside the EU.

If the quality of a recovered material is sufficient to consider its performance equal to that of the virgin material, then it is possible to compare the amount recovered to total demand for that resource. This correlation between the consumption of a resource and the recycling of the corresponding waste stream can be analysed in physical (weight) or economic (value) terms. Figure 3.1 shows the physical (weight) indicators for nine different waste types.

Current recycling rates provide an indication of the extent to which recyclables could meet the EU's total consumption of resources at present. The calculations assume that the quality of the recyclables fully matches the quality demands of the industry.

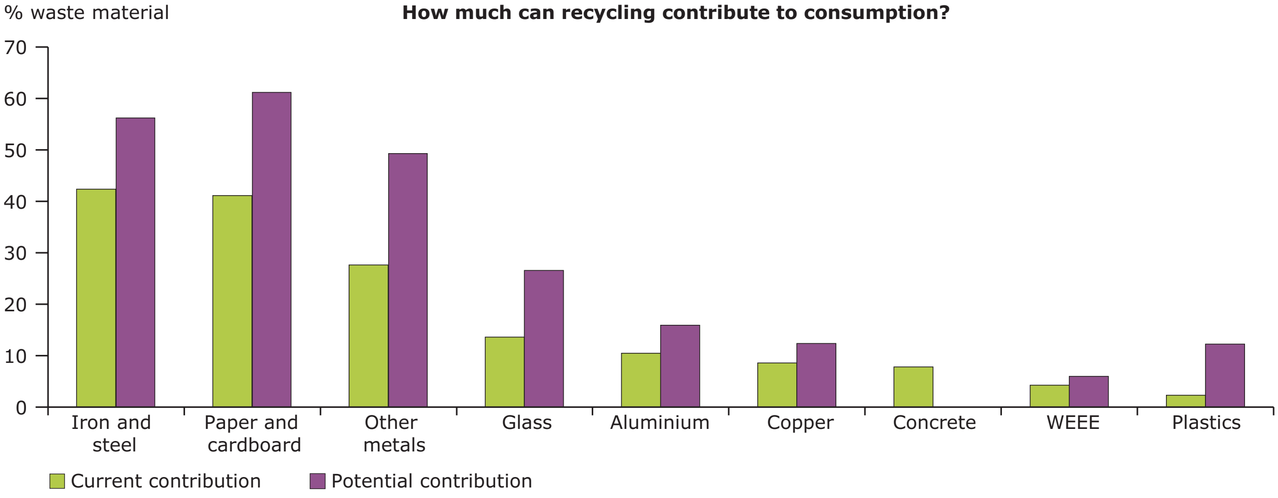
As Figure 3.1 shows, recycling already covers a reasonably large share of EU consumption of certain materials. In weight the current coverage is 41 % for paper and cardboard, 42 % for iron and steel, 10 % for aluminium, 28 % for other metals ([2]), 14 % for glass, 10 % for aluminium, 9 % for copper, 8 % for concrete, 4 % for WEEE and 2 % for plastics.

Data on EU waste generation signal the maximum amount that could be recycled. Assuming that all waste is recycled provides an indication of the maximum potential for recyclables to meet EU material consumption needs. Of course, this upper limit is theoretical because in reality not all waste can be recycled. Still, since recycling of most materials is growing in the EU, it is interesting to examine recycling's hypothetical maximum contribution to total EU resource consumption. Would it be possible to cover a much larger proportion or even all EU resource use though recycling?

As Figure 3.1 shows, recycled paper and cardboard and recycled iron and steel could cover more than 55 % of demand these resources, while recycling of other metals would cover approximately 50 % of demand. These potential figures could increase substantially if recycling infrastructure and collection rates improve. However, recycling cannot cover 100 % of EU resource demand. This is partly because the growing EU economy is accumulating goods, for example in the construction sector. This accumulation acts as long-term storage for materials that will not

([2]) In this figure, 'other metals' refer to silver, gold, platinum, lead, antimony, zinc, tin, nickel, tungsten, molybdenum, tantalum, magnesium, cobalt, bismuth, titanium, zirconium, beryllium, chromium, germanium, vanadium, gallium, hafnium (celtium), indium, niobium (columbium), rhenium, thallium and manganese.

**Figure 3.1 Recycling's current and potential contribution (*) to meeting EU demand for various materials, 2006**




**Note:** The calculation of EU consumption is described in detail in ETC/SCP, 2011. The reference year for concrete is 2004.

(*) The current and potential contribution figures are both based on the infrastructure available in 2006. Future changes in collection rates, improved recycling structures and market conditions could significantly influence the potential contribution figures.

**Sources:** Eurostat, 2010c and 2010e; Prognos, 2009.

be available for recycling for many years. In addition, there are technical limits for recycling, which vary depending on the material, and the quality of recycled materials often does not (yet) fully match demand. As a result, some materials are considered to be 'downcycled' rather than recycled.

The current and potential figures presented in Figure 3.1 vary considerable among the waste types, making it hard to draw overall conclusions. However, some trends are apparent:

- In general there is considerable room for improvement. For all nine resource groups, recycling can potentially cover a larger percentage of total EU consumption.
- EU resource consumption is sufficiently large that recycling cannot meet total EU demand for any of the resource groups. In fact, except for paper and cardboard, and steel and iron, recycling would cover less than half of consumption even if 100 % of waste materials were recycled.
- Paper and cardboard, and iron and steel are the most used waste resources.
- Recycled plastics and WEEE provide the lowest coverage of demand both currently and in the maximum recycling scenario. For plastics this is explained by the proportion of plastics that are recycled due to the complicated sorting procedure and the lower quality of the final recycled material. Moreover, recycling competes with incineration since significant amounts of energy can be recovered from plastics. Contrastingly, a significant percentage of the WEEE collected is recycled but the amount collected is relatively low. This is due to the significant exports of second-hand electronic and electrical equipment from the EU, increasing EU stocks of electronic and electrical equipment, and the lack of adequate collection infrastructure. In the case of rare metals in WEEE, dissipative use can reduce recycling rates, which may also contribute to low coverage of demand.
- Aluminium recovery has also fallen well short of demand despite high levels of recycling. This is simply because consumption is much greater than waste aluminium generation and recycling. Aluminium is being used more and more in construction, meaning increased stockpiling.

## 3.2 New technologies are essential to improve recycling rates

New recycling technologies are clearly essential for the shift to a green economy, enhancing resource-efficiency and potentially also offering business opportunities and export potential for innovative firms and economies. With this in mind, the EU eco-innovation initiative (EU, 2011) is making nearly EUR 200 million available to finance projects in the period 2008–2013 and recycling is one of the main areas receiving funding.

Environmentally sound technologies include a variety of cleaner production process and pollution prevention technologies, as well as end-of-pipe and monitoring technologies. But technologies need not be limited to scientific and technical innovations. Technology transfer also includes soft technologies, such as knowledge, systems and management approaches (UNEP, 2009a).

Box 3.1 describes progress in developing and implementing new technologies to recycle plastics, paper and cardboard waste, highlighting some of the challenges and successes.

## 3.3 Consumption-oriented measures are also needed

New recycling technologies can deliver huge benefits. In the context of deliberations on how to achieve a green economy, however, it is important to recognise the limits to recycling's potential contribution, as well as the opportunities it presents.

More recycling is possible and highly desirable. But since recycling cannot cover 100 % of demand, the EU cannot become an ideal closed-loop society. If we want to achieve genuinely sustainable patterns of resource consumption then we must accept that there is a need to go beyond technological fixes and identify ways to manage society's material consumption.

**Box 3.1 Progress in developing recycling technologies for plastic, paper and cardboard wastes**

A greater variety of technologies are needed to recycle plastic than other waste types. The reasons are differences in the purity of post-producer and post-consumer waste (European Commission, 2008c) and varying treatment needs for different types of plastic (ACRR, 2004). For example, plastic bottles made of PET (polyethylene terephthalate) cannot be recycled together with transport packaging made of LDPE (low-density polyethylene).

Sorting plastic wastes at the preliminary stage is the most significant activity in the recycling loop (Al-Salem et al., 2009), raising the quality of the waste by grouping types and colours. It is crucial but costly. Although automatic sorting techniques have emerged in recent decades, increasing opportunities to recycle plastic waste, most recycling facilities still focus on manual sorting (European Commission, 2008c).

The most commercially available automatic sorting technique is the near infrared detector. It uses a spectroscopic identifier to help separate plastics from non-plastics and identifies up to ten different classes of plastic. Optical devices then enable the plastics to be sorted by colour. Further technologies separate plastics from other waste fractions and differentiate differing densities of plastic (European Commission, 2008c) but further improvement of sorting technologies is still needed.

Sorting of paper and cardboard wastes has a long tradition. Paper and cardboard wastes are sorted and traded in more than 50 different qualities. Sorting of paper and cardboard wastes is still dominated by manual sorting activities and is expected to become even more labour intensive as the composition of waste paper is increasingly heterogeneous and contaminated (Cost Action E48, 2010) This is connected with an increased need to check the quality of collected paper.

However, technologies also play an important role in sorting paper and cardboard. Before non-contact quality sensors (particularly near infrared spectrometry) emerged a few years ago, quality control methods had particularly consisted of pulping-screening devices (Cost Action E48, 2010). Innovations for recycling paper, such as multiple loop flotation deinking systems dispersers ([3]) and fractionation ([4]) have been developed and introduced to the market in the last couple of decades (Cost Action E48, 2010). Previously, fibres from recovered materials were mainly used to produce brown grades of paper and cardboard but the introduction of new technologies means that white grade paper can be produced, suitable for newsprint and magazines (Cost Action E48, 2010).

([3]) A hot dispersion unit or disperser is often included in a wastepaper reprocessing line to reduce the size of remaining visible ink specks (McKinney, 1995).

([4]) Fractionation is a unit operation for separating a fibre stream into two or more flows (fractions) on the basis of fibre properties (Cost Action E48, 2010).

# 4 Securing supplies of rare metals and other critical resources

- Some rare metals are critical for emerging technologies such as renewable energy systems.
- Scarcity of rare metals is expected to limit future economic and technological development.
- Improved recycling of rare metals can provide an important source of inputs to European production.

During the 20th century, society's uses for metals grew rapidly, leading to a substantial shift of metal stocks from below ground into human applications above ground. Beside mass infrastructural applications like steel in buildings and aluminium in planes, metals are increasingly used for innovative technologies. Demand for metals is increasing, most notably in emerging economies but also in industrialised countries.

## 4.1 A potential bottleneck for technological development

Research indicates that some types of raw materials, especially the so-called 'critical metals' might become a bottleneck for economic and technological development in the near future (UNEP, 2009b). Heightened demand for these raw materials will increase various environmental, economic and social risks. Securing supplies of raw materials is particularly critical for Europe, Japan and the US, which have limited raw material reserves compared to existing consumption.

Although often extracted in relatively small quantities, rare metals have important environmental impacts, mostly due to their low ore concentration. Recycling can mitigate these impacts by generating (secondary) raw materials that can potentially offset increased raw material demand in the future. As is increasingly recognised, the move towards a green economy, with its focus on sophisticated environmental technologies, will significantly increase demand for certain materials. This represents an additional pressure on the natural resource base above and beyond the overall growth of the world economy (ISI/IZT, 2009). Better recycling will obviously be essential, especially for those materials that lack adequate substitutes.

## 4.2 Fourteen critical raw materials for the EU

Raw materials are essential for the EU economy. In 2010 an ad hoc group, working under the Commission and in close cooperation with Member States and stakeholders, identified 14 raw materials, many of them metals, which are highly important for the EU economy and show a high supply risk (Table 4.1). The supply shortage was assessed within a ten-year perspective.

## 4.3 Projections of raw material demand and emerging technologies

A study by the German Federal Ministry for the Economy and Technology analysed the raw material demand arising from 32 emerging technologies (ISI/IZT, 2009). The analysis delivered significant insights into the interdependence between technological change and demand for raw materials.

The study compared the projected raw material demands of emerging technologies in 2030 to today's total world production of specific raw materials. The results (Figure 4.1) provide an indication of supply risks and of the need to expand mining and recycling capacities.

## 4.4 The need for better collection and recycling processes

Figure 4.1 shows significant risks to security of supply. For gallium, projected demand from the technologies analysed rises from 18 % of global

### Table 4.1 Critical raw materials for the EU

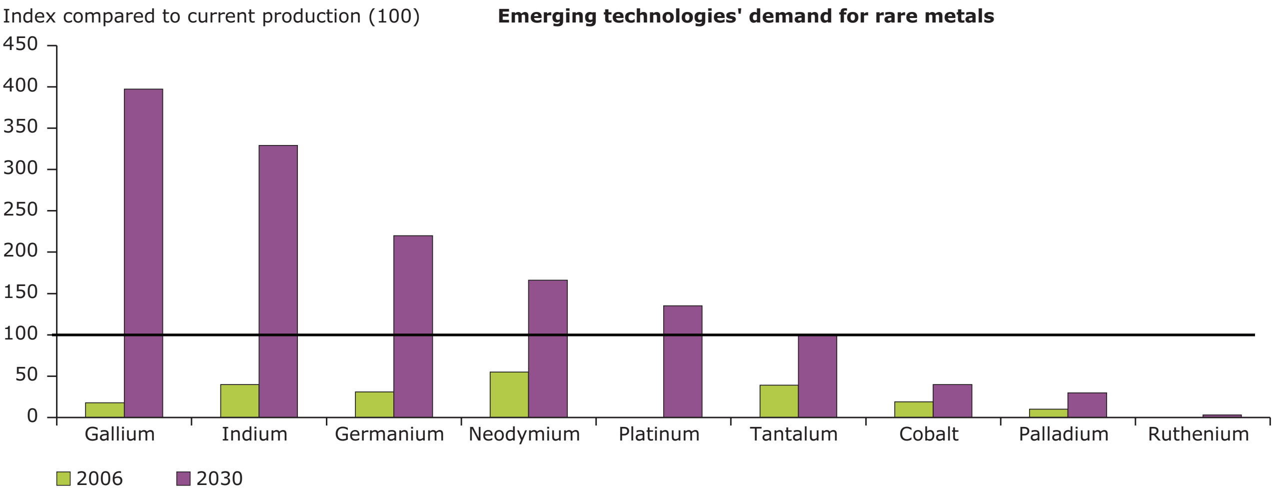
| Material | Emerging technologies (selected) | Material | Emerging technologies (selected) |
|---|---|---|---|
| Antimony | Micro-capacitors | Indium | Displays, thin-layer photovoltaics |
| Beryllium | Nuclear power, military applications | Magnesium | |
| Cobalt | Lithium-ion batteries, synthetic fuels | Niobium | Micro-capacitors, ferroalloys |
| Fluorspar | | Platinum group metals (PGMs) | Platinum: fuel cells, catalysts<br>Palladium: catalysts, seawater desalination |
| Gallium | Thin-layer photovoltaics, Integrated circuits, white light-emitting diodes | Rare earths: yttrium, scandium and lanthanides | Many technological devices including superconductors, hybrid cars, optoelectronics, cathode ray tube technology and lasers |
| Germanium | Fibre optic cable, infrared optical technologies | Tantalum | Micro-capacitors, medical technologies |
| Graphite | | Tungsten | Automotive, aerospace, medical, lighting applications |

**Note:** Platinum group metals (PGMs) include platinum, palladium, iridium, rhodium, ruthenium and osmium.

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

**Source:** European Commission, 2010c.

### Figure 4.1 Global demand of selected emerging technologies for raw materials in 2006 and 2030 relative to global output of each material in 2006




**Source:** Based on ISI/IZT, 2009; and Elsner et al., 2010.

annual output in 2006 to 397 % by 2030 (i.e. four times global production in 2006). Similarly, demand for indium in 2030 is projected to equal 329 % of 2006 production, for germanium the figure is 220 %, for scandium it is 230 %, for neodymium it is 166 %, for platinum it is 135 % and for tantalum it is 100 %.

Demand for rare metals will greatly increase in the future, especially in emerging technologies such as renewable energy and information technology. The EU lacks geological stocks of these metals or has very limited reserves and therefore depends almost entirely on imports. For multidimensional economic, technical and geopolitical reasons, scarcities and supply bottlenecks are likely to occur in the near future. Recycling of rare or precious metals is therefore especially crucial if the EU is to be a frontrunner in the renewable energy field, for example in solar and wind energy.

At present, however, global recycling rates of rare metals are often very low. For gallium, germanium, indium, neodyium and tantatium, the recycling rates are estimated to be less than 1 %. For ruthenium, the rate is approximately 15 %, while for cobalt, palladium and platinum the rates are 60–70 % (UNEP, 2011b).

The first step in increasing the recycling of rare metals is to collect more waste containing rare metals, for example WEEE. However, collecting more WEEE is not a complete solution; WEEE recycling processes must also improve.

Today a large proportion of the rare metals used in manufacturing are lost. This is either because the WEEE ends up in developing countries, which lack sufficient recycling infrastructure, or because the WEEE is inappropriately dismantled in Europe, losses occur due to inefficiency in the final recycling process, or recycling is not economically viable.

Significant challenges remain in improving product design to facilitate dismantling and improving final recycling processes. In other words, the improvements in sorting and recycling technologies for plastic waste achieved during the last twenty years (see Box 3.1) need to be matched in other recycling areas, notably those dealing with rare metals.

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