Study on the Competitiveness of the European Companies and Resource Efficiency

Final Report

Revised version after the Stakeholders Consultation Workshop and including policy recommendations

Client: Directorate General- Enterprise and Industry

Rotterdam, 6th July 2011

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Executive Summary

Introduction

Resource efficiency is one of the main challenges the European Union is facing at the moment. Globalization, the increased world population and the rise of emerging economies resulted in an increased competition over natural resources globally. In Europe, various resources are subject to depletion or are not necessarily extractable. In response to these challenges, national and EU-wide regulations and policy initiatives have been developed to guide the European economy towards more resource efficiency and environmental sustainability.

For the European companies, inaccessibility of resources leads to high dependence on imports and higher production costs compared to their international competitors, who face less stringent environmental policies. In the face of these challenges, the European companies are adopting several measures to increase the efficiency of the resources they use.

In the light of this background, the study on the “Competitiveness of the European Companies and Resource Efficiency” aims at understanding the issues that European companies face with regards to “resource efficiency”. The study set forth five main questions:

- What are the **drivers** that trigger companies to invest in resource efficiency?
- What are the **measures** (business practices and strategies) that companies adopt in order to increase resource efficiency?
- How do companies **monitor/measure** their resource efficiency performance?
- What are the **barriers /market failures** impeding greater resource efficiency for companies?
- What **policy measures** can be taken to incentivise greater resource efficiency?

Approach

The study analysed nine “resource intensive” sectors: food and drinks, cement, non-ferrous metals, electronics, chemicals, automotives, steel, glass and finally pulp and paper, from a value chain perspective; thus examining the value added to materials starting from their extraction (at the raw material stage) to their disposal (waste). The selection of the nine sectors was based on two criteria: 1) their high dependence on resources in their production, 2) the potentially high impact they may have on the environment through their daily operations.

The study set two levels of organizational learning:

- “First order learning”, where companies adopt incremental changes in production, by implementing “short term” investments, such as end-of-pipe technology, staff training, improving resource monitoring and audit, etc.;
- “Second order learning”, where companies adopt fundamental changes to the way they operate and which involves longer term investments i.e. adoption of higher level technology, incorporation of major structural changes, investments in research and development or the use of substitute/ alternative materials.

While first order measures bring about substantial improvements in environmental performance, the second order measures (when successful) produce more and longer terms environmental benefits. There is a sequential relationship between the two levels of learning, meaning that, companies are not likely to move to the second level of learning unless they have exploited their opportunities in the first order level of learning.

Findings

What are the **drivers** that trigger companies to invest in resource efficiency?

The analysis of the nine sectors showed that the increasing **regulatory pressure** on the EU companies is one of the strongest drivers to adopting resource efficiency measures. However, many industries saw potential risks with more stringent and rapidly changing EU regulations, which result into higher uncertainty levels and the creation of challenges for long term investments.

The nine sectors acknowledged the importance of resource efficiency as a viable strategy for **cost reduction, product quality improvement and increased productivity**. And because firms are commercial entities, **the costs versus the benefits of investments** in resource efficiency are strong drivers/barriers to investment. Although investment is assumed to create a win-win situation for the investors and the society, the economics of the firm do not necessarily support this. The **time horizon for investment, pay back time** and **certainty** of the business environment also count towards costs or benefits for investment in resource efficiency.

Relationships across the nodes of the **value chain** induce resource efficiency, where retailers' buyer power can influence suppliers' behaviour when they introduce new standards to which producers need to comply with. **Investor's relations** with firms also determine companies' behaviours towards resource efficiency; investors are more willing to invest in more environmentally responsible companies. In addition, the increasing consumer pressure pushes companies towards improving their **corporate image**.

What are the **measures** (business practices and strategies) that companies adopt in order to increase resource efficiency?

The industries examined, on individual basis, increased their resource efficiency over the past few years through the adoption of various measures. The research found that the majority of the companies utilize both first and second order measures:

- First order measures are the most prominent, e.g. increasing or maintaining the high share of **recycling of materials** rates, use of **green and intelligent information technology** along the production cycle, the use of **green business models**, etc. However, there were barriers to their wider use, .e.g. the lack of access to finance, lack of knowledge and lack of sharing and dissemination of best practices, i.e. there is still room to increase their further adoption;
- Second order measures are less used, but they do occur. There is evidence on companies introducing new substitutes of material, e.g. the use of **renewable (bio-based) materials**, **investment in R&D**, etc. This finding implies that many companies exploited their 'first order learning" opportunities and are moving towards a "second order" level. Both the lack of finance and access to knowledge and information were barriers to the further implementation of these measures.

The relative importance of resources (water, minerals, atmosphere, etc…) varied across sectors and affected the nature and intensity of measures adopted by each industry to maintain the efficiency of the resource. Industries directed their measures at the strategic resources to them.

How do companies **monitor/measure** their resource efficiency performance?

The research found that there was a lack of a comprehensive approach to measuring resource efficiency at the company level. The companies examined reported on some of the resources they use but not on all of them. Their measurements were often confined to the measures they adopted for their strategic resources; e.g. in a high energy consuming sector, measuring energy consumption was more prominent than measuring other resources. At the company level, the most relevant indicators are those that demonstrate progress in a comparative manner, i.e. results achieved compared to a previous performance or a baseline, or those that show the relationship between resource efficiency and the competitiveness of the firm such as productivity or cost savings resulting from resource efficiency. Indicators- in general terms should be sector specific and material specific.

What are the **barriers /market failures** impeding greater resource efficiency for companies?
Misalignment and lack of incentives: actors along the value chain do not necessarily share the same incentives; for example, the developer who installs lifts in buildings is not interested in a "resource efficient" lift, but in a "cheaper product". In addition, a lack of financial incentives was observed (e.g. lack of financial support, high cost of recycling, long pay back time for large investments) together with a lack of market demand for the higher environmentally performing products.

Another observed barrier is the **lack of access to knowledge, skills, technology and best practices** on resource efficiency (which is more difficult for SMEs than for large enterprises).

Although resource efficiency is addressed through various EU policies there is a **lack of a comprehensive approach and clarity** regarding resource efficiency at the EU level.

Finally, the low quality of the recovered materials in many industries, does not allow their recycling, which creates **barriers to recycling.** This problem is aggravated by the increased **international competition** over secondary material and waste in the EU.

Conclusions and policy recommendations

The EU industries examined in the study made substantial improvements in the implementation of resource efficiency measures, however, our observation is that companies adopted the measures that focused on optimising the use of the "same" resources; i.e. they focused on using the resources "right", thus increasing their EFFICIENCY. Rarely, did companies try to increase the EFFECTIVENESS of their resource use. This would entail a focus on the use of the "RIGHT RESOURCES rather than on the use of the SAME RESOURCE RIGHT. In practical terms, for using the right resources, companies should ask themselves two questions: are we using the right resources? Are there alternative resources that can be used in production and that can produce the same products but with a higher environmental quality? Although some evidence towards increased effectiveness was found in this research, the effectiveness approach was less prominent than the efficiency approach as per our definition of efficiency and effectiveness in this paragraph.

It is important to note that , in the case of natural resources, there will always be limits to efficiency because no matters how efficient industries can be, there will always be a need for a minimum amount of natural resources and a minimum level of waste too. Therefore the focus on efficiency is very important, and represents a short/medium term perspective to resource efficiency. The vision for resource efficiency in the EU, however, necessitates a "longer term" approach to resources; an approach that would go beyond the efficiency of the "existing/same" resource and that would focus on the potential opportunities that can be created by simply thinking "outside the box" and the introduction of new substitutes that can replace the heavy reliance on natural resources. As such, research, development and innovation (R&D&I) are key instruments to achieve this vision by introducing alternative material, new product designs, and products with new and more sustainable characteristics.

Based on this reflection, the policy solutions 1, 2, 3, 4 presented below are important directions for action towards resource efficiency in the EU and can be seen as overarching concepts that incorporate more targeted policy solutions:

Policy solution 1: Support the EU industries to increase resource effectiveness- using the right material by focusing on research development and innovation to introduce alternative material, new products designs and products with more sustainable characteristic.

Policy solution 2: Increase support to material efficiency- using the material right, which would entail adopting measures that maximise the use of the “same material”. This would include recycling, industrial symbiosis, and measures towards cradle to cradle approach.

Policy solution 3: Introducing economy-wide Eco-Efficiency indicators
Measuring resource efficiency at the firm level, has given some indications on the consumption of resources, but could not give an indication of the “level of efficiency” of firms. Therefore, setting efficiency indicators is an important policy tool to manage resources at the EU level.

Policy solution 4: Address the current barriers to resource efficiency, leading to the following recommendations:

1. Enhancing a circular economy and increasing synergies among industries to address the misalignment of incentives problem by enhancing the industrial symbiosis, reforming the current waste legislations and the introduction of a single market for waste and recycling across the EU;
2. Considering Market Based Instruments (MBIs) to address the lack of incentives problem; reforming taxes and subsidies to support resource efficiency, green procurement and resource pricing are all market based instruments that can be used;
3. Improving access to finance to address the problem of lack of incentives;
4. Using benchmarks and performance levels to address the problem of lack of incentives, to help the adoption of first order measures;
5. Adopting measures towards changing consumers’ behaviour in order to address the lack of market demand problem through launching information campaigns, marketing (including control on green commercial claims); and labelling schemes;
6. Further support to R&D for innovation to address the limits of BAT problem and to enhance the use of second order measures;
7. R&D support for the development of green business models for businesses;
8. Dissemination of good practices through industry platforms and networks to address the lack of access to information and knowledge problem through closer linkages between all actors including technology suppliers and enlarged industry platforms and networks;
9. Better definition of the term resource efficiency (and thus communication on resource efficiency) and the introduction of an action plan to address the problem of unclear EU policies;
10. Improving the separation of waste at source for a better quality waste to address the horizontal barriers, through the installation of effective waste management systems and the appropriate infrastructure at municipal levels.

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1 Background

1.1 Introduction

This final report presents the research findings, conclusions and policy recommendations of the study titled “*Competitiveness of European Companies and Resource Efficiency”* commissioned by the European Commission in July 2010 under the Framework Contract on Sector Competitiveness Studies (ENTR/06/054) signed between the Ecorys consortium, led by ECORYS NL, and DG ENTERPRISE. The study has been revised after a stakeholder consultation Workshop held by the Commission on 14 February 2011 in order to include stakeholders’ comments (Summary of the proceedings report of the workshop is in Annex A).

1.2 Purpose of the study

The basic assumption of this research is that European companies in the “resource-intensive sectors” are taking serious measures to increase their resource efficiency. With no exception, given the new environmental regulations in the EU, all companies react to environmental challenges in several ways.

Given this assumption, the purpose of this study is to “*provide an overview of the main issues related to ‘resource efficiency’ which enterprises are faced with in the EU*”.

With this overall objective, the study set forth five main questions that needed to be answered:
- What are the **drivers** that trigger companies to invest in resource efficiency?
- What are the **measures** (business practices and strategies) that companies adopt in order to increase resource efficiency?
- How do companies **monitor/measure** their resource efficiency performance?
- What are the **barriers /market failures** impeding greater resource efficiency for companies?
- What **policy measures** can be taken to incentivise greater resource efficiency?

1.3 Methodology

There is almost no comprehensive definition of what constitutes a “resource-intensive sector” but many industries around the EU can, be so considered. In general terms, there are two criteria that define resource-intensive industries: 1) the high level of resource they need for their production, 2) the potentially high impact they may have on the environment through their daily activities (such as CO2 emission and its impact on the atmosphere). Given the variety of industries that may fall under these criteria and the scope of the study, nine sectors were selected to be the subject of the research, most of which fall under the above mentioned criteria. These sectors were:
1. Food and drinks processing;
2. Cement;
3. Steel;
4. Glass;
5. Non Ferrous metals (with focus on Copper and Aluminium);
6. Chemicals;
7. Paper and Pulp;

8. Automotives;
9. Electronics.

The selection of these sectors was done in consultation between the client and the consultant and they were analysed in terms of drivers, measures and barriers to further resource efficiency.

The methodology used for data collection and analysis in this study followed two main methods; desk research and stakeholders consultation.

The Desk research, comprised:

- Review of the classical literature on the processes of organizational learning, in order to form a theoretical framework for the typologies of measures adopted by firms for the purpose of achieving resource efficiency; and,
- Review of the classical economics literature, particularly in relation to investment decision, drivers to investments and incentives for firms to adopt resource efficient measures;
- Reviews of the practices adopted by firms in the EU in the nine sectors - subject to this study, on their web-sites or through their industry associations. Practices adopted by non-EU firms were also explored.

By that, the study collected evidence from both the theoretical and the practical worlds.

The Consultations with stakeholders were one of the pillars of the study. Following the literature review, the consultant circulated a questionnaire to all the industries represented in the study, which informed the industry specific sections. Following the write up of each industry section, the report was circulated to industries' associations for further verification and additional comments which were communicated to the consultant.

Finally, the European Commission has organized a workshop that took place at the European Commission premises in Brussels/Belgium on February 14th, 2011, where industries stakeholders were invited. The workshop has generated additional input which considerably informed this report.

Analysis

For the analysis of resource efficiency measures, the study adopted a "supply chain" approach, meaning that it traced resource efficiency from extraction, going through production and finally through consumption and waste management. As such, the study followed the definition of resource efficiency as understood from the terms of reference of this project, where resource efficiency referred to "*the sum of **material** resource efficiency, **natural** resource efficiency, energy efficiency as well as **waste generation** and impact"*. The three dimensions highlighted in this definition prescribe the approach that was followed to analyse the measures, barriers and drivers to resource efficiency.

Based on that the study examined the measures adopted by firms towards the **material** resources used as input in the production cycle (such as water, raw material and energy), and went further to examine the measures associated with **natural** resources (such as the impacts of CO2 emission and the likes) and ended the analysis by examining the waste (treated here as resource too) management and the measures taken by companies to maximize the use of waste.

As mentioned above, the analysis was done against a theoretical background drawing on the incentives and motivations of industries to invest in resource efficiency and the types of measures that would follow based on their investment decisions.

Limitations of the research

One of the main objectives of this research was to obtain empirical data and information from companies in the nine sectors studied on two important topics. The first topic concerns the amount of investment they intend to utilize to increase their resource efficiency. The second topic is the dynamics of their decision making process when it comes to their investment decisions in this direction.

Data and information collection on these topics did not prove to be successful because this type of information is usually classified as “confidential” information, which private businesses are not likely to share with third parties. Obtaining this type of information would have provided the research with a stronger edge in support to the theoretical sections we have provided in chapter 2.

Because this research is done at a micro level (company level), obtaining financial data specifically about the impact of resource efficiency measures on the competitiveness of firms (increased sales, better position in the market, opening new markets, increased profits, etc.) would have strengthened the results of the research. But given the fact that financial data at a micro level was not empirically obtainable, this dimension of the research is not the strongest. However, as will be seen from the sectors overview, uniformly, all sectors agreed that resource efficiency is an important dimension to increase firms’ competitiveness particularly when it comes to reduced costs. And in conjunction to that, firms do take measures to increase resource efficiency. Most firms indicated that they undertake these measures both for competitiveness reasons because it is part of “business as usual” action to maximize profits, and to comply with regulations. As such, in any case, be it for profit making reasons or for compliance to regulations reasons, the discussion about resource efficiency and competitiveness is still valid and relevant even though financial data was not readily available to the researchers.

1.4 Rationale of the study: Why Resource Efficiency

Resource efficiency is one of the important challenges the European Union is facing at the moment. Globalization and the increased world population resulted in an increased competition over natural resources globally. The rise of emerging economies and the increased upgrade of their industries resulted into the introduction of exports restrictions on raw material as their industries are moving higher-up in the production value chain. Increased restrictions over exports has led to a scarcity of raw material and created also competition over recyclable material. In addition to that, various resources in the EU are subject to depletion and when possibly “available”, they are not necessarily extractable. The key issue here is that the areas available for extraction in the EU are constantly decreasing due to other land uses and the long lapse of time between the discovery of deposits and the actual extraction. Global warming and the consequent impact on biodiversity, water and environment raise additional questions around the preservation of natural resources as well.

Whereas scarcity of some raw materials, or access constraints to others, present one dimension of the problem, the less-than-optimal use of material and natural resources is another dimension of the problem. Economic activities require resources such as materials, land, and energy. At the same time, they create material residuals in the form of waste and/or emissions which re-enter the environment. The impact of economic activity on resources and environment is industry-dependent and variable although omnipresent. According to a recent report from UNEP (2010), building & construction, agriculture & food, and metals & manufacturing are resource-intense industries with considerable impact on resources and environment. A noteworthy example is the imprint of agriculture; an industry which alone makes up for 70% of the world’s freshwater consumption, 38% of land-use, and 14% of greenhouse gas emissions. Processes involving fossil fuel combustion are marked as a second primary source of pressure on the environment. In the EU, a series of initiatives (will be discussed briefly in the next section) have taken up resource efficiency issues and regulations have been adopted in order to address them.

As such, the global and regional (EU) developments raised above have strong implications for the EU companies as they are presented with a variety of short - and long-term challenges as a consequence. Resources accessibility challenges, in practice, translate into dependence on imports from countries outside the EU, and new environmental legislation translates into additional costs. These factors consequently result in the emergence of new non-EU competitors who not only have a comparative advantage in terms of price and accessibility to natural resources, but also face less stringent standards of environmental and social performance. This further reduces costs of production and consequently increases comparative advantages of non-EU companies.

In addition, recent developments indicate that many of the resource rich economies are more inclined to preserve their natural resources for the purpose of their national development, therefore adding to the challenge of natural resources accessibility in the EU. Thus, in order to be able to compete in an interdependent global economy, efficient use of natural resources for the EU is the ultimate objective as well as means to survive in a globally challenging and interdependent environment. On company level, the adoption of strategies aiming to enhance the efficient use of resources - increasing in price - lies in the self interest of business entities in order to minimize costs. However, increasing resource efficiency at company level nearly always involves investment, and so we need to understand the trade-offs that influence this decision.

Building on that and in the context of many initiatives undertaken by the EU related to resource efficiency it will be insightful – through this study – to understand, how companies deal with resource efficiency issues in practical terms, and how they manage to curb possible negative implications of current increasing pressures.

1.5 Resource efficiency policy initiatives in the EU

As mentioned in the previous section, the EU is well aware of the current issues around natural resources efficient utilization. The current economic crisis has catalysed the urgent need to provide sustainable policy solutions for the EU economy and its business sectors. In order to address the above described manifold challenges and guarantee long-term economic and social progress, the EU has responded with a number of policy initiatives. In this section, we summarize these initiatives while linking them to the study problem statement.

1.5.1 The EU 2020 Agenda

The Europe 2020 agenda is a 10-year strategy proposed by the European Commission on March 3, 2010 with the aim to stabilize the European economy after the global economic crisis and setting out a vision of Europe's social market economy for the 21st century. The Europe 2020 agenda puts forward three mutually reinforcing priorities:

- **Smart growth:** developing an economy based on knowledge and innovation;
- **Sustainable growth:** promoting a more resource efficient, greener and more competitive economy;
- **Inclusive growth:** fostering a high-employment economy delivering social and territorial cohesion.

In order to define specific economic and social goals for the year 2020, the European Commission has proposed a number of EU headline targets which represent the three priorities of smart, sustainable and inclusive growth. In general the targets concern the increase of employment and investments in R&D, the reduction of greenhouse gas emissions and the share of early school leavers and the number of European living below the poverty line[1].

The EU has put forward seven flagship initiatives to catalyze the progress for each of the headline target. As far as the competitiveness of the European companies in the context of greater resource efficiency is concerned, two of the seven flagship initiatives are of special interest.

Flagship initiative 4: "Resource efficient Europe"

This initiative aims to help decouple economic growth from the use of resources, support the shift towards a low carbon economy, increase the use of renewable energy sources, modernise the EU's transport sector and promote energy efficiency.

To accomplish these aims at EU level, the initiative will focus on mobilising EU financial instruments, enhancing the use of market-based instruments, modernising and decarbonising the EU transport and infrastructure sector, completing the internal energy market, promoting renewable energies and upgrading Europe's networks. In addition the initiative will aim to adopt and implement a revised Energy Efficiency Action Plan and promote a programme in resource efficiency supporting SMEs and households.

In addition, the EU Member States are encouraged to diminish environmentally harmful subsidies, deploy market-based instruments such as fiscal incentives and procurement to adapt production and consumption methods as well as to develop smart, upgraded and fully interconnected transport and energy infrastructures and make full use of ICT. The Member States have to make sure that the implementation of infrastructure projects within the EU Core network is coordinated amongst each other.

Flagship initiative 5: "An industrial policy for the globalisation era"

The goal of this initiative is to improve the business environment, notably for SMEs, and to support the development of a strong and sustainable industrial base able to compete globally.

The European Commission aims to interact closely with stakeholders in different sectors (business, trade unions, academics, NGOs, consumer organisations) in order to create a new framework for a modern industrial policy and in order to support entrepreneurship, to guide and help industry to be prepared to meet the challenges and opportunities of a global "green" economy and to promote the competitiveness of Europe's primary, manufacturing and service industries. The framework will address all elements of the increasingly international value chain from access to raw materials to after-sales service.

This goal ought to be reached by:

- Greater energy and resource efficiency in manufacturing sectors;
- Reduced transaction costs of doing business in Europe by promoting clusters and improving affordable access to finance;
- Promoting the use of technologies and production methods that reduce natural resource use;
- Enabling access to the Single Market and the international market beyond;
- Supporting the transition of service and manufacturing sectors to greater resource efficiency;

[1] The national poverty line is defined as 60% of the median disposable income in each EU Member State.

- Increasing the share of effective recycling across industrial sectors;
- Improving European standard setting in order to leverage European and international standards for the long-term competitiveness of European industry.

In this context, DG ENTR has published a Communication on 'An industrial policy for the globalization era' in October 2010.

1.5.2 Resource Initiatives by the EU

In order to pursue the goals of the EU 2020 strategy, the European Commission aims to put forward numerous initiatives related to 'Resource efficiency' within the timeframe of 2010 to 2012. As listed in the ToR the initiatives will all relate to the Europe 2020 strategy and especially aim to catalyze the goals put forward under the flagship initiatives 4 and 5. The initiatives include the following:

- Energy 2020: A strategy for competitive, sustainable and secure energy;
- Energy infrastructure priorities for 2020 and beyond – A Blueprint for an integrated European energy network;
- Tackling the challenges in commodity markets and on raw materials;
- Low-carbon economy 2050 roadmap;
- European Energy Efficiency Plan 2020;
- White Paper on the future of transport;
- 2020 EU biodiversity policy and strategy;
- Revision of the Energy Taxation Directive;
- Roadmap for a resource-efficient Europe;
- Cohesion Policy Reform;
- Energy infrastructure package;
- Trans-European Networks for Transport (TEN-T) revision;
- Energy Roadmap 2050;
- Smart grids;
- Security of energy supply and international cooperation;
- Review of priority substances mentioned in the Water Framework Directive;
- Strategy for the sustainable competitiveness of the EU construction sector;
- Action Plan towards a sustainable bio-based economy by 2020;
- Strategic Transport Technology Plan;
- Revision of the legislation on monitoring and reporting of greenhouse gas emissions.

For 2012, the most relevant initiatives are:

- Review of Sustainable Consumption and Production/ Sustainable Industrial Policy Action Plan;
- Thematic strategy on waste and recycling;
- Eco-innovation Action Plan.

The close look at the above initiatives reveals that overlaps will certainly occur .It is the aim of the European Commission to adopt a coherent approach with regard to the implementation of the above listed initiatives in order to make use of thematic and administrative synergies. Examples which illustrate the coherence between policy initiatives nicely are the Roadmap to resource efficient and low carbon Europe in 2020, the Low Carbon Energy Roadmap 2050 and the White paper on the future of transport (including decarbonisation). Although having different time horizons the initiatives aim to depict ways in which the existing policy frameworks can be adapted to support the decarbonisation of the European economy. Furthermore all initiatives aim at presenting the benefits of a transition towards a low-carbon economy and that these benefits outweigh the challenges associated with low-carbon transformation. A low-carbon economy is seen as the best economic strategy for Europe in order to stay competitive, secure jobs and economic prosperity. The White paper on the future of transport aims to depict how solutions from research and development, which address the challenges of decarbonisation of transport without limiting mobility and trade, can be fostered and supported. While the above mentioned initiatives address mainly the questions related to the production side of industries and how to deal with outputs such as CO2 emissions, the raw material initiative adds an additional angle to the above mentioned initiatives. It focuses on the resources from the view of their “source”, thus addresses the supply side of the value chain. It addresses the important questions on how to improve access to raw material both at the EU level and at the international level as essential inputs for the competitiveness of the European Industries.

Based on a number of indicators the European Union monitors the progress in its sustainable development strategy. Sustainable development in the area of consumption and production makes up an important part of this strategy. In the article Sustainable development – Consumption and Production (Eurostat, 2010) the progress in these two areas are displayed. In terms of resource productivity the EU is well on its way of obtaining its goals. Resource productivity is measured as the total amount of materials directly used by an economy in relation to economic activity. Over the 2000-2005 a decoupling of resource use and economic growth took place; a first step towards using less resource input to produce more. Furthermore, resource use and waste was examined. Whilst progress has been made, there are still points of critique. Consumption of fossil fuels for example increased and municipal waste increased in all but six EU countries. But at the same time, municipal waste was more often recycled or composted while landfill practices declined with 4.2% over the period 2000-2007. Atmospheric gases have declined nonetheless a slowdown in decline rate since 2000. Thirdly, consumption patterns are examined in the sustainable development report. With an increase in households and their expenditure over the period 2000-2007 household consumption of electricity increased as well. Increasing living standards and accompanying changes in consumption of electronics are indicated as main contributors of this trend. Overall energy consumption of countries increased as well, though at a slower pace (0.6%). Biggest concern in the consumption pattern area nevertheless is the car ownership which grew with an approximate 2.7% yearly average. Lastly, the report takes into consideration production patterns. A positive development is found in the number of organizations in the EU27 certified according to the Eco-Management and Audit Scheme. In 2007 almost 4,000 organizations were certified according to this scheme. Furthermore the number of eco-labelled products and services grew almost exponentially since its introduction in 1996 the EU-25 counted almost 500 awarded eco-labels in 2007. Organic farming and livestock density showed progress as well, leading to a favourable result for the production patterns section. The findings of the sustainable development report underline the importance of resource efficiency; i.e. the focus of this report.

The examples shown above confirm that the initiatives towards 'Resource efficiency' are interlinked, coherent and pursuing the same goals.

1.5.3 Resource efficiency and competitiveness of EU companies

As mentioned above, dependence on resource imports from countries outside the EU present a clear challenge to the international competitiveness of EU companies. In order to maintain competitiveness, the **physical and knowledge infrastructure** of the EU economy have to be adapted in order to guarantee the **security of supply** of energy and resources at **competitive prices** and in an **environmentally sustainable manner**. With its EU 2020 strategy and the accompanying initiatives listed above, the EU policy-makers have taken first steps to create the needed framework.

But because, increasing resource efficiency nearly is accompanied by an investment, there is need to understand the framework within which companies make investment decisions. This framework includes the costs and benefits of the investment decisions, and the barriers to them (which represent a market failure). It should also use the analysis of costs, benefits and barriers to help companies to become more resource efficient whilst avoiding creating a disadvantaged position of the EU industries vis-à-vis their competitors.

To maintain their international competitiveness in a global economy, the latest report "Towards Sustainable Industrial Competitiveness policy" (Ecorys 2010 b, p. 14-15) recommended that companies should follow three transformation strategies:

1. Process innovation and reducing resource-intensity
Investing in technologies and production methods that reduce resources and energy-intensity are a key transformation strategy. In the energy-intensive basic material industries such as chemicals and steel, the potential for increasing energy productivity typically relates closely to core process technologies.

2. Moving to 'up-market' segments
EU industries have responded to globalization pressures by specializing and differentiating their products, by moving into niche markets and by moving to 'up-market' segments. Increased differentiation and moving to higher value-added segments can however be difficult for parts of the resource-intensive industries, if they are unable to differentiate their products or compete on technological intensity. However, investment and development in 'up-market' segments will reduce the industry's exposure to consequences of supply-side sensitivity. For example, in the copper higher end sector scientific research on copper indicated that it combats hospital-acquired infections. As such, copper can be used in touch surfaces in hospital thus acting as a supplement to standard infection control practices. Higher value hygienic door knobs were used in hospitals for the first time by a hospital in Ireland (Eurocopper 2010 a, p. 1-5).

In essence, "moving to up-market segments" will require technological development. This latter in the context of resource efficiency and greener economies is dependent on availability of and access to raw material. The "Critical raw material for the EU" report of the Ad-hoc working group on defining critical raw material, has illustrated some scenarios which show for example, that the introduction of electric vehicles is dependent on the availability of Lithium, which is the main source for sustained battery power. In a similar manner, the production of rechargeable batteries associated with the increased use of portable equipment implies the increased use of the same raw material.

It should be acknowledged however that an up-market segment is not sufficient for the sustainability of industries, because industries rely mainly on economies of scale and mass production for their sustainability. This strategy should be looked at in the framework of multiple strategies for improved competitiveness.

3. Increase presence in growth markets and relocate to low-cost countries
This strategy presumes both the capacity of EU firms to undertake such investments and the absence of foreign investments restrictions. It would also allow these EU companies to take advantage of the lower cost base in these markets.

Despite clear advantages for the industry in terms of costs, this strategy can hardly be called favourable from a European perspective. In addition to job losses, relocating to low-cost country may result into greater carbon leakage and deterioration of the fact that environmental regulations in low cost countries are sub-optimal.

The carbon leakage problem is the most relevant to this study, thus proposing the relocation of industries as a “way out” of the increasing costs problem, will have its downside, thus affecting the environment and resource efficiency elsewhere (tackling the relocation problem does not fall within the scope of this study).

European businesses and the EU 2020 Agenda – The Resource Efficiency Alliance
On a sectoral level, European businesses are already active in order to accelerate a successful implementation of the objectives under the EU 2020 agenda. Rising resource costs, the financial and climate change crisis mean that more and more companies are examining ways to introduce resource efficiency measures as a way of saving money as well as protecting the environment. However, structural changes are required to achieve improvements on the scale needed, such as widespread adoption of new innovative technologies along the value chain.

One example on how public and private stakeholders actively turn the policy objectives under the EU 2020 Agenda into reality is The Resource Efficiency Alliance, an initiative by European Partners for the Environment.

The Alliance aims to reach the objectives related to the EU 2020 Agenda by mobilizing synergies on the basis of sectoral voluntary “bottom-up” approaches along the value chain. The Alliance organizes workshops and action plans for different sectors (e.g. metals, cement, banks, retail, procurement, construction, water) aiming to depict tools and mechanisms which can make the value chain of production more efficient. The Alliance further aims to:

- diffuse engineering knowledge for interested parties value chain strategies and action plans;
- connect key players in complex global supply chain issues;
- seek combined environmental and economic benefits;
- increase business competitiveness by improving resource efficiency;
- drive innovative value chain solutions deriving from multi-stakeholder approach.

Throughout the dialogue across different business sectors as well as with public authorities, the Resource Efficiency Alliance tries to stimulate a “system perspective” and “life cycle thinking”. It is the aim to set-up new business partnerships as a source of eco-innovation and help to make the value chain across different sectors more resource efficient and less carbon intensive – goals which are also put forward in the above mentioned flagship initiatives under the EU 2020 Agenda.

Sectoral initiatives, such as the Resource Efficiency Alliance imply that on the micro level, new strategies and business decisions are necessary in order to achieve these objectives.

1.6 How to read the report

This report is structured in four chapters:

Chapter 2 will give an overview based on literature review of three important topics for this research. The first one is the typology of measures adopted by companies to increase resource efficiency. The second topic is related to investment decision making determinants and the third one is the barriers and market failures to resource efficiency as identified by previous research and literature. This chapter will serve as the theoretical background that will be utilized in the assessment of measures and barriers faced by EU companies towards further resource efficiency.

Chapter 3 will examine the nine sectors selected for the study. It will explore the multitudes of resource efficiency measures that EU companies adopt across their chain of production and their supply chain. The indicators used by companies to measure their resource efficiency will be examined also be examined together with the specific industries' barriers. Against barriers and market failures to resource efficiency, specific policy recommendations will be given.

Chapter 4 will present the general conclusions and policy recommendations for further resource efficiency on the basis of the industry findings in Chapter 3.

2 Resource efficiency - a theoretical background

The main purpose of this study is to assess the drivers, barriers and measures that different companies in different industrial sectors see, face and take with regard to improving resource efficiency.

The diversity of the selected industries is immense and each sector faces different incentives, barriers and measures and further bases its investments decisions on different determinants and financial structures. It is therefore impossible to assess the different industries based upon a common general framework. However, in this chapter, we will try to give a limited economic theoretical background that can be linked to resource efficiency. By that, this chapter aims at creating a theoretical background that can explain investment decisions in resource efficiency measures undertaken by firms in different industries. It will thus explore three important aspects:

- The type of measures which can be linked to resource efficiency;
- The investment determinants related to resource efficiency;
- The barriers and market failures related to investment decisions.

The presented aspects therefore serve as "tools" to better understand why certain firms in particular industries may or may not invest in resource efficiency measures.

2.1 Typology of resource efficiency measures

In order to categorise particular measures adopted by companies for further resources efficiency we use Argyris and Schon model of organisational learning (1978, 1996, cited in Garica Morales, V., et al. 2009, p. 568). According to Argyris and Schon, the organisational learning process occurs at two levels:

Single loop learning - also called **First Order[2] Learning** (Lant and Mezias, 1992, cited in Garica-Morales, V., et al. ibid) is a simple way of adaptation and change where firms' actions aim at utilizing their existing resources by changing their routine behavior and modifying their existing rules. The result of such change is an "*incremental adaptation of the established premises that improves the existing competences and standard operating procedures, while maintaining and adapting the status quo*." (Garcia-Morales V., et al., ibid, p. 569).

First order learning includes changes that do not affect the structure of the organization, such as acquiring higher skilled labor force, training staff, changes in procurement processes and practices, etc.

In the context of resource efficiency and from a technical perspective, we associate this type of learning with a "process" related measure that does not constitute an essential part of production but is an "addition" to it. Examples of this type of measures are the introduction of waste water treatment plants and filters to reduce dust emission and tightening water pipes. Such, so-called

[2] We will use the terms single loop/First order learning interchangeably in this report.

“end-of-pipe”[3] technology measures aim at reducing the harmful effluents of production, and reducing the production **of by-products**.

First order learning measures are considered to be short term actions. They help to increase the competitiveness of an industry if it is forerunner of an international trend. Therefore from a policy perspective, if regulations and policies stimulate first order measures, first implementers will have the competitive advantage of “first movers”. This advantage will slowly disappear once all industries adopt similar measures.

We adopt this concept to label the measures undertaken by companies in this sphere as: **First order measures**.

Second loop learning - also called **Second Order Learning**[4] (Lant and Mezias, 1992, cited in Garicia-Morales, V., et al, ibid, p. 569) is a more complicated level of learning. It goes beyond the existing routines and processes. It highlights constant innovations and radical changes in organizational structures and values. Second order learning creates new systems rather than fragmented ideas. This type of measures includes the use of higher level technologies that go beyond the add-ons presented in the First Order measures. In the context of this study, we make a link between this type of learning and the use of “cleaner technology”, as well as the introduction of “new products” that are more resource efficient. In resource efficiency literature, cleaner technologies are a superior type of measures compared to “end-of-pipe” technologies. They aim at reducing not only the by-products of the production process but also at reducing resource use (both as input and output to the production process) at the source through the use of clean methods or clean products (Frondel, M. et al., p. I). This type of learning/adaptation will involve a high degree of innovation and is associated with investment in research and development.

Compared to first order learning, second order learning is long term oriented. Research evidence indicate that investment programs in second order learning lead to significant cost savings and the increase of total factor productivity of firms. (Hobach et al, 1995, Hitchens et al. 2003, Waltz 1999, cited in Rennings, K and C. Rammer 2009, p. 443). In the context of this study, we adopt this concept to label the measures undertaken by companies in this sphere as: **Second order measures**.

The reason we selected Argyris and Schon’s Models of learning is to emphasize the importance of the dynamics of learning and the importance of looking at the first order measures and second order measures as two consecutive processes. At the first level, firms will strive to discover, retain and exploit the already available knowledge. When all first order measures for further resource efficiency are exploited, firms then start to think of second order measures. Thus the adoption of first order measures is a pre-requisite before companies start to think of higher levels investments. It is part of the organizational leaning process.

Building on the classification of measures undertaken by firms regarding first order and second order measures, the study will be able to provide insights about relevant general policy measures that would enhance adopting measures in either direction as appropriate per industry.

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[3] The official OECD definition of end-of-pipe technology is as follows: Expenditure on “end-of-pipe” technologies used to treat, handle or dispose of emissions and wastes from production. This type of spending is normally easily identified even within the context of ancillary activity because it is usually directed toward an “add on” facility which removes, transforms or reduces emissions and discharges at the end of the production process.

[4] We will use the terms double loop learning/Second order learning interchangeably in this report.

2.2 Investment determinants related to resource efficiency

As all companies across the sectors-which will be assessed at a later stage of this report- are commercial entities with the ultimate goal of profit making, it is of interest to present and understand the underlying determinants of their investment decisions.

Whether a company invests in new technology or other assets depends upon multiple overarching aspects such as:
1. The financial aspects of the investment, including size, cost and return on investment;
2. The time horizon and uncertainty of an investment;
3. the environmental regulations and standards in place related to the investment;
4. The cultural setting in which an investment takes place;
5. The market structure.

The first three aspects will be elaborated in this section, while the last two aspects will be briefly discussed in section 2.3.

2.2.1 Financial determinants

Investment decisions are determined by the calculation of the **costs of investments** versus the **expected return/benefit** of the particular investment. If investments are not likely to have financial returns, firms are not likely to invest. Therefore, before companies make investment decisions, they consider a set of variables:

1. The return on investment (RoI)

In order to move to resource efficiency measures, companies will incur these real costs (I):

A. Capital cost: investment in resource efficiency involves the purchase of equipment in the form of end of pipe technology equipment (first order measures) or cleaner technology equipment (second order measures). The real cost of investment in both types of technologies is not uniform for both types, in most cases investment in second order measures is much higher than investment in first order measures.

B. Labor cost: measures adopted by companies will require a certain level of adaptation of the skills of their labor force. Such adaptations may require training of existing staff or hiring other skilled staff. For some technological upgrades to happen, overhauling the majority of the technical staff might be needed.

C. Information cost: while moving to higher resource efficiency measures, companies may not possess the know how to do that. Knowledge will not only cover the technical knowledge associated with the choice of technology but also the creation of the organizational structure that supports the new technologies. This would involve a few non-technical aspects such as the writing of new company policies, developing codes of conducts, etc. Acquiring the knowledge necessary to develop and implement the technical and non technical aspects will incur cost.

D. Structural changes costs: moving to more resource efficient operations may be accompanied by structural changes which may include the creation of new departments and the installation of monitoring and control systems, internal audits, accounting and reports.

In calculating the (RoI), firms expect to earn back the real cost of the investment (I), plus an additional profit (r). This latter is determined by the anticipated rate of profit of this investment (rI). The rate of profit is usually an unknown variable; companies do not know the real profit rate, but they rely on historical information to predict this rate. The higher the profit rate is, the higher the expected return on investment and their investment decision will be made based on that profit rate.

*2. The **financial cost** of the investment*

In order to acquire the funds that will cover the above mentioned costs, firms resort to two sources: the first is borrowing the money from a bank or other lending agencies at a certain interest rate (i) and the second is using available funds. Decisions about particular investments and how to finance them are highly depended on the optimal capital structure of the particular company within the sector. These cost structures highly differ from sector to sector. In this latter case, a firm incurs an “opportunity cost” resulting from the forgoing opportunity to lend its money to other companies at a certain interest rate (i). In both cases, companies have to consider the **affordability of the real costs added to them the financial costs**.

In addition, Pindyck and Solimano (1993) argue that once a company invests, **it can not disinvest or reverse its investment**, thus **it also incurs additional costs** by forgoing the opportunity to wait until further information about the desirability of the investment is available (p.263).

*3. The potential **profit (R)** of an investment*

The potential profit will be equal to the return on investment minus the total cost of investment (S. Bowles, et Al. Understanding Capitalism, Competition, Command and Change 2005, p. 268-71). A positive outcome of this calculation increases the probabilities of investment and vice versa.

Profit of investment may not necessarily be calculated in financial terms. In the light of the climate change and resource efficiency debate, the non-financial factors started to influence the value and investment attractiveness of firms. Thus companies can gain substantial benefits of an **improved corporate** image especially in high environmentally/resource efficiency aware context. The study conducted by Del Rio Gonzales (2005) found that the adoption of green technology in the pulp and paper industry in Spain was driven by firm’s desire to maintain and improve their corporate image (foot note in Renning, K and C. Rammer, ibid. p. 446).

Recent developments indicate that sustainability criteria play an important role in investment decisions; many firms, especially SMEs, rely to great extent on external investors when considering investments in resource efficiency measures. For such investors, the success of an investment is dependent on the investor's ability to discern the factors that influence the market's valuation of the firm in which an investment may be made and then judge the accuracy of that valuation.

Investors are increasingly concerned about issues such as climate change and resource scarcity. This concern will be reflected in investment decisions and will gain more importance in the financial analysis of industries and companies. Investors also take into consideration issues such as pollution, resource depletion, ecosystem change, waste disposal, the use of toxic chemicals, the license to operate in communities, and other environmental issues, in order to fully understand the environmental risks and opportunities facing the companies before they invest (CFA 2008).

On the benefit side, and from a sectoral perspective, we argue that investment in resource efficiency particularly in the use of raw material and effective waste management decreases **dependency on imports** from international markets and hence induces stability of industries. It minimizes the risks of material price fluctuations and uncertainties in the international markets which inhibit long term planning and investment. Therefore, decreasing dependence on import material, while capitalizing and maximizing the use of existing resources in a sustainable manner **reduces** the industry **uncertainties** with regards to those imports.

2.2.2 *The time horizon and uncertainty*

The time horizon is a key element in decision making. Decisions can be regrouped in three theoretical groups (Lipsey et al.) The first one is the short term and discusses issues like 'how to best employ existing plant and equipment'. The second one – the medium term – tackles issues like 'what new plant and equipment and production process should be selected, given the framework of known technical possibilities. The third and last one is the long term. Here, the discussion will be about 'how to encourage or adapt to the invention of new techniques'. The short, medium and long terms will be different in time, in function of the characteristics/ process of innovation of the sector. In the context of resource efficiency, investment in higher level efficient technologies (example, energy efficiency) requires heavy investments, which would thus imply longer term vision and results.

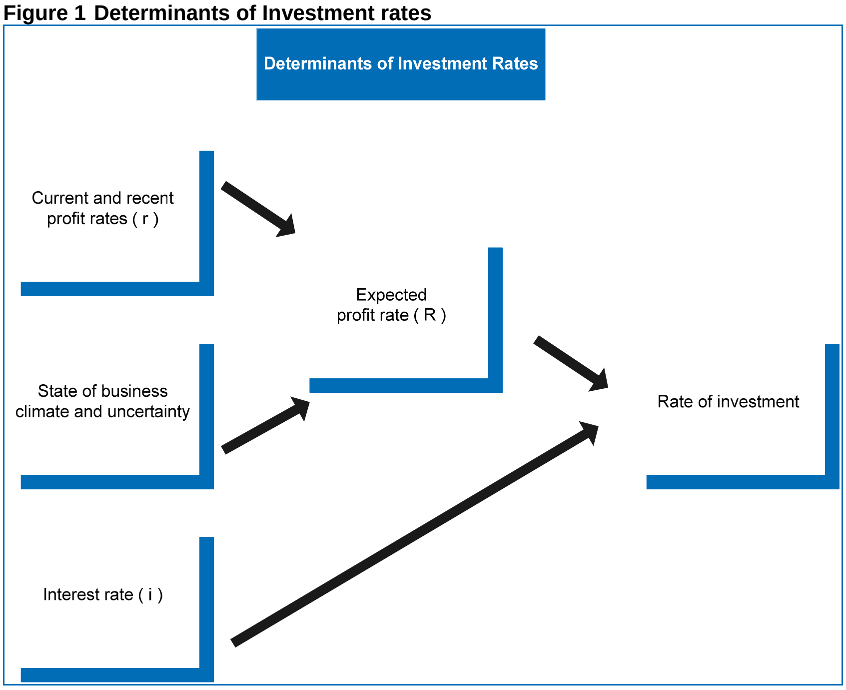
Together with the time horizon, uncertainty will increase. Bowles S. et al. (2005, p. 437) stipulates that uncertainties around investments will increase together with an unstable **state of business climate**. An unstable business climate will go hand in hand with high taxes, high interest rates and stringent or changing regulations. Empirical evidence found that uncertainties around real exchange rates and volatility of exchange rates generally influence investment rates negatively (Bopkin, G. and Onumah 2009, p. 136).

Policy measures implemented in order to limit climate change have changed the corporate landscape in which companies operate. In this landscape carbon-based energy sources face restricted use, increased taxation, and/or increased regulation (see Appendix D, under Environmental, Intergovernmental Panel on Climate Change 2007). As such, the **uncertainty around regulatory changes and their consequences may hinder investors to properly assess the potential future effects of regulation and changing cost structures**. Additional uncertainty arises from fluctuating Carbon prices, particularly for energy intensive sectors. Future environmental, resource and climate change regulations are likely to have knock-on effects across other industries.

Uncertainty in resource efficiency covers also operational issues which are related to companies' capacity to absorb and implement the change towards resource efficiency. These include for example, the uncertainty about the most appropriate technology to be used and uncertainty about the availability of knowledge to use such technology (see section 2.3 for further discussion on barriers to investment).

Based on the above discussion, the determinants of investment can be summarized in the following diagram.

Figure 1 Determinants of Investment rates



Source: Bowles S. Et Al., ibid., p. 437.

2.2.3 Environmental regulations and firms competitiveness

In addition, environmental regulations and standards may influence investment decisions. With respect to resource efficiency, the EU introduced environmental regulations and standards aiming at increasing resource efficiency. Academic literature on resource efficiency argues that environmental regulations may enhance companies' competitiveness and encourage technological development (Porter and van der Linde 1995, cited in Renning, K and C. Rammer, p. 442-3). As such, they are a strong push-factor to investment and to adoption of measures towards furthering resource efficiency. Porter and van der Linde argue that as environmental regulations enhance innovation; this latter creates niche markets for environmentally desired products. Research also proved that there is a **positive relation between investment in resource efficiency and improved sales** (Renning, K and C. Rammer, ibid., p. 442-3). These latter are likely to be the result of increasing consumer demand for more environmentally friendly products. In support of this supposition, Popp (2002) found that the strongest impact that regulations on energy prices had in the US was on innovation. His findings suggest that environmental regulations not only curb the negative environmental impacts but also induce technological development. Similarly in the paper and pulp industry in Spain, regulations pressure was the second main driver of green technology in Spain (footnote in Rennings, K and C. Rammer, ibid. p. 446).

Contrary to these findings, one of the recent studies (Rehfeld et al 2006, cited in Technopolis. p. 36) revealed that the higher prices of the environmentally friendly products were mentioned as one of the reasons of the low market performance. Based on these research results, it can be argued that the impact of **environmental policies aiming at resource efficiency measures on the competitiveness of companies are not decisive**, and thus call for further understanding.

On an international level, excessive regulations result in high costs to resource intensive industries. When increased costs impact the price of the sold products, industries face fiercer competitions in the international markets particularly from third countries. These latter have less than optimum environmental standards which implies lower social and environmental costs. As such, higher environmental costs in the EU places the EU industries at a disadvantaged position vis-à-vis its international competitors.

2.2.4 *Investment determinants implication on resource efficiency investments*

In the previous section, we presented the general factors that companies take into account before they decide on their investments in resource efficiency measures. In this section, we display how the economics of the firm would in general terms define the strategy and investment decisions with regards to resource efficiency. In essence, unless resource efficiency measures support profitability of the firm, investment in these measures are not likely to take place. The conditions necessary for the success of each of these strategies are not the main point of discussion at this moment.

A mentioned earlier, companies are commercial entities and their ultimate goal of existence is profit maximization. Investment for profit maximization in any firm occurs through the manipulation of eight determining factors. We also present how these economic determinants affect the strategies of the firms both for profit maximization and their implications' on the measures they would adopt towards resource efficiency in particular. We list these determinants in Table 1, highlighting the ways they impact profit (column 1), where the (+) sign indicates a positive relation between the determinant and profit rate, while the (-) indicates a negative relation. In column 2, we present examples of strategies that companies adopt to influence these determinants. And, in column 3, the implications of these strategies on investment decisions in resource efficiency measures are shown (only the applicable ones).

Table 1 Profit determinants and resource efficiency strategies

Column 1 Determinant of profits/costs	Column 2 Strategies to raise profit/reduce costs	Column 3 Implications on Resource Efficiency Investments
1. *Price of output (+)*	*Gaining monopoly power.*	
2. *Labor Productivity (+)*	*Speed up production line, Introduce more efficient labor, saving technology.*	
3. *Amount of (raw) materials and machines used per hour of labor (-)*	*Developing new processes, reducing machines down time.*	*Use of efficient modes of production, reducing waste of material.* *Reduction of the number of machines reduces the use of energy, but the intensity of machines use offsets this reduction.*
4. *Price of materials (-)*	*Assuming accessibility to raw material, firms will try to find suppliers offering lower prices – diversify and increase the number of suppliers (to be more independent) - become more vertical integrated (by acquiring mines, etc).*	*Relocating, Investing in a recycling network (and thus increase the % of recycled material in production flow).*
5. *Hourly wage (-)*	*Use cheaper labour.*	
6. *Price of capital goods used in production (-)*	*Use machines at lower prices.*	*Use of less efficient machines, less than optimum technology.*

Column 1 Determinant of profits/costs	Column 2 Strategies to raise profit/reduce costs	Column 3 Implications on Resource Efficiency Investments
7. *Capital goods in use per hour of labour employed (-)*	*Use of production methods requiring fewer capital goods.*	*Use of fewer capital goods that may be more efficient but more polluting due to lack of safety gears or waste treatment.*
8. *Capacity utilization rate, or the percentage of owned capital goods actually in use (+)*	*Finding new markets so as to put idle machines at work.*	

Source: Ecorys adapted from Bowles S. et Al. 2005, p.251.

From Table 1, one could determine four determinants of profit and their subsequent strategies that have strong implications on investment in resource efficiency measures. These are determinants 3, 4, 6 and 7. The close look at these determinants reveals that: Some of the strategies associated with these determinants may have contradicting implications on resource efficiency. According to this logic, **some profitable strategies are more supportive to resource efficiency and are also compatible with profit maximization, such as the use of recycled material, the reduction of raw material used in production, or the reduction of machines used** (which will also reduce the use of energy). **However, not all strategies may be able to combine the use of the most resource efficient technologies with profit maximization**. The use of inefficient technologies or **relocating investment to low cost countries which might lead to a carbon-leakage problem and a production leakage as well** (determinants no. 6 and 7) are examples for that. Whether an investment aiming at higher resource efficiency will also lead to higher profits again depends on the following determinants:

- The time horizon of a particular investment (difference in profitability in the long - and short-terms);
- The competitiveness and market position of a firm (differences between a monopolist and a firm under perfect competition);
- The size and cost of an investment in new technologies.

In support of this latter argument, the economic literature argues that **efficiency is not necessarily a synonym of profitability**. In many cases, the use of “efficient technologies” [5] might be less profitable, because it increases other inputs such as intermediate goods or capital goods, thus increasing costs and reducing profitability (Bowles, S., et Al., Ibid. p. 336). In that sense, one could argue that in the case of resource efficiency, on one hand, the **use of efficient technologies might create trade offs between different resources or between the nodes of one value chain**, thus not necessarily creating a win-win situation across the board and on the other hand, **profitability MAY not necessarily be synonymous to resource efficiency** either as explained through the example strategies given above. Thus it is not wise to assume that companies will be always motivated to adopt or invest in resource efficiency measures.

It might be valuable in this context as well to bear in mind what Bowles mentioned about technology; "*technologies are harnessed to the criterion of profitability*" (p. 338). Based on that, it can be argued that if technologies are harnessed toward a different criterion, which in relevance to this context is "resource efficiency" then investors' criteria for technology selection and investment might also be different.

[5] We define efficient technologies as Best Available Technologies (BAT).

2.3 Barriers and Market Failures

Even when the balance between costs and benefits is favorable to companies, studies have shown that there are a few barriers to innovation towards resource efficiency in the EU. The study requested by the European Parliament's committee on Industry, Research and Energy: "Eco-innovation-putting the EU on the path to a resource and energy efficient economy[6]" (2009) has presented a theoretical overview of the barriers/potential market failures and incentives for innovation in resource efficiency measures. The theoretical framework is built on the general innovation theory and identifies barriers and incentives on the basis of supply and demand, but it is also enlarged to include the environmental aspects to resource efficiency, thus covering as well the environmental regulatory aspects. The framework identified the following barriers and incentives:

Table 2 Framework: Barriers and incentives

Grouping	Barrier	Explanation
Supply side	Technological and management capacity	Access to knowledge about new processes and products R&D activities, financial resources and human capital.
	Appropriation problem and Market characteristics	Accumulation of human capital and available knowledge spills over. If the innovator is unable to capture all the social returns it generates, there are fewer tendencies to investment unless there is sufficient protection of the new generated knowledge. The research on the market characteristics and its relation to resource efficient innovation did not give a uniform picture. On one hand, in monopolies, the appropriation problem is overcome because firms fear less the imitation of their products or operations, thus they guarantee a higher social return of their investment. On the other hand, monopolies may not have an incentive to innovate. They monopolize the market any way.
	Path dependencies	"Innovation breeds innovation" (Baumol 2002 cited in Horback, J, et al 2007, p. 6) in one unit of production will be accompanied by changes in other units too. This is also true through the supply chain, where for instance retailers can influence producers and where producers can influence raw material suppliers. The inefficient production system and lack of knowledge may constitute a barrier towards resource efficiency.
Demand Side	(Expected) market demand: state consumers and firms	The introduction of a new product or the same product with higher environmental standards is accompanied by higher prices without observable increased quality. Uncertainty surrounds the marketability and profitability of the product.
	Social Awareness, environmental consciousness	Lack of awareness and consumer responsiveness will determine market demand and will affect negatively companies investment decisions for resource efficiency innovation.

6 The study selected three key sub-sectors: Housing- Deep renovation and Smart Metering, Mobility- Green electric cars and car sharing, Food and drink- Community supported agriculture (CSA) and Sustainable Sourcing of Retailers. The study uses three types of Eco-innovation: Product innovation, system innovation and process innovation. In that sense, it is identical to the typology used in this research, hence relevant to refer to its conclusions.

Grouping	Barrier	Explanation
Institutional and political influences	Environmental policy (incentive based instruments or regulatory approaches)	Negative effects characterizing environmental problems are external to companies; regulations may force firms to realize environmental benefits through regulations (Porter and Van der Linde 1995, cited in Horbach, J. et al, ibid, p.7).
	Fiscal systems	Pricing of eco-innovative goods and services.
	Institutional structure	The existence of pressure groups such as industries, NGOs and trade associations and the extended knowledge network may affect positively or negatively resource efficiency measures.

Source: adapted from European Parliament 2008, p. 26.

Empirical evidence resulting from the European Parliament study showed that **financial and information barriers** were the main problems facing further development of resource efficiency measures in the EU.

2.3.1 Information barriers

An information barrier is a result of asymmetry of knowledge and information about resource efficiency measures among producers and users. This barrier is also a result of the variance at the levels of management and technological capacity of producers. In addition, producers demonstrated a lack/insufficiency of knowledge about:

1. The role of recycling as a way of material resources recovery;
2. The long term benefits of long-term pay back, which was found to be particularly true in the case of SMEs.

In addition, when material and resource efficiency would offer a market advantage, information is not shared among companies. In reality, incentives to share knowledge and information may come at the expense of individual companies if it will benefit its competitors. As such a certain level of property rights protection should be present to enhance a sharing culture.

As long as information and knowledge is not available to industries, environmental policies are not likely to produce further efficiency, argued Jaffe et al. (2002, ibid), because companies will continue to do their best within the limits of knowledge they have and they have access to.

In the same line, the U.S. Environmental Protection Agency found that information barrier exists among U.S industries particularly in the area of energy efficiency. It found that there is lack of a systematic approach to energy management, and a lack of leading-edge knowledge on energy efficient technology. Not only lack of information causes a problem but also an excess of knowledge combined with an inadequate capacity to evaluate and select the appropriate technologies constitute a barrier. The lack of coordination among the different “knowledge bodies" about the sector creates a market failure and causes a sub-optimal use of the available information (Chapter 4, p. 4) too.

2.3.2 Financial barriers

A financial barrier is where someone is unable to afford to access something because they are unable to make the payments needed to pay for it. Financial barriers may result from "split incentives" among different stakeholders, such as for example, between the investor and the user. Also, in the case where investment and costing are carried out by different departments in one organization, there is likely to be a lack of coordination and non optimal use of financial resources. Added to this, the lack of understanding of the long term benefits of long term pay back contributes negatively to financial resource allocation to resource efficiency.

Technopolis' final report on eco-innovation (2008) confirmed the existence of financial barriers towards resources efficiency[7] particularly in access to suitable source of financing, the large amounts of financing needed upfront and the high cost of innovation. In addition, Technopolis observed the existence of excessive perceived economic risk by industries (p.35). Also, uncertainty about the application of the new technology and its performance and returns on investment results into the application of relatively high discount rates to investments towards resource efficiency (Hausman 1979; Ruderman et.al. 1987; Ross 1990, cited in Jaffe et al. ibid., p.49).

In a similar manner, the U.S. Environmental Agency found that competing capitals can suppress further investment in resource efficiency (in the case of energy efficiency). Where producers have to choose between investment in core products and investment in other "accessory" products (products that do not contribute to the quality or quantity of their core produces; such as energy), their preference goes to investment in the core products. The study also found that the economic outlook of industries can be a determinant factor of companies' decisions for further investment.

2.3.3 *Speculation and price volatility*

One of the important characteristics of resources markets is price fluctuation and volatility. Uncertainty about the availability of resources such as for example, metals or energy results into speculations and contribute to further prices fluctuations. In this case, uncertainty drives prices high and leads to increased stocks of material and cause even more scarcity as stocks are kept in reserve for times of scarcity. This consequently causes scarcity and higher prices of resources.

2.3.4 *Other barriers*

Competition intensity and patent protection

As mentioned earlier, investment in resource efficiency is a private good since it contributes to companies cost reduction. However, there is an innovation spillover expected, because "*innovation breeds innovation*" (Baumol 2002, cited in Horback, J, et al 2007, p. 6). Investors will be willing to invest if they reap the benefits of being the first movers, otherwise, they will fail to appropriate most of the social benefits that they generate as a result of their investment (Jaffe et al. 2002:44, cited in Horbach J. and C. Rennings, ibid, p.6). As such, the more the competition is intense, the less expected innovation because companies fear their margins would not cover their research and development costs. (European Parliament, ibid, p. 26).

Culture and Personal behavior

The Parliament committee study also highlighted a few barriers to resource efficient behavior as well. These are:

- External constraints such as inappropriate infrastructure, costs and working patterns;
- Habits also including consumer behavior;
- Skepticism;

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[7] Eco-innovation is defined as "creation of novel and **competitively priced goods, processes, systems services, and procedures** designed to satisfy human needs and provide a better quality of life for everyone with a life-cycle minimal use of **natural resources** (materials including energy and surface area) per unit output, and a minimal release **of toxic substances**". In that sense, the definition encompasses the three dimensions used in this study, material, natural and waste. It also encompasses the two types of measures referred to under the typology section 4.1.1.

- Disempowerment: the feeling that a person can not be a change agent.

The barriers referred to in this section should trigger policy solutions that would curb these barriers and hence facilitate investment towards resource efficiency.

3 Resource efficiency aspects and measures in different industrial sectors

3.1 The food and drinks processing industry

The food and drinks processing industry[8] is one of the largest EU manufacturing sectors. It is largely dominated by SMEs who represent 99,1 percent of the industry, employing 63 percent of the total industry employees and generating 48.7 percent of the industry's turn over. Over the past 10 years the industry witnessed a stable growth in terms of production at 1, 8%. However, in terms of investment in Research and Development, it is lagging behind compared to its competitors. As such the EU food and drinks processing industry needs to improve its international presence and competitiveness in the face of emerging economies like China and Brazil. Innovation in the industry is very low. Further innovations, according to the industry association (CIAA 2010), can be done by exploring the opportunities offered by nanotechnologies and Genetically Modified Organisms (GMOs)[9]. On these latter technologies, the Euro barometer on food-related risks in 2010 has shown scepticism and a high level of perceived risk by EU consumers[10] (EC, 2010 a, p. 31).

3.1.1 Drivers towards greater resource efficiency

Resource efficiency for the Food and drinks industry is becoming a pressing issue. The reasons behind this pressure came to light during the economic crisis and the surging food prices particularly in 2007-2009. As the core products of the food and drinks industry are based on agricultural products, changes in prices due to international competition and scarcity affect heavily the industry. The increasing population size especially in emerging economies resulted in an increasing demand for food products with increasing price pressure. Combined with changing climatic conditions; droughts or flooding, the problem aggravated and resulted into further scarcity of food. As such, the food and drinks industry in the EU is faced with two challenges: the accessibility of raw material at competitive prices and the sustainable supply of healthy food.

The rising awareness about social and environmental responsibility places further pressure on the industry since it is associated with stringent regulations that limit the use and consumption of resources, such as the IPPC directive and Carbon market (ETS). The increasing energy prices place additional burden on the industry. This has been emphasized by the study on the competitiveness of the European Food and Drinks industry in 2007 which indicated that the industry’s main environmental challenges are represented in the reduction of input with particular attention to water and energy (EC 2007, p. 43).

In the face of the above mentioned challenges, the industry finds itself compelled to adhere to strict measures for resources efficiency in order to survive and maintain its competitiveness. The consultations held with stakeholders of the industry indicated that the industry is committed to resource efficiency - not only for the material it uses for production like raw material, energy and water, but also in its emissions and the effect of its operations on the environment. According to

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8 Agriculture as such falls outside the scope of this study, however the links with the Foods and Drinks processing industry will be made as appropriate.

9 The consultant does not take any position with regard to the industry’ call for exploring opportunities in the direction of GMO. This presentation is only meant to give a picture of what is going on at the industry level without assessment or qualification.

10 According to the report, 66% of EU-27 consumers have worries about GMOs content in food.

one stakeholder, "*Resource efficiency makes good business sense".* Efficiency measures will lead to a decrease of production costs and increase the competitiveness of the industry. In the light of these challenges, the efficient use of resources is vital for the sustainability of the sector.

3.1.2 Measures towards greater resource efficiency

The literature review conducted through this exercise reveals that companies within the sector have been following two main directions of action. The first is: the **full use of material** in **production** such as raw material, energy, water, etc. in the form of reduction and recovery programs, recycling and re-use of material. The second is **reducing GHG emissions** and the impact on environment through investment in low carbon energy, use of alternative sources, energy audits and feasibility studies.

Below we present in further details the measures undertaken by companies to achieve a further efficient use of resources:

Material Resources Efficiency

In the face of depleting natural resources, climate change and impact on agricultural crops, the full use of material through waste prevention and the reduction of waste is the main approach of companies towards raw material efficiency. Waste prevention took the form of first order measures as follows:

The use of by-products of the industry as inputs for other industries such as fertilizers and animal feeds: for example, in the European Spirit industry, the organic left over after fermentation and distillation are re-used in production. The spent grains can be sold as animal feed, while the liquid residues are generally concentrated to form syrup used also as animal feed. Although, the benefits derived from the use of these by-products may not constitute benefits to the food and drinks industry itself, it enters into the production cycle of another industry. As such, it reduces the pressures arising from the need for fresh food, thus reducing costs and contributing to environmental sustainability. (Source: information given through questionnaire circulated to industry representatives).

Another example is The European Sugar industry, which has shown a 100% use of raw material. While the industry processes 110 million tonnes of beet on yearly basis, sugar constitutes only 16% of this amount. However, the industry succeeded to make use of the remaining components as follows:

- Water (75%) **reused** for beet washing;
- Molasses (3.5%) **used as animal feed**;
- Beet pulp (5%) **used as animal feed**;
- Other material (0.5%) incorporated into sugar factory lime.

The use of by-products for bio-energy production and as sources of renewable energy: again in the spirit industry, distillers are considering the by-products as alternative energy sources. This is done through the generation of green electricity from biogas generators (anaerobic digestion), where electricity is exported to the electricity grid. Also, the excess heat is used to heat the neighbouring buildings. In France, the Cognac Industry established REVICO - a wastewater treatment plant, treats 300 million litters of the industry's by-products every year. The plant uses digesters to produce biogas, which is fed into a combined heat and power plant. Surplus heat and electricity (2.5 GWH) is exported off-site (questionnaire handed in by the Spirits industry).

Water is one of the most important components of the industry be it for hygienic or cooling purposes or as a main product (various drinks). According to the "Study on water efficiency standards" commissioned by the European Commission DG ENTR in 2009, (EC, 2009 C, p. 23) the introduction of technical measures to improve water efficiency such as changes in processes, higher recycling rates and the use of rainwater could lead to huge water savings amounting to 15 to 90%. We expect that the large variation could be explained by the difference between the core products of industries and the extent of the use of water for cooling. This means that the drinks industry is an intensive user of water since water is a main component of many of its products (there are exceptions though to this, such as for example, the whisky industry). So the suggested measures will have minimum impact on water use. While for industries that rely on other products as a main product such as meat for example, huge water savings can be accomplished if recycled water is used instead of fresh water, thus contributing to higher levels of savings.

Practices across EU companies on water efficient use have shown two different types f measures that fall under our classification of first order measures:

- The introduction of new practices to reduce water consumption such as developing **water consumption monitoring** tools, **modifying cleaning and housekeeping practices, preventing water leakages**, increasing awareness and **staff training**.

An example of these practices is "Burton's food" (UK), which carried out a water investigation in 2008, and found anomalies which deserved further analysis. This latter was done through the a detailed **sub-metering** of water usage, and resulted in the identification of **possible savings of 73,000** cubic meters of water, and the reduction of 42% in water used per tonne of product. (Source: Food and Drink Federation - UK, Our Five Fold Environmental Ambition - Progress report 2009):

- **Investment in water efficient technology** specifically for **water re-use** in the production process such as **recovering water from steam**. Improving the quality of waste water is a practice done through the valorisation of the organic components contained in the waste water to produce energy and fertilizers.

In some cases, investment in water efficient technologies has led to substantial economic gains. For example, R&R ice cream in the UK has invested in water efficiency by installing an effluent plant which uses ultra filtration and reverse osmosis technologies, thus reducing discharges to 50% and **allowing costs savings of around £100,000**. In addition, recycled water used of washing and cleaning processes will substantially reduce water consumption, thus **saving the company another £19,000**. (Source: Food and Drink Federation - UK, Our Five Fold Environmental Ambition - Progress report 2009).

In France, substantial investment in water efficiency measures represented around 67% of total investments in environmental protection measures (CIAA 2008, p. 36).

The SME Brewery sector has equally shown involvement in technology investment. An example of that is Brewery Liefmans in Belgium which installed a cooling tower to cool and recuperate water, thus saving water rather than draining it to the purification installation after cooling. This investment resulted into 20% savings of water consumption (CIAA, ibid.)

One of the recent initiatives dedicated to water efficiency is the Federation House Commitment, established in 2008 in the UK. The aim of the initiative is to support the members of the food and drinks industry to achieve maximal water use and consumption. It set a target of 20% reduction to be achieved by the year 2020, compared to 2007. According to the latest progress report published by the initiative (2010), the industry managed to reduce the amount of water used for the industry by 1.7% in 2008 compared to its baseline of 2007. This has been achieved through the implementation of several measures:

- Water recovery and re-use schemes;
- Rain water harvesting;
- Dry cleaning operations;
- Fitting more efficient taps and toilets.

Packaging: within the framework of resource efficiency, the packaging industry is an important player together with the Food and drinks industry with this latter being one of the most important clients of the industry. The packaging industry faces similar challenges associated with environmental sustainability. As such, it thrives to reduce the use of packaging material through a few practices:

- Packaging material reduction: The industry is undertaking measures to **reduce the volume and weight of packaging** material to the required levels of safety and hygiene. In the same line, companies use environmental **design guidelines and Life Cycle Assessment**, which combine **lower weights of packaging material** with **recycle-ability of materials and overall reduction of packaging environmental impacts**;
- The use of a set of packaging sustainability metrics agreed by the Consumer Goods Forum, a global organisation including retailers and manufacturers, can help driving resource efficiency.

Table 3 Example of efficiency achieved in the packaging industry

Company	Measure	Efficiency achieved
Diageo's Leven Bottling and Packaging Plant (Carbon Trust Energy efficiency Award 2009)	• Installation of thermostatic temperature controls in the dispatch area and bottle storage warehouses; • Two high-speed doors were installed between warehouses to retain heat; • New controls installed to automatically shut down compressed air and electricity supplies when the lines are not in use.	• annual savings of 750 tonnes of CO2; • Reducing costs by £150,000 a year.

Source: Scotch Whisky Association - UK: http://www.scotch-whisky.org.uk/swa/96.html- green house gas case-study.

Other measures involving the light weighting of spirits bottles led to emission reduction both for glass production and transport of goods. For example, one Scotch whisky Company reduced the weight of a popular whisky by 20g and managed to save 400 tones of glass and 300 tones of CO2 per year. (Source: answers from questionnaire circulated to industry representatives). It must be noted here that the industry is not necessarily involved in the technicalities of bottling weight reduction. But being an important client to the packaging industry, it can influence part of the supply chain in a direction that favours resource efficiency.

Natural Resources Efficiency

In general terms, the food and drinks processing industry accounts for a relatively small share of emission at the EU level[11]. This small share of emission does not include the emissions of

[11] According to the CIAA, 1.5% of the EU-15, excluding agriculture which is one of the main emitters of GHG.

agriculture, which is one of the most resource intensive sectors in the globe. Emissions resulting from the use of energy in the food and drinks processing industry affect the natural environment particularly as a result of GHG emission and hence make the industry subject to ETS. This latter is mandatory to the food and drinks industry, particularly for combustion installations over 20 MW (mega watt) capacities. In order to achieve GHG emission efficiency, the industry has shown two streams of practices, which we classify as second order measures:

- **Investment in low carbon technology:** this includes potential for the co-generation, tri - and poly generation, and the gradual move towards HCFC and HFC free refrigeration technology;
- **Reliance on alternative sources such as:**
  a. Switching from oil and solid fuel to natural gas, renewables and biomass for heat generation;
  b. Using by-products, waste and process water as sources of bio-gas;
  c. Use by-products as renewable, CO_2 neutral fuels in combustion plants;
  d. Explore other alternative sources such as solar and wind energy.

There are few examples throughout the industry that showed its capacity to be both a user and producer of energy through the transformation of bi-products into effective sources of energy. The benefits of such investment are usually felt on long term, and they depend on companies' willingness and ability to invest. The following table shows some examples of measures, achievements and at the same time indicators used by industries to monitor their progress:

Table 4 Examples of good practices in CO_2 reduction – Food and Drinks Industry

Company	Measure	Results achieved/ indicators used
Chivas - Strathclyde grain distillery	An improvement programme, including: • Energy efficiency & heat recovery investments; • Process control; • Management development	Between 2005-2008: • Annual energy consumption & CO_2 emissions reduced by 7%; • Increased production by 24%.
Glen Grant distillery in Rothes	Investment of £400,000 on energy efficiency measures: • Replacing steam traps to save energy on pumping; • Installing multi-pass condensers to raise the water discharge temperature from the cooling system to heat up the still charges.	• Increase of Spirit production by 4%; • Gas savings reduced costs by over £80,000 a year.
Glenmorangie distillery	A £250,000 investment aiming at recovering latent heat from new wash stills to heat other process waters.	175 tonnes of CO_2 expected to be saved per year with less than one year pay back period.
Diageo's - Roseisle distillery	Has built-in heat recovery systems that permit heat from distillery cooling systems to be used at an adjacent malting.	Less fossil fuel requirements.
Ian Macleod Distillers' Glengoyne distillery	Installing an economiser on the boiler, and an improved heat recovery system.	• Expected 5% less gas usage; • 80 tonnes of CO_2 saving per year.

Source: Scotch Whisky Association - UK: http://www.scotch-whisky.org.uk/swa/96.html- green house gas case-study.

Energy and electricity: except for some sub-sectors such as sugar, starch, meat and dairy the food and drinks industry is a low-energy user, but the use of energy is at the core of its operations. It is essential for boiling, evaporation, pasteurization, drying and cooling. In the face of the rising energy prices, the industry is adopting a certain set of measures to achieve further efficiency:

- Adoption of sector specific **best practices**;
- Implementation of **energy audits**;
- Integration of **energy efficiency concept** in the daily **business operations**;
- **Benchmarking** energy use depending on the size of plant and operations;
- Seizing opportunities offered through national **energy efficiency schemes**;
- Use of **alternative treatment methods** for water recovery such as **anaerobic treatment**.

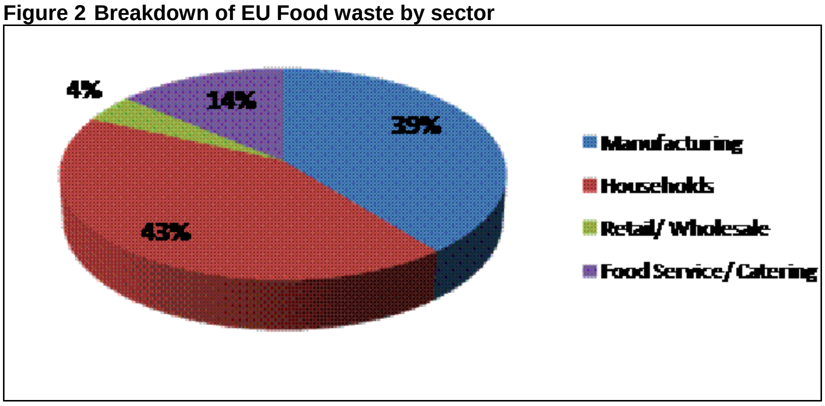
Another good example of energy reduction can be seen in the spirits industry in the UK. Following **significant investment and facility upgrades**, the Spirit Energy efficiency company (SEEC), whose members are Scotland grain distillers, malt distillers, and the gin and vodka sectors, managed to reduce the energy used to produce a litter of pure alcohol by 18%, since the scheme was set up in 1999. Growth of production seems to have decoupled from CO2 reduction, because the previously mentioned reduction was accompanied by a 22% of production increase.

Households (consumers) are important users of material resources in their daily activities. While the packaging industry has tailored the sizes and portions of food products to the consumer needs (such as the single portion salad mix), thus reducing the potential waste of products, the consumer's planning or ill-planning definitely affects consumption. In general terms, the material resources use in the household depends very much on the purchasing decisions and planning of the consumer.

Waste generation and impact

Food waste in the EU is estimated at around 89 million tonne per year, the distribution of which (Figure 2) across the different sectors reveals that the highest rates are produced by household at 43%, followed by the manufacturing sector at 39%.

Figure 2 Breakdown of EU Food waste by sector



Source: Green Cook – the Netherlands

Waste prevention is an exemplary solution to an efficient use of resources. However, in the case of the food and drinks industry, while by-products are an excellent way of minimizing waste, there is still minimum level of waste produced by the industry. As such, waste management is an important element in the sustainability of the sector.

Waste generated from the food and drinks industry can be divided into two segments: Solid waste and industrial waste water. A considerable portion of the solid waste can be converted into a by-product, while a smaller portion remains as waste. In general terms, manufacturers recycle waste and use recovery techniques to reclaim the resources embedded in waste.

In terms of waste water, there are three important elements, all considered to be first order measures that industries take into account:

- Reduction of waste water through efficient processing methods;
- Improve quality of water through state of the art water treatment;
- Optimize the reuse, recycling and recovery of waste water.

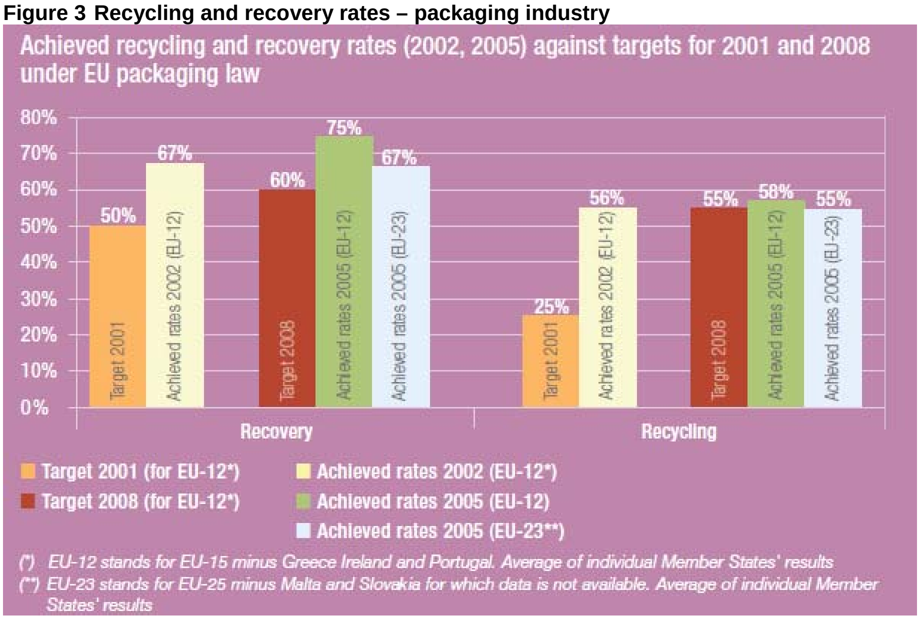
Waste is generated along the food and drinks value chain, starting from the agricultural materials used, to water, to packaging waste.

Starting from the agricultural material, as mentioned earlier, the industry strives to achieve a maximum utilization of material, thus using the industry's **by-products as input** to other industries. According to the Confederation of the Food and drink industry of the EU (CIAA), 30% of the food is wasted in households, which is worrisome from an environmental perspective. The full utilization of household food waste is not yet optimal, which calls for action in this area.

As for water, water waste management requires investment in water efficient technology. Such investments are for water re-use in the production process by **recovering water from steam**, **improving the quality of waste water through water-treatment** and finally **recycling of waste water**.

Being one of the important suppliers of the food and industry, the packaging industry reduces food waste, through tailored packages and products protection. And although it contributes to generating packaging waste, this latter seems to have a high level of recovery through recycling.

Figure 3 Recycling and recovery rates – packaging industry



Source: CIAA, 2008.

As such, **recovery schemes** across the EU have been established in order to ensure efficient waste management. The role of consumers become prominent here as well, where increasing awareness of the consumers about separation, collection and disposal of food packaging waste is essential to ensure the effectiveness of these schemes.

3.1.3 Barriers towards greater resource efficiency

Throughout the literature reviewed as well as the consultation conducted with representatives of the food and drinks processing industry, the main challenges that are facing the industry now are related to uncertainty about **the energy prices**. Energy prices, according to the industry may compromise the profitability and hence the competitiveness of the industry especially in the absence of an internationally binding agreement.

Bearing in mind the fact that the food and drinks processing industry is dominated by SMEs –more than 90% of the industry, there is a risk that these small units may not be able to switch to renewable energy sources and longer term investment due to their relatively limited financial resources. **Access to knowledge** has been identified as a major issue towards resource efficiency especially for SMEs. In addition, the potential use of technology to raise heat or to create steam is a barrier that faces the whole industry regardless of its size because technology needs to be tested yet and finances for such schemes require substantial amounts of investment.

Despite of the good examples mentioned in the above section, according to the "Study on water efficiency standards" commissioned by EC DG ENT in 2009, plants are reluctant to replace old and inefficient technologies due to **pay back time** for investment being uncompetitive.

3.1.4 Conclusions and policy implications

The food and drinks industry’s major issues of concerns are energy use, water consumption and carbon dioxide emission. Measures undertaken by companies to address resource efficiency demonstrated a mix of first and second order measures, but with heavier emphasis on first order measures. As such, we believe that there is substantial room for improvement in the food and drinks industry to improve resource efficiency performance. First order measures, in our view, need to be exploited further by the industry in order to achieve the maximum utilization of its existing resources. From a policy perspective, intruding benchmarking, technology based and performance based standards and green labelling will induce the use of first order measures. However, standards should not be too ambitious otherwise they may result into crippling the parts of the industry that will not be able to comply due to the relative high costs. Associated with these standards, a reward system could be introduced for highly performing firms.

Given the lack of knowledge sharing, it is beneficial to devise technical assistance programs for companies and the provision of consultancy services to companies that have least access to the efficient processes and systems.

In addition, in order to curb the lack of knowledge, best practices should be made available to the industry through technology platforms and industry associations.

In terms of access to finance, subsidies for plants’ upgrades can be a good incentive to support SMEs in order to curb their difficulties in access to finance.

On a different note, we have observed that monitoring of resource efficiency is done on a company level from a “resource” perspective, but without a comprehensive approach to resources as a whole. This means that there is room for improving monitoring of resource consumption and production if companies are able to install viable monitoring systems.

In terms of further investment in second order measures, we argue that due to the nature of the Food and Drinks industry, investments for resource efficiency at the product level may be difficult, especially that it would probably rely on nanotechnology and GMOs, which may not be acceptable from a consumer point of view as mentioned earlier. As such, investments should be encouraged in the areas of energy efficiency and hence CO2 emission reduction. Because these areas of investment fall outside the “knowledge base” of the food and drinks industry, cooperation between the energy sector and the food and drinks sectors should be encouraged in the field of research and development. Technology platforms and increased multi-stakeholders dialogues is an important element in this direction.

Correct pricing of resources (water, energy, CO2 emission), can be a good solution to control demand. While large firms may have a lesser problem dealing with pricing issues due to their access to economies of scales, SMEs may not. As such, subsidies to SMEs or tax incentives to SMEs who already apply resource efficiency measures could alleviate the burden on SMEs.

On the consumer side, we believe that there is room to improve household performance of food consumption by improving consumer awareness through public media particularly about the food lifecycle. As change of behaviour takes time to occur; improving awareness can start at an early stage of childhood, perhaps in the schooling system, where early behaviour starts to form. Policies to improve and implement waste separation systems across the EU are important measures to consider as well.

3.2 The cement industry

Cement is considered to be one of the most important building materials used across the globe. In total three billion tonnes of cement were produced worldwide in 2009, of which approximately 7% were produced in the European Union. The cement industry is an upstream element of the construction sector and therefore highly linked to the latter. The latest recession has emphasised once again how tight this link is. In 2009, cement consumption in Europe fell in all countries, in some by more than 40%, due to a hefty decline in construction and the collapse of the housing market (CEMBUREAU, 2010a).

The main component of cement is clinker. Clinker is produced from raw materials, such as limestone and clay, which are crushed and fed into a rotary kiln. The clinker burning takes place at a temperature of 1450°C where the active calcium-silicate and other compounds are formed.

The clinker is then ground with gypsum. Other materials such as granulated blast furnace slag, fly ash from coal fired power generation, natural pozzolans, and limestone may be added to the clinker and gypsum during or after the grinding process, producing a range of cement types. Fuel mainly originating from fossil fuels and non-renewable resources constitute the main material inputs to the industry. With a generic, weighty product such as cement, price and customer service are the main differentiators among companies (CEMBUREAU, 2010b). Solutions for energy efficiency and energy source substitution in this energy-intensive industry thus take centre space focus in each company as a reducer of costs. Hence, resource efficiency is mainly achieved through efficient energy use.
Emissions from the cement kiln come from the physical and chemical reactions of the raw materials and from the combustion of fuels. The main constituents of the exit gases from a cement kiln are nitrogen from the combustion air, CO2 from calcinations and combustion, water from the combustion process and the raw materials, and excess oxygen. The exit gases also contain small

quantities of dust, chlorides, fluorides, sulphur dioxide, NO_x, carbon monoxide, and still smaller quantities of organic compounds and heavy metals.

3.2.1 Drivers towards greater resource efficiency

Energy use and CO2 emissions are the two most important resource efficiency elements associated with the cement industry. The main CO2 emissions are both raw material-related and energy-related and occur during the clinker burning:

- Raw material-related emissions are produced during limestone (CaCO3) decarbonation to calcium oxide (CaO) in the kiln and account for about 60% of total CO2 emissions;
- Energy-related emissions are generated both directly through fuel combustion and indirectly through the use of electrical power.

High levels of CO2 emissions and the high energy costs which amount to 40% of cement production costs have long been part of the business decisions. As such, the cement industry uses waste as a substitute for primary raw materials and fossil fuels. This ensures that both, natural raw materials and fuels are preserved and CO2 emissions are reduced.

3.2.2 Measures towards greater resource efficiency

The conference paper, produced in 2004 by ECOFYS (The Netherlands), Lawrence Berkeley National Laboratory (USA) and IEA Greenhouse Gas R&D Programme (UK) introduced various options for the industry in order to achieve its energy efficiency objectives and to reduce its CO2 emissions. It focused on four areas of action, representing a mix of both first and second order measures:

1. Energy efficiency improvement and shifting to more energy efficient process;
2. Replacing high carbon fuels by low carbon fuels;
3. Application of alternative cement;
4. Removal of CO2 from the flue gases.

Out of the four options presented above, the paper pointed to the reduction of the carbon content of the fuel used for combustion as the main option for CO2 emissions reduction. This could be achieved through the usage of alternative sources of energy like, for example, natural gas. An additional alternative source to reduce CO2 emissions would be to use waste derived materials. On the one hand, this reduces the pressure on the use of fossil fuels thus reducing energy costs and on the other hand, it provides a sound waste management solution, otherwise the waste would have to be incinerated or land-filled. So, the use of alternative materials provides both economic and environmental benefits. Based on that, the cement industry advocates for further resource efficiency through the use of alternative fuels and alternative raw materials as sources of energy, in a waste recovery process called “co-processing”. According to this process, the high temperatures reached in the kilns provide excellent conditions for the thermal treatment of various types of waste. That can be used as alternative fuels such as used tires, sewage sludge, waste oils, and plastic. Thus they are co-processed in cement kilns.

The impact of co-processing on kiln emissions can be summarised as follows:

- **Sulphur oxides – SO_2:** Alternative fuels have no influence on total SO_2 emissions;
- **Nitrogen oxides – NO_x:** Alternative fuels do not lead to higher NOx emissions – in some cases, NO_x emissions can even be lower;
- **Total organic carbon – TOC:** there is no correlation between the use of alternative fuels and emissions levels;

- **Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF):** No difference has been found in dioxin emissions when alternative fuels are used;
- **Hydrogen chloride – HCl:** HCl emissions vary irrespective of the fuel used;
- **Hydrogen fluoride – HF:** There is very little difference in HF emissions when using alternative fuels;
- **Heavy metals:** Emissions vary irrespective of the fuel used. However, nearly 100% of them remain either in the cement clinker matrix or the cement kiln dust as non-leachable compounds. In any event, alternative fuels undergo a rigorous acceptance and inspection procedure before being used;
- **Dust:** Dust emissions taken under both fuel regimes indicate no difference between the two.

In the co-processing of alternative fuels, the installations meet the same standards as dedicated waste incinerators.

It is noteworthy to mention here that 10 years ago, the World Business Council for Sustainable Development launched the "Cement Sustainability Initiative" - (CSI); a worldwide voluntary initiative which produced a performance overview of 240 companies - participants of the initiative and covering 893 cement installations worldwide. The performance overview was included in the WBCSD's report "Getting the Numbers Right", published in July 2010 and highlighted the industry's performance until 2008. The report made reference to Key Performance Indicators to be used for the measurement of the industry's performance, some of which we list hereunder:
- Average thermal efficiency per tonne of clinker: MJ per tonne of clinker;
- Substitution of conventional fuels by alternative fossil fuels and biomass: Fuel mix and thermal substitution;
- Mineral components and clinker to cement ratio;
- Electric power per tonne of cement;
- Production volumes and CO2 emissions per kiln type;
- Gross and net CO2 emissions per tonne of clinker.

In the next section, we present some of the current examples from the European Union on resources efficiency measures adopted by the cement industry. It must be noted, however, that for the cement industry, it is very difficult to draw a clear line between what we called "natural resources" and "material resources". This is due to the fact that, as implied above, the impact of the industry on the natural resources (environment) is very much dependent on the "material resources that it uses" in its production cycle.

Emissions to air

Besides energy use, emissions to air are the main environmental issue for the cement industry. CO2, as discussed before, is emitted in large quantities as a result of the process limestone calcinations and the intensive use of fossil fuels. In addition to CO2 the industry also releases gases in the forms of nitrogen oxides, sulphur dioxides, and hydrocarbons. Ambient air quality analysers are used in cement production facilities to monitor emissions of these substances.

All high-temperature processes generate nitrogen oxides. They are formed during the combustion process either by combination of fuel nitrogen with oxygen within the flame or by combination of atmospheric nitrogen and oxygen in the combustion air. The latter, called thermal NO_x, is the major mechanism of nitrogen oxide formation in the kiln flame. Cement kilns NO_x emissions are formed independently of the fuel as a consequence of the high temperature in the kiln.

Fuel $NO_{x,}$ resulting from nitrogen compounds in the fuel, is of a lesser importance. In cement rotary kiln systems, formation of fuel NO (nitrogen monoxide) in the area of the main firing is insignificant.

NO_x emissions from a cement kiln are normally determined by the airborne nitrogen rather than by the fuel fired.

Nitrogen monoxide (NO) accounts for about 95% and nitrogen dioxide (NO_2) for about 5% of nitrogen oxides present in the exhaust gas of rotary kiln plants.

Primary measures such as flame cooling and SNCR as secondary measure (selective non-catalytic reduction) are the overall means applied to reduce NO_x from the clinker production process.

As explained, NO_x is formed from nitrogen and oxygen, independently of the fuel, as a consequence of the high temperature in the kiln. Nevertheless, some slight changes in the emissions while co-incinerating waste may be observed:

1. NO_x from primary firing can be lower if alternative fuels include water or require more oxygen (impact on the flame temperature, which is lowered). The effect is comparable with the one of flame cooling;
2. NO_x from secondary/precalciner firing can be lower if coarse fuel creates a reducing zone.

Sulphur oxides are generated from the sulphur and sulphur compounds found in the raw materials and fuels. Because of the alkaline nature of the materials used in the cement making process and the oxidising conditions, a large proportion, especially those from fuels, is absorbed and trapped into the cement clinker and the cement kiln dust (CKD). The remainder is emitted in flue gases as SO_2.

High SO_2 emissions are to be expected when the raw materials contain volatile sulphur compounds (e.g. pyrite). Indeed, these oxidisable compounds may be converted to SO_2 as early as in the upper cyclone stages. This SO_2 can be captured in the raw mill by the finely ground raw material.

When needed, sulphur oxide emissions can be decreased through secondary control techniques.

Dust is an important issue due to its impact on human health as well as the environment. Dust from kilns, raw mills, clinker coolers, and cement mills is collected and recycled back to the kiln. This way, toxic particles and substances such as metals and mercury can be limited (European Commission, 2010c.) The transportation of raw materials and quarrying are also sources for dust (Ecotech, 2010).

Emissions to water

Emissions to water are not an issue in this industry since water is mainly used as a cooling material. Therefore, the production process has no real impact on surface and groundwater quality.

Biodiversity

The industry is highly dependent on quarrying for its raw materials. Quarrying, however, if unregulated or performed in an unsustainable manner, can have a large impact on the biodiversity in the area, such as destruction of habitats, loss of species, and deregulation of ecosystems. The cement sector uses abiotic resources found in the environment of which biodiversity and ecosystems are part. As such, biodiversity conservation, ecosystems management and land-use preferences play an important role in its long term resource and reserve strategy. Over the years, the cement industry has become more involved and active in the promotion of biodiversity in order to limit its impact on the environment. For example, a range of studies conducted in several European countries have demonstrated that correctly managed quarries are able to provide habitats to some protected species. In addition, proper planning and rehabilitation can positively contribute to biodiversity conservation. Enhancing ecosystems, developing biological corridors, collaboration with universities and research centres to increase scientific knowledge on the topic and raising awareness are all points of attention promoted by CEMBUREAU, the European Cement Association. This association also makes an effort to spread best practices in the industry to stimulate other companies to take action and to speed up learning processes. Although the association shows obtained successes with pride, it recognises at the same time that more can be done to further biodiversity in quarries (CEMBUREAU, 2010).

The main drivers for quarry rehabilitation and biodiversity conservation are both social and legislative, and not specifically economic ones. Environmental groups put pressure on the quarry companies and the national and EU directives pointed at biodiversity preservation, such as the EU birds and habitats directives and provide a legal framework which the companies must comply with (European Commission, 1992).

Material Resources

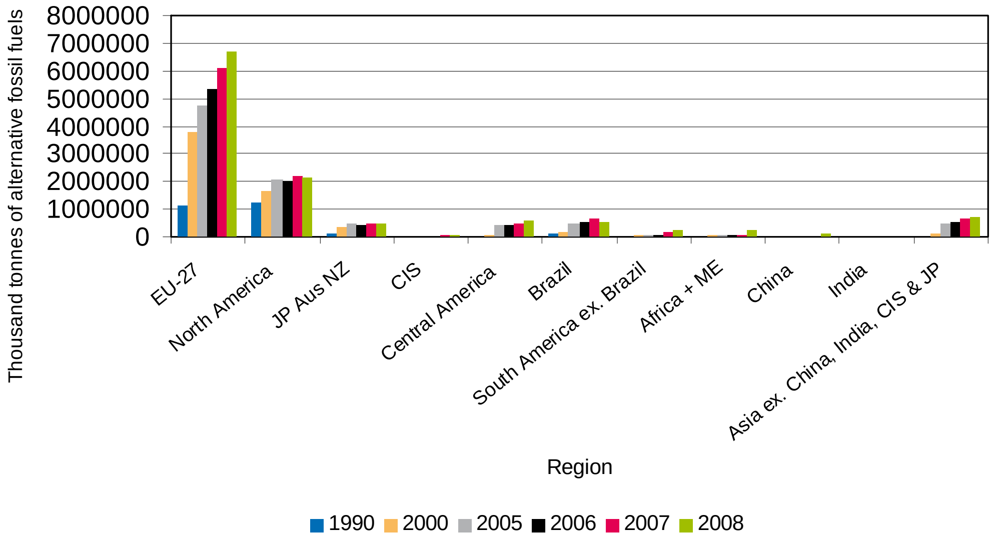
According to the CSI report, the European cement industry has already embarked on the use of alternative sources of energy in order to reduce its reliance on raw material and fuels and achieved substantial progress in this area. For example, in 2006, 5Mt of coal were saved by using alternative fuels as a fossil fuel substitute, which counted for 18% of the energy requirements. This substitution rate is much higher than in other parts of the world. North America and Japan-Australia-New Zealand obtained 11% of their sources from waste, particularly alternative fossil fuels. Latin America uses 10% alternative energy, 6% of which is fossil and 4% is biomass. Asia began a substitution rate of about 4% in 2006. Usage of alternative sources of energy in the Middle East is fairly limited (Getting the numbers right, 2010, p. 18).

Despite the relative higher performance of the EU compared to other regions of the world, CEMBUREAU believes that the use of alternative resources in some European countries is still limited and there is margin for improvement, although this will depend on the availability of substitutes materials and the extent to which new technologies will help in testing and introducing these substitutes.

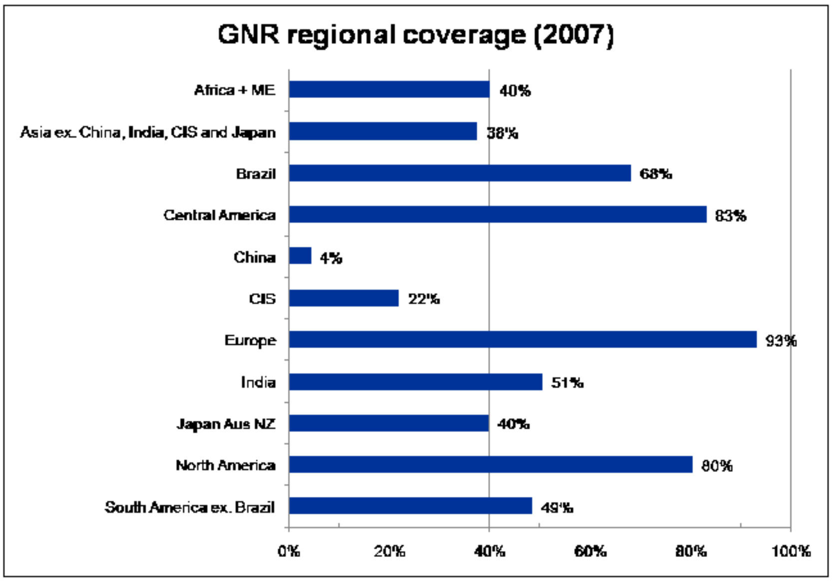
As mentioned earlier, clinker is one of the main components of cement. It can be substituted by other materials such as granulated blast furnace slag, fly ash from coal fired power generation, natural pozzolanas, and limestone. These may be added to the clinker and gypsum during or after the grinding process, producing a range of cement types. The lower the clinker ratio is, the higher the saving of resources (natural resources and CO2 emission) is.

The use of alternative fuels worldwide shows a high utilisation rate of the EU compared to other world regions. Furthermore, the rate of alternative fuels utilisation has increased drastically from 1990 to 2008.

Figure 4 Use of alternative fuels in different regions of the world



Source: http://www.wbcsdcement.org/gnr-2008/geo/GNR-Indicator_313-geo.html.



Source: http://www.wbcsdcement.org/index.php?option=com_content&task=view&id=63&Itemid=130.

Below are some examples regarding the **use of alternative raw materials**:

The Netherlands: ENCI

The ENCI plant in Maastricht (the Netherlands) has been working with the Limburg Purification board since 2000 for the purpose of the re-use of sewerage sludge as an alternative material for fuel. Eighty thousand tonnes of dried sludge are co-processed annually in the kiln.

Germany - CEMEX

The CEMEX plant in Rüdersdorf/ Germany is located in an area that produces close to three million metric tonnes of garbage per year. The plant uses alternative fuels such as animal meal and domestic wastes which represent 53% of total fuel and supplies 48% of total energy needs of the plant.

Other worldwide examples

Taiheiyo Cement in Japan has been working for some years with local government to reduce the burden of municipal solid waste on Japan's limited landfills and has three systems for recycling municipal waste:

- **Ecocement:** A cement manufacturing process whereby half the natural raw materials used are replaced with ash from municipal waste incinerators. The world's first Ecocement facility opened in Chiba in 2001 and has the capacity to take incineration ash from the municipal waste of 1.5 million people. A second Ecocement plant opened in 2006 and recycles incineration ash into cement from 25 cities and 1 town in Tokyo prefecture;
- **Fly Ash Washing:** a pre-treatment system that removes chlorides and recovers heavy metals to allow municipal waste incineration ash to be used for Portland cement;
- **AK System:** an idle cement kiln is used as a biodigester. Waste can be brought directly by garbage trucks to the biodigester where it decomposes for about 3 days, after which it is transformed and sorted into a safe fuel and raw material for Portland cement. The Saitama plant currently uses all the municipal waste generated by a nearby city (15,000 tonnes per year).

Source: CEMBUREAU.

In general terms and on the global level, the use of alternative fuels, particularly the use of waste, varies considerably across the world regions. These variations are related to a few factors:

1. Level of development of waste legislation;
2. Law enforcement;
3. Waste collection infrastructure;
4. Local environmental awareness;
5. Availability of waste.

Natural Resources

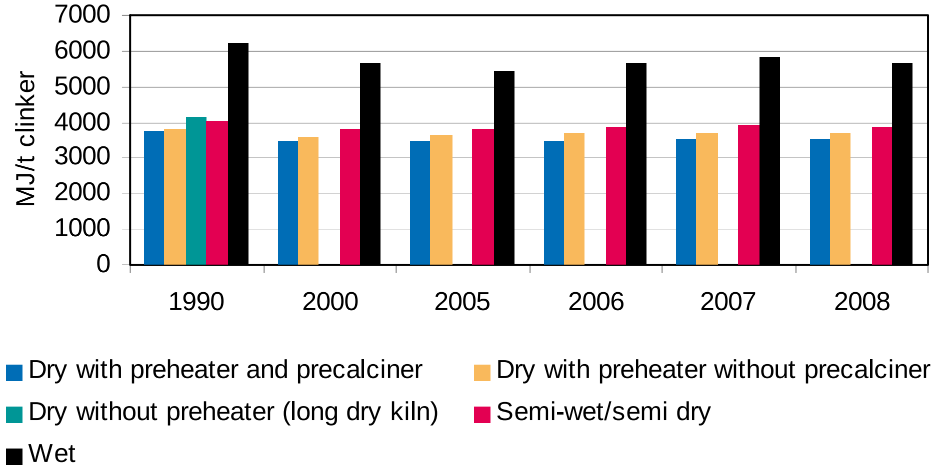
The use of energy and carbon dioxide emissions are pressing issues for the industry in terms of natural resource efficiency. For both resources, we have observed the existence of both first order measures represented in process related measures but also second order measures represented in the use of alternative material.

On the use of energy: The energy bill of the industry represents a large proportion of production costs which, in the light of increasing energy costs, represents a challenge to the industry. The best thermal energy efficiency achieved was 2,900 MJ/tonne (back in 2006). The average European energy use was close to this rate: 3,677 MJ/tonne, i.e. 10% higher than the best practice (getting the numbers right, 2010, p. 15). Europe's main assets behind this relative high performance lies in a number of first order measures represented in the selection of **production processes using pre-heaters (PH)** kilns without pre-calciner (PC) (the usage of the former is more efficient that the latter) as well as a lower number of semi-wet and wet kilns **(dry kilns provide the highest efficiency)**. In addition to this, the average European kiln size is relatively large, and thus tends to have smaller heat losses per unit of production.

In North America the average thermal consumption is 4200 MJ/tonnes which is 25% higher than the above mentioned European reference performance (2,900 MJ/tonne). North America relies on an asset base consisting of **wet, semi-wet and long dry kilns,** which is not as efficient. Renewing the asset base in North America has been slow due to low energy prices, the complex and lengthy business associated procedures (permits, lengthy court and appeal procedures) (Getting the numbers right, p.16).

Below is a figure showing the relation between the different types of processes and energy consumption, where the use of PH-PC is more energy efficient than other combinations of processes:

Figure 5 Weighted average thermal energy consumption per tonne clinker per kiln type (ALL GNR participants)



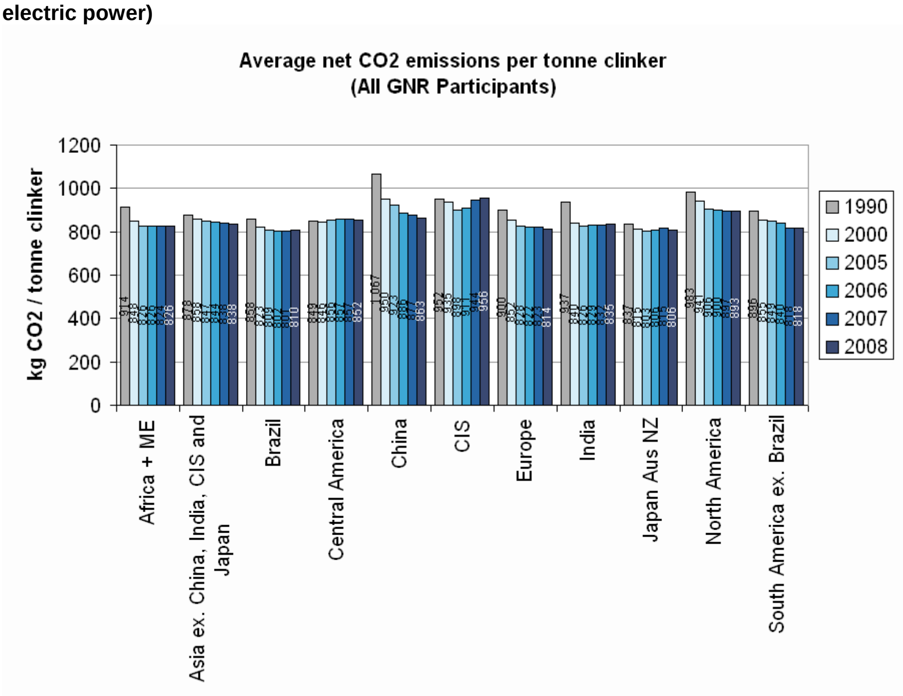
Source: http://www.wbcsdcement.org/gnr-2008/EU27/GNR-Indicator_3210a-EU27.html.

On carbon Dioxide: Carbon Dioxide emissions from the cement industry result from two sources:

1. The calcinations of limestone: a chemical reaction in which limestone is converted into calcium dioxide;
2. Combustion of fossil fuels.

The below figure shows the weighed average of CO2 emissions from the cement industry across the different regions of the world:

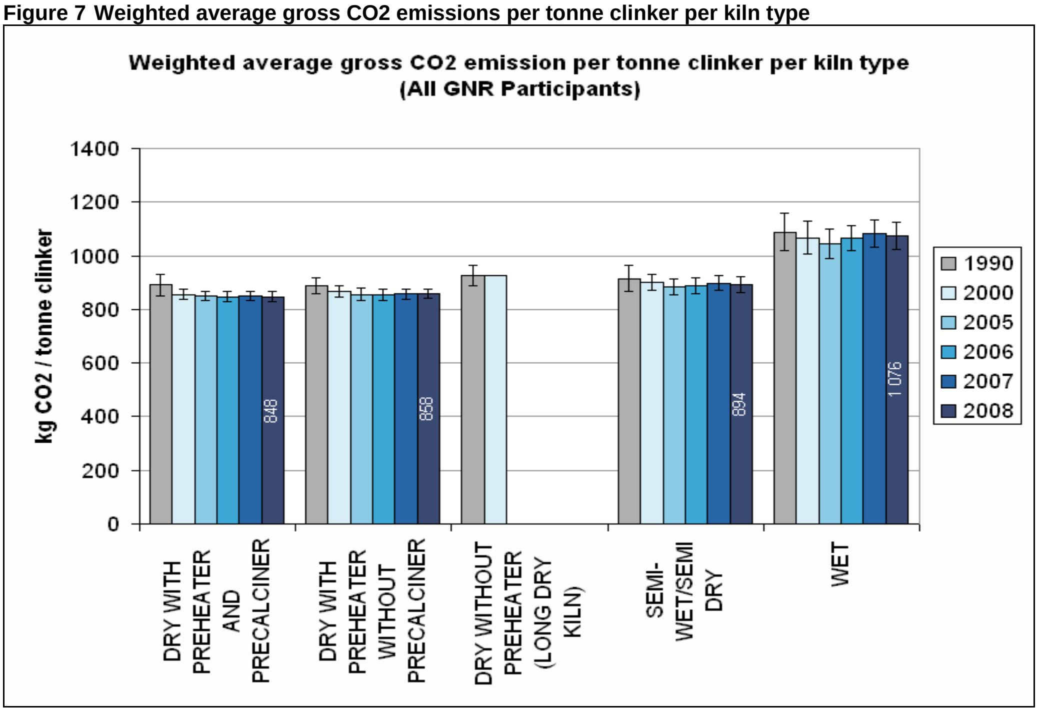
Figure 6 Weighted net CO2 emissions per tonne clinker over time by region (excluding CO2 from electric power)



Source: http://www.wbcsdcement.org/gnr-2008/geo/GNR-Indicator_324-geo.html.

From 1990 to 2008, North America had the highest CO2 emissions compared to other regions (calculated based on the average net CO2 emission per tonne). CO2The reasons behind the variations in the different regions' performances are related to: **Process emissions** (from wet, semi-wet, dry), **fuel mix and clinker mineralisation**. The dominant fuels used in North America, Asia and Africa are mainly coal and petcoke, which have a higher CO2 content if compared to natural gases, or alternative fossil fuels and biomass, which account for 18% of the energy used in Europe.

Figure 7 Weighted average gross CO2 emissions per tonne clinker per kiln type



Source: http://www.wbcsdcement.org/gnr-2008/EU27/GNR-Indicator_327a-EU27.html.

Measures adopted by European companies towards resources efficiency in the direction of CO2 reduction revolved around:

- Changes in production processes (first order measure);
- Clinker substitution (second order measure).

The following examples show some CO2 reduction practices by several European companies:

Romania: Holcim

Holcim embarked on CO2 reduction through the production of blended cements on the basis of a substitution of clinker with fly ash. The aim of this project was to achieve a 1.3 million tonne CO2 reduction between 2004 and 2012. The outcome of the project in the first year was a substantial reduction of 133,000 tonnes of CO2 (Source: Cement Sustainability Initiative web site: http://www.csiprogress2007.org/index.php?option=com_content&task=blogcategory&id=33&Itemid=35, accessed on November 18, 2010).

Ukraine - Podilsky

Investments amounting to €140 million are planned to convert production process from wet-process to modern clinker production line. The plant is expected to reduce CO2 emissions by 0.7 million metric tons per year.

In technical terms, it is obvious that in terms of processes and types of kiln, the dry process is more efficient than the wet process in terms of CO2 emission and energy use and that the use of pre-heaters and pre-calciners is more efficient than other combinations of kiln systems. To summarise this section, a comparison between different practices across different regions of the world is given below.

Table 5 Comparison of practices across different regions of the world

Region	Performance	Practices
Europe	Average thermal consumption is almost equal to global average and 10 % higher than the best practices - alternative fuels constitutes 20% of energy needed	High proportion of preheater kilns without pre-calciner Lower number of semi wet and wet kilns Average size of kiln is 0.9-1.1 million tones of clinker production per PH-PC
China-India, +Asia:	Average thermal efficiency close to the thermal efficiency of the most efficient PH-PC kiln Asia: sources 4% of energy use from alternative fuel (1996)	Pre - heater kilns with or without pre-calciner * 1.9 tonnes of kiln production
Japan		Majority of production is PH-PC Renewal of industrial assets For Asia: Source of fuel: pet coke and coal: high in CO2 content
Australia		
	Australia only: Alternative fuel is 11%	Majority of production is PH-PC
CIS	Average thermal consumption 80 % higher than rest of Asia, and 65% higher than the rest of the world Gross CO2 emission per tonne of clinker is 5% higher than the global average	Old wet kilns - fuelled with low priced gas and low CO2 intensity
North America	Average thermal efficiency 25% above good practice Alternative fuel represents 11%	Large number of wet, semi wet and long dry kilns Source of fuel: pet coke and coal: high in CO2 content
Latin America	Sources 10% of energy from alternative fuel	
Middle East	Insignificant use of alternative resources	

Source: Ecorys - adopted from CSI - Getting the Numbers Right 2007.

Waste generation

The scanned literature/ resources about waste generation in the cement industry places little emphasis on the waste produced by the industry. In fact, it highlights the use of waste as an input for production necessary to increase efficiency at that level. Waste produced by the industry is limited to the following:

- Kiln dust removed from the bypass flow and the stack off-gas cleaning when not recycled;
- Used sorption agents (granular limestone, limestone dust) arising from the flue-gas cleaning system when not recycled;
- Packaging waste (plastic, word, metal, paper, etc.) arising from the packaging step.

Most of this waste is immediately recycled back into the production process. Waste that cannot be processed is supplied to other industries, recycled in waste recycling facilities, or is processed by waste disposal facilities.

After cement has served its purpose in concrete in buildings, the waste can be recycled for new applications. In the Netherlands, construction and demolition waste (CDW), which accounts for over 40% of concrete, is recycled as road construction material. Application of CDW in road reduces raw material use, prevents landfill, and reduces emissions (Hendriks and Janssen, 2001).

A Spanish industry example - Cementos Molinos Industrial (CMI)
This Spanish cement company CMI has a production capacity of 40.000 tonnes of calcium aluminate cement and 1.640.000 tonnes of Portland cement.

The cement industry makes great use of energy, raw materials and water. CMI understands the importance of the environment and therefore intends to keep a balance between the companies' needs and the resources available and therefore is a member of the Cement Sustainability Initiative (CSI). The initiative wants to develop a global sector approach for mitigation of greenhouse gas emissions. CMI considers sustainability to be a strategy to diminish the environmental impact, to increase competitiveness and to live up to the demands of interest groups. The factors for energy efficient usage that CMI considers to be most important are:
- Extraction of raw materials;
- Emission of CO2 and other greenhouse gases;
- Polluting emissions from the production process;
- Consumption of fossil fuels and electricity;
- Noise emissions;
- Waste.

CMI's existing production plant has been upgraded and a new production line will soon be ready for use. This project contains significant environmental improvements. CMI **uses by-products of other industries** into the cement production process as to decrease the amount of natural resources that needs to be extracted. Looking at the 2009 sustainability report one can see that usage of natural resources has **decreased since 2007**. In order to further improve resource efficiency CMI is participating in industry-wide projects (e.g. Sostaqua) to find alternative by-products that can also be used. In order to reduce greenhouse gas emissions, CMI has been using **alternative energy sources**. Furthermore, the **total consumption of energy** (electricity, carbon products and petroleum derivatives) of CMI has **decreased by over 16%** over the past three years.

Annual measurements are done to measure the amount of **noise** generated from the cement production process. The measurements showed that the upgraded production plant will generate substantially less noise.

Looking at waste generation one can see that only a very small portion is recycled (2007: 18%, 2008: 1%, 2009 20%), an area where further improvements can be made. (Source: Cement Molins Sustainability Report 2009).

3.2.3 *Barriers towards greater resource efficiency*
Since 1993, the EU has achieved efficiency gains at 2.2%. However, these achievements are not expected to continue at the same rate since energy efficiency technology is somehow reaching its limits particularly in terms of clinker technology. This has been confirmed by the Cement Sustainability Initiative (CSI) which states that existing clinker making technologies do not provide

further potential for significant energy efficiency gains. According to the same report, the maximum efficiency achieved marks the technical limits of thermal efficiency in the day-to-day operations as well. These facts have been highlighted by the Heidelberg Technology Center (in 2009) which confirmed that the potential for the resources optimisation has almost been fully exploited and there is need for further investment in research and technological development if further efficiency is to be achieved. For the industry, the way forward is not only to focus on increasing the use of alternatives for raw materials and fuels such as biomass and alternative fuels as alternative sources of energy, but also to find out ways for clinker substitution in a way that does not jeopardize the total resource efficiency across the production process and the value chain as well.

The industry expects that the enforcement of the Waste Framework Directive will increase the supply of waste to the cement industry. However, competition for waste material and biomass is expected to increase largely as well.

Some industrial sectors such as the power sector and iron manufacturing can be the source of clinker substitutes (as mentioned earlier, particularly fly ash). The cement industry is concerned that efficiency measures associated with these industries are expected to restrict the availability of substitutes and to result in further constraining the resource efficiency of the cement sector. Other sources of clinker substitutes should also be explored taking into account the environmental and safety performances of these substitutes.

Biomass availability at a competitive price will increase the resource efficiency of the industry. However, due to subsidies from the EU to the transport and power sectors (which absorb close to 90% of biomass), the availability of biomass is a challenge for the industry.

3.2.4 Conclusions Policy implications

It is obvious from the above presentation that the European cement industry has achieved substantial resource efficiency gains and can be considered as a forerunner compared to other parts of the world. As indicated earlier, there is still room for the industry to maximise resource efficiency on an aggregate level through the implementation of first order measures which are likely to increase resource efficiency. Benchmarking and performance standards are good approaches to encourage firms to increase their resource efficiency. Discussions regarding benchmarking CO2 emissions have already taken place.

Based on the research results, the utilisation of alternative fuels is beneficial both in terms of reducing energy consumption and reducing CO2 emissions. Coordination between the industry and municipal waste authorities could be a good starting point particularly for the use of sewage sludge as alternative sources of energy. The interdependency between cement and other sectors raises the point that achieving a closed cycle or a cradle-to cradle-approach is possible through the best utilization of the outputs of certain industries as inputs for another.

As indicated through research, for second order measures and further efficiency to take place, there is a need for technological breakthroughs that can only be achieved through encouraging research and development (R&D) in the cement sector. This should be done in cooperation with academia and technology platforms to achieve best results. Subsidies for R&D in the sector could be considered as an incentive measure.

On the other hand, the dependence issue among industries is another aspect that represent the possible trade offs associated with resource efficiency. This means that resource efficiency measures in one industry may have a negative effect on the resource efficiency of another industry.

As such, striking a balance in resource efficiency policy to the extent that would as much as possible cause the least harms possible is advisable. From an aggregate perspective, there must be a good understanding of dependence issues and the accumulated impacts across the value chain.

3.3 The steel industry

Approximately 1,3 billion tonnes of steel were produced in 2007. To meet the growing demand for steel around the world, the World Steel Association expects the production levels to double by 2050. The European steel industry has made substantial efficiency improvements over the last decades on both energy reduction and dematerializing, leaving little room for improvement with the current technologies. The main environmental concerns for the steel industry are energy consumption, recycling and the need for innovative technologies to decrease CO2 emissions.

3.3.1 Drivers towards greater resource efficiency

Besides the iron ore used for the production of steel, large amounts of coal, electricity and natural gas are consumed by steel mills. The energy input of an integrated steel production facility comes to about 83% from coal, approximately 10% from electricity and 7% other (ESTEP, 2009).

The energy consumed in the blast furnace accounts for up to 75% of the energy content of the coal, which is used in the form of coke as a chemical reductant, furnace burden support and fuel. Other significant areas of energy use are the sinter and coking plants and downstream process stages. (World Steel Association, 2008).

Primary steel is produced by reducing iron ores to iron and converting iron into steel and accounts for about 75% of world steel production. Energy requirements for the production of primary steel vary from 19.8 GJ/tonne to 41.6 GJ/tonne. The actual figure depends on the steel grade produced and the technology used. The energy intensity averages for the main primary production routes can be found in Table 6. Secondary steel accounts for about 25% of world production (45% of the production in Europe) and is produced by recycling steel in an electrical arc furnace (EAF). This production route reduces the energy-intensity to 9.1 – 12.5 GJ/tonne. However, because of the durability and long life of steel, there is not enough recycled steel to meet future demand using only the secondary steelmaking method.

Table 6 Energy intensity of steel production methods

Production route	Energy intensity	% of steel production
Blast furnace – basic oxygen furnace (primary steel)	19.8 – 31.2 GJ/tonne	66%
Blast furnace - open hearth furnace (primary steel)	26.4 – 41.6 GJ/tonne	3%
Direct reduction – electric arc furnace (primary steel)	28.3 – 30.9 GJ/tonne	6%
Electric arc furnace (secondary steel)	9.1 – 12.5 GJ/tonne	25%

Source: World Steel Association, 2008.

Energy intensity values for the EU steel industry are however significantly lower if compared to the worldwide values presented above. For the integrated routes, which include the use of blast furnace, coke ovens, sinter plants and Basic Oxygen Furnace converters, energy intensity ranges between 17-23 GJ/tonne of hot rolled products. For the electric arc furnace, energy intensity ranges between 3.5 and 4.5 GJ/tonne (EC, 2010d, p. 1).

As energy constitutes a large portion of the production costs of steel (20-40%), manufacturers have strived to improve efficiency of the production process. Consumption of reducing agents has been drastically reduced in the past decades. The most efficient steelmaking processes have optimised energy use by enhancing control of each step of the production chain. Improvements that have been made are for example the development of new sensors for measuring bulk properties, modelling processes and increasing the productivity of the industrial tools. Additionally, fully reusing waste gases from the blast furnace, coke oven and basic oxygen furnace (BOF) reduced the need for additional fossil fuel resources. They are used as a direct fuel substitute or for the internal generation of electricity and typically contribute 40% to total energy. These process improvements and the increase of recycling have led to a reduction of about 50% in energy and 60% in CO2 required to produce a tonne of crude steel over the past 40 years (ESTEP, 2009).

Besides increasing efficiency, steel products have offered savings over the life cycle of the end products. For example, Advanced High Strength Steels (AHSS) reduce the amount of steel used in cars making them 9% lighter, which leads to a reduction in fuel consumption and greenhouse gas emissions. Also, application of zinc coating will protect steel framing of buildings or bridges from corrosion and can increase the life expectancy from 40-100 years to 377 years.

The energy consumption of the most efficient steel mill in Europe operates now close to its physical limits and improvement margins for energy savings are therefore only 10-15% (this range applies to the whole industry, considering that best performers would not improve their energy efficiency). However, applying Intelligent Manufacturing will optimize all the improvements made in different parts of the supply chain. Intelligent Manufacturing consists of integrated control of the global supply chain supported by IT systems and with the addition of intelligence provided by modelling, diagnostic tools, artificial intelligence and expert knowledge. This concept can still improve quality, just in time delivery, production levels and increase savings in energy and raw materials by looking at the whole supply chain and integrating all the improvements made by different individuals in different departments. Medium-term energy efficiency improvements can also be achieved through technology transfer to less efficient steel plants. Additionally, with the existing technologies energy savings can be increased through better recovery of waste heat, including low temperature heat and heat recovery outside the plant. An example is off-heat capture, which could be used in district heating grids.

However, to achieve major changes in the way steel is made in the long term, breakthrough technologies are needed. Therefore, the European Steel Industry has created the Ultra Low CO2 Steelmaking (ULCOS) consortium, bringing together 48 organisations from 15 countries to develop innovative technologies which will potentially reduce CO2 emissions. In the first phase research has led to 80 potential technologies. In February 2008 the four best technologies have been selected to be transformed into a full-scale industrial model in the demonstration phase. The most promising technology is the Top Gas Recycling Blast Furnace (TGR-BF) with Carbon Capture and Storage (CCS). The other proposed technologies are Hisarna smelter technology with CCS, ULCORED with CCS and Alkaline Electrolysis. All of these technologies reduce the use of coal in the production process and have the potential of reducing CO2 emissions by 50% to 80%. In addition, both technologies ULCOS and Hisarrna have the potential of reducing energy consumption by 10-15% (EC 2010 d,. p. 4). The financing of the programme comes for 60% from the partners; the Research Fund Coal Steel contributes the remaining 40%. In the first phase € 80 million has been invested in the research. The expected costs of the demonstration phase are € 700 – 800 million.

Natural resource efficiency aspects and measures

Raw materials used for the production of primary steel are iron ore, limestone and steel scrap, which are widely available in natural resources. Material that serves as an input for the steelmaking process, but do not form part of the end product is coal. The coal is carburized into coke, the primary reducing agent of iron ore. World reserves in coking coal are estimated to last for 100 years (World Steel Association, 2008). Raw materials used for the production of secondary steel are recycled steels and/or direct reduced iron (DRI) and electricity.

In order to improve the natural resource efficiency, the steel industry aims at **substituting the use of at-risk materials** or those that have a **major environmental impact**. To reduce CO2 emissions and air pollution fossil-fuel based reducing agents need to be replaced by renewable sources, such as biomass. Research of the ULCOS programme found a potential replacement of coal in charcoal, as it is highly reactive, but is low in impurities such as sulphur (SOx), Nitrogen (NOx) and ash. Further investigation has focused on the supply and sustainable use of biomass and the process of converting biomass into charcoal. At the moment the work has started to optimise the charcoal production in line with the steel industries requirements. NOx emissions can also be reduced by using advanced burners or exhaust gas treatment facilities, to decrease SOx emissions the steel plant can use de-sulfurisers.

Because of the high temperatures needed for steel production, water is mostly used for non-contact cooling of the product. The use causes no deterioration in quality and the water can be redirected to the watercourses. In some cases salt water is used for cooling purposes. Water used for cleaning and rinsing is often treated and used again.

Waste generation and impact

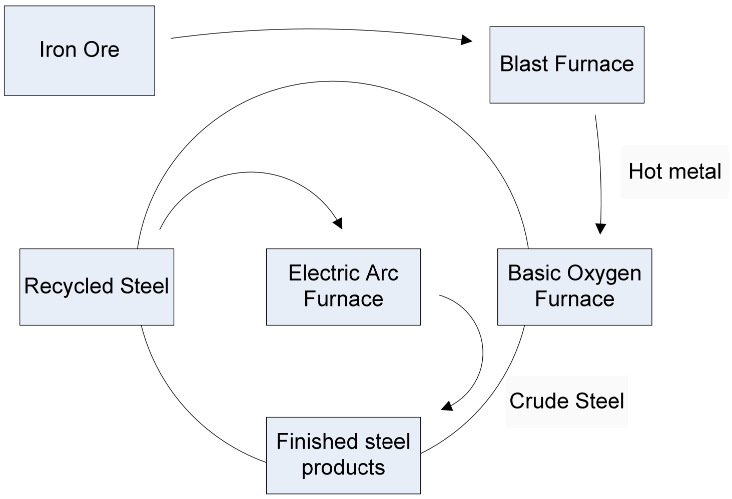
Steel can be recycled 100% and is indefinitely recyclable without loss of quality (World Steel Association, 2008). In the production process, recycled steel requires about a third of the amount of energy needed to produce steel from iron ore, due to the chemical energy required to reduce iron ore to iron using reducing agents. In 2006 459 million metric tons (mmt) of steel was recycled worldwide.

In Europe 90% of used products are recycled as scrap in the electrical arc furnace to produce new steel (ESTEP, 2009). However, due to the immense growth of steel consumption and the long life of steel products (an average of 40 years), a more realistic share of recycled scrap going into the steel production is around 45%. If, in theory, the production of steel would stagnate, it would take 40 years to reach a share of 90%. Taking into account the economic growth in emerging economies as well as the population growth, the idea of producing steel mainly from recycled material is unrealistic. As such, the need for primary material can not be overruled.

Against the background of increasing competition for material resources and resource scarcity within Europe, the share and efficiency of recycling will become even more important to European steel companies in order to stay competitive. However, with the current recycling rate there is some room for improvement. Steel recovery rates are about 90% for machinery, 85% for automotive and construction and 50% for electrical and domestic appliances. Recycled steel is collected from production waste in steel facilities and foundries (home scrap), downstream production processes (industrial scrap) and from discarded products (obsolete scrap), on the medium term, there is room to improve secondary steel collection. Initiatives for small improvements are for example the recycling of tires in steel plants and the increase of recycling of electrical and domestic appliances.

The most important by-product of steel production is slag. It can be used in cement production, road construction, as fertilizer and in coastal marine blocks to facilitate coral growth. Other by-products are gases produced in the steelmaking process. These gases are fully reused as energy for the furnace or the power generation plant.

Figure 8 Steel production cycle



Source: Eurofer.

With regards to consumers' role in collection of steel, an example of that is the UK company TATA (http://www.tatasteeleurope.com/en/responsibility/cspr/) which is promoting the collection of steel containers and is disseminating information about it to households and students. It has developed on its website a "recycling bank" locator in order to help consumers dispose of their used steel containers thus acknowledging the role of consumers in collection.

3.3.2 Measures towards greater resource efficiency

Best practice comparison

Looking at the life cycle of steel one can see a closed-loop system. The industry recycles around 90% of steel, in some countries up to 98%, to reduce energy and material costs and reduce the impact on the environment. Life cycle assessment is seen as an appropriate tool for the industry for assessing environmental impact and selecting new technologies (Losif et al. 2009). Because emerging countries play an important role in steel production and show a growing demand for steel it might be of interest to compare practices in the life cycle of steel in the European Union with those in China, India and the United States.

Table 7 Indication of resource intensity of EU, Asian and US steel companies

	EU-27	Asia	USA
Material resource efficiency	Reduction of energy consumption by 50% and reduction of CO2 emissions by 60% since 1970.		Reduction of energy consumption and CO2 emissions by 33% since 1990.
Natural resource efficiency	Research on the use of biomass in the form of charcoal in order to replace coal. Recovery and use of slag.		Reduction of air releases is seen as the largest area of potential improvement. Recovery and reuse of slag.
Waste management	Approximately 45% of produced steel comes	Recycled scrap steel accounts for 8% of total	Around one third of the produced steel comes

	from steel scrap. The recycling rate of steel products is 95% across the EU-27.	steel production.	from steel scrap. The recycling rate of steel products is approx. 83%.

Source: World Steel Association, 2009; Steel recycling institute, 2008; China Daily, 2006.

What is striking about the comparison between the countries is that only 8% of total production in China comes from steel scrap, while Europe and the United States produce respectively 45% and 33% from steel scrap. One explanation for this can be the enormous growth in steel demand in the past years and the relative small availability of scrap due to the long life of steel products.

Compared to steel plants in emerging economies like China, India and the CIS countries, European steel plants have higher costs and deal with stricter regulations regarding climate change. European organisations understand that investment in breakthrough technology is needed to stay competitive in the market. ULCOS is the largest and most important research and development programme in the steel industry which has a focus on breakthrough technologies that will reduce CO2 emission 50%. Most research programmes in Asia and the United States are less ambitious, but are exploring some of the same technologies to achieve CO2 reduction. However, the FINEX[12] iron making process is currently seen as one of the state-of-the-art processes that reduces greenhouse gas emissions.

The comparison above shows that in general terms the European steel plants are relatively advanced when it comes to recycling and technologies that reduce CO2 emissions and increase energy efficiency. However, it is important that Europe continues to invest in research and development for breakthrough technologies to stay ahead of competitors.

3.3.3 Barriers towards greater resource efficiency

The most important **technical barrier** for the steel industry is that with the current technology there is little room for improvement in energy savings and CO2 reduction technology. Against this barrier, some aggregate gains can be achieved when all plants uniformly adopt the best available technology.

The breakthrough technologies that for example the ULCOS programme is working on are based on a different steelmaking process. Therefore, to develop and test these technologies in a full-scale plant a **large financial investment** is required. Moreover, implementing one of these new technologies in existing steel plants will radically change the plant. The coke plant will become partly or entirely redundant and large financial investments will be needed to build a new furnace or implement other new technologies in the production process. This will also require large investments from the existing steel plants. To ensure that the steel plants are willing to make these investments the new technology has to save costs on the long term.

On a medium term, while secondary steel constitutes a good opportunity for resource efficiency in the EU, access to secondary steel is - to some extent - constrained by third countries policies to restrict scrap exports.

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[12] The FINEX process is an innovative process which allows the use of low-cost iron-ore fines and does not need expensive coke. This reduces hot-metal production costs by approximately 15% per ton in comparison with the blast-furnace route.

3.3.4 *Policy implications and conclusions*

The steel industry is performing well considering resource efficiency. Efficiency is achieved in:

- Energy consumption;
- Recycling and the use of waste materials;
- Decreasing levels of CO2.

Basically, the adoption of the BAT in all plants and investments in technological breakthrough can be made as an EU - wide policy.

3.4 The glass industry

Glass products come in many forms ranging from construction material to packaging material, from glass fibre cables to glass wool. The glass industry is essentially a commodity industry, although many ways of adding value to high volume products have been developed to ensure the industry remains competitive. Moreover, some of the smaller volume sectors produce high-value technical or consumer products. But over 80% of the industry output is sold to other industries, and the glass industry as a whole is very dependent on the building and the food & beverage industries (European Commission, 2009a). Dependency on other industries became painfully clear during the recession. European container glass production, for example, showed a healthy production of 22.5 mt container glass with year-on-year (yoy) growth of 4.1% in 2007 until recession turned this growth into shrinkage of 1.3% (yoy) in 2008 and a staggering 9.7% (yoy) in 2009 to just over 20mt. production. [13]

Sectors within the industry are most notably the container glass, flat glass, continuous filament glass fibre, domestic glass, special glass, mineral wool, high temperature insulation wools, and frits sectors, with some overlap existing. The diversity in sectors and products emphasizes the large diversity of the glass industry in general. The difference among sectors irrevocably leads to large ranges in efficiency, emission, and environmental priorities. However, all sectors are impacted by energy prices due to their energy-intensive production processes. Whereas only some sectors can compete based on high-value technical or consumer products, the rest of the industry is highly dependent on resource efficiency for their competitiveness. With raw materials generally widely available, energy efficiency is thus a major driver for the entire industry.

3.4.1 *Drivers towards greater resource efficiency*

The main environmental concerns and resource efficiency drivers for the glass industry as a whole are **emissions to air and energy consumption**. Glass making is a high-temperature, energy-intensive process, and the energy is provided either directly by the combustion of fossil fuels, by electrical heating or by a combination of both techniques. In general, the most significant emissions include nitrogen oxides, particulate matter, sulphur dioxide, halides and in some cases metals. Water pollution is not a major issue for most installations within the glass industry, although clearly there are exceptions. Water is used mainly for cleaning and cooling and is generally readily treated or re-used. Process waste levels are relatively low with many solid waste streams being recycled within the process. However, the glass industry is very diverse and the difference among sectors within the industry concerning efficiency, emission, and environmental priorities is large.

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[13] Calculations by the consultant based on numbers from FEVE association website (Available from: http://www.feve.org/index.php?option=com_content&view=article&id=10&Itemid=11 [Accessed 02/12/2010]).

3.4.2 *Measures towards greater resource efficiency*

In the EU25, approximately 35mt of final product glass in various forms were produced in 2006 according to the “Comité Permanent des Industries du Verre” estimations (CPIV). Whilst production levels have increased, manufacturers have also strived to further improve efficiency in what is an energy-intensive process, fuelled by the need to operate furnaces at over 1600^{o}C. **Improvements in furnace efficiency** had a significant impact on the amount of energy required to melt a tonne of glass. Furthermore, energy consumption is decreased through the use of recycled glass called cullet. For every 10% cullet, or recycled glass, used in the production process a producer saves 2-3% energy compared to using raw materials (Glass Packaging Institute, 2010). Besides increasing efficiency, container glass producers e.g. have reduced the weight of the bottles. Therefore, glass containers today are 40% lighter than those produced 20 years ago (Glass Packaging Institute, 2010).

Glass making is an energy-intensive process for which the three main sources of energy come from fuel oil, natural gas and electricity. The energy necessary for melting glass accounts between 45% and 80% of the total energy required to manufacture glass. Other significant areas of energy use are fore hearths, the forming process, annealing, factory heating, and general services. The container glass sector, which could serve as just a general indication for the entire industry, shows the following typical pattern of energy usage:

- Furnace 79-82%;
- Fore hearth 6%;
- Compressed air 4%;
- Lehr 2%;
- Others 6%.

The energy requirements experienced in the various sectors vary widely from about 3.3 to over 40 GJ/tonne. The actual figure depends heavily on the furnace type, scale, method of operation and type of glass. Using large furnaces, which have a lower surface area to volume ratio, keeps the energy requirement for melting generally below 8 GJ/tonne. Progress with energy efficiency has been made through reducing the heat loss that occurs during the energy-intensive, high-temperature process of glass making. For example, a modern regenerative container furnace will have an overall thermal efficiency of around 50% with waste gas losses around 30% and structural losses making up the vast majority of the remainder. Furthermore, progress has been made by increasing the percentage of cullet used in production. On average an increase of 10% cullet results in a reduction of 2-3% of energy usage, avoid the generation of one tonne of waste and the extraction of 1,2 tonnes of raw material. FEVE, in collaboration with institutions and companies in the EU and USA, conducted a Life Cycle Analysis (LCA) for the container glass industry. This LCA is based on the cradle-to-cradle approach where all stages – from extraction to recycling and reuse – are taken into account when calculating the environmental impact of glass. LCA will provide companies and legislators with transparent data across the entire life cycle, making it possible to point out areas for attention and improvement (FEVE, 2010b).

This LCA shows that for every tonne of cullet recycled in a container glass furnace, about 670 kg of CO2 are saved on a cradle-to-cradle basis

Since the 1960’s the glass industry has been able to reduce its energy usage by an average of 1,5% per annum. However, this decline has slowed down recently because thermodynamic limits are approached (European Commission, 2009). Hence, we believe the industry will face the challenge of finding new ways to increase resource efficiency in the future. Main driver to reduce energy-consumption related emissions, such as CO2, is the cost saving that can be accomplished through more efficient usage of energy. Increased energy costs do not provide any incentive but only add extra burdens. Incentives exist only when alternative and efficient technologies are available to reduce energy use and emissions. In the flat glass sector, possible improvements are quite limited within the state of current technology.

Raw materials for glass making such as silica sand, soda ash, and limestone are widely available in natural sources. Soda ash is available in natural and synthetic form. Natural soda ash use in the glass industry is very limited in the EU and is highly dependent on its geographic location. Furthermore, cullet is used to reduce the dependence on virgin material. In the flat glass sector, one tonne of cullet allows saving approximately 1.2 tonnes of primary raw materials, ie, to produce 1 tonne of glass, 1.2 tones of raw materials or 1 tonne of cullet are needed. Materials that serve as input for the glass making process but do not form parts of the end product include water, energy, and ancillary materials. Water is not a widely used resource in the process and serves in the majority of sectors as cleaning or cooling substance for which loop systems are in place. Ancillary materials include substances such as processing aids and cleaning materials that are very specific to each individual sector.

Emissions to air

The greatest potential for emissions and air pollution arises from the melting activities in the glass industry. The main pollutants arising from these processes are (EC 2009a):

- The products of fossil fuel combustion and the high-temperature oxidation of nitrogen in the combustion atmosphere;
- Particulate matter arising mainly from the volatilization and subsequent condensation of volatile batch materials;
- Gasses emitted from the raw materials and melt during the melting processes.

Use of electrical heating could eliminate the pollution created by the burning of fossil fuels in certain glass sectors (not for the largest furnaces of the container and flat glass industry). An example is the 70-80% energy cost saving reached by Electroglass when it converted two gas-fired fore hearths to electric (Glass International, 2010b). Besides the off-site emissions associated with the production of the electricity, electric furnaces have a narrow use in the glass industry due to melting capacity limitations. However, in this case off-site emissions associated with the production of the electricity used should be taken into consideration. Pollution levels from particulate matter and raw materials are sector specific and depend heavily on the materials used. Emissions by means of dust created from recycling glass in the facility are monitored and controlled for through dust filters (Glass International, 2010a).

Besides emissions created in the melting process, the glass industry encounters emissions created in other stages of production. Open spaces and leakages from storage silos provide an example of how emissions to air could arise besides in the melting process, but these emissions are low as the use of closed silos is now the reference. Another would be emissions from the coatings and dyes applied in some sectors. However, the bulk of emissions originate from the melting process (process + fuel emissions) and emissions referred to in this paragraph are somewhat ancillary.

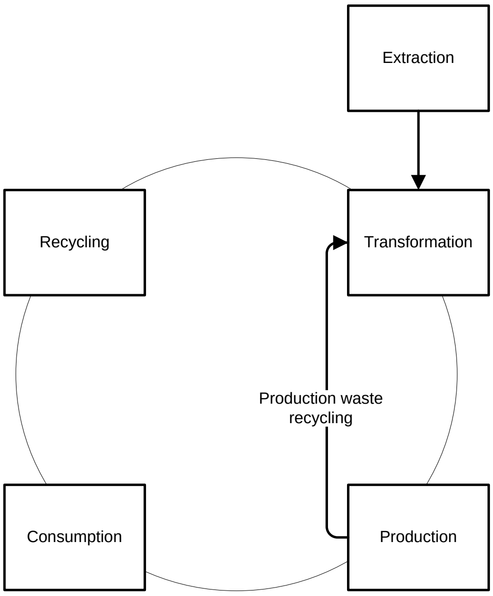
Emissions to water

Overall emissions to water are low in the glass making industry. Water is used predominantly for cooling and cleaning and can therefore easily be recycled or treated.

Waste generation and impact

Glass is an ideal recyclable material since it can be recycled 100% and endlessly as it will not lose quality (Maltha, 2010a). In the production process itself, virtually all waste created is immediately recycled back to the furnace (Owens-Illinois Inc, 2010). Hence, the lifecycle of glass describes a loop where glass rejected in the production stage is redirected to the transformation stage where it is melted again and reintegrated back into the production process. Figure 9 displays the lifecycle.

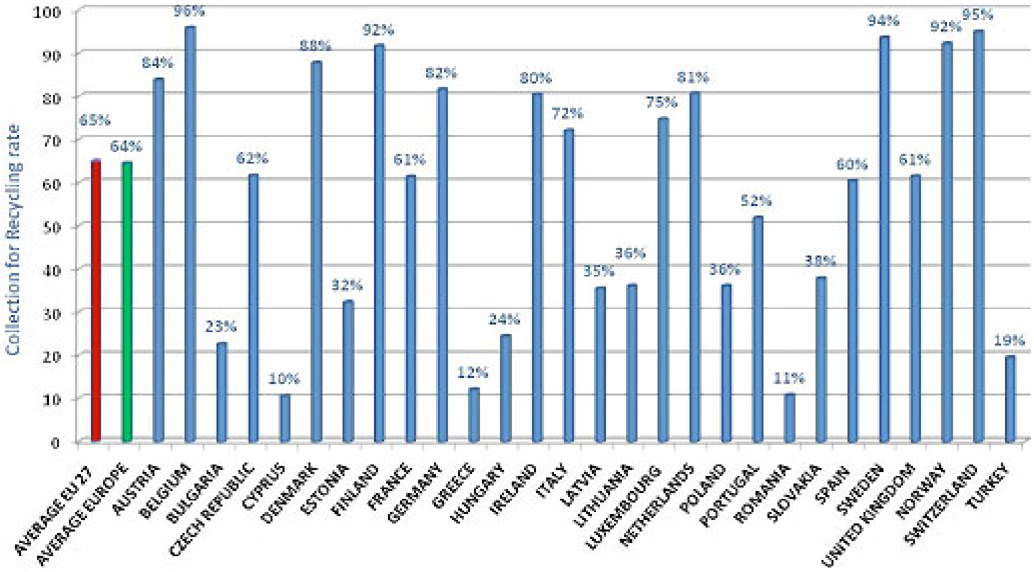
Figure 9 The glass production lifecycle



Source: Ecorys.

Recycling of finished glass products, however, varies considerably by Member State. In 2007 the average glass recycling rate in the EU was roughly 61% but extremes such as Belgium (100%) and Cyprus (10%) exist at both ends of the scale (European Commission, 2009b). Over the past few years, glass recycling has increased on average about 1% per year in the EU (European Commission, 2010 b). The overall average recycling rate in the EU may be higher than those in the US (60% (European Commission, 2010 b) versus 22% (Keep America Beautiful, 2006) respectively in 2003, but looking at recycling in individual Member States in Figure 10 uncovers a large difference in individual recycling rates.

Figure 10 Glass containers collection for recycling in Europe in 2008



Source: FEVE, 2010 c. Available online from:
http://www.feve.org/index.php?option=com_content&view=article&id=10&Itemid=11.

Countries with high recycling rates such as Belgium, Switzerland, and Sweden have a number of benefits and costs related to their practices. Based on the analysis in the previous paragraphs, the consultant lists the following.

Table 8 Costs and benefits related to recycling

Benefits	Costs
Availability of cullet for use in glass production.	Recycling facilities for collecting, separating, and cleaning the cullet
Reduced energy consumption in production 2-3% decline per 10% cullet increase For example in Belgium this would mean a reduction of approx. 29 million euro in energy costs[14]	Maintenance of glass collection containers
Reduction of landfill For example in Belgium 366,864 tonne of glass was recycled in 2007 which would otherwise have ended up in landfill (European Committee, 2009b)	
Reduction in raw material use	

In the case of high rate recycling countries such as Belgium and the Netherlands the benefits are likely to outweigh the costs. In the Netherlands for example the collection system is in place, the collection, separating and cleaning of the cullet is done by private companies such as Maltha, and contracts are in place so local government can monitor performance of these companies. These companies, in turn, recover their costs and maintain a healthy profit through preventing fees and taxes for land filling and the sale of high quality cullet to glass producers. Producers of glass then

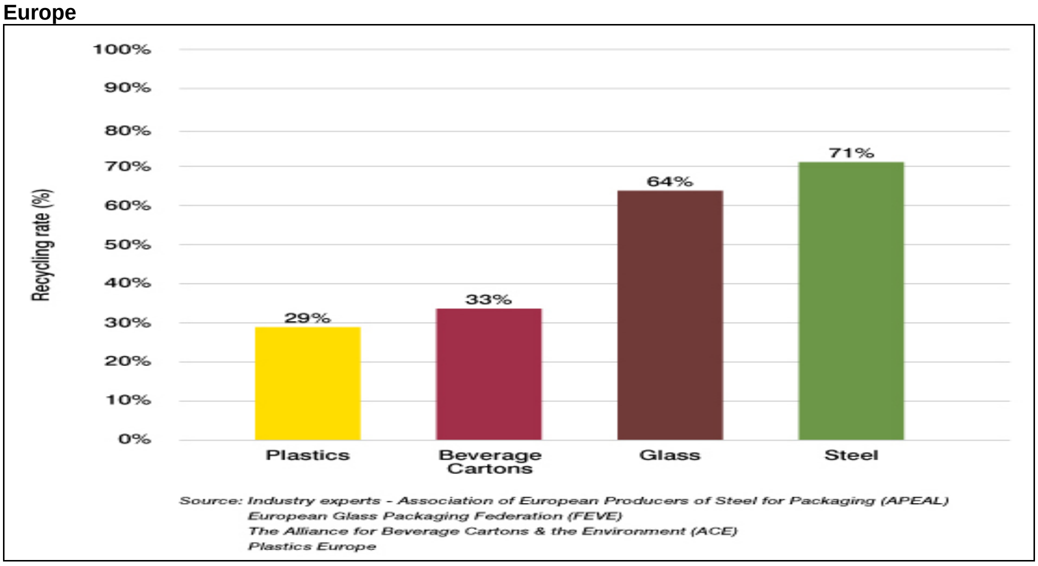
[14] Melting takes on average 8 Gj/ Tonne glass = 2222KWh = 2.2 MWh. Melting makes up approximately 75% of all energy costs. Producing a tonne of glass would thus cost approximately 3MWh. In Belgium, 1 KWh for industrial users costs 0.107 euro effective as of November 2009 (Europe's Energy portal, http://www.energy.eu/#industrial). Producing 1 tonne of glass would hence cost 317 euro in energy costs. A 10% increase in use of cullet leads to a decrease of 2-3% energy costs i.e. 317 times 2,5% = 7.90 euro per tonne of glass. In Belgium 366,864 tonnes of glass was recycled in 2007 (EC, 2009b). Based on 10% cullet saving 7.90 euros, an estimated 366,864 * 79 euro = 28,982,256 euro in energy costs were saved.

save on raw material purchases and energy expenses, hence making the system desirable and economically viable.

A word of caution is at place while interpreting this cost/benefit analysis. Countries such as Belgium, the Netherlands, Sweden, and Denmark are typically rather small countries with good quality infrastructure in place. Due to the fact that these companies have a long tradition of recycling they are not burdened by potentially high start-up costs of a collection system anymore. Larger countries without a proper collection system in place may not only be burdened with start-up costs but also with higher collection costs when the distance between collection and recycling facility increases or infrastructure is less optimal.

Looking at glass as a packaging material, the industry already achieves reasonably high rates of recycling compared to other industries as presented in Figure 11.

Figure 11 Recycling of main packaging materials in Europe in 2008 Glass collection for recycling in Europe



Glass recycling in the Netherlands

An excellent example of increased recycling can be found in the Netherlands. Up from 87% in 2008 to 92% in 2009 the Netherlands shows a neat improvement that exceeds its goal of 90% (Nedvang, 2010). Reasons for the increase in glass recycling are predominantly found in the more positive attitude of Dutch citizens towards recycling. Marketing campaigns have brought recycling under the attention of the Dutch citizens hence have increased their awareness of recycling and improved their attitude. Furthermore, the constructive collaboration among partners in the recycling process such as the industry and municipalities has led to a higher percentage of products recycled. Moreover, finished glass producers have a good reputation of contributing to the recycling of glass.

A combination of limited geographical space and early legislative measures taken by the Dutch government has led to a relatively very high percentage of waste recycling. The Netherlands is known for its density in terms of living space. With almost 500 people living together per square kilometre, the Netherlands is one of the densest countries in the world[1]. With consumption levels on the rise and very limited space available for landfill the government realized early on that the Netherlands would face a serious waste problem if it would not put regulations and systems in place. "You cannot create an innovative waste processing market by simply raising awareness. What ultimately proved to be the deciding factor in the Netherlands were the regulations implemented by the government" says Dick Hoogendoorn, director of the Dutch Waste Management Association and previously director of a large waste processing company (EVD, 2008 p.9). Incentives for companies as well as citizens and the creation of organizations such as Nedvang brought awareness and collaboration in the Dutch glass market.

On 5 March 1983 a glass container was installed in the last municipality in the Netherlands thus making glass collection for recycling available throughout the entire country (Maltha, 2010b). Recycling of glass in the Netherlands is done by private companies such as Maltha b.v. and is regulated by Nedvang. Regulation guarantees clear agreements between parties such as municipalities and collecting and processing companies and monitors quality. Over the years, the collection of glass has increased and has undergone innovations such as the glass containers that make it possible to separate collection based on colour. Furthermore, the industry has united itself in networks such as 'Stichting Vlakglas Recycling Nederland' and 'Stichting Kringloopglas' that guide the glass recycling process from collection to processing and re-use (Maltha, 2010a). Collaboration between Dutch technical universities and recycling companies has proven to provide the Netherlands with top notch systems and a leading role in European recycling (EVD, 2010; Maltha, 2010c).

3.4.3 *Barriers towards greater resource efficiency*

Recycling rates differ widely among Member States. In countries such as Finland and Sweden recycling is very much the norm whereas in the UK widespread 'kerbside' recycling is something relatively new, but in the relatively short time it has been in use it has proven to be very successful at increasing recycling rates (British Glass, 2003).

As mentioned before, the EU could still gain significant efficiency and environmental advantages through the implementation of efficient recycling systems in all individual member states and to encourage recycling by means of a punishment-reward system i.e. taxing dumping practices and rewarding innovative efforts and recycling initiatives. Member States should also be strongly encouraged to set up separate collection of waste (Article 11.1 of the Waste Framework directive goes in the right direction, but FEVE believes that the wording "where technically, environmentally and economically practicable" could reveal to be a main barrier towards greater resource efficiency. On the contrary, Member States should be encouraged to set up separate collections for flint and coloured glass, in order to ensure the most efficient recycling of resources.

It should be taken into account the possible technical barrier that arises from uncoordinated individual behaviour such as in the case where producers bring another product on to the market that has an influence on the recycle-ability of the total product group.

In the same line, the workshop discussions with glass producers revealed that there are difficulties to obtain clean waste that is of good quality and non-toxic. Separation at source could thus be a good approach to solve this particular issue, such as for example in the case of buildings demolition, where waste streams can be separated, thus will play a more effective role as a source of urban mining.

3.4.4 *Policy implications and conclusions*

Using the Netherlands as a best-practice example, the consultant highlights a number of critical factors for a successful waste management system in the glass industry:

- Government regulations discouraging dumping of finished glass products by means of taxation, and stimulating recycling and reusing through subsidies and tax advantages for investments in recycling - and reusing equipment and innovation;
- Industry networks uniting collecting, recycling and processing enterprises to provide a common platform for coordination, regulation, and certification of entities present in the glass lifecycle;
- Marketing campaigns directed at citizens to create awareness of recycling and to improve attitude towards recycling;
- In addition to these, the use of urban mined material for the industry can be strengthened through the encouragement of a more sustainable products design that supports a "cradle to cradle" operation rather than a "cradle to grave" operation, whenever technically possible. When products are designed in way where they can be recycled over and over again so as to reduce the use of virgin material, substantial gains can be achieved.

In the European Parliament and Council a start has been made to regulate waste disposal by means of the waste framework directive. This directive, published in 2006, aims at structuring and encouraging reuse of waste in the Member States of the union. Additionally, an end-of-waste criteria mechanism for waste glass, pursuant article 6 (1) and (2) of the Waste framework Directive 2008/98/EC is aiming at further encourage recycling of waste glass in the EU. These guidelines still leave a lot of freedom for policy creation in individual Member States; hence inequality among states remains large. Industry networks, associations, and organizations are present and put much emphasis on recycling and reducing the environmental impact of the industry as a whole (FEVE, 2010a; UEVM, 2010). Organizations like the Federation of European Container Glass (FEVE) support their members and sector through research and monitoring to provide transparent information about the impact of the industry. We thus believe them to play an important, connecting role within the industry that could prove to be of much value to creating an even more efficient and sustainable glass industry.

Marketing campaigns directed at citizens have so far mostly taken place at the national level but only in a few countries. We therefore stress that awareness of glass recycling and implementation of collection systems depend greatly on the stance of the individual Member State. Large scale, Europe-wide campaigns could raise the awareness of glass recycling but their impact would be rather limited if proper collection and process systems and infrastructure are not in place.

3.5 The non-ferrous metals industry (focus on aluminium and copper)

Non ferrous metals include a large number of metals such as aluminium, copper, zinc, lithium, gold, tungsten and cobalt, among others. The combined global output, of primary refined base non-ferrous metals in 2009, was about 76 million tonnes (mt), marking a downward trend from 80 mt in 2008 as the recession curbed demand.[15] Non-ferrous metals enter in the production of several products which are essential for the modern society, starting from cars, to medical equipment and to mobile phones. In this section we will use data and references to aluminium and copper who have the lion's share of the NFM production on a global level, without undermining the importance of other non-ferrous metals.

Aluminium accounts for nearly half[16] of the annual output tonnage and, as a light metal its significance in terms of volume is even greater. Aluminium, copper and zinc represent more than 85% of annual global non-ferrous metals production. As the non-ferrous metals (NFM) industry provides products for end users across many industries, developments in the global economy act as powerful drivers of NFM demand and consequently prices. To give an impression, the global recession drove down demand for most of the non-ferrous metals in 2009; in the case of aluminium for example, total production (primary plus secondary) fell by more than 8%.

Over the past three years, global production of non-ferrous metals has tended to outstrip usage,[17] as new mining, smelting and refining projects have been completed and idle capacity has been re-commissioned in the anticipation of stronger demand. As a result of this, reported stocks have tended to increase. To an extent the supply-demand balance for many NFM is cyclical, with new players entering the market or investments in capacity increases taking place when prices are high (Ecorys a, 2010).

Energy efficiency and access to primary and secondary material to achieve resource efficiency are major drivers in the industry.

[15] This includes primary production of aluminium, copper, lead, nickel, zinc and tin. Unless otherwise indicated, the source for production, usage and trade data is World Bureau of Metal Statistics, *World Metals Statistics Yearbook 2010*. Data for the European Union are consistently for EU27. The term 'usage' is used for the use of each metal although, of course, metals are transformed and incorporated in products rather than 'used up'.

[16] Calculation from *World Metal Statistics Yearbook 2010* data.

[17] With the notable exception of copper over the past few years, where average refined production over the 2007-2009 period (18.18 mt) is nearly equivalent to average refined usage (18.16 mt) (ICSG, 2010).

3.5.1 Drivers towards greater resource efficiency

Like the previously discussed glass industry, the NFM industry depends on highly energy-intensive processes. Main source of the energy used is electricity (Eurometaux, 2010a). Sectors within the NFM industry each have different energy needs. Consequently, the role that energy costs play varies depending on the percentage of total costs they make up for. Aluminum, copper, and zinc comprise the largest users of energy in the industry.

Energy costs make up for approximately 35% of total primary aluminum production costs (Ecorys, 2010 a). In the value chain of the aluminium sector, primary smelting is significantly the most energy consuming activity/sector. For refining of alumina, the energy use per ton of product is between 225-260 kWh, where for primary smelting the energy use ranges between 14.000-16.000 kWh per ton of product. Recycling of aluminium scrap is significantly less energy-intensive, secondary re-smelting requires energy use between 120-340 kWh/t. For copper, energy costs for primary production can add up to 28% of total costs (Ecorys, 2010 a). The production energy requirement for a number of processes using copper concentrate is in the range of 14 to 20 GJ/tonne of copper cathode. The exact figure depends mainly on the concentrate but is also dependent on the smelting unit used, the degree of oxygen enrichment and the collection and use of process heat (EEA, 2009). Secondary production saves as much as 80% of the energy costs necessary in primary production (Eurocopper, 2010 b).

The cost share of energy in the production cost structure for the NFM industry, particularly aluminium, copper and zinc is significant. Given that an Aluminium smelter should pay full European market prices of approximately 60 €/MWh (incl. grid cost), this would take approximately 50 % of gross production value (2300 $/t). Therefore, increases in the electricity price have a significant impact on the production costs for these sectors, especially since the industry cannot pass on its (increased) energy costs to downstream users due to global trading via the London Metals Exchange.

Its high reliance on electricity makes the industry vulnerable to shifts in electricity supply and price. Costs and dependency on unpredictable supply of electricity from inside as well as outside the European territory have driven innovation in energy efficiency. Over the past decades, the NFM industry has made considerable efforts to increase the energy efficiency of its processes. Aluminum production, one of the largest non-ferrous metals in terms of production, accomplished considerable energy efficiency gains in their primary production processes in Europe. According to the European Aluminum Association production has become as much as 33% more efficient since 1950 and 7% over the past 2 decades.[18] The copper industry has managed to reduce its energy usage by 54% since 1995, hence obtaining considerable efficiency gains. Drivers of these improvements in energy efficiency are, according to the industry association, social responsibility, market forces, and EU policies (Eurocopper, 2010 b). However, efficiency gains in the industry have reached a plateau and will face more restraints in the nearby future due to the approach of efficiency boundaries put up by the laws of physics (Eurometaux, 2010b). As such, technological breakthroughs reducing the energy consumption and carbon emissions, although necessary, are not expected for the next two to three decades (European Commission, 2009).

High energy usage rates lead to high emissions rates. CO2 is a problem that has had considerable attention from manufacturers over the years. Two examples of applications of renewable energy sources in European and Non European production plants of NFM are provided in the text below.

[18] Numbers adopted from European Aluminum Association (EAA). Available from: http://www.eaa.net/en/about-aluminium/aluminium-and-sustainability/primary-production/.

In the autumn of 2010 **Rio Tinto Alcan** announced two investments totalling $487m at its aluminium smelter in Straumsvik, Iceland (ISAL). It is to spend US$347m on modernising and increasing the ISAL smelter's capacity by 20% following the completion of a long-term energy supply agreement (based on hydropower) with Landsvirkjun, the Icelandic power utility. The new contract came into effect in October 2010 and will run until 2036.A further$140m is to be invested in a casting facility to produce value-added billet. The smelter, which dates from 1969, is expected to commence the gradual increase of its production in April 2012 and complete the production increase by July 2014.

RUSAL is investing in an additional aluminium smelter in Siberia with a capacity of 588,000 tonnes, due to come on stream in two phases in 2013 and 2015. It has plans also to build another smelter in Siberia with a design capacity of 750,000 tonnes. The investment reflects its strategy of focusing on production based on low-cost captive hydro power. Source: Ecorys, 2010 a.

3.5.2 Measures towards greater resource efficiency

As a net importer of raw material, the EU is facing increasing constraints and difficulties in procuring the necessary raw materials for the industry. Tendencies of emerging and transitioning economies to use these materials for the growth of their own industries increase competition for these metals. Due to trade policy features that provide competitive advantages to some but not all operators, the competition is also distorted. Securing a level economic playing-field for access to raw materials is thus a vital goal for the industry and a field where the EU comes in to play an important role for the industry (Eurometaux, 2010b).

Increased competition over raw materials and high energy costs drove part of the industry towards an increased intake of secondary materials (scrap). At the company level, changing the type of material (from ores and concentrates to secondary material) would mean also changes in the company's practices. These will be related to both technical changes in the production lines as well as changes in procurement practices and supply chain management. Subsequently, these changes would entail staff training and awareness rising.

Similar to the steel industry, the use of secondary resources alone cannot cover the total demand in the non-ferrous metal industry, as it accounts for 40-60% of the total input. Primary resources are essential in order to cover the total demand and to produce higher quality products. Primary materials, as mentioned before, are mainly imported from countries outside of Europe. In the case of Aluminum (for example), bauxite is necessary for the production of aluminum, of which small amounts are mined in the EU while the larger amount is mostly extracted outside the EU. Half of the primary aluminum needed is transformed within Europe. For copper production, copper mines that can be exploited economically are not widely present in Europe currently, except for a few locations in Europe; Poland, Portugal, Spain and Sweden, the biggest of which is the one in Poland[19] .[20] Most copper mines have built refining facilities close to the mines, which makes it more difficult to find primary materials for the refineries in Europe.

Emissions to air

Emissions to air in the non-ferrous metals industry are sizeable. A ton of primary aluminum produced results in 8.6 tons of CO_2 emitted to air. Reduction of these emissions can be obtained by using secondary aluminum. For comparison, a ton of secondary aluminum produced results in only 0.3 tons of CO_2. The main reason for this remarkably lower level of emissions is the lower

19 http://www.mbendi.com/a_sndmsg/facility_srch.asp?gloc=C5&ftyp=63.

20 Adopted from IPPC. Reference Document on Best Available Techniques in the Non-ferrous Metals Industries.

energy consumption necessary to melt scrap. Whereas primary production could need up to 15 MWH to melt a ton of aluminum, secondary production only needs as much as 0.7 MWH per ton (Ecorys, 2009). As mentioned earlier, though secondary materials are essential, they are neither abundantly available nor sufficient for a high quality product. Thus, primary materials are likely to remain in use with a sizeable contribution to emission to air.

Emissions to air do not only include CO2, in the case of aluminum, as an example, it includes other materials such as Fluoride from primary aluminum electrolysis plants. This latter, the industry managed to reduce its emission by 55% from 1997 to 2009. Other emission includes Benz (a) Pyrene, which is emitted by paste plants and anode plans, which emission was reduced by 80% between 1997 and 2009 in the EU. (European Aluminum Association, Sustainability Report 2010 p. 25).

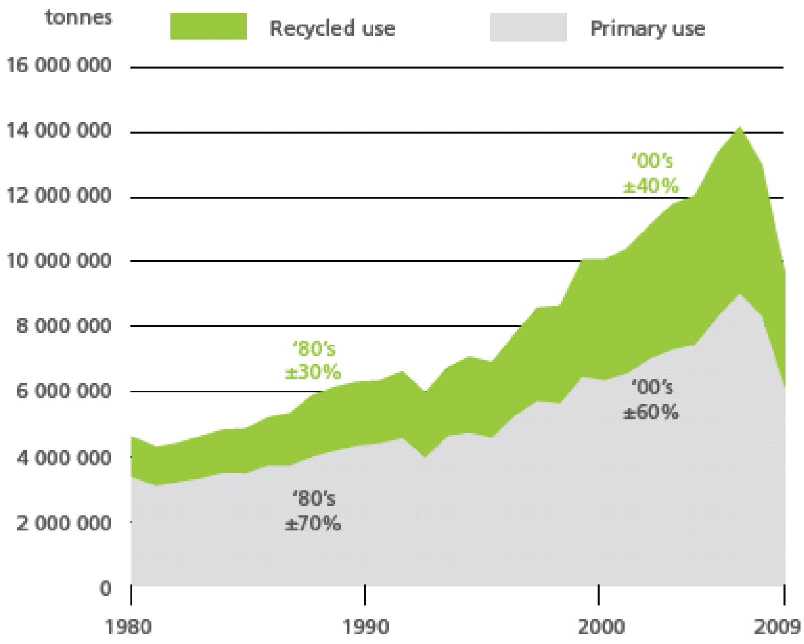
Techniques to reduce emission to air vary considerably across the NFM sector. For instance, in the case of Aluminum, the use of oxyfuel technology (use of oxygen instead of air in the production process) reduces direct and indirect GHG including CO2 and NOx. CO2 emissions can be reduced by up to 50% and Nox can go below 50 mg/MJ. The use of oxyfuel technology may cause an overheating of the aluminum surface; therefore the industry has been cautious in its application. The introduction of the principles of “flameless” combustion for aluminum melting will counter the effect of such high temperature and has proven to deliver high melting rates, reduced oxidization, less fuel consumption and lower Nox emission (H. Stephen and Joachim von Scheele, 2009, Emission Monitoring and Reduction in Aluminium Production. p.3).

Waste generation and impact

Waste generated in the NFM industry poses a number of concerns at macro - and micro level.

The use of secondary aluminum in production equals to using up to 20 times less electricity compared to primary consumption (Ecorys, 2009). The recent trends show an observable increase in the recycling of aluminum in the EU. The following diagram illustrates the evolution of aluminum recycling in the EU from 1980 to 2009.

Figure 12 Evolution of aluminium recycling in Europe



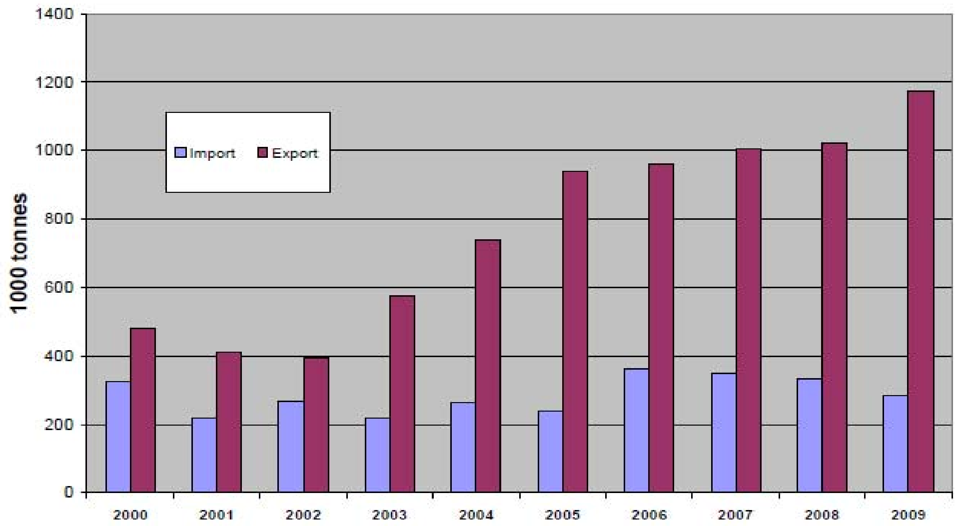
Source: European Aluminum Association- Sustainability report 2010.

The use of secondary materials in copper manufacturing consists of 45% of total input. Copper is a high value recyclable product since it can be 100% recycled and never looses quality. Secondary materials do not only prevent waste from being dumped in landfills but also help restrain energy consumption in production processes. Similar to aluminum, in secondary production copper only consumes 20% of the energy necessary for primary production (Eurocopper, 2010 b).

Advancement of increased availability of secondary resources and the recycling process can be made according to industry association Eurometaux through four pillars, described in detail in the document "Eurometaux's proposals for the Raw Materials Initiative":
- Enforcing trade-related environmental legislation;
- Creating a level playing field for secondary materials;
- Improving management of secondary materials;
- Assess economic viability of recycling.

According to Eurometaux's pillar 1, enforcement of legislation should be enhanced in order to prevent a leakage of waste material to third countries outside Europe. As can be seen in Figure 13 the export of waste increased during the last years and the EU evolved from being a small net importer of copper scrap (ca. 200 000 tons in 1999) to a large net exporter (900 000 tons in 2009). As a result, the EU will rely heavily on the import of primary material so as to secure production and demand. Important is an improvement and elaboration of the Waste Shipment Regulation (WSR) in order to overcome shipments done in violation of the waste legislation which currently account for 19% of total shipments (average based on the inspections performed in 2008 and 2009) (EC 2009 d, p. 11). Furthermore customs control would aid the containment of illegal outflows.

Figure 13 Import and export of EU27 for copper scrap (according to code HS 7404)



Source: Eurometaux, 2010 p. 10.

Secondly, Eurometaux stresses that shipment of waste to non-EU recycling centres should be done in an environmentally sound manner (ESM). A certification scheme would assure to "level the playing field" for industrial pre-processors and refiners. The certification scheme should cover the current EU jurisdiction and WTO rules already set out. Furthermore, collaboration efforts should be put in place with parties in third world countries. According to Eurometaux, valuable resources now end up in third world countries where they not only are not recovered but also pose a serious threat to the health and safety of the local population. Hence, complex recycling should be done at Best Available Technology recycling centers, often situated in the EU, in order to optimize the recycling process and limit environmental and safety hazards (Eurometaux and Öko-Institut, 2010).

The third pillar centers on reuse of materials. Proposals by Eurometaux covered in this pillar include eco-leasing, increased availability of data on recycling, and amplifying research on recyclability of non-ferrous metals. Eco-leasing describes a system where users of non-ferrous metals, particularly in the construction industry, could lease part of the life cycle of non-ferrous metals. The initiative is pointed at increasing the awareness of recyclability of building materials and to encourage the reuse of materials. Main goal would be to lower the percentage of materials ending up in landfills and to reduce the need for primary resources through more abundantly available secondary resources.

Eurometaux' s fourth pillar elaborates on recycling of non-ferrous metals. Some metals are important to recycle due to their large volumes and the economic value that recycling brings to the industry (cheaper input price, less energy needed and less emission. Aluminum and Copper are examples of such metals. Other metals may not necessarily bear such economic value due to their small volume or due to their unfavorable environmental, health or safety impacts. For these latter, new strategies should be identified to make sure they are collected at the end of their life. Here pressure from governments is important to assure execution.

The location and nature of investments depend to a large extent on the segment / product and the specifics of that segment in terms of material supply, capital intensity and markets. For instance Umicore, a large precious metals recycler in Europe states that in recycling, the investments that the company currently has in the EU are huge and can not just be shifted elsewhere. Moreover, for end of life recyclable waste, the main inputs still come from the EU as well as North America, Japan and Korea, so it makes little sense to move to low cost or emerging economies. For industrial waste, there is a need to be close to where the industries producing secondary materials are. (Ecorys, 2010 a).

3.5.3 Barriers towards greater resource efficiency

As follows from the previous paragraphs, the barriers towards greater resource efficiency can be found in material, technical, and financial constraints. In terms of material resources efficiency, it is obvious that the industry is facing challenges to access both primary and secondary material. Being a net importer of primary and secondary material in an increasingly competitive market and facing a leakage of secondary material creates problems of material accessibility for the European NFM industry. Adding to this, is the leakage of valuable secondary material which makes clear that more secondary material could be made available to the industry, hence increasing resource efficiency. As such, several market constraints impede the industry's access to these materials, on the one hand, the increased competition over primary and secondary materials from third countries combined with higher production costs for the EU industry due to the higher environmental costs (such as the ETS), and higher recycling costs place the industry at a disadvantaged position vis-à-vis its international competitors. The fact that the industry can not pass additional environmental costs to downstream industry prevents it from keeping its profitability. The mentioned accessibility problems do not directly relate to the topic of discussion in this research, "resource efficiency", but they affect the profitability of the industry and hence its competitiveness. Since profit making is essential for further investment, addressing the factors that impede the profitability of the industry is important.

In addition, the industry faces **technical barriers** towards greater resource efficiency. The two largest sectors in the industry, copper and aluminium, have both indicated that energy efficiency efforts in their plants have reached plateaus. Technical breakthroughs are necessary to continue the energy efficiency gains obtained over the past two decades. However, these breakthroughs involve substantial **financial means** and require large investments of companies in uncertain times. Here too the EU can play a role to aid the industry in their efforts in the form of subsidies and as a facilitator of research and knowledge sharing.

In addition to these factors, uncertainty plays an important role as an impediment to further investment in resource efficiency in the sector. Insecurity around electricity supply and the new EU regulations regarding short term electricity contracts do not allow the industry to have a long term vision for investments.

3.5.4 Policy implications and conclusions

There exist already a large number of EU legislations and directives that push the industry towards further resource efficiency. It is not the purpose of this section to address these legislations but to help addressing the barriers towards further resource efficiency. Therefore, given the barriers to the industry, there are a few important policy considerations that need to be taken into account:

- The need to address the issues surrounding access to primary materials;
- The need to address the issue of the collection and leakage of secondary material through further elaboration of the waste shipment directive;
- The need to address the high cost of energy in Europe and the electricity market;
- The need to address the issue of waste disposal.

The current situation of the access to primary materials is that most raw materials are imported. Increasing the supply of raw materials can be done in two ways; 1) by fostering sustainable mining in the EU, 2) by addressing the issues of international competition and creating a level playing field for the EU industries in the international market.

Addressing the issue of the high energy prices will mainly require addressing distortions in the electricity market on one hand and on the other hand enhancing research and development within the energy sector in conjunction with the NFM sector. Because the technical knowledge of the energy sector falls within the energy sector, it will be hard to convince the NFM sector (or any other sector) to invest in finding other sources of energy. As such, the energy sector is a major player here, where, investment in research and development has to be done in cooperation between the energy sector and the NFM sector.

Legislation

One of the main problems facing the NFM industry is the large amount of exports of waste material to other countries outside the European Union, which is caused by the rising interests of countries outside EU in NFM scrap and the tendency of those countries to keep their stocks for national use. In addition, given the fact that 10% of total shipments outside the EU are done in violation of the Waste Shipment Regulation (WSR) (based on the inspections performed in 2008 and 2009) (EC 2009 d, p. 11), strengthening legislation by enforcing and extending the Waste Shipment Regulation (WSR) and custom control aid can be seen as two tools in limiting exports in violation of the directive. In order to ensure a level playing field and to minimize the risk of imposing citizens to health issues because of waste production, waste should be recycled in an Environmentally Sound Manner (ESM) and complex waste at the Best Available Technology (BAT) recycling centres. Safety measures and health requirements are key points of attention in improving waste recycling legislation.

Information sharing

There is need for sharing information and knowledge dissemination on the recycling of complex materials and to provide an information system with details on recycling complex waste materials.

3.6 The chemicals industry

The European chemical companies rank among the biggest, most prosperous and innovative players within the global chemical industry. In the EU, it is composed of around 30 000 different chemicals, the majority of which fall under the so-called Specialty and Fines Sector. This sector is responsible for producing many chemical ingredients and accounts for 94% of all manufacturers and formulators in Europe. As such they represent the ‘building blocks’ for the European manufacture of inks, pigments, surfactants, dyes, pharmaceuticals, pigments, food additives, electronics, sensory products, advanced materials, sensory products, etc. They also account for around EUR 157 billion per year to European Gross Value Added.

As far as environmental and sustainability efforts are concerned, the European Chemical industry has been very active. The EU reduced its GHG emission intensity (emissions per unit of production) by 55% since 1990, and is today more GHG emission efficient.

Besides that, different European chemical regions and companies have to cope with a large variety of challenges to safeguard their competitiveness. Following the conclusion of the GATT Uruguay Round, chemical import duties to the EU have substantially decreased which have reduced substantially the input price to the industry. On the other hand, it has also resulted in increased competition coming from players in third countries. Competition has resulted in a decrease of the EU chemical industry share from 32% to 1999 to 24% in 2009. In addition to that, stringent environmental requirements of a new chemicals policy add additional costs to the industry.

3.6.1 Drivers towards greater resource efficiency

Basic chemical manufacturing can be divided into inorganic and organic chemicals. It can further be divided into commodity and specialty chemicals. The chemical industry produces a wide range of mostly primary products for a variety of industry sectors such as organic and inorganic basic chemicals, polymers, solvents, electronic chemicals and other fine and speciality chemicals. Further, the chemical industry produces a number of finished products such as adhesives, paints and inks, lubricants etc. About 50% of the entire chemical production is provided as an input raw material to other industrial sectors.

The chemical industry is highly focused on environmental performance. The major companies and industry associations sponsor industry-wide environmental initiatives and environmental research programmes.

Multiple aspects have heightened the industry’s focus on resource efficiency. Amongst these aspects are:

- Increasing demand within the EU and worldwide;
- Diminishing material and energy resources;
- Increasing competition from companies outside the EU;
- Stricter environmental legislation.

3.6.2 Measures towards greater resource efficiency

Energy is a key factor in cost competitiveness within the EU chemicals industry. It relies on energy products such as oil, gas, coal and biomass - both as energy source and as raw material. The chemical industry can be considered as the most important energy consumer among manufacturing sectors. As such, energy costs represent an important competitiveness factor on the worldwide scene. Improving energy efficiency is therefore of paramount importance for the chemical industry. Currently, the EU chemical industry is the most energy efficient compared to other areas in the world. Therefore, a substantial increase in the energy efficiency is more dependent on a technological breakthrough. Further improvement on the energy front can be gained through the substitution of fossil fuels by biomass and renewable feed stock. It must be noted however that introducing these substitutes will imply that the biomass involved would be classified as waste. The industry is aware of the importance of the introduction of renewable resources to support the competitiveness of the industry thus calls for strengthening industry clusters. However, investments in energy efficiency remain necessary to maintain the current competitive advantage.

Whereas large players in the sector have already implemented a large number of environmental and resource efficiency measures, such as the development and installation of better catalysts which improve the yield of a factory, the industry strives to spread energy efficient technology/culture to SMEs as well.

As an example on the use of alternative sources of energy, the UK uses Methane as a feedstock for fertilizer manufacture, ethane (a gas found in conjunction with North Sea oil deposits) and naphtha from oil, which are starting points of most chemical industry processes.

In the area of the use of raw material in the industry, process intensification offers a substantial opportunity to maximise raw material efficiency. In its Resource Efficiency PPP program, CEFIC will highlight fundamental technological changes related also to process intensification. This latter will offer opportunities to improve efficiency in terms of energy intensity (energy use/unit of output) across the production cycle.

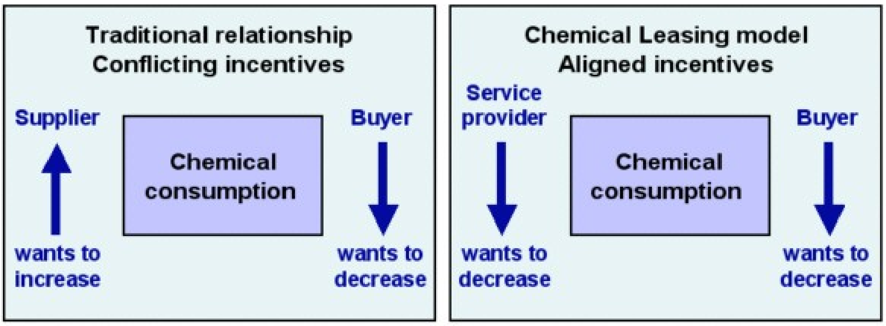
Green business model example: Chemical Leasing

Under known business circumstances, a chemical company sells its products to customers who then become owners of the chemicals they bought. That also implies that the customers are responsible for the use and disposal of the chemicals. Considering the above, the producers of chemicals (especially for use in downstream industries) have little economic incentive to become more resource efficient to recover the sold products to customers. This business logic can be related to negative releases to the environment when the customer lacks the know-how to dispose of the chemical products.

In order to decrease the environmental impact and increase the efficient use of resources, the concept of Chemical Leasing (ChL), which relates much more to the service related with the use of chemicals, has evolved. Under ChL, the customer pays for the chemical services, not for the product itself. When applying ChL business models, the producer does not just provide the chemical, but also his know-how on how to reduce the consumption of chemicals and how to optimize the conditions of use. While in the traditional model the responsibility of the producer ends with the selling of the chemical, in ChL business models the producer remains responsible for the chemical during its whole life cycle, including its use and disposal. Figure 14 shows a simplified scheme to help understand the concept and the incentives that motivate actors' behavior.

Consequently the economic success of the supplier is not linked with product turnover anymore but it is associated with the more value added services that it provides. The chemical consumption becomes a cost rather than a revenue factor for the chemicals supplier., as such the optimization of the material used and increasing efficiency are more valid targets than increasing sales of a the chemical substance. This approach to business reduces the environmental pollution. Against this background ChL can be seen as a key element of sustainable chemicals management systems. ChL has become a successful method of chemical management within various industrial sectors.

Figure 14 Scheme of chemical leasing



Source: adopted from: http://en.wikipedia.org/wiki/File:ChL_service.jpg.

Natural resource efficiency

The European chemical industry is especially concerned about the amount of water being used during different production stages. Production methods and products which contribute to efficient water management and water pollution control are regarded as measures which can have a substantial impact.

The emission of ozone-depleting substances (ODS) is also an aspect which falls under the target of becoming more efficient and environmentally friendly with respect to natural resource use.

The production of certain chemicals result in the emission of more ODS. The development and implementation of more precise waste air measurement processes can make the monitoring process more accountable on the one hand; new filter and emission capture technologies could further reduce the overall emissions.

Besides the chemical industry own performance with regards to resource efficiency, being a supplier for many downstream industries, it also contributes to efficiency solutions to their clients industries.

For example, as a second order measures, DSM, a global science based company (headquartered in the Netherlands) introduced two “bio-based” performance materials for the automotive industry. These are Palapreg ® ECO P55-0, which is a bio-based resin used for the automotive body parts and EcoPXX ™ which is bio-based high performance engineering plastic. The usage of both materials contributes to solutions towards negative environmental impacts resulting from the use of fossil based fuels for the automotive industry (Source: Cefic 2010, p. 17).

In a similar manner, the chemical industry enables energy savings through its products such as in the following examples:

- Energy Conservation (the use of effective lighting and insulation);
- Energy Storage (batteries, gas storage and supercapacitors).

Waste generation and impact

Because of the materials used and the contribution to hazardous waste in the chemical industry, there are many developments in the field of waste legislation. The legislation mainly focuses on avoidance of waste and assigning liability to the producer in case of non-compliance. Main areas of legislation are:

- Water Quality;

- Air Quality;
- Integrated Pollution Prevention and Control;
- Emissions;
- Mitigation of consequences of major accident hazards.

Since hazardous waste increased with 13% between 1998 and 2002, recycling is an area where more efficiency can be achieved. Besides technological breakthroughs, there are multiple ways of recycling and reusing waste streams.

In the Netherlands, the US chemical company Dow uses municipal wastewater throughout production stages where high-pressure steam is needed at one of its plant sites. The recycling of water resulted in 65 percent less energy use at this particular facility compared to the alternative option of desalinating seawater. The reduction in energy use is the equivalent of lowering carbon dioxide emissions by 5,000 tons per year. This concept could be applied at other locations around the Europe.

Another unique case of recycling is the use of landfill off-gas. Instead of using natural gas, methane off-gas from local landfills can be used. The gas is used as fuel to generate steam for various production processes of latex carpet backing.

EU case study: BASF

Energy savings

Energy costs may make up as much as 60 percent of the manufacturing costs for chemical products. Promoting efficient use of resources is therefore in the industries' own interest. At BASF's major production sites around the world, BASF uses a Verbund approach that links production and energy requirements in an intelligent manner. Primary energy carriers are used optimally both as raw materials and for generating electricity and steam. Heat from production processes is not discharged into the environment but captured to power downstream production plants (see energy balance diagram). Without this Energy Verbund, the total energy needed to generate electricity and steam in BASF Group power plants in 2008 would have been around 4.5 million metric tons of oil equivalent – approximately 54% higher than the actual figure of 2.9 million metric tons. The Verbund is one of the prime strengths in ensuring the efficient use of resources. It therefore offers a crucial competitive advantage, while also having a positive impact on the environment.

Waste management

At BASF, the appropriate disposal of waste is very important. BASF’s fundamental principles are “avoid, reduce, and recycle.” Residual waste is only disposed of when all other possibilities are exhausted. Sewage sludge from the BASF wastewater treatment facility at the Ludwigshafen site, for example, is used to generate electricity and heating. In addition, since the beginning of 2008, the sludge has been enriched by the addition of substitute fuels for thermal recovery. Worldwide, BASF’s production, including all former Ciba sites, generated 1.69 million metric tons of waste in 2009 (2008: 1.77 million metric tons). Oil and gas exploration accounted for 0.19 million metric tons of this waste. Around 42% of BASF’s waste was recycled or subjected to thermal recovery (2008: 43%); BASF aims to continue to increase this rate. The residual waste was disposed of by underground storage (14%), through incineration (44%) and by landfill (42%). According to the customary international categories, 554,500 metric tons of the waste disposed of was classified as hazardous and 413,800 metric tons as non-hazardous.

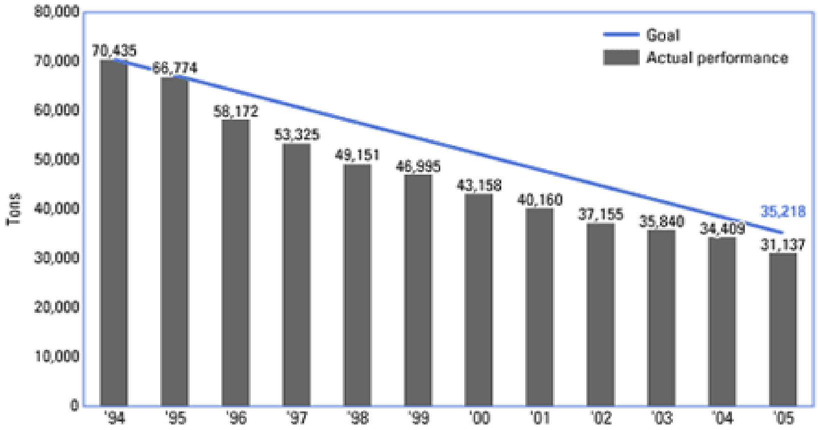
US case study: DOW Chemicals

Dow Chemicals has set forth the following performance goals with respect to resource efficiency:
Reducing:

- Chemical emissions by 50 percent compared to 1994;
- Priority compounds by 75 percent compared to 1994;
- Dioxin emissions by 90 percent compared to 1994;
- Waste and waste water generated per pound of production by 50 percent compared to 1994;
- Energy use per pound of production by 20 percent compared to 1994.

DOW has reduced chemical emissions by 56 percent since 1994. The goal was achieved while realizing production increases of 31 percent during this same time period. The figure below visualizes this development.

Figure 15 DOW chemical emissions reduction



Source: Dow Chemicals.

3.6.3 *Barriers towards greater resource efficiency*

Throughout the research, a number of different barriers towards greater resource efficiency have been discovered. According to a study on the resource efficiency of the German chemical industry, carried out by the Wuppertal Institute, technological and institutional barriers have to be differentiated.

The chemical industry in general and SMEs in particular depend on competitive advantages. These advantages are assured through expenditures in R&D and a corresponding high number of patents for large chemical companies. SMEs protect their know-how not always through patents but through accelerated innovation cycle and strict confidentiality. This business culture inhibits the exchange of know-how and technological transfer amongst SMEs and leads to knowledge gaps with respect to resource efficiency technologies.

A further barrier can be seen in the fact that chemical companies are often material suppliers to other industries therefore have lesser incentive to material savings through recovery. New business models that would capitalize on the product added value - such as chemical leasing could overcome this barrier. Thus profits will be made on higher selling prices and higher margins.

3.6.4 *Policy implications and conclusions*

Improvements in resource efficiency in the chemical industry are already occurring without any policy implications. The efficiency improves because:

- Increased worldwide competition requires companies to become more resource efficient;

- The increasing demand for chemicals leads to more production and thus an opportunity in terms of economies of scale;
- Diminishing material and energy resources obligate companies to start using alternative resources.

By several means, EU policy can enhance greater resource efficiency in the chemical sector. Tools that can be used by the EU are; subsidising, legislation, taxes & tariffs and sharing information.

Research and development

The output of the chemical production can be used for several products (adhesives, paints and inks, lubricants, organic and inorganic basic chemicals, polymers, solvents, electronic chemicals and other fine and speciality chemicals). Since 50% of total chemical output is used as raw input for other production processes, the chemical industry fulfils an important task. Demand for chemical products is increasing substantially. The importance of the industry indicates that technological improvements and breakthroughs are beneficial to more sectors. Subsidizing innovation through Research & Development (R&D) in the chemical industry would thus yield indirect benefits to many other industries. Especially, SME's lack the financial resources to make substantial investments in R&D. A tremendous improvement in resource efficiency can be achieved if subsidies would be available. Concerning waste disposals, companies that reuse their waste as a secondary resource can be subsidized to stimulate this process.

Taxes & tariffs

Chemical producers are often material suppliers and therefore improvements can be made to material savings and using waste as a secondary resource. To overcome this barrier, a quota can be introduced on waste disposal (% of total production) and taxes can be imposed on disposed waste above the quota.

Information sharing

Many SME's do not share their knowledge on resource efficiency because their innovations are not patented. EU policy could foster information sharing by organising knowledge-sharing platforms on a local or regional level and by establishing information sharing systems online, easily accessible for Small - and Medium Enterprises. In addition, information can be shared between bigger companies and SMEs. Communicating the benefits of reusing the waste after production by using publications/ press releases and extensive information on the cyber world would enlarge the willingness to change the current status in terms of resource efficiency.

3.7 The paper and pulp industry

Global pulp and paper production in 2008 was about 192.1mt and 390.9mt respectively. European companies represented over 25% of the production worldwide. The industry provides other industries with a large variety of products, ranging from packaging materials to (bases for) sanitary products and newsprint. Like other industries previously discussed, the pulp and paper industry suffered from the economic recession. Production of both pulp and paper was down 13.5% and 10.4% respectively in 2009 compared to 2008 in CEPI countries (18 European countries represented by the CEPI industry association for pulp and paper, representing 95% of pulp and paper industry in Europe). The recession thus ended a steady growth of 1.7% in the paper industry in CEPI countries (CEPI, 2010a).

Paper being a relatively generic product, makes competition in the industry based on efficiency and access to fibres. Energy prices, availability of forests, access to secondary material, and efficient production processes drive the industry. With production still exceeding consumption, competition in the industry is tough (CEPI, 2010a). Hence, energy efficiency and access to natural resources are the major drivers to accomplish resource efficiency in the pulp and paper industry.

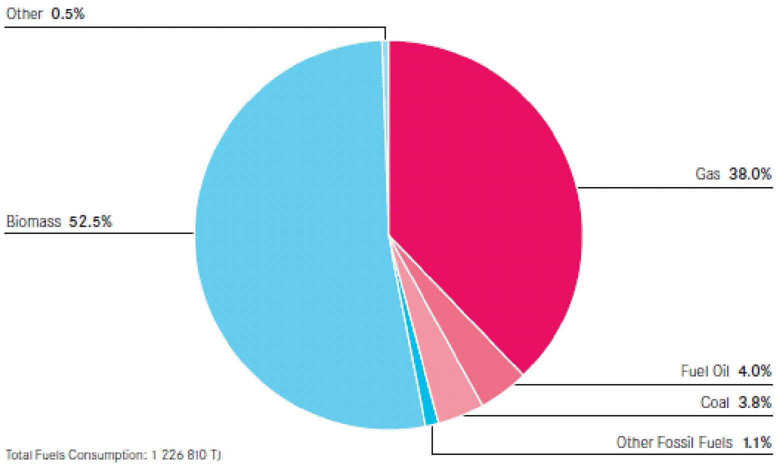
3.7.1 Drivers towards greater resource efficiency

The main environmental concerns and resource efficiency drivers for the pulp and paper industry as a whole are **natural resource availability, emissions to water and energy consumption**. Availability and access to forests in the EU and Russia are of key importance to the industry since most of their primary material input is directly sourced here. It is important to mention that one of the strength of the EU is the abundance of forestry and resources for pulp and paper. However, an existing threat regarding access to raw material from Russia might present a challenge to the EU in the future for timely provision of raw material. Furthermore, paper making is a water - and energy-intensive process, and the energy is provided either directly by the combustion of biomass fuels or gas. The current development in the energy market and the increased prices of energy, impose the adoption of practices that would reduce the use of energy in the industry. In general, the most significant emissions include CO2, nitrogen oxides, sulphur dioxide, and particulate matter. Water consumption and pollution are concerns in the industry due to the large quantities of water necessary in the pulp and paper making processes. Process waste levels are relatively low with many solid waste streams being recycled within the process. Similar to other industries relying on natural resources, the paper and pulp industry in the EU faces biodiversity conservation and associated European regulations. The sector is making efforts to protect forest biodiversity whilst ensuring that forests remain a source of raw material.

3.7.2 Measures towards greater resource efficiency

Energy consumption in the pulp and paper industry is a hot topic. Due to its intense use of energy in all stages of the paper-making process, the industry is heavily affected by rising energy costs and emission regulations. Most commonly used sources for energy are biomass and gas, as can be seen in Figure 16.

Figure 16 Fuel consumption CEPI countries 2008



Source: CEPI, 2010a.

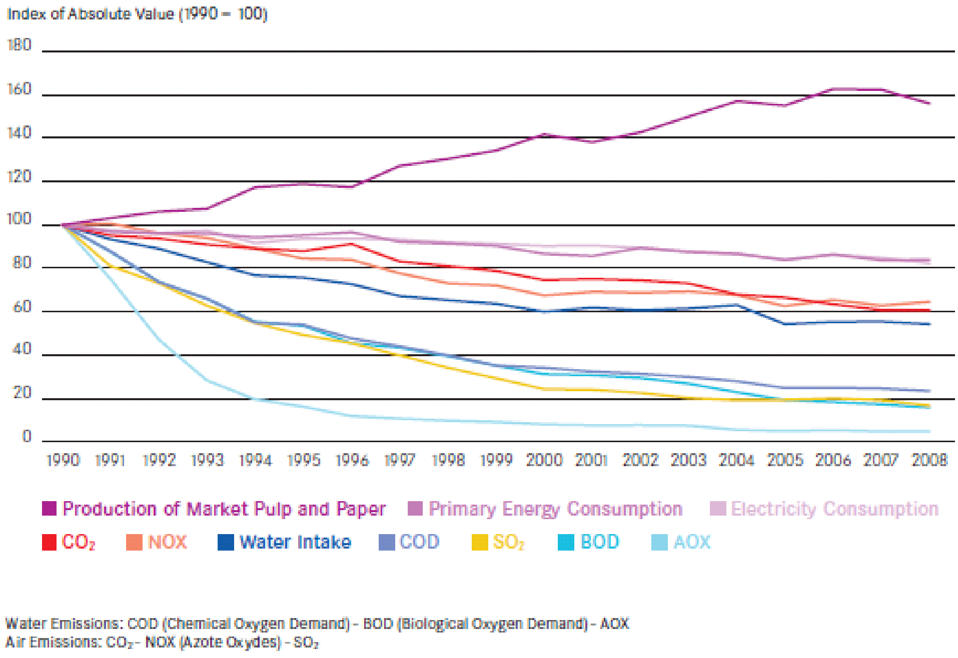
Energy comes from multiple sources. Biomass is created in the process of paper and pulp making and is therefore ready at hand. After wood residues, black liquor, and pulp and paper sludge have undergone some minor treatment these materials are ready to be used as bioenergy in conventional furnaces. The availability of biomass as energy source as a result of the production process makes the industry self-sufficient up to a 54.4% usage rate of biomass energy compared to total energy used in 2008. In total, the pulp and paper industry in Europe makes up for over a quarter of all the biomass energy consumed in Europe, making it the biggest single user and producer of bio energy (CEPI, 2010b). However, the other half of the energy needs to come from more traditional sources, mainly gas. For these sources the industry is still highly dependent on external providers, hence making it vulnerable for changes in energy prices and regulatory and market uncertainties. At the same time the industry has made progress making processes more energy efficient. Specific electricity consumption in MWh per kt production declined from 1.24 in 1990 to 1.04 in 2008; a decline of 16.1% over a period of 18 years (CEPI, 2010a).

Raw materials come for a large part in the form of wood. At the present time, wood is widely available in the EU, Sweden and Finland. These countries produce together almost 60% of all pulp in the EU and build on their vast resources (CEPI, 2010a). On the contrary to what might be generally believed, woods in the EU are actually growing and only 60% of annual growth is currently used. Responsible forest management reassures access to this natural resource also in the future (CEPI, 2010c). However, a new threat has recently arisen in the industry. The focus of the EU to create a greener Europe through the use of Renewable Energy Sources (RES) has fuelled competition for wood and has made the industry increasingly worried about the prices of raw materials. Recently mills have stopped production occasionally in the absence of material (CEPI, 2010d). Thus, consequences for the industry do not only come from increased competition for their core raw material but also in the form of rising costs and a risk of decreasing competitive position for their products on the world market. In conclusion, regional changes render the industry less competitive on a global scale (CEPI, 2008; CEPI 2010c).

Emissions to air

More efficiency in energy consumption has led the pulp and paper industry in Europe to lower their carbon footprint over the past two decades while increasing their production. Figure 17 shows how the production increased about 60% over the past 18 years while emissions and energy consumption have declined.

Figure 17 Evolution of production, energy consumption, and emissions EU 1990-2008



Source: CEPI, 2010.

Substances in emissions to air most important in the pulp and paper industry are CO2, nitrogen oxides (NO_x), and sulphur dioxide (SO_2). CO2 mainly comes from the energy-intensive processes used throughout the entire production process of paper. Efficiency gains and a higher usage rate of biomass energy have contributed to lowering the CO2 output. Main source of NO_x can be found in energy generation in the form of fuel combustion (Finish Forest Industries Federation, 2007). More efficient processes have induced a decrease in this harmful greenhouse gas of almost 40% relative to 1990 (see figure7), from 1.31 kg/ton of product in 1990 to 0.84 kg/ton of product in 2008. Sulphur dioxide is a natural by-product of the pulp making process. To transform wood fibres into pulp the lignin that exists in the cell walls needs to be broken down (CPI, 2010a; Paper Industry, 2010). This process together with the combustion of fuel creates SO_2. Filters and more efficient systems have decreased SO_2 tremendously over the past decades, from 1.69 kg/ton of product in 1990 to 0.29 kg/ton of product in 2008. These gains in sulphur oxide reduction are driven by the strict regulations of EU's legislative framework comprising amongst others the IPPC directives for air emissions of the industry (Intergraf, 2010).

Emissions to water

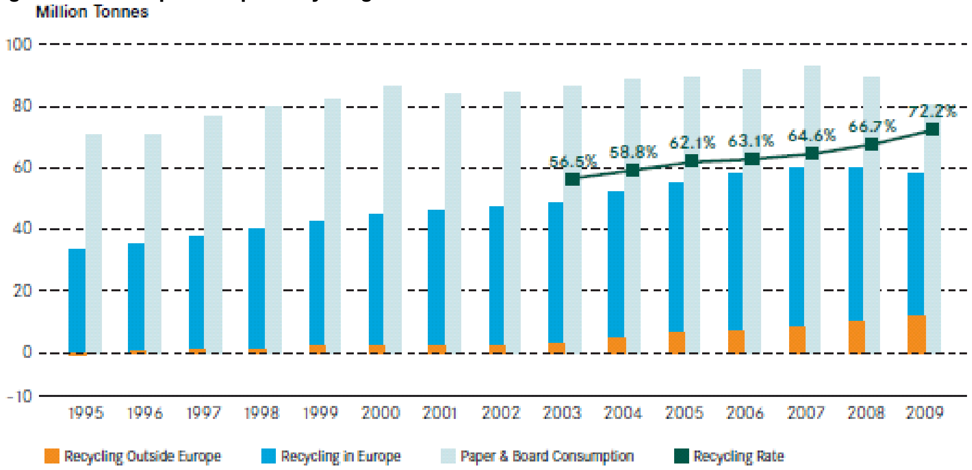
Production of pulp and paper is water intensive. Water is used to dilute fibres for pulp, to shape paper sheets and to clean. During the production process chemicals used to create pulp and paper end up in water (CPI, 2010a). In Figure 17 it can be seen that COD, BOD, and AOX, the main emissions to water, have reduced in Europe over the years with 76.3%, 83.7% and 94.9% respectively from 1990 to 2008. Better quality management and purifiers have contributed to this decrease. The industry takes water usage and the impact it has on water bodies serious and has committed itself to increase water consumption efficiency as well as water treatment improvement (CEPI, 2009). Industry association Confederation of European Paper Industries (CEPI) has taken the lead in developing water foot printing tools to measure the industry's impact on water. Its water reporting system is currently under development and is projected to be ready in 2011 (CEPI, 2010b).

Waste generation and impact

Pulp and paper are highly recyclable materials. During production, most of the waste created is immediately recycled back into the system or used for other purposes within the industry. For example, wood chips that are still too big after the refining process, are often used for compost in orchards or as bioenergy. Recycling of paper is done via a process where paper is first separated into fibres and mixed with water. Then all extraneous materials are removed such as staples and paperclips. Moreover, the ink is removed in a de-inking process, often followed by a bleaching process to make the paper pulp white again. The pulp is consequently used to make new paper. Recycling paper has benefits such as reduced use of virgin material, water, and energy besides a much reduced impact on air and water. At the same time, one should keep in mind that in the process of recycling paper more bleach is utilized. When the bleaching process contains chlorine, the process once again could have an impact on the environment in the form of potential water pollution (Paper industry, 2010). Paper cannot be recycled indefinite since the fibres become shorter with every lifecycle turn completed. On average paper can be recycled six times before the fibres are too short to form paper of good quality; hence some virgin material is always necessary in this industry (CPI, 2010b; Paper Industry, 2010).

In Europe recycling paper is by now a widespread practice. As Figure 18 shows, recycling rates have been rising sharply over the past years. Another interesting trend highlighted by the graph is the increase in recycling of European paper outside of Europe. Growing demand in China and other East Asian countries is mentioned as a reason for this leakage (WRAP, 2010). This seems to make up most of the growth of recycling while recycling in Europe has been more or less stable over the past four years.

Figure 18 European Paper recycling 1995-2009



Source: European Recovered Paper Council, 2010.

Recycling paper seems to be a long standing tradition in most European Member States. In 2007 the average European Member State recycled 75% of all paper packaging waste. Unlike collection in the glass industry, where a large difference exists between recycling rates of individual Member States, paper recycle rates in general are high for each individual member. The lowest recycling rate is found in Cyprus (39%) and the highest in Bulgaria (98%)[21]. Cyprus is clearly an exception and most member states recycle the majority of their paper waste.[22]

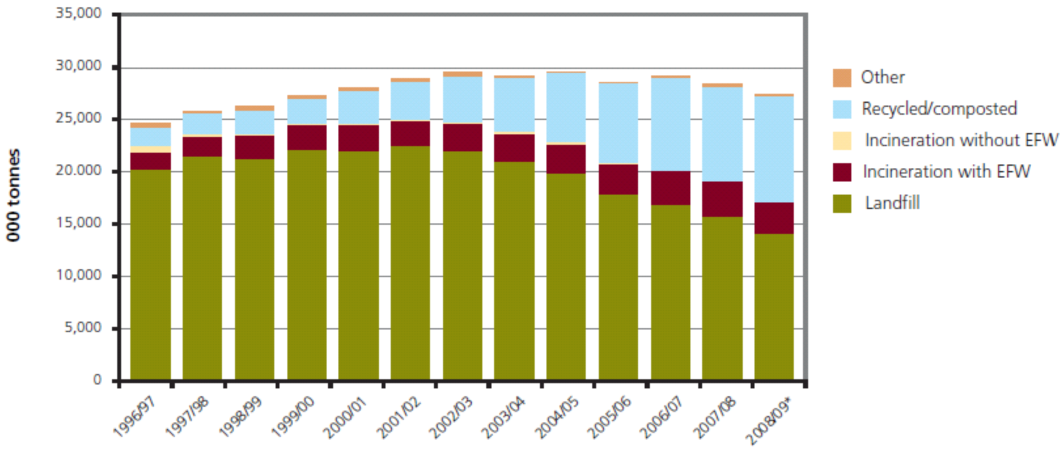
Policy highlight: UK

To comply with their own waste strategy introduced in 2000 and European waste directive, the UK has taken on stimulants and regulations to advance a greener economy and society. Regulations such as the landfill escalator and Landfill Allowance Trading Scheme have created incentives to divert waste such as paper from landfill to other waste management options such as recycling. At the same time incentives such as additional funding for local authorities through the private finance initiative have led to a major increase in kerbside recycling facilities and new waste treatment facilities. Furthermore, initiating institutions such as WRAP (Waste and Resource Action Programme) have led to wider availability of information on waste management through a one-stop-shop and awareness creation. These initiatives resulted in a 19% decrease in total waste to landfill from 2000 to 2006, 36% of all municipal waste recycled or composted in 2008, and 58% of all paper and cardboard recycled in 2008 (WRAP, 2010; Defra, 2009).

[21] Recycling rates calculated by source as paper and board waste recycled/ (paper and board waste generated – exported + imported) Source: European Commission, 2009. Packaging and waste 2007. Available from: http://ec.europa.eu/environment/waste/packaging/data.htm [Accessed 14/10/2010].

[22] Numbers calculated by the consultant based on packaging and packaging waste numbers provided by the European Commission. Source: European Commission, 2009b. Packaging and packaging waste 2007. Available from: http://ec.europa.eu/environment/waste/packaging/data.htm [Accessed 14/10/2010].

Figure 19 Composition of waste management in the UK



Source: Defra, 2009.

According to Waste Watch, a UK-based organization that creates awareness of waste and recycling, recycling paper has major benefits for the environment. Not only does it save natural resources by using secondary material, but also disposal problems are reduced. They estimate that a tonne of recycled paper saves:

- at least 30,000 litres of water;
- 3000-4000 KWH energy;
- 95% air pollution (Waste Online, 2006).

Considering the costs of water and rising energy prices using recycled paper has also economic benefits for companies. Reduction of methane, a greenhouse gas produced in landfills by biodegradable products such as paper, has further economic benefits now the ETS is in place. The Waste and Resources Action Programme (WRAP) calculated in a LCA that one tonne of paper and cardboard recycled avoids 1.4 tonne CO2 compared to landfill and 0.62 tonne CO2 compared to incineration (CPI, 2010c). In their study "Environmental Benefits of Recycling – 2010 update" WRAP assessed different LCAs and their outcomes. The general conclusion is that landfill is in all impact fields, such as natural resources, energy consumption, and water consumption, the worst option for paper waste disposal. According to this study it is more difficult to draw up a generic conclusion for these two options since differences between incineration with energy retrieval and recycling are smaller. Depending on the facilities and the energy mix incineration might, in some impact fields, be the better option. However, in other impact fields such as water consumption, recycling is at all times the better option of paper waste disposal (WRAP, 2010). Other studies such as the forthcoming Progress Report on the Thematic Strategy on the Prevention and Recycling of Waste state that recycling is at all times the better option from an environmental perspective.

Based on the above, the consultant concludes that unless a country has top notch incineration facilities with access to a relatively clean energy mix (i.e. consisting of a high level of renewable resources) and access to abundant raw materials (which could be the case in for example Sweden), recycling remains the best option in terms of economic and environmental impact.

One aspect not looked at before in this chapter is the export of recyclable paper. In terms of innovation a case study of the paper and pulp industry in the UK highlights this important issue. According to the "Environmental Benefits of Recycling – 2010 update" study the market for recycled paper products in the UK is estimated to remain stable the coming years. At the same time, markets for paper recycling abroad in countries such as China are growing. The part of the paper collected in the UK that is exported is likely to grow over the coming years. Since the market for recycled paper products in the UK is not evolving it is likely that innovation at recycling facilities in the UK is hindered (WRAP, 2010). Paper waste leakage from Europe could therefore have consequence for future innovation and energy and resource efficiency in the paper and pulp industry for individual member states. At the same time it could be an opportunity for the European paper machinery industry. China's paper market growth is hindered by a lack of quality virgin fibres. Their dependence on secondary paper is therefore tremendous, as is their demand for high quality recycling apparatus such as collecting, sorting, and de-inking machinery (China Paper Shanghai, 2008). Developing recycling machinery and facilities of high quality and efficiency in Europe could thus not only prove valuable in Europe but could also become a high-value export product.

Portuguese industry example - Grupo Portucel Soporcel

The Portucel Soporcel group is a Portuguese pulp and paper company founded in 2001 after the merger of Portucel and Soporcel. The company is located in Setúbal, Figueira da Foz and Cacia. The group has an annual production capacity of 1.55 million tons of paper and 1.34 million tonnes of pulp. The group is Portugal's third largest paper exporter.

A lot of attention is paid to the environment, sustainability and energy efficiency. Most of the group's efforts in trying to be more resource efficient focus on a more eco-friendly production. The group states that their paper is 'truly *ecological, biodegradable and recyclable, manufactured form renewable resource planted specifically for this end'.* Between 2000 and 2007, the Group's investment in environment protection projects amounted to some 270 million euros. Production processes are monitored and controlled in order to improve the environmental performance. The following environmental goals are put forward by the group:

- More use of renewable energy;
- Decrease consumption of fossil fuels;
- Increase recycling;
- Reduce CO2 emissions;
- Improve waste management.

In 2008 the Portucel Soporcel group was the second best performing Portuguese company in terms of environmental impact. In order to create more energy efficiency the group starts at the beginning of the production process. The group owns 120 hectares of woodland which is mainly occupied by the Eucalyptus globulus tree. This plant produces high quality paper and at the same time uses less wood. The group can therefore manufacture 80g/m^2 instead of 75g/m^2 thus **using less raw materials** when producing the same amount of paper. The plant also contributed to the group obtaining the certification under the Programme for the Endorsement of Forest Certification Schemes (PEFC) in August 2009. A common problem in the industry is that 100% eco-friendly paper often does not meet the minimum quality requirements and thus companies hesitate to produce it. The Portucel Soporcel group therefore has launched a pioneering product at European level – Navigator Hybrid, made with 30% recycled fibres and 70% new fibres, which contributes to **re-using resources and to the continuous planting of new trees** thanks to the incorporation of virgin fibres. Furthermore the group has invested in mechanisms to reduce fossil fuel usage. This resulted in a **58% decrease in CO2 emissions** between 2000 and 2008. The group also contribute to a sustainable society by generating renewable energy from biomass. The main sources for this energy are waste, like lignin, bark and wood waste, resulting from the production processes. Biomass now produces over 90% of all the group's energy demands and thereby further optimizes the resource efficient production process (Source: Environmental Statement of Grupo Portucel Soporcel).

Company Comparison

Before the recession, Chinese paper companies bought a tonne of recyclable paper for 100$ compared to 500$ paid for a tonne of virgin fibres. Compared to home market prices 100$ per tonne provided recyclable paper exporters with a healthy profit before the recession lowered demand and prices for European and American recyclables (French, 2009). Considering the growing importance of the Chinese paper industry in the world market, this section intends to compare a European company with a Chinese competitor hereby focusing on resource efficiency.

For the comparison, the companies SCA from Sweden and the Chinese incumbent Nine Dragons Paper have been selected based on their market share. Both companies are considered the largest in their respective territories. SCA develops, produces and markets personal care products, tissue, packaging, publication papers and solid-wood products. Furthermore, it is Europe's largest private forest owner with a holding of 2.6 million hectares of forest (SCA, 2010a). Nine Dragons Paper is the largest producer of containerboard products in China and one of the largest in the world in terms of capacity. The company primarily produces linerboard, including Kraft linerboard, test linerboard and white top linerboard, high performance corrugating medium and coated duplex board (Nine Dragons Paper, 2010). Investigating their corporate websites provided the consultant with the insights displayed in Table 9.

Table 9 Pulp and Paper industry - EU versus China - Resource Efficiency - Company comparison

	SCA (Europe)		Nine Dragons (China)	
	Goal	**Measures taken**	**Goal**	**Measures taken**
Material resource efficiency	100% control over of fresh-fibre raw materials (check results)	• Supplier screening; • Introducing stricter controls.		
Natural resource efficiency	Reduction CO_2 emissions from fossil fuels by 20% by 2020 (2005 as base year) (year-end 2009 2.2% reduction obtained)	• Investment in fuel reduction at plants; • Investment in wind energy in cooperation with Statkraft; • Use of wastewater sludge as renewable energy.	Energy consumption and CO_2 emission reduction	• Use of low-grade fuels, including waste paper pulp and sewage from wastewater treatment; • Methane collection and use as fuel; • Coal storage dome reducing amount of dust.
	Reduce water consumption by 15% in 2010 (year-end 2009 4.9% reduction obtained)	Reusing water from production processes.		
Waste generation and impact	Reduce organic content (BOD) in wastewater by 30% by 2010 (year-end 2009 40% reduction obtained)	Installing new biological treatment at plants	Wastewater treatment & recycling	• Introduction of anaerobic aerobic two-stage biological treatment; • Monitoring systems for

	SCA (Europe)		Nine Dragons (China)	
	Goal	Measures taken	Goal	Measures taken
				wastewater discharge; • Use of purifying agents.

Sources: Table adopted by Ecorys from Nine Dragons Paper, 2010 & SCA, 2010b.

Whereas in Europe the source of fibres is of importance and monitored strictly by SCA this seems less of a concern for the Chinese Nine Dragons Paper. This could be explained by the large amount of recycled paper used for the production of Nine Dragons Paper's products. As outlined in the previous paragraph, China has a lack of high quality fibres which makes it dependent on recycled fibres. Hence the dependence on wood raw materials of Nine Dragons is considerably lower than that of SCA since this company has its own forests at disposal.

A remarkable difference among the two companies is their innovative activities in the area of resource efficiency. Whereas Nine Dragons Papers notifies the public about the implementation and acquisition of more efficient and cleaner apparatus and systems, SCA seems to be more involved in the research itself. SCA reports many projects and incentives centring on resource efficiency such as the collaboration with Statkraft to develop windmill parks in North Sweden and their Resource Management System (RMS) to monitor resource utilization and environmental impact (SCA, 2010b). Developing innovative, more resource efficient technology and processes could not only benefit companies such as SCA through reaching their own environmental targets but could also prove a viable export product in the growing Chinese paper industry.

3.7.3 Barriers towards greater resource efficiency

Following the findings in the previous paragraphs the consultant highlights three barriers for resource efficiency in the EU pulp and paper industry:

Non-transparent energy markets

The lack of transparency in the European energy markets creates uncertainties and presents the industry with high energy costs. As a consequence the competitiveness of the industry is under threat. Furthermore the uncertainty about future energy prices delays and/or moves innovation and investment in new production sights and recycling facilities.

Emissions Trading System and Renewable Energy Sources

Now the ETS is installed in Europe and the use of RES is heavily promoted, the pulp and paper industry is not only affected directly through higher energy prices and taxations. Indirect consequences of the ETS result in tougher competition for raw materials such as wood. Wood and wood products are attractive sources for bioenergy. Increased interest in these materials has augmented prices and competition which result in higher costs for the pulp and paper industry. The industry calls for a lifecycle approach whereby wood is not used for energy generation at the beginning of its lifecycle but later on in the form of production waste or end-of-lifecycle scrap paper, when it proves no worth for the paper industry anymore.

Input of recyclable paper

Recovery of recyclable paper in the EU is relative to the collection of other recyclable materials high. However, there are still gains obtainable through further increase of the amount of paper collected via kerbside collection systems, collection points, and corporate waste collection. Furthermore, a leakage of recyclable paper leads to less availability of paper as secondary resource for the European pulp and paper industry. As the UK example shows, countries such as China have a high demand for recyclable paper while demand for recycled paper products in the home market is relatively stable. This in turn leads to less innovation in recycling facilities in the UK. Judging from the graph in Figure 18 the UK is not the only European country where exports of recyclable paper are increasing.

3.7.4 Policy implications and conclusions

The previously highlighted barriers to resource efficiency lead to a number of policy implications. The transparency of the energy market needs to be increased. Not only the pulp and paper industry but all energy-intensive industries in Europe suffer directly and/or indirectly from the lack of transparency in the energy market. To enhance innovation and to stimulate investment in European facilities policies should aim at creating greater transparency to reassure the industries their investments will be sustainable in the future.

The availability of secondary resources in the form of recyclable paper is threatened due to exports to third countries. A stable market for recycled paper products provides insufficient demand for such products and stimulates the outflow of secondary materials. In turn this leads to reduced investment in recycling facilities. Whether or not the outflow of recyclable paper will pose a real issue for the European industry in the future is not clear at the moment. Monitoring the amount and sort of paper flowing out of the EU would help to get insight in the possible consequences for European companies. At the same time opportunities for export of high quality recycling machinery and facilities exist in markets such as China which has a growing paper demand but lacks high quality virgin material. Policies directed at stimulating innovation in the recycling industry could hence prove beneficial for the European industry as well as create export and expertise opportunities.

3.8 The automotive industry

The European automotive industry is often regarded as a major engine for the European economy. Various automotive companies are based in the EU and generate substantial economic activity through materials and parts supply, R&D and manufacturing as well as sales and after-sales services. According to the European Automobiles Manufacturers' Association, vehicle manufacturing supports over 3.5 million European jobs with an additional 9.1 million citizens employed in automotive non-manufacturing activities. Exports are valued at over €70 billion annually.[23]

Further, the automotive industry is highly engaged in technological research which is also aiming at reducing $CO2$ emission and building more sustainable and resource efficient cars.

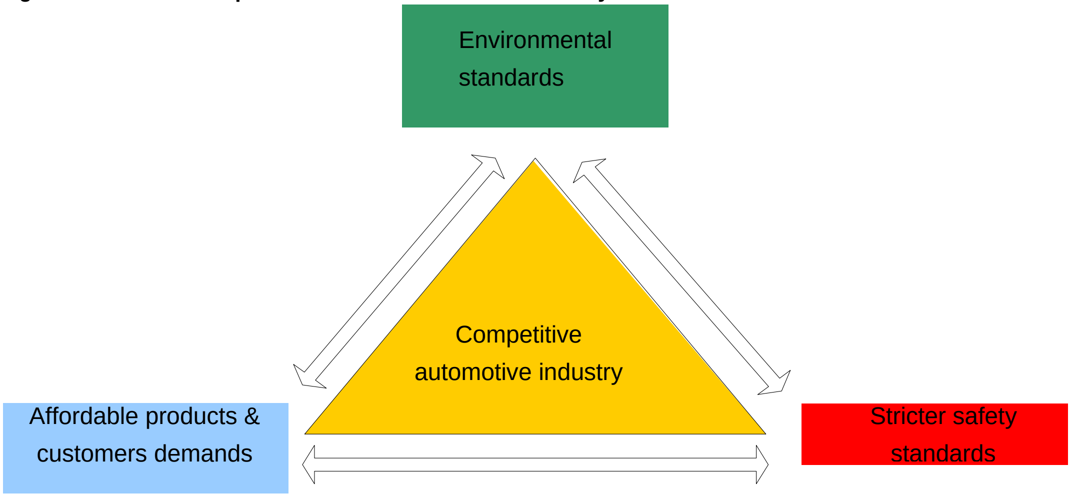
3.8.1 Drivers towards greater resource efficiency

European automotive companies are selling their products in a sector which is expected to grow substantially on global scale in the next years. However, this applies mainly to emerging and growing economies where people are seeking more freedom and mobility. In already established markets, such as North America and Western Europe, no substantial growth is expected and the trend goes inter alia towards leaner, greener mobility.

23 Information retrieved from ACEA.

The competition within the automotive sector is becoming much more intense and the pressures on the car industry in the competitive global market are many and varied. The Figure below illustrates the interlinked pressures the industry is facing. The improvement of resource efficiency along the production life cycle plays an important role to address these pressures. However, **trade-offs** might happen between the various "pressures" in order to increase sustainability. For example, the cost of technological innovations which can reduce emissions and increase fuel efficiency may reduce affordability.

Figure 20 Interlinked pressures in the automotive industry



Source: Ecorys.

Climate change and rising energy prices demand efficient energy usage as well as the increased use of alternative energy sources. Furthermore, dwindling natural resources make efficient handling of these resources essential, and necessitate a search for substitutes and the use of recycled materials. Finally, increasingly strict environmental regulations require the continuous reduction of the environmental impact attributed to wastewater, waste and production-induced emissions.

3.8.2 Measures towards greater resource efficiency

The European automotive industry is a driver for innovation in Europe. Research and development is conducted into safer, cleaner vehicles as well as improving manufacturing processes, logistics and mobility management. According to the European Automobile Manufacturer's Association (ACEA) the automotive industry is Europe's largest private investor in R&D. **Each year automobile producers invest €26 billion – or 5% of turnover** – in projects aiming at delivering more sustainable and competitive products. The industry files around 5,900 new patents every year in fields such as materials technology, recycling, ICT and telematics, energy and fuels, drive-train development, aerodynamics and ergonomics.

An overarching approach by the automobile industry to reduce resource use (material and natural resources as well as waste) along the entire production cycle includes **Green-IT** which helps to make the production processes more efficient and less resource intensive. Research focuses on the standardisation of components and the modularisation of sub-systems during production stages. **Tools and methods for virtual manufacturing and engineering** are seen as one option to improve time to market, supplier integration and distributed engineering footprint.

Material resource efficiency

In the future, the use of **light, smart and innovative materials** will be essential in order to meet environmental, safety and price demands. The research within the automotive industry focuses on materials such as:

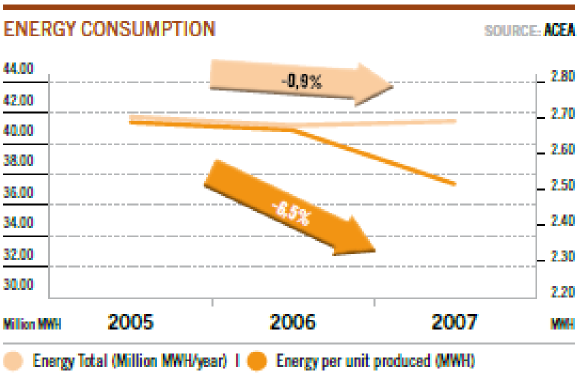
- carbon fibres, natural/glass fibres;
- high strength steels and aluminium;
- magnesium technologies;
- hybrid materials.

In addition, **IT tools for the optimisation of energy use** throughout the overall vehicle life cycle, from raw material extraction to the final product recycling are seen as solutions to decrease resource use.

Natural resource efficiency

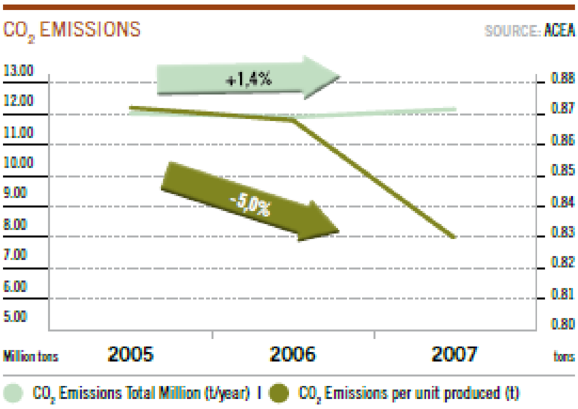
The pressure to reduce the impact on natural resources stems more from environmental legislation and the expectations of society than of cost reduction aspects. The achievements in terms of improved resource efficiency are illustrated in the figures below.

Figure 21 Automotive Industry environmental performance



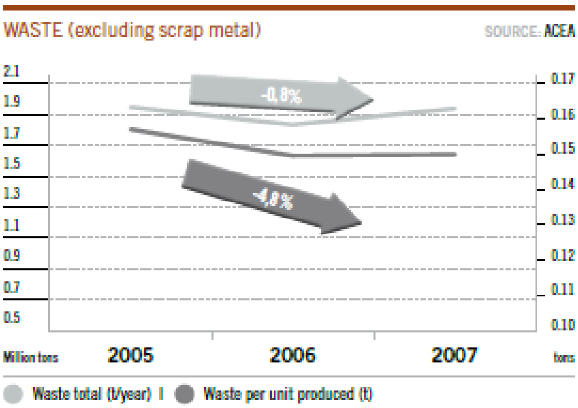
As cars are equipped with more and more features to make them safer and more environmentally-friendly, the complexity of production increases as well, with negative effects on energy demand. However, manufacturers constantly work on improving energy efficiency. As a result, energy consumption per vehicle produced has decreased by 6.5%.

NOTE *The figures include direct and indirect energy consumption, i.e. from on-site and external energy suppliers.*



CO_2 emissions per vehicle produced decreased by 5%, mostly through efficiency increases, and somewhat helped by a warm winter in 2007. Differences in the trends on energy consumption (previous graph) and CO_2 emissions have to do with changes in the energy mix available at the different production sites.

NOTE *As for energy, the figures include direct and indirect emissions, i.e. from on-site and external energy suppliers.*



The amount of waste per vehicle went down 4.8%, thanks to efforts by the manufacturers to reduce waste.

NOTE *Scrap metal, which is recycled and then used as a secondary raw material, is not included.*

Source: ACEA (document handed to consultant).

European auto manufacturers have significantly reduced the environmental impact of vehicle production in recent years. Per unit produced, energy consumption, CO2 emissions, waste, water use and VOC emissions have all decreased. At industry level, results are also influenced by the number of vehicles produced. In most cases, however, thanks to increased environmental efficiency, the rise in vehicle production from 2005 to 2007 was accompanied by a reduction of absolute emissions and consumption at the industry level. The figures concern passenger car manufacturing at production sites in the EU27.

With respect to decreasing the environmental impact during the **production stage**, Toyota Motor Europe can serve as a good example. The principle of waste reduction in embedded in the Toyota production System. As a result, Toyota has reduced the use of volatile organic compounds, water and energy per car by 63% since 1993.

With respect to decreasing the environmental impact during the **product in use stage**, the following areas present the largest potentials for improvement:

- Improvement of combustion engines for efficiency;
- Diversification of fuels and energy sources;
- Diversified infrastructure for fuels and energy supply;
- Electrification of the drive train;
- Optimization of vehicles.

Waste generation and impact

European recycling legislation, such as the ELV directive (End of Life Vehicles) which was adopted in September 2000, and the concern over the security of material supply are major drivers for recycling and reducing waster in the industry.[24]

[24] End of Life Vehicles Directive available under: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0053:EN:NOT (last found on the 23rd of November 2010).

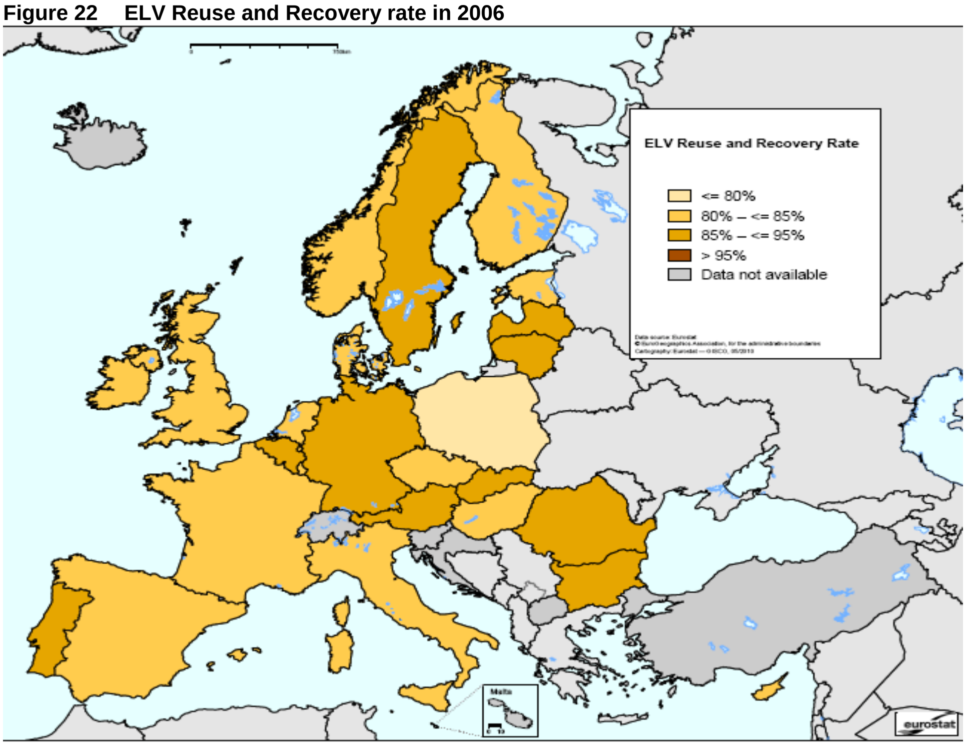
The mentioned ELV directive set out the following two targets:

- Ensure that a minimum of 85% of vehicles are reused or recovered (including energy recovery) and at least 80% must be reused or recycled from 2006;
- Increasing to 95% reused or recovered (including energy recovery) and 85% reused or recycled by 2015.

The volume of ELVs arising each year is increasing (increase in arisings requiring treatment by 2015 from approximately 10 million tonnes to 14 million tonnes). Further, five Member States (Germany, UK, France, Spain and Italy) are responsible for approximately 75% of EU 25 vehicle de-registrations.

The figure below presents an overview of ELV reuse and recovery rate across the EU in 2006.

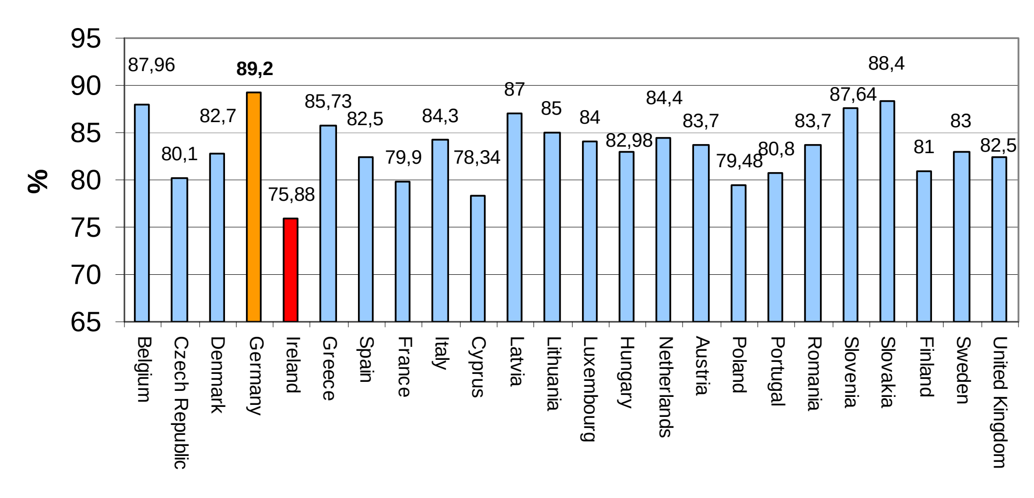
Figure 22 ELV Reuse and Recovery rate in 2006



Source: Eurostat.

The figure below presents the reuse and recycling rate of ELVs by Member State based on 2010 data for the year 2008. It makes clear that the recovery rate of end of life vehicles is the highest in Germany (89,2 %) whereas it is lowest in Ireland (75,88%). Looking at the countries with high recycling rates it is obvious that those are the countries with industry-led recycling systems (e.g. Netherlands) and those with free market approaches (e.g. Germany), but this does not however, explain the differences. A major part of the differences can be found in definitions and monitoring systems rather than in reality, i.e. harmonization of national monitoring rules can help to harmonize the results in the Member States.

Figure 23 Reuse and recycling rate of ELVs by Member State in 2008



Source: EUROSTAT.

As surfaced under the natural resource efficiency section above, principles of avoiding waste and the environmental impact of that waste are important.

An integrated approach, including all component suppliers and production stages is adopted by some companies in the industry aiming at:

- Using biodegradable packaging;
- Using recovered waster water from nearby municipalities;
- Separating waste streams;
- Recycling components after the product-use stage.

Fiat Group Automobiles Auto – an Italian industry example

Fiat Group is an Italian automobile manufacturer that was founded in 1899. In 2009 Fiat was the leading carmaker in Italy and the ninth largest in the world. The group contains many famous auto brands like Ferrari, Lancia and Iveco. All information below is taken from the Fiat 2009 Sustainability Report.

The environment has always been important for the Fiat Group, and Fiat pays attention to many aspects of sustainability. In the 2009 sustainability report it is stated that: '*Satisfying the growing demand for mobility, while reducing the impact a vehicle can have on society and the environment throughout its life cycle, is a strategic necessity'.* In Fiat's sustainability strategy attention is paid to many facets of the company, such as improvements in production, R&D and also internal processes. In order to achieve more efficient usage of resources Fiat strives for:

- Innovative use of alternative and traditional fuels;
- Reduction of CO2 emissions;
- Recycling of cars and components;
- Optimisation of the group's energy performance;
- Reduction of waste;
- Reduction of impact of logistics.

Energy efficiency is taken seriously and many results have been achieved in the past. To support innovation with respect to fuel usage and combustion in Italy the Fiat group contains **48 R&D centres**. Research resulted in the **introduction of 2 new technologies** for gasoline as well as for diesel engines (MultiAir and MultiJet), that improve combustion as to reduce harmful emissions. All Fiat's efforts are rewarded as they had the **lowest average CO2 emissions** amongst the top selling brands in Europe for the first half of 2009 for the third time in row. In 2009 Fiat was the only full-range brand to have already reached the average **European target for 2012-2015 of 130 g/km**. Recycling of cars and components is taken seriously by Fiat. Fiat gained experience with the Fiat Auto Recycling project from 1992 and the end-of-life vehicle Framework Programme Agreement signed in 2008. Currently Fiat plays a leading role in the recycling field as 95% of the groups cars are recoverable by weight. Furthermore Fiat initiated a major project that focused on recovering energy from residual materials generated by the end-of-life vehicle recycling process, called **target fluff**.

In order to increase efficiency of Fiat's own resources, an **energy action-plan** has been **introduced** to reduce energy consumption by 15% between 2010 and 2014. Fiat already achieved a **reduction of paper and toner consumption** by 25% in 2009 by introducing eco-friendly toner and replace personal printers.

Furthermore, logistics is an important aspect within the group and therefore it is an important goal to achieve greater resource efficiency in this area of the production cycle as well. To contribute to this the company **only uses low-emission vehicles** (Euro III-IV-V) for logistics. (Source: Fiat Sustainability Report 2009).

Toyota – an international best practice example

The Japanese automobile company Toyota has embedded environmental management and resource efficiency measures in its corporate management systems like hardly any other automotive company before.

In its recent environmental action plan Toyota categorises directions of the environmental activities requiring to companies toward 2020 to 2030 in three key themes:

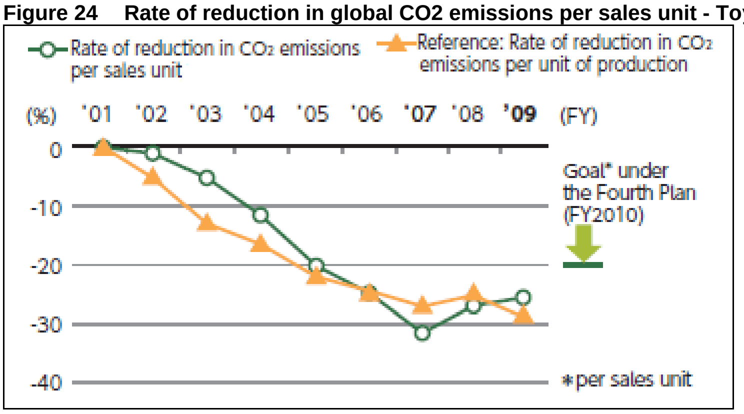
1. Establishing a low-carbon society;
2. Establishing a recycling-based society;
3. Environmental protection and establishing a society in harmony with nature.

Based on these three themes Toyota formulates programs, specific actions and objectives in the Toyota's corporate activity fields of development and design, procurement, production, logistics, sales and recycling, and promote environmental management.

Measures adopted in previous environmental action plans have helped to increase **material resource efficiency** drastically.

In the area of production, breakthrough approaches to better productivity have been made throughout Toyota, including engineering innovations and daily improvement efforts to thoroughly eliminate energy waste to reduce per unit consumption. In recent years, however, per sales units have been adversely impacted by significant curtailment of production and decreased sales. In order to stop the downward trend, the Toyota Group has unified to take action, consolidating low-work load processes, reducing energy consumption and turning off power during non-operating hours. Figure 24 presents the rate of global CO2 reductions achieved by Toyota through material resource measures.

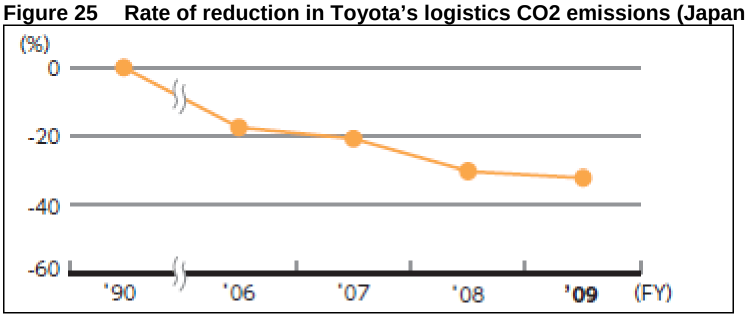
Figure 24 Rate of reduction in global CO2 emissions per sales unit - Toyota



Source: Toyota.

In the area of logistics, various improvements are under way intended to reduce CO2 emissions. Three specific avenues are targeted, namely, total transportation distance reduction, modal shift and fuel efficiency improvement.

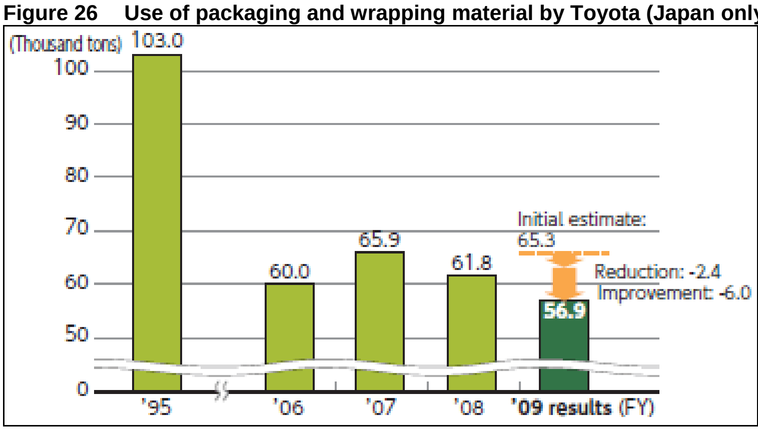
Figure 25 Rate of reduction in Toyota's logistics CO2 emissions (Japan only)



Source: Toyota.

In order to reduce the use of packaging and wrapping materials, Toyota implemented measures that included simplifying wrapping specifications (e.g., reducing wrapping materials for bumpers) and expanding the use of returnable shipping containers. As a result of these measures, along with a reduction in shipment volume, total usage decreased to 56,900 tons.

Figure 26 Use of packaging and wrapping material by Toyota (Japan only)



Source: Toyota.

With regard to **natural resource efficiency** Toyota has taken and is continuing to take a number of actions which involve the ones presented in the table below.

Table 10 **Main examples of Toyota's biodiversity conservation activities**

Category	Action item	Details
Automobile, housing businesses etc.	Global warming countermeasures	Improved global fuel efficiency CO_2 reduction in production and logistics activities
	Response to atmospheric environment problems	Reduction in emissions gases Reduction of VOC emissions
	Promotion of resource recycling	Promotion of recyclable design Expansion of recyclable material use
	Afforestation activities at plant sites	Planting of trees native to the region
	Reforestation	Restoration of undergrowth through tree thinning (Mie Prefecture)
	Considering new R&D facilities to be in harmony with nature	Preservation of habitats for rare animals and plants Maintenance of mountain forest areas
Contribution to social issues	Human resource development and the protection of rare species	Natural environment education at the Shirakawa-Go Eco-Institute and the Forest of Toyota
	Global afforestation	Afforestation using native species (China, Philippines)
	Toyota environmental activities grant program	Initiatives focusing on biodiversity and global warming

Source: Toyota.

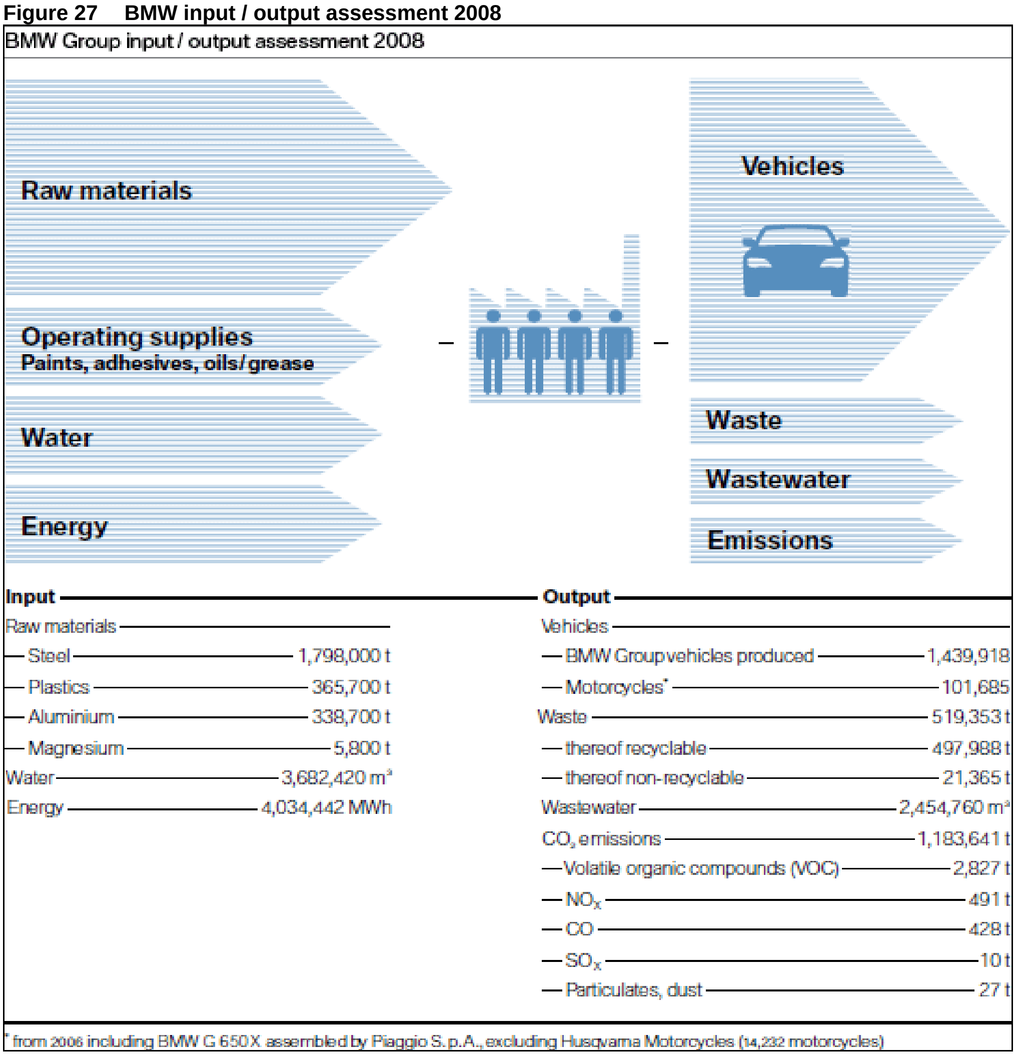
BMW – a European best practice example

The BMW Group is also regarded as a front-runner amongst European car manufacturers with respect to resource efficiency. Figure 25 displays the group's resource input and output assessment. The company aims to reduce the amount of resources consumed and emissions produced per vehicle by 30% from 2006 levels by the year 2012.

Measures to achieve those goals include:

- Returning all scrap from our press shops directly to the steel producers – so that they can melt it down to make new metal;
- Using less wax and film to protect the surfaces of new vehicles during delivery and using closed freight cars for rail transportation. This already saves 75 tons of preservative wax a year;
- Filtering tiny metal pieces out of vacuum cleaner bags at the Leipzig plant in Germany – so that these can be reused later;
- Using any waste that is left over after all as fuel for combined heat and power plants – instead of fossil fuels;
- Waste only ends up in the trash if there is absolutely no alternative. "Trash", in the figurative sense, of course – since every kind of waste is disposed of appropriately;
- The same approach also applies to conserving water as building a car uses a lot of water;
- Choosing low-emissions transport for material supplies and transport of cars (almost all BMW plants are connected to railways);
- Continuing to monitor resource consumption;
- Investing in Research & Development of greener technologies.

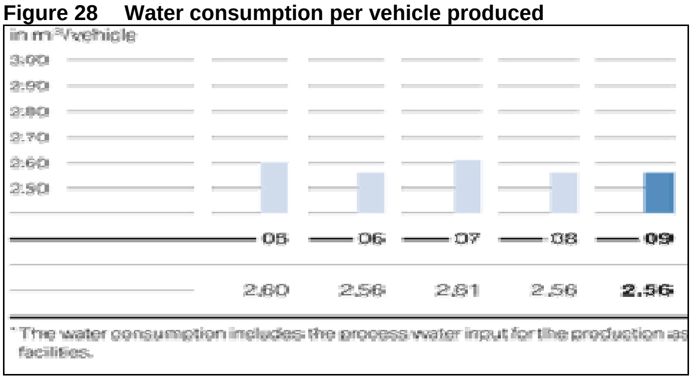
Figure 27 BMW input / output assessment 2008



Source: BMW.

With water BMW has already reached the 100% mark at its engine plant in Steyr in Austria which generates zero liters of process wastewater. A closed water cycle and complex filter systems ensure not a single drop is wasted. The new paint shop structure in Spartanburg plant (USA) led to a reduction in water consumption of 335,000 m3 of water and 68,000 m3 of process wastewater in 2008.

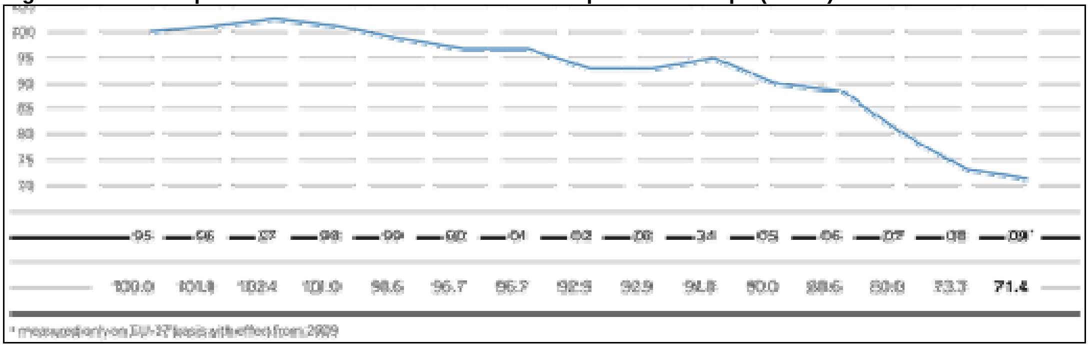
Figure 28 Water consumption per vehicle produced



Source: BMW.

Further Group-wide energy savings of 1.1 million MWh of energy between 2007 and 2008 as well as a reduction in carbon emissions per vehicle produced from 0.84 tons in 2007 to 0.82 tons in 2008 have been achieved.

Figure 29 Development of CO2 emissions of BMW Group cars in Europe (EU-15)



Source: BMW

3.8.3 Barriers towards greater resource efficiency

The mentioned as well as other manufacturers have and are continuing to improve their resource efficiency. Existing regulations and market prices are existing drivers.

However investments in new fuel technologies are sometimes hindered by:

- A lack of infrastructure and standardization for electric drives; absence or low stage of development of mature battery technology;
- Lack of global harmonized mobility requirements in the context of changing economic, ecological, social and infrastructure condition.

Furthermore, car manufactures claim that the timeline for compliance with resource efficiency improvement standards (e.g. fuel efficiency in the EU) is not accordable with the innovation cycle of the automotive industry. The industry is already investing heavily in R&D but sees physical limits to speed-up innovation even further. A further aspect concerns the already high rates of resource efficiency of some producers. The example of BMW shows that, at least in some areas such as water recycling, the maximum efficiency has been achieved already.

3.8.4 Policy implications and conclusions

The European automotive industry and its component suppliers are of great economic and social importance for the EU. In some European countries, such as Germany, a large number of jobs are dependent on the automotive industry. Therefore, the competitiveness of the industry sector is important. As the industry is already heavily investing in R&D, EU policy should further assist the industry by implementing union-wide standards with respect to new fuel technologies (e.g. standards and norms for electric chargers etc.). Such standards could provide investment security to the automotive industry, trigger further R&D and help to gain international competitiveness.

3.9 The electronics industry

The European electronics industry accounts for ca. 19% of the 1,115 billion Euro global production of electronic equipment, presenting a value of 217 billion Euro in 2009. The mentioned global production value is equally divided between mass market product categories (PCs, mobile phones, game consoles, etc.) and professional electronic equipment. Europe's role in mass market electronic production has diminished substantially since the crisis of 2001 to represent only 11% of the world output in 2009 but, with a share of 28%, it has a far more important position in professional electronic equipment production. But Europe's electronics industry is losing market share to competing regions.[25]

3.9.1 Drivers towards greater resource efficiency

The environmental awareness of the European electronics industry increased in recent years, due to **anxieties over energy security and global warming as well as pressures on the availability of raw materials and natural resource for manufacturing**.

The environmental footprint of the electronics industry is considered rather significant. An example which illustrates this footprint is a 2-gram 32MB memory chip. The production of that electronic device requires as much as 1.200 grams of fossil fuels, 72 grams of chemicals and 32.000 grams of water.[26]

The electronics industry is characterised by a **rapidly changing array of products** and therefore a **large amount of electronic waste**.

Furthermore, the use of rare earth elements in electronic products has increased over the past years, especially due to emerging products related to the IT technology. New, advanced battery, magnet and optoelectronics technology is depending on the use of rare earth metals. Rare earth magnets are small, lightweight, and have high magnetic strength so have become a key part of the miniaturization of electronic products which as been seen over recent years. The key rare earth metals in magnets are neodymium, praseodymium and dysprosium. For example neodymium is an important metal for hard disks in computers. Rare earth metals (particularly erbium) also act as laser amplifiers in increasingly important fibre optic communication cables. Through the 1950s, South Africa was the world's rare earth source, using the rare earth metals bearing monazite mineral. From the 1960s until the 1980s, the Mountain Pase mine in California was the leading producer. At the current moment all these resources are dwarfed by the scale of Chinese Bayan Obo mines that are responsible for the majority of global rare earth metal production. About 97% of world rare earth metals are produced in China, which has recently set export quotas and very serious duties for its metals.

> "It takes 350 kilograms of rare earth metals to make a 1.5-megawatt wind generator"[27]
>
> According to some estimates, up to 30 times as much gold can be found in cell phone circuitry as can be found in the gold ore processed in gold mines (some 150 grams per tonne, compared to a measly 5 grams per tonne), meaning that mining electronic waste really is as lucrative as striking gold. To add to that, the same quantity of cell phones also contains 100kg of copper and 3kg of silver, as well as numerous other materials.[28]

In the meantime, alternative energy projects and the electronic industry in the EU cannot do without these metals and warnings have been sounded regarding an impending shortage of rare earth metals.

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25 Information retrieved from the Electronics Industry Market Research and Knowledge Network under www.electronics.ca.

26 E.D. Williams, R.U. Ayres, and M. Heller, "The 1.7 Kilogram Microchip: Energy and Material Use in the production of Semiconductor Devices," Environmental Science & Technology, 36, 5504, 2002.

27 http://www.itar-tass.com/eng/level2.html?NewsID=15702495&PageNum=0.

28 http://www.urbanmining.com.

Rare earths are hard to refine. It is challenging to separate trace elements of minerals from large amounts of ore in an environmentally safe way (rare-earth mining produces radioactive waste). Production costs are high and also bringing new sites in to production is costly. The limited supply of the minerals in the marketplace is mostly the result of economics and environmental concerns, not scarcity.

This shortage has caused another recently developed source of rare earths that is E-waste that has significant rare earth components. However, there are no commercially available recycling technologies of rare earth elements from end of life electronic products amongst others due the small amounts used per product. Further research and the development of new technologies, on this matter is still needed.

3.9.2 Measures towards greater resource efficiency

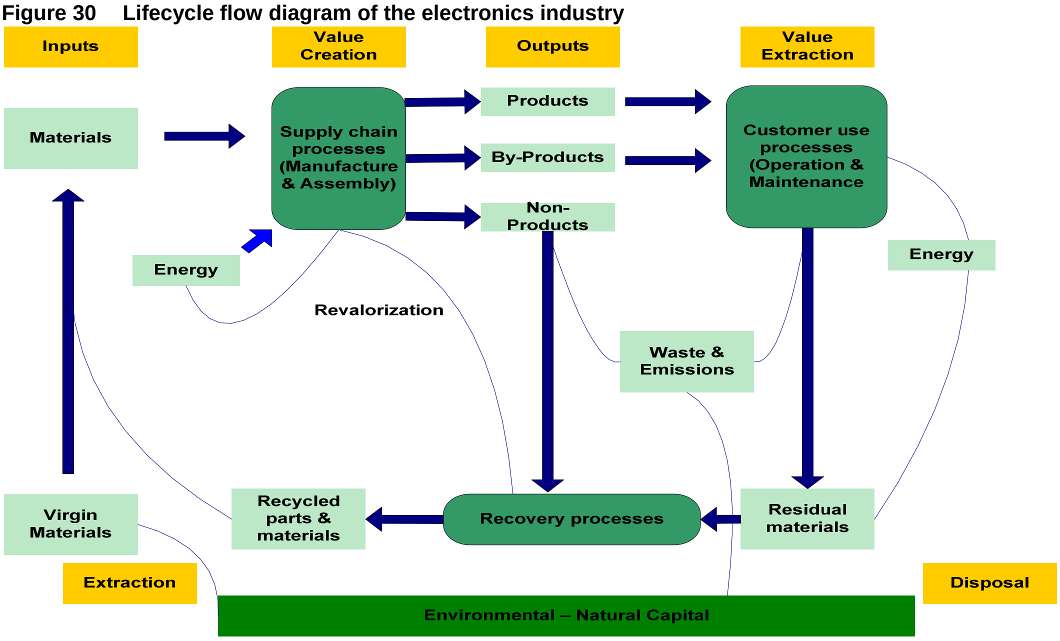
Design for energy efficiency has delivered breakthrough results over the last decade and there are many activities on energy efficiency already ongoing. Significant investments of the electronics sector on design for energy efficiency delivering breakthrough results have been made over the last decade, which has resulted in great resource efficiency gains in the use of ICT as well as Consumer Electronic devices.

Leading electronics firms have adopted a business practice called **Design for Environment (DfE),** aiming at taking the entire environmental impact and life cycle into consideration when producing a new product. The Figure below illustrates the life cycle flow diagram of the electronics industry.

The DfE focuses on the following four major aspects of product design:

1. *Design for dematerialisation* → aiming at minimising the material input as well as the associated energy and resource consumption at every stage of the life cycle;
2. *Design for detoxification* → aiming at minimising the potential for adverse human or ecological effects at every life cycle stage through the replacement of toxic or hazardous materials;
3. *Design for revalorization* → aiming at increasing the recycling rate of materials and resources in order to limit the extraction of virgin materials;
4. *Design for capital protection and renewal* → aiming at assuring that human, natural and economic capital stay available for production.

Figure 30 Lifecycle flow diagram of the electronics industry



Source: www.electronicadvocate.com.

Material resource efficiency

Various measures to increase material resource efficiency across the electronics industry exist. The electronics industry has, compared to many other industries, one advantage which could help the industry to increase its material resource efficiency and the resource use of the society as such further: **Many consumer electronics products combine the functions which previously had to be delivered in a variety of products**. A mobile phone combines the functions of a camera, digital agenda, GPS, watch, music player, TV or computer. Therefore, fewer materials are used throughout several stages of production and also delivery. However, as overall demand for electronic products is increasing, this argument is challengeable.

On the other hand, as put forward in the 2008 ELECTRA Report, a joint report by the EU's electrical and electronic engineering industry and the European Commission, the increased demand for communication technologies across different sectors of the economy (such as transportation, health, energy generation and distribution) could help to make production processes more efficient and less resource intensive.[29]

In addition, new electronic products are designed to be **energy-efficient** and use less electricity. Examples are the plasma televisions developed by Panasonic. These devices have reduced the standby power consumption by 90% since 2000.

Natural resource efficiency

Related to the "One device – many functions" aspect presented above, the natural resource use also profits. As the electronics industry ships a lot of its products around the globe, the shipment and actual delivery of multi-function products is becoming less carbon intensive and pollutes less air then the delivery of many products which can only provide one function.

Waste generation and impact

Across Europe, the recycling of electronic products has gained increased importance. The EU **Directive on Waste from Electrical and Electronic Equipment (WEEE)** aims to increase the re-use, recycling and recovery of this kind of waste. It is complemented by the Directive on the Restriction of the use of certain **Hazardous Substances (RoHS)** in EEE, substances that are often contained in the equipment and may end up leaking into local water supplies when dumped in landfills.

The EU estimated that only one third of electrical and electronic waste in the EU is reported as separately collected and appropriately treated. The other two thirds are potentially still going to landfills and to sub-standard treatment sites in or outside the European Union.[30] As the **collection target of 4 kg per person per year** does not properly reflect the amount of WEEE arising in individual Member States, the European Commission has proposed a recast for the WEEE (and RoHS), which is currently under discussion. The proposal aims at setting collection target rates reflecting how much WEEE arises.

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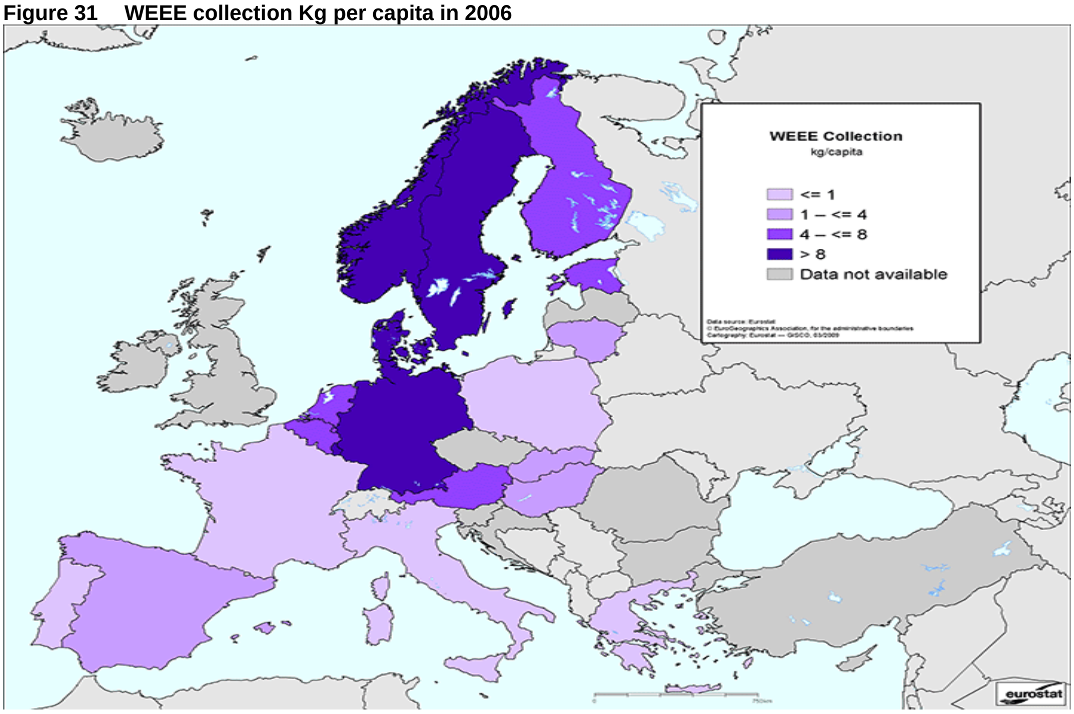
[29] ELECTRA Report (2008). Twenty Solutions for growth and investment to 2020 and beyond. Available under: http://ec.europa.eu/enterprise/sectors/electrical/competitiveness/electra/index_en.htm (last retrieved on the 3rd of January 2011).

[30] Information retrieved under: http://ec.europa.eu/environment/waste/weee/index_en.htm (last retrieved on the 3rd of January 2011).

The figure below shows WEEE collection data in Kg for Member States in 2006. The Eurostat data for 2007 and 2008 are still under validation. Some data might therefore be subject to change but the 2008 data shows a significant increase in some countries and provides first-time data for some Eastern European countries and UK/Ireland.

Figure 31 WEEE collection Kg per capita in 2006



Source: Eurostat.

On the other hand, the above statements can also be challenged by the fact that the Member States only report such WEEE collected by producer responsibility schemes and neglect valuable WEEE collected and recycled by other actors. The latter aspect is not covered in the above figure and therefore does not analyse the consequences that this has for managing WEEE. A report from the Netherlands showed that from a total of 18.5 Kg of WEEE that is generated per inhabitant per year, 14.8 Kg (80%) is recycled, with 5.7Kg (31%) being recycled by the producer funded WEEE system.[31]

Example 2 – Resource efficiency in the German Waste Treatment and Recycling Technology Association

"Through the rise of recovery rates in Europe there will be a high potential to boost resource efficiency".

The Waste Treatment and Recycling Technology Association within VDMA represent the German suppliers of such technologies.

Members of the association built the following waste treatment and recycling technologies:

- Technology for integrated circuitry (on-site);
- Recycling technology (e.g. for electrical and electronic equipment, mixed waste fractions) such as:

[31] Refer to DIGITALEUROPE statement on the European Commission recast proposal of directive 2002/96/EC of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE), COM (2008) 810/4 recast. http://www.digitaleurope.org/index.php?id=1062&id_article=322.

- Sorting technology;
- Sensor sorting technology;
- Reducing technology.

- Technology for renewables/waste to energy (bio-gas, energy recovery, incineration).

The resource efficiency measures used are:

- Recycling rates (input-output-analysis of the plants) e.g. iron, non-ferrous-metals, precious metal, plastics etc.;
- Energy use of the machines/plant (energy-efficiency).

The effectiveness of recycling technologies, with respect to resource efficiency, depends on the process/plant/machine and the type of recovered material. To give some examples:

- Recovery rates from recycling process cooling devices: iron 35%, plastics 15%;
- Recovery rates form recycling process ferrous shred: 99% Copper, 100% steel;
- Plastic recycling: over 99% separations of foreign substances (such as metals, paper, etc.).

The energy use efficiency depends on the specific machine/plant. Some sensor sorting machines or whole recycling plants achieved up to 25 % reduction. However the main question in the field of recycling technology is the energy content of the recovered material. Through the use of secondary raw material it is possible to save the energy input needed for the production of the primary material. For example the production of high-alloyed primary steel needs 105 MJ/kg, for one tone secondary steel only 11,5 MJ are needed. Above all the use of primary resources is declining.

The main drivers towards resource efficiency

Raw material scarcity will be a big issue in the next years especially concerning to primary raw materials in Europe. Europe does not have a lot of **primary material resources**, but Europe can have a huge sum of **secondary raw materials**.

Some countries (like China) started to buy magnitudes of e.g. electrical and electronic waste equipment with the aim to recover rare noble earth.

Another driver will be **the price** of primary and secondary raw material in the future. The price development for rare noble earth and other resource needed for electronic products is already alarming. As an example; the price of cerium oxide has increased sevenfold since 2009.

The potential of resource efficiency measures

Research and Development is a main focus for the industry to promote resource efficient technologies.

On the other hand the big challenge is to bring more resource efficient technologies on the market.

VDMA launched a study in 2009 to indicate the share of the engineering industry towards an energy efficient industry. One of the main results is: **only 40% of possible energy savings are realized**. Nevertheless today energy efficient machinery technologies realize final energy savings in the amount of the current demand of 48 millions households in Europe (VDMA 2009).

The barriers towards greater resource efficiency

At the moment the recycling technology industry sees the **missing market penetration of efficient technologies** as a major barrier.

Further, for the implementation of recycling technology one pre-condition is the existence of a legal framework with binding high recovery quotas (for industrial waste and municipal waste) and charge fees for some waste fractions.

Example 2 – Resource efficiency in lifts and escalator electronics

The Lifts and Escalators Association within the VDMA (German Engineering Association) is the body which represents the interests oft the German Lifts, Escalators and Components industry and is the forum and platform for the industry. Which sales of more than 1.4 billion (new installations) it is the industry's leading representative. Companies of all sizes are represented in the association. The lifts and escalators Association represents 80% of all new lift installations in Germany, in the case of escalators and moving walks about 95%.

The main drivers towards resource efficiency

The main driver to increase the resource efficiency is the energy consumption of lifts and escalators and the correlated cost savings for building owners.

The EU-Sponsored E4 project (short for energy-efficient elevators and escalators) is a Europe-wide study on the energy consumption of lifts and escalators. The result of this study shows a high energy saving potential through the consistent use of best available technologies (such as highly efficient drives and components, disconnectable components). To expand the empirical basis of available measurement data on energy consumption of lifts the power consumption of 74 lift systems in various building types was examined in the context of the E4 project across Europe.

The potential of resource efficiency measures

Based on the above mentioned project, the possible energy saving potential across the European stock, based on the best available technologies (such as highly efficient drives and components, disconnectable components) amounts to about 60% of energy used could be saved.

The barriers towards greater resource efficiency

Even if awareness for the subject of energy efficiency in lifts is increasing in German-speaking countries, there is still a lack of sensitivity and information particularly on the operator side. As an independent association VDMA starts to provide information to the operators (with a brochure about energy efficiency for lifts), information campaigns and the identification of energy efficiency of systems.

One obstacle to the use of energy-efficient solutions is the circumstance that lifts are often installed by a developer who after completion sells or leases the building to an end user. From an economic point of view the primary consideration for the developer is cheap procurement.

3.9.3 Barriers towards greater resource efficiency

The barriers towards greater resource efficiency in the electronics industry have been mentioned already above. The core barriers for the electronics industry can be summarised as follows:

- Missing market penetration of efficient technologies;
- The missing of a legal framework with binding high recovery quotas (for industrial waste and municipal waste) and charge fees for some waste fractions;
- Lack of information or access to capital (especially for SMEs);
- Missing public awareness.

3.9.4 Policy implications and conclusions

A suitable regulatory measure in this context would be to increase controls on illegal exports to reduce the amount of WEEE leaving the EU declared as used equipment.

A consequent application of the EU's Green and Sustainable Procurement Programs could be seen as a suitable market based instrument across all member states that would find the strong support of the electronics industry.

3.10 Overview of resource efficiency aspects and measures across industries

In order to summarise the findings of all nine industries, the below table aims at providing a summary and overview of the most important areas where industries are active with regards to resource efficiency, measures and indicators identified across industries.

The aspects, measures and indicators discovered throughout the analysis are very similar across industries but have a different importance for every industry. The table tries to rank the level of RELATIVE importance of the presented aspect, measure and indicator for each industry as follows:

- One tick, meaning less important;
- Two ticks, meaning important;
- Three ticks meaning very important.

To interpret table 11, let's look at the overview of the glass industry as an example. The glass industry does not face any material resource shortages as they are widely available at affordable prices. Energy consumption is the most important area of action with regards to resource efficiency. As energy consumption can be reduced by recycled material and new production processes, these measures are the most important ones for the industry. In terms of measuring efficiency indicators, energy consumption indicators are the most prominent but to a lesser extent, the availability of recycled material and GHG emissions as they relate to costs as well.

A different explanatory example is the Steel industry. The availability and affordability of material resources is very important for the industry, and therefore is the rate of recycled material being available. As steel-making is an energy intensive industry, the energy costs are also very important. In order to maintain a competitive advantage, the steel industry also has to invest in R&D and new production processes. New technologies and even plants are not regarded as important in the short-to medium-term as the investments are very large.

Table 11 Overview of resource efficiency aspects, measures and indicators used across nine industries

Aspects	Industry sector								
	Glass	P & P	Food	Steel	NFM	Cement	Autom.	Electr.	Chem.
Material Resources		✓		✓✓✓	✓✓✓		✓	✓	✓
Natural Resource	✓✓	✓✓	✓✓	✓	✓	✓✓	✓✓✓	✓✓	✓✓
Waste generation	✓	✓	✓✓✓	✓	✓✓	✓	✓✓✓	✓✓✓	✓✓
Energy consumption	✓✓✓	✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓	✓✓✓
Measures									
Recycling	✓✓✓	✓✓✓	✓	✓✓✓	✓✓✓		✓✓✓	✓✓✓	✓✓✓
New production processes	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓✓	✓✓	✓✓
Green IT			✓✓			✓✓	✓✓✓	✓	✓
Supply chain management	✓	✓✓	✓✓	✓	✓	✓✓	✓✓	✓	✓
New technologies and plants							✓	✓	✓
Research and development	✓	✓	✓	✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓
Indicators									
GHG emissions/ reduction	✓✓	✓✓	✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓✓
Amount of recycled material used	✓✓	✓✓✓	✓	✓✓	✓✓	✓	✓✓	✓✓✓	
Energy consumption/reduction	✓✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓
Raw material consumption/reduction		✓	✓✓	✓✓✓	✓✓		✓✓	✓✓✓	✓✓✓
Water consumption/ reduction		✓✓✓	✓✓✓						

Note: This rating is based on a limited number of company examples and how they showed their current resource efficiency challenges and associated measures. Other considerations may have not been taken into account in this rating.

4 Conclusions and recommendations

At the outset of this project, we have selected nine resource-intensive industries to be the subject of this study. In our methodology, we have selected the value chain approach in order to better understand the functioning of resources across every industry. In this chapter we present an overview of the findings of the research with regards to the drivers, measures, barriers and indicators of resource efficiency. The findings presented in this chapter have been informed by the results of the stakeholders consultation held at the European Commission premises and take into account additional information and input that were raised during the consultation. As such, it is recommended that the reader reads through the consultation proceedings report as well.

Based on the findings, we will elaborate on the policy recommendations that could guide the way forward for the “Resource Efficiency” agenda of the EU. The recommendations are intended to be general lines of thinking rather than specific measures directed at specific industries, since these latter have already been dealt with in the previous chapter.

4.1 Drivers to resource efficiency

Regulatory pressure

Organizations do not operate in a vacuum; the environment surrounding them plays an important role in shaping their actions and performance. This study found that resource efficiency is increasingly an important topic for EU industries; where both the need and incentive for companies to change towards further resource efficiency are quite strong. The current political context in the EU is characterised by rising political and societal pressures resulting from the increasing awareness about resource efficiency and the accompanying regulations. In the current context, environmental taxes, compliance with environmental standards and energy efficiency targets are all measures that imply the continuation of trends for increasing costs of resources and result into companies adopting several measures towards resource efficiency.

The study found that compliance with environmental regulations is perceived as a strong driver to resource efficiency and a push factor for firms towards more efficiency. However, many industries see potential risks with more stringent and rapidly changing EU regulations, producing higher levels of uncertainty and creating challenges for long term investments for industries.

Competitiveness improvement

The increasing competition over natural resources arising from emerging economies and the increasing prices of raw materials have triggered the EU industries towards resource efficiency in order to decrease their production costs and maintain their competitiveness. Driven by the objective of reducing costs, the industries representatives consulted in this study acknowledged that resource efficiency is an important and valid strategy for cost reduction and increasing competitiveness.

Companies are commercial entities, the costs versus the benefits of investment in resource efficiency shapes their investment decisions and determine the type of measures they use. Although the conventional wisdom states that investment in resource efficiency measures creates a win-win situation both for investors and the society, the economics of the firm do not necessarily support this supposition. And, while gains to society are evident, the same is not true to the firm, i.e.

studies examining the impact of resource efficiency measures on the competitiveness of the firm have not been decisive. Some showed that investment in resource efficiency is likely to increase firms' competitiveness (e.g. through improved sales), while others attributed the lower market shares to the higher prices associated with better environmental performance. As such, the determination of investment in resource efficiency hinges upon the evaluation of the costs versus the benefits of such investment.

In their "calculations" of costs and benefits, investors consider the time horizon of investment as well as the certainty of the surrounding business environment. In the case of an uncertain business environment, investors grow cautious about their long term investments and tend to focus on shorter terms. Longer term investments, involve second order measures - which are likely to yield higher societal benefits, but may not bring about immediate benefits or may not be financially affordable for the firm due to higher costs. In this case, the adoption of resource efficient technology is not synonymous to more profitability and vice versa. In such a situation, investors may be inclined to use less efficient technology which may be more profitable for the firm. This supposition implies that investment in resource efficiency does not necessarily occur automatically as part of the company strategy for increasing profitability unless the cost-benefit analysis leans towards more benefits than costs.

In this research, empirical data on the relationship between the resource efficiency measures and the increased competitiveness of firms was limited. For instance, data on cost reduction, increased productivity levels and larger profit margins achieved as a result of resource efficiency measures were not accessible to the researchers. Only a few examples on this relationship emerged through this study; an example from the packaging industry firms demonstrated the relationship between the increased production level and efficiency measures and cost reduction. It must be noted however that, given the limitations of this research, it was not possible to give a scientific qualification to this association.

The corporate image

The competitiveness of firms does not only cover the explicit financial dimension, but also includes issues like the "corporate image" of the firm and corporate social responsibility aspects. More and more, companies place higher emphasis on their corporate image by demonstrating their respect to the environment and by taking measures towards that objective. The rising importance of corporate image is due to the increasing consumer pressure and increased awareness about environmental matters and the increasing pressure on performance transparency and reporting requirements. These latter are exemplified in initiatives such as the "Global Reporting Initiative" which reinforces companies willingness to be better performers towards the environment.

Another type of pressure arises from relationships across the value chain and investors relations with firms. For instance, buyers in the value chain, through the exercise of buyer power, drive suppliers to adopt measures and standards that would guarantee higher sales of products or better image of retailers. Investors according to the findings of this research, are more willing to invest in companies that are more socially and environmentally responsible.

As such, increasing resource efficiency is not driven only by policies and regulations; companies have great interest to reduce costs and to become more resource efficient as long as this will improve their competitive position in the market.

Despite the fact that the research showed that regulations and standards, resource pricing and competitiveness improvements were strong drivers to resource efficiency, the regulatory side of the story had more weight than the competitiveness side. Our interpretation is that compliance with environmental regulations is still a stronger motivation to resource efficiency than competitiveness and it can be argued here that the financial returns for resource efficiency are still not fully optimized or fully understood by firms.

4.2 Measures towards resource efficiency

It was obvious through this research that the European industries have substantially increased their resource efficiency over the past few years. Companies have adopted measures to increase the efficiency of their resources in various ways. By nature, these measures were related to the resources (atmosphere, raw material, energy, etc.) they are designed for. Uniformly, all these resources were considered to be important elements to increase resource efficiency for all the industries. However, the focus of the measures across industries varied considerably based on the relative importance of the resources for the industries. For some industries such as the glass industry, efficiency in the use of raw material is relatively less important than energy efficiency because of the abundance of raw materials on the one hand and on the other hand because the industry is a high consumer of energy. The picture is different for other industries such as the NFM and Steel industry. For these industries, scarcity of raw material is one of the most important "resource related" issues. For the food industry, raw material and water prices are considered to be highly important elements that may enhance/inhibit resource efficiency. For the downstream industries automotive and electronics, raw material does not constitute a real issue because they rely on semi-manufactured goods. For them, the reduction of energy consumption during production processes is the most important "resource related" issue.

Despite of the varying degrees of importance of each resource for each industry, the industries examined in this research have shown a standard typology, by which they followed two types of measures:

- **First order measures:** were the most prominent across all industries, e.g. increasing or maintaining the high share of **recycling of materials** rates, use of **green and intelligent information technology** along the production cycle, the use of green business models, etc. However, there were obvious barriers to their wider use, such as the lack of access to finance, lack of knowledge and lack of sharing and dissemination of best practices. Therefore, there is still room to increase their further adoption;
- **Second order measures:** were less used, but they do occur. There is evidence for companies introducing new substitutes of material, .e.g. the use of **renewable (bio-based) materials,** especially in packaging, investment in R&D, etc. This finding implies that many companies have already exploited their 'first order learning" opportunities and are moving towards a "second order" level of learning. Both the lack of finance and access to knowledge and information were also barriers to the further implementation of these measures.

The importance of this typology of measures lies in the fact that, it highlights the gradual progress in the performance or the learning process that firms go through in terms of resource efficiency measures. In practical terms, this notion implies that firms will not move to second order measures unless they exploit the potential gains from the implementation of the "first order measures". This notion has also strong policy implications as it implies that policies imposing the implementation of "second order measures" may not bring the expected results unless firms implement first order measures.

4.3 Measuring resource efficiency

The study found that companies monitored some of their resources using specific indicators, but they do not necessarily measures all the resources they use. Measurements were sometimes confined to the most important resource to the sector/industry. For instance, in a high energy consuming sector, measuring energy consumption is most important, for the food industry, measuring water consumption is most important, etc. In our perspective, this finding is very important because it means that:

- There is a lack of a comprehensive approach to resource efficiency at the level of the industries studied;
- While this conclusion seems to be simple, it challenges the definition of resource efficiency used at the start of this project, being “the sum of material resource efficiency, natural resource efficiency, energy efficiency as well as waste generation and impact”. This is simply because the “concept of summation of efficiency of natural resources did not exist within industries, based on the empirical evidence.

On a sectoral level, data on resource efficiency was not uniformly available on an EU level. The fact that the EU is aiming at increasing resource efficiency implies that there should be a baseline against which measuring progress towards the desired objectives can be done. In general terms, the indicators observed through this study can be allocated to the following five thematic areas:

Table 12 Overview of specific resource efficiency thematic areas as per the findings of the study

Material resources	Natural resources	Energy	Waste	General
Consumption of material (Amount)	CO2 emission reduction/ savings- per unit of product	Annual energy consumption	% Recycled material to production	Expenditure on resource related R&D
(Amount) Savings of input material (ex. Water)	(Amount) Emissions to air	Annual energy savings	Recycling rates	
(%) Savings of input material (ex. Water)	(%) Reduction of emission to air	Amount of fossil fuels required	Waste collection rates (national levels)	
	(Amount) Emissions to water	Average thermal efficiency per unit of production		
	(Amount) Reduction of emissions to water	Substitution of conventional fuels by alternatives %		
	(%) Reduction of emissions to water	(Amount) Primary energy consumption		
		(% and amount) Savings on primary energy consumption		

As evidenced through the study, at a company level, many of the above mentioned thematic areas were found to be measurable and they were the most commonly used by companies. Our assumption is that for the monitoring of these indicators, the installation of monitoring systems is crucial; otherwise the monitoring will mainly be based on estimation and would be considered an inaccurate measure of resource efficiency.

While these are viable indicators, not all of them can demonstrate the efficiency level of the economic activities. The simple indicators presenting the amount of material used for production for example, are not sufficient indicators unless given in a comparative or relative manner. Based on that, the better indicators are the ones that show progress in a comparative manner, i.e. showing progress against a baseline for example, or the ones that show benefits accrued as a result of resource efficiency measures like for example "savings" in material or natural resource used or the rate of substitution in production. In a similar manner, an indicator like "rate of recycled material used in production" is not necessarily useful, because, the amount of recycled material will vary considerably depending on the volume of production and also because the introduction of a more suitable material (such as glass fibre instead of only steel in the automotive industry) may override the need for a recycled content in the production process. Therefore, judging critically the thematic areas in the above table, one can conclude that, not all the indicators reported by industries are necessarily indicative of the level of resource efficiency they reached and may not be useful in measuring resource efficiency.

On the policy level, there are few elements that need to be taken into account for setting indicators, these are:
- Indicators should be sector specific; and that
- Given the context of "resource efficiency", indicators should be material specific and they should measure the resource use in terms of consumption and production per sector. It important to highlight here the fact that, due to the numerous materials used in various production lines, the selection of the materials should be based on their "strategic importance" both for the industry and at the EU level.

On a national level, the micro-level indicators used by companies may not be indicative to the level of resource efficiency of economies as mentioned earlier. As such, the introduction of the concept of Eco- Efficiency is in a very good position to provide a method to tackle this issue. Eco-Efficiency as a concept addresses resource efficiency, i.e. minimizing the resources used in producing a unit of output and resource productivity, i.e. the efficiency of economic activities in generating added value from the use of resources. It also incorporates the production of waste. Eco-efficiency indicators are widely used on company levels (though they have not been too obvious in this research). Examples of these indicators are CO2 per unit of production, energy/ per unit of production. In the same line of thinking, the UN Economic and Social Commission for Asia and the Pacific (ESCAP) suggested the viability of "Eco Efficiency" indicators at a macro level, but using instead GDP as a numerator for calculation. According to ESCAP, indicators could be produced at an economy-wide, regional and sector level. Table 13 suggests a few indicators that could be relevant to the current context:

Table 13 Eco-Efficiency Indicators using Monetary value as numerator

Sector	Resource use-intensity	Environmental impact intensity
Industry	Energy intensity (m3/GDP) Water Intensity (m3/GDP) Material Intensity (DMI[32]/GDP)	CO2 intensity (t/GDP) Solid waste intensity (t/GDP) BOD[33] intensity (t/GDP) COD[34] intensity (t/GDP)
Manufacturing	Energy intensity (m3/GDP) Water Intensity (m3/GDP) Material Intensity (DMI/GDP)	CO2 intensity (t/GDP) BOD intensity (t/GDP) COD intensity (t/GDP)

32 Direct Material Input.
33 Biological Oxygen Demand.
34 Chemical Oxygen Demand.

Sector	Resource use-intensity	Environmental impact intensity
		Solid waste intensity (t/GDP)
Households and other Consumers	Energy intensity (m3/GDP) Water Intensity (m3/GDP) Land use intensity (Km2/GDP	CO2 intensity (t/GDP) Municipal Solid waste intensity (t/GDP) Wastewater intensity (m3/GDP)

Source: adapted by Ecorys from ESCAP 2009.

The importance of the suggested framework lies in the fact that it can provide a measure of efficiency of resources and allows for the comparison between countries, regions, etc. Linking resource performance to a monetary value provides a "standardized" approach to measuring resource efficiency and could widely contribute to the current discussions- in the EU context- about de-linking economic growth from environmental deterioration.

4.4 Barriers to resource efficiency

The barriers/market failures to resource efficiency are categorized in this section according to their causes:

- Misalignment of incentives

Incentives along the supply chain and between different actors are misaligned: Across one value chain, incentives for resource efficiency may not necessarily be aligned. In the "lifts" example provided in the previous chapter, the developer who installs the lifts in a building is not interested in a more "resource efficient" lift or escalator. For him, the criterion for the selection of a product is mainly "cheaper procurement". Other examples from other industries outside this research also clearly demonstrate this misalignment, e.g. in the relationship between the tenant and the owner of a building, the owner has less interest in installing better insulation windows or more efficient energy consumption heaters as long as he/she is not the beneficiary of such action.

Misalignment of incentives across the EU for resource efficiency creates varying incentives across industries. For instance, industries representatives interviewed /consulted in this research argued that resources in the EU are managed at a national level rather than at an EU level. Congruent with that, for instance, are the waste legislations which are considerably different across the EU. As a result, multinationals face difficulties exporting waste to other countries (intra EU) as they have to comply with different technical specifications.

- Lack of incentives

Absence of financial incentives in the form of tax breaks and subsidies, for example, were important elements missing from the picture of resource efficiency at EU level. Financial barriers were particularly relevant for industries dominated by SMEs (eg. Food & drinks and chemicals industries), where they account for more than 90 percent share of the total industry. Investment in resource efficiency measures usually requires large upfront investments, which may not be affordable by SMEs, except through obtaining financial assistance from financial institutions. Thus, for SMES, when loans applications are cumbersome or present unfavourable conditions to them, they have more difficulties to make substantial investments in resource efficiency.

Despite the fact that subsidies at EU levels for different sectors do exist, such as for instance the subsidies to the energy sector (example, heating plant in Sweden, subsidy of EC and government amount to 0.81 Million Euro), SMEs usually have the double problem of: 1. being too small to qualify for eligibility to EU funding and 2. risk aversion makes financial institutions less willing to support SMEs.

Limited financial incentives are exemplified in the relatively **high cost of recycling for some industries:** a few industries indicated that the separation of recyclable material involves high labour costs (e.g. in the case of separating precious and non-ferrous metals from electronic goods), which makes the export of scrap material cheaper than local recycling. In general terms, the price of secondary material is lower than the virgin material, but the increased competition over secondary material particularly from third countries results in their price increase and creates access difficulties for the EU industries. In addition, concerns about further increase of secondary material prices due to subjection of recycling to the ETS were raised by some industries too.

Contributing to the lack of financial incentives is the **long pay back time for large investment** which is not only a barrier for SMEs but also for larger companies. Large investments in resource efficiency often result in product price increase. This latter, although justifiable from the environmental and the investor's perspectives, may not meet the market demand it is expected to. Thus for the firm it will mean a loss in market share and competitiveness. The literature review conducted through this research has pointed out to cases where market shares have declined as a result of additional costs associated with environmental performance.

Lack of market demand: there is an observed lack of market demand for more resource efficient products. Trends in industries are always evolving and certain products may not necessarily gain wide public acceptance which may slow down resource efficiency improvements. For example, new technologies (e.g. electronic and paperless ticketing and payments via mobile phones) applied in some parts of the world (e.g. in Japan) have lower market penetration in Europe and are not widely used due to a lack of public acceptance. This latter is highly attributed to differing cultures and people's habits across the EU.

In addition to the "acceptance" factor, consumers' choices are usually influenced by short-term considerations and habits. As such, consumers' choices may not necessarily coincide with the more sustainable solutions.

Limits to the Best Available Technology (BAT): if widely used, BAT can deliver substantial results. Currently, BAT are not necessarily widely used nor adopted on an industry-wide level, for many reasons, including lack of access to finance, long pay back time, and access to knowledge. For some industries, the technological limits (have been reached as far as energy efficiency is concerned (e. g. Non-Ferrous metals industry). For some other industries, the best available technology may not necessarily lead to substantial efficiency gains. For some sectors (automotives, steel and cement), there are already promising technologies in the pipeline that are likely to increase efficiency, but most of them are unlikely to be fully deployed in the short term. Therefore, even for industries that have access to BAT, the limits of these for further resource efficiency have been frequently reported by industries, whereby the BAT is not able to lead to substantial additional efficiency gains. Hence, there is need for a technological breakthrough and an upgrade of the BAT if greater efficiency is to be achieved. Having reached the technical limits in some industries find little incentive for investment in resource efficiency measures.

- Lack of access to Information and Knowledge

The findings of this study showed that often, SMEs are disadvantaged compared to larger enterprises. SMEs in general terms, lack access to knowledge, technology and best practices. As has been demonstrated through the study, the chemical and food& drinks industries can be considered as good examples of SMEs dominated sectors, and representatives of this aspect. Across the whole study, it was obvious that sharing of best practices, information and knowledge on resource efficiency measures is not yet optimum among industries and there is room for improvement in sharing knowledge.

In addition to the general lack of knowledge about technologies and best practices, important elements relevant resource efficiency are missing from the EU context. These are the following:

- Data on the Life Cycle Analysis (LCA) of products;
- Sound methodologies to assess the implications of resource efficiency at the product level and from a supply chain perspective; and
- Reliable collection, recycling and end-of-life data in EU.

- Governance barriers

Lack of a comprehensive approach to resource efficiency at an EU level: it is true that resource efficiency is addressed through various policies in the EU, such as the Eco-design directive, the Ecolabelling directive, the Raw Material Initiative, etc., these measures are dispersed under several initiatives. Consistent with this aspect, is the lack of definition of "what resource efficiency actually means". This notion has been obvious by examining the way industries measure resource efficiency. In reality, there was no "efficiency" measure to their resources; i.e. their resources were measured in terms of consumption or in terms of savings in consumption. But, how efficient these savings are was not clear.

Uncertainty around the current policy environment in the EU was raised as one of the important barriers to resource efficiency. According to industry representatives who attended the workshop in February 2011, the current state of affairs in the EU policy development arena is perceived as being uncoordinated and is giving contradicting signals to industries. These signals create a high level of uncertainty to industries and may inhibit long term vision and solid investment plans for the development of industries. Uncertainty arises from the high level of activism at the policy level which creates feelings of instability and results in speculations. The example of carbon market demonstrates such an effect, where speculations arising from uncertainty about carbon market's supply results in high volatility of prices and consequently price increase.

Lack of a level playing field for industries: more stringent environmental legislations in the EU create a disadvantaged position for its industries compared to their international competitors. On the one hand, industries in third countries are not subject to the same environmental costs that EU industries are subject to which gives those countries a cost advantage over the EU. On the other hand, some EU industries- (such as NFM and steel) can not pass the price increases of their products to the downstream industry because they are bound by the international market price at the London Metal Exchange (LME).

- Horizontal barriers

Quality of the recovered material: many industries (glass, electronics, and chemicals) indicated that there is great potential for recovering material from waste. However, in many cases, the quality of the recovered material does not allow for its recycling. For instance, the glass industry finds it difficult to have access to good quality non-toxic waste, which then jeopardizes opportunities for effective urban mining. Based on that, the prevailing perception is that, despite of the efforts for recovering material at EU level, recovery rates can be improved.

Trade of recovered material and export outside of Europe: uniformly, the practices examined by all industries reveal that there is a great potential for further efficiency through the use of waste and proper waste management systems including proper implementation of EU waste legislation. However, international competition over scrap and waste is largely increasing in the EU, which can make waste material scarce and difficult to access for EU industries. This is particularly true in the case of NFM and also increasingly, pulp and paper.

4.5 Policy recommendations

Policy solution 1: Support to the EU industries to increase resource effectiveness (using the right resources)

It was obvious through the findings of the study, that the EU industries examined made substantial improvements in the implementation of resource efficiency measures be it in the form of first order or second order measures. It was obvious also that most measures focused on optimising the use of the "same" resources; i.e. they focused on using the resources "right", thus increasing their EFFICIENCY. Rarely, did companies try to increase the EFFECTIVENESS of their resource use. This would entail a focus on the use of the "RIGHT RESOURCES rather than on the use of the SAME RESOURCE RIGHT. In practical terms, for using the right resources, companies should ask themselves two questions: are we using the right resources? Are there alternative resources that can be used in production and that can produce the same products but with a higher environmental quality? Although some evidence towards increased effectiveness was found this research, the effectiveness approach was less prominent than the efficiency approach.

It is important to note that , in the case of natural resources, there will always be limits to efficiency because no matters how efficient industries can be, there will always be a need for a minimum amount of natural resources and a minimum level of waste too. Therefore although the focus on efficiency is very important, it is can still be considered a short/medium term perspective and the vision for resource efficiency in the EU necessitates a "longer term" approach to resources; an approach that would go beyond the efficiency of the "existing/same" resource and that would focus on the potential opportunities that can be created by simply thinking "outside the box" and the introduction of new substitutes that can replace the heavy reliance on natural resources. Research, development and innovation are key instruments to achieve this vision by introducing alternative material, new product designs, or products with new and more sustainable characteristics.

Policy solution 2: Increase support to material efficiency (using the resources right)

The emphasis on the effectiveness use of resources does not undermine the importance of increasing the efficiency of the materials currently used. On the opposite of that, the efficient use of material through the avoidance of waste and the re-use of material in the production cycle whenever it is possible and efficient is the other side of the coin for resource efficiency in the EU. However, given the limits to efficiency, efficiency measures will only lead the way forward on the shorter term rather than on the longer term.

Policy solution 3: Introduce economy-wide Eco-Efficiency indicators

On the other hand, the study also found that measurement of resources efficiency both at the company level and EU level was to a great extent missing. Indicators are important policy and management tool. Measuring resource efficiency at the firm level, has given some indications on the consumption of resources, but could not give an indication of the "level of efficiency" of the use of resources. Therefore, the indicators used at firm level may not necessarily be useful at a policy level.

Naturally, as the study has identified a few barriers and market failures for resource efficiency, it is important to address them through specific policy measures. The text in the following paragraphs provides policy recommendations specific to the barriers identified in the previous section:

Policy solution 4: Address the current barriers to resource efficiency

Addressing the misalignment of incentives problem

Recommendation 1: Enhancing a circular economy

Increasing and fostering the circular economy means encouraging industries to create a circular flow of material, not only within one industry but also between industries. Enhancing a circular economy will increase industries collaboration with each other and will help minimize possible misaligned or contradicting incentives.

- **Enhancing industrial symbiosis**

Industrial symbiosis means that industries should be able to find synergies and create harmony in the way they operate. In the context of resource efficiency, this means that, synergies for the use of resources should be coordinated in the most efficient way. The examples of the study showed that for the use of waste:

1. Industries use the waste resulting from their own processes as an input in their own production process. For example, waste was used as a source of energy (e.g. food industry) or as an input in the core product (e.g. as glass);
2. Industries use waste, by-products or services from other industries as an input in their production process. In this case, waste was used as a source of energy such as in the cement industry. The table below shows the direction of waste in each of the 9 sectors studied.

Table 14 Directions of waste

Waste source	Industry output (of waste)		Industry input (of waste)	
Industry	Back in same industry	To other industry	From same industry	From other industry
Food and Drinks	X	X	X	
Cement	X		X	X
Glass	X	X	X	X
Electronics	X		X	
Steel	X	X	X	
Automotives	X	X		X
NFM	X		X	X
Chemicals	X		X	
Paper and Pulp	X	X	X	

The importance of the above grid lies in the fact that it helps to understand the interdependence of sectors on each others' outputs of waste thus preserving the whole resource system and creating a cradle-to-cradle approach to resource management, and by using the materials "right".

Given the objectives of achieving industrial symbiosis and given the barriers represented in misalignment of incentives, enhancing industrial symbiosis will mean that actions should take place in the following directions:

- **Filling information gaps**

As has been shown, by-products or services from one company or sector often have the potential of being used by other companies. When the possibilities for re-use of materials or services is not happening, it is mostly due to an information market failure, which can be supplied by setting up mechanisms that ensure a better information flow between businesses. This has the potential of underpinning regional growth, creation of clusters and smarter use of materials, whilst also creating less waste disposal and economic benefits for enterprises.

- **Improve product design for recycle-ability or end-of life**

This is to make sure that whenever possible and *efficient*, products should be designed for recycle-ability and of good quality to enter again in production cycle. In several instances, where waste was reported to be "unclean " or "toxic", the usage of waste in the production process becomes irrelevant. Thus policy measures to strengthen eco product design can drive forward the quality of waste to be recycled and re-used in production and be better supportive to the "cradle to cradle approach".

- **Introduction of a single market** for both waste and recycling can reap substantial benefits to industries given the scattered interests and varying legislations of the Member States.

- **Better understanding of the product life cycle (across the value chain)**

The research identified opportunities to achieve efficiency gains through a better understanding of the product life cycle, particularly through the understanding of resource flow from one node of the value chain to the next node. According to the findings of this study, in many cases, resource efficiency at one node of the value chain results in efficiency at another node of the chain. For example, the food packaging industry provided solutions for consumers to increase their own efficiency and consumption. Similarly, the chemical industry provides resource efficiency solutions to the automotive industry and its customers through innovation in environmentally friendly materials.

- **Reform of the current waste legislations**

The current waste legislation should take into account the important materials that are currently classified as waste, while they are in fact resources (e.g. PVC for the chemical industry, recovering phosphate from landfill). In addition, the reform should consider the materials of strategic importance to the EU and which are exported to third countries for reuse as "second hand objects" such as for example, cell phones, computer screens, etc. Even in the incident that export activities are not performed in violation of the WEEE directive, from a policy perspective, it is important to consider that some strategic resources may be being exported. The flip side of the coin to this action might be interpreted as an introduction of market restrictions, which is in contradiction to the current EU trade policy on the one hand and on the other hand causes restrictions to businesses operating in the field of second hand material exports. As such, it is important for the European Union to set its priority in either direction.

Other policy actions that would address the "misalignment of incentives" problem are:

- Introduce incentives for recycling, e.g. "recycling certificates" in order to mitigate the high cost of recycling;
- Introduce common collection platforms and waste management schemes;
- Introduce a minimum level of recycled content in production in some cases. This recommendation should be handled with caution, because the use of a sustainable primary material, may override the need for the introduction of a recycled content in the production process. The technical feasibility and desirability of this recommendation from a life-cycle perspective should be further explored with industries;
- Introduce quality criteria for recycled products (in the EU market);
- Seize opportunities offered by clusters and geographical proximity to increase opportunities for further industry symbiosis and alignment of incentives;

- Extend producer responsibility (EPR) as an enhancer to further efficiency along the value chain (upstream and downstream). EPR implies the improvement of the product design surrounding the life-cycle of the product and the effective recycling of waste; and
- Ensure the sustainability of the construction sector as a source of waste material.

Addressing the lack of incentives problem

Recommendation 2: Considering Market Based Instruments (MBIs) to introduce financial incentives

Reflecting environmental externalities in the price of resources is an important push factor and driver for efficient resource use. According to the findings of this research, the lack of financial incentives represented in resource prices not reflecting their real prices was a strong factor that halts further resource efficiency. The solution to this barrier is the introduction of MBI.

It must be noted that our recommendation to introduce MBIs should be handled with caution because we are not in a position at this point- given the scope of the research- to define the appropriate MBIs that can be used to further resource efficiency. The definition of the appropriate MBI is contextual and depends very much on the overall regulatory environment in each country in the EU, hence, further research is needed in that direction. But, through this section we will explore with the reader what is meant by MBIs, their forms and purposes, their pros and cons and the conditions for the effectiveness of their implementation and results.

A MBI is a policy tool that aims to induce a change in behaviour of economic agents by internalizing environmental or depletion cost through a change in the incentive structure that these agents face (rather than mandating a standard or a technology). MBIs can be taxes, charges, subsidies, marketable or tradable permits and other financial incentives. MBIs can be implemented across an entire economy or region, across different economic sectors, or by environmental medium (e.g. water, soil or air). The following are potential MBIs:

Shifts in taxes to resource (internalising external costs)

Resource related taxes “eco-taxes” are based on the “polluter pays principle” and aim at enhancing producers’ behaviour towards adopting more resource efficient behaviour. The fact that producers pass price increase to consumers induces also the consumers’ behaviour towards resource efficiency.

Setting the tax at the right level is very important, therefore information on the marginal damage caused by external factors (other than the producers activity) need to be set correctly. Aside from that, setting taxes is likely to promote long term efficiency activities and provide incentives for research in resource efficiency, particularly with the persistence of tax. In order to keep this incentive, environmental taxes can be offset by reduction of taxes elsewhere such as labour tax, income tax, social security contributions, etc.

While taxes provide companies with certainties about the costs they may incur, they do not provide certainties about environmental outcomes. Companies may choose to pay the taxes rather than to improve their environmental performance, because it is cheaper than investment. In times of economic crisis, companies may also resort to evasive actions by relocating to places outside the regulated area, thus causing carbon leakage and dislocation of industries outside Europe. Companies may also try to alter their records or engage in corruption with government officials in order to avoid taxes or to enjoy tax breaks. On a different note, imposing taxes may contradict other policies, e.g. subsidies to water. Taxes on raw materials would also be contradictory, since the EU is undertaking efforts so that trading partners do not apply export restrictions, based on respect of open trade.

The level of effectiveness of taxes in terms of their impact on environmental outcomes depends on:

1. Rule of law and low corruption levels: to ensure tax collection and completion of proper performance levels and to avoid possible falsification of records or complacency between organizations and governments;
2. Proper enforcement of property rights: to keep companies' interest in investment in resource efficiency without loosing their competitive edge being front runners;
3. A proper reporting system: to allow taxing or tax breaks based on performance; and
4. Government capacity to implement the measure, which would imply the installation of an effective organizational structure, processes, procedures and trained personnel.

Reforming subsidies to support Resource Efficiency

Subsidies are a form of state aid tool that takes two forms; a direct form such as financial credits or grants and indirect in the form of tax breaks or provision of goods at lower price than the real price. Subsidies have strong advantages on national and regional levels because they offer a competitive advantage to companies at international levels. In addition, they are likely to induce people's interest in resource efficiency because they offer a price reduction to the resources used, thus guaranteeing an immediate effectiveness. Subsidies are a strong tool to support the introduction of innovative products in the market in the case of uncertain sales and product demand. More specifically, subsidies are beneficial to SMEs and can help them adopt standards and performance benchmarks.

On the downside of this story, economically and socially, subsidies may be inefficient as they may present market entry barriers to more competitive organizations and cover-up actual inefficient use of resources if applied wrongly. As subsidies create a group of advantaged organizations, it also creates another group of disadvantaged ones. These latter might be discouraged to invest since their own taxes finance the subsidies to their competitors, which may impede also innovation at a certain point. The introduction of subsidies might be tempting to companies towards illicit behaviour, e.g. to falsify their records in order to be eligible for subsidies. In the EU context, it is important that subsidies would not jeopardize competition principles of creating a level playing field for industries. Therefore, the basic condition for the implementation of subsidies is that they should be addressing a "market failure" and not a "company failure". Their value should be balanced in a way to guarantee that the change in the companies' behaviour would not occur with a lower subsidy. In order to be able to achieve the positive objectives of subsidies while minimizing the negative impacts, it is important to take into account a few important matters:

1. In order not to impede innovation or create feelings of resentment from investors, subsidies should be a temporary action given for the achievement of specific objectives;
2. The implementation of subsidies should be as transparent as possible to avoid illicit behaviour; and,
3. Setting the right amount of subsidy.

Green procurement

Green procurement refers to the acquisition of goods and services by public services while taking into account environmental factors such as energy efficiency, recycle-ability, etc. Public procurement constitutes around 20% of GDP in the EU, as such green procurement can act as a trigger to further resource efficiency across different sectors in the EU. Given this fact, green procurement practices are likely to have a wide environmental impact through the creation of incentives to buy and sell green products. Even though, green procurement creates additional compliance costs to businesses and subsequently increased product/service price, it is expected that on the long run, due to creation of economies of scales, compensation of these costs and even benefits can be achieved.

In order for green procurement to be a viable tool, there is a need to have accurate information about products, where buyers should be able to make a decision on their purchases, therefore, it is important to consider setting up information disclosure systems such as eco-labelling, Environmental Management systems (EMS) and the likes.

From an institutional perspective, there should be measures in place that would guarantee the enforcement of green procurement practices. For the implementation of which, implementers should have the technical knowledge and expertise for the application of the scheme. The European Commission can play an effective role in coordination of efforts across the Member States. It can also induce the exchange of information between the implementing governments and various industry actors. This level of coordination is crucial to achieve the desired outcomes of the green procurement schemes and to enhance dialogue between industry stakeholders and governments.

Resource pricing

The pricing of resources means applying a price to the use of resources. Resource pricing can take various forms; "user fees", effluent discharge fees, and product charges. Given that the users' expenses are mainly determined by their own use of the resource, the advantage of this tool lies in limiting the users demand (depending on their willingness and ability to pay). Therefore, price signals can act as strong drivers to resource efficiency. Pricing of resources is a tool that can be applied on a local level where the users are identifiable (individual consumers, or companies) and supports further resource efficiency and restricts demand. On the opposite side, pricing resources raises an important point of debate, with regards to putting EU companies at disadvantage internationally by having more expensive resources than their competitors.

In the EU context, many resource prices are already partly or fully reflective of their scarcity, such as waster or electricity. Therefore, resource pricing should only be applied to the extent that it reflects the "correct" price.

At the end of this section, it is important to remind the reader that the above measures (taxes, subsidies, green procurement, resource pricing) are given as examples of potential policy actions to further resource efficiency. The appropriateness of each of them should be examined carefully.

Recommendation 3: Improving access to finance can provide a strong financial incentives

Improving access to finance can involve several areas of action:

- Include resource efficiency in the 9th principle of the SBA (Small Business Act) instead of the focus on only energy efficiency and introduce actions towards integrating the concept in the SBA as a whole;
- Influencing banks;
- Introduce financial means to promote SCP including early markets; and
- Involve the public sector for risk mitigation.

Recommendation 4: The use of benchmarks and performance levels provide strong incentives for resource efficiency

We have seen through the industries studied in this research that the majority of industries start resource efficiency measures at a "first order measure" level. When no more efficiency is expected to be achieved through first order measures, they move to "second order measures". This research proved that, there is still room for improvement at the first order level, where companies adopt incremental changes that can achieve efficiency gains.

The use of benchmarks and standards is a good tool to enhance the use of first order measures and they are a common factor for several policy actions (setting tax rates, subsidies, labeling, etc.). For setting benchmarks and performance standards for firms, the basic assumption is that standards developers are aware of the level of efficiency that needs to be reached and the "appropriate technology" to be adopted. However, policy makers are not always in the best position to determine these standards. For instance, the Japanese program to improve resource efficiency - the Front Runner Program set dynamic standards for some products like TV and computers. The success of the program has been the result of an *extensive consultation* process between the Japanese government and the industries (source: Umwelt Bundes Amt, Wuppertal Institute for Climate, Environment and energy 2008, Resource Efficiency: Japan and Europe at the Forefront, Synopsis of the project and conference results and outlook on Japanese-German cooperation, 2008, p. 14). This means that developing the right standards has to be done not only by the legislator but in close cooperation with the industries involved.

In the same line, setting technological performance levels for firms may imply incurring high costs associated with the purchase of expensive technology particularly those related to emission reduction and energy efficiency. It also implies that firms are somehow forced to share the responsibility in solving the resource efficiency problem regardless of the costs. Thus it does not take into account the affordability of the required changes. As such, SMEs may be victims of such standards. Applying technological standards, even for the large firms may not necessarily be cost – effective. This argument should be seen in the light of the discussion about the costs and benefits of resource efficiency measures for firms. The question here is what the "right" standards are. The question is rather a challenge and relates again to our earlier argument about the assumption of complete knowledge about the exact levels of performance that can be reached, otherwise, standards can be unachievable or cost inefficient.

On the downside of this picture, setting technological standards, unless they are dynamic, is likely to freeze innovation and inhibit further technological development. As discussed earlier regarding the costs and benefits of resource efficiency measures, companies, being commercial entities, will seek their own interest in their investment. Therefore, with a lack of incentives to continuously improve efficiency, they are likely to do the minimum just to meet the required levels of performance and not to go beyond these. Thus, there should be an additional instrument to support this measure, e.g., the availability of funds for investment in research and development or green labelling. It can be concluded here that, setting standards alone can not achieve resource efficiency; it must be accompanied by other instruments that are able to mitigate the risks arising from the use of standards and benchmarks. As such, performance standards should be realistic in their ambitions.

Other actions related to the introduction of performance standards include:

- The need to identify the priority products/sectors/resources where performance standards need to be applied and where potential efficiency gains can be achieved;
- Introduction of long-term resource efficiency targets;
- Extended Implementation of Ecodesign (including design for recycling) to further include resource efficiency aspects, which are now less in the focus than energy efficiency- in that sense, it will be important to have clear indicators on resource efficiency on a company level; and;
- Improve data and information on the life cycle analysis/ sustainability methodology for products in order to identify potential efficiency gains and where performance standards should be more stringent in one node than others.

Addressing the lack of market demand problem

Recommendation 5: Adopting measures towards changing consumers behaviour

As market demand constitutes a strong incentive for industries to introduce innovative products, consumer education for the purpose of changing behaviour is crucial in this process. Consumers should be able to know the value of purchasing "more resource efficient" products. Behavioural change can happen by means of:

- Information campaigns;
- Marketing (including control on green commercial claims); and
- Labelling.

Addressing the limits of the Best Available Technology

Recommendation 6: Further support to R&D for further innovation

As has been obvious through the research, technological limits have been reached for the production processes of some industries and that further resource efficiency can only be achieved through technological breakthroughs. Technological limits concern the second order measures adopted by industries. These types of measures require higher investments and R&D, as well as total or partial restructuring of the industrial processes.

Support to R&D by governments can take various forms. It can be in the form of direct financing to public scientific entities such as universities or research institutes or funding private R&D efforts. It can also be in an indirect form by providing tax incentives to promote R&D. Governments can also provide support to R&D in the form of long term, low rate investments and encourage loans.

Besides the above financial incentives, there exists a number of non-financial incentives, such as, a reasonable level of protection of intellectual property rights and improving human resources capacity through university education, which can influence the amount of research done in resource efficiency.

Investment in R&D provides innovative solutions to industries and helps to build up human resources capacity for future developments. However, it might lead to a free riders' problem, where imitators of new technologies reap benefits as well. Similarly, the results of R&D efforts are not necessarily evident, they are subject to trial and error, and thus they bear in themselves a risk of failure, which is a natural part of the evolutionary process of innovation.

Recommendation 7: R&D support for the development of green business models

Supporting green business models implies defining innovative ways of doing business that provide sufficient incentives for industry players to act in a resource efficient manner. Green business models address the organization of work and management of business rather than addressing the environmental aspects of a certain product. In our research, we have introduced the Chemical Leasing model, which was based not on the consumption of material but on higher value added product through the services provided by the company. As such, the profits of companies do not lie in the quantities of sales, they lie in the sales of services and the know-how about dealing with the leased material in an environmentally sound manner.

Aside from the Chemical Management Services model, other models are already known in several Nordic countries. These include, the "functional sales model", where consumers pay for the outputs of the products rather than for the product itself. An example of that is the Swedish company which produces airplane engines. Through a new business models it does not sell the engine itself but it sells the power the airplane engines ('power by the hour') rather than buying the engine itself.

According to the business model, the company has the incentives to optimize and maintain the product and at the same time ensure the cost effectiveness of the life cycle cost of the product.

Businesses, however, are likely to delve into finding new business models if there is a strong incentive to do so or if the risk of changing the business model is perceived as being too high. A strong incentive for businesses in this case could be in the form of support to R&D towards finding and elaborating possible resource efficiency gains through business models. Changes in companies' business models may lead to changes in ownerships or shared responsibilities between companies, which is why best practice examples are needed to show how these relations can be build.

Further policy actions can be adopted to address the barrier of limitations to BAT:

- Support for demonstration and market introduction of new technologies for which it is difficult to attract private investment and can help overcome uncertainty problems;
- Increase awareness through case studies, documentation of effects, demonstration projects. These initiatives should be targeted both to the supply side (making businesses consider changing their model) and to the consuming side (businesses and private consumers) to increase the demand of services rather than products;
- Encourage public-private partnerships in R&D and innovation. The government roles in this type of relation should remain at the level of defining broad lines of objectives rather than engaging in the technological specifications. These latter should be left to the private sector to identify;
- Companies often assess the risks of engaging into green and innovative business models as being too high. Guiding papers and European common standard for these models could prove to be a way forward;
- Promote green business models in public and private procurement;
- Green business models should become an integrated part of existing and coming innovation instruments.

Addressing the lack of access to information and knowledge

Recommendation 8: Dissemination of good practices through industry platforms and networks

The study showed that there is still room for further improvement in the area of first order measures through knowledge dissemination and diffusion of best practices. For the rapid dissemination of technology and the awareness of potential improvements, closer linkages are needed between all actors including technology suppliers. It must be born in mind that knowledge transfer among the individual companies is not very much likely to happen naturally as it is not in their interest to share their comparative advantage with others.

Other potential measures to address the lack of access to knowledge are to:

- Improve education and skills on resource efficiency and green production; and
- Improve the knowledge base through research projects and the identification of knowledge gaps.

Addressing the Governance and regulatory barriers

Recommendation 9: Better definition of the term resource efficiency and the introduction of an action plan towards it

On a policy level, one important element surfaced as crucial and necessary for an effective resource efficiency action. This was the definition of “what resource efficiency actually meant”. Besides the fact that resource efficiency means “more with less” in the simplest of terms, there is a need to shift our thinking from “being” resource efficient towards “doing”. In practical terms this means the translation of the concept into an actionable plan with specific objectives to be reached. Associated with this fact, setting objectives can only be meaningful, when there is a good understanding of the opportunities for resource efficiency across the value chain. Due to the nature of "resources" and the fact that many can be re-used endlessly, tracing the life cycle of resources is an important dimension that surfaced through this research and that needs further elaboration and understanding. Understanding this dimension will help elaborate further resource efficiencies not only in one industry level but also at cross-sectoral level.

Recommendation 10: Increasing the policy coherence across the European Commission

Coherence and clarity of the European policies was one of the priority issues identified by industries' stakeholders. Such observation implies that the EC perhaps needs to reconsider its internal work management and how different topics are tackled by specific units internally. Overlaps and common areas of work should be worked on in close collaboration among the units in order to avoid conflicting or incoherent messages to industries.

In the same line, in order to create coherence across EU policies, it is recommended that the Commission increases its level of collaboration with industries in order to be able to set up the right benchmarks and standards based on "real-life", practical perspective from the industries. As such, the establishment of a multi-actor platform for discussion regarding resource efficiency is important.

Recommendation 11: Better communication of the impact of resource efficiency policies to the public

In general terms, the European Commission works on a large number of studies and publishes research results usually on the EC website. Further dissemination of the results of resource efficiency studies and their impact on the industries performance should be given more attention.

Addressing the horizontal barriers

Recommendation 12: Separation of waste at source for a better quality waste

Through the research, there have been instances where waste separation has been inconsistent across the Member States and which contributes to the misalignment of incentives problem. There are already existing good examples emerging from Member States and that can be used and shared with others (such as the Netherlands, in Glass industry), which will definitely bring about more results. Improving waste separation at source requires substantial upgrade and improvement of infrastructure where these are not fit for purpose.

On trading of recovered material and export outside the EU, see Recommendation 1 under Reform of current waste legislation).

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6 Annex A: Report on the “Resource Efficiency and Competitiveness” Workshop 14-02-2011

1. Welcome and Introduction

The Workshop was attended by some 120 participants from different industry sectors, Member States, Commission departments, academia and NGOs.

The opening started with some introductory words from Mr. Didier Herbert, Head of Unit of the Directorate General for Enterprise and Industry of the European Commission. In particular he asked stakeholders what *actions* should the Commission prioritise and how *investments* in resource efficiency (RE) could be incentivised.

Following this, Mr Stefan Moser, Deputy Head of Unit at the Secretariat General of the Commission presented the recent Commission Communication “A resource-efficient Europe – Flagship initiative of the Europe 2020 Strategy”. He underlined the need for urgent and co-ordinated action on Resource Efficiency. Life cycle data was deemed essential in the analysis. Finding the right indicators for resource efficiency was also crucial. He also informed participants that the Commission is working on four key initiatives linked to resource efficiency: The low-carbon economy 2050 roadmap (due in March); the White Paper on the future of transport (due in March); the Energy Roadmap 2050 (due in the autumn) and the Roadmap for a resource-efficient Europe (due in the summer). The European Semester in 2012 would deal with Resource Efficiency within the EU 2020 strategy.

2. Presentation of the study on Resource efficiency and Competitiveness

Mr. K. Rademaekers (Ecorys), Mr. J Berg (Ecorys), Ms. S. Zaki (Ecorys)

The study authors presented the findings of the study.

Several industry associations commented constructively on the report. In general, the situation of their sectors was well described, but made comments on aspects that had been missed out or issues that had not been well understood.

Some stakeholders pointed out that more attention should be paid to the supply chain and value chain. A lot of potential for resource efficiency may be found in the interaction among companies rather than within them. It was also pointed out that there are various barriers to recycling. Product design was also mentioned as key. The importance of speculation and volatility of prices was emphasized as something the study should refer to. Lack of skills was also mentioned as a barrier. Stakeholders underlined the importance of keeping costs of measures down, having in mind international competitiveness.

3. Best practice in Resource Efficiency: case studies from industry. What are industry sectors doing to help themselves become more resource efficient?

There are many examples of businesses investing to become resource efficient. Some companies illustrated why they decided to invest, what they did, the benefits and problems they faced. Below we summarise some main issues that emerged. For more details please see relevant presentations on the DG ENTR Workshop webpage:
http://ec.europa.eu/enterprise/policies/sustainable-business/sustainable-industry/sustainable-industry-forum/index_en.htm

Best practice in Resource Efficiency: Case Studies of achievements from Industry	
Saint-Gobain – Mr. R. Quirijns	Successfully closed the loop for gypsum; from mining to recycling. The company received a silver award for cradle to cradle approach in construction products. Having access to clean waste of good quality and non-toxic is an issue. Separating carefully at the source can help. For instance, regulation could require that when buildings are demolished waste streams are separated (crucial for effective urban mining). In order to support cradle to cradle approach, products need to be designed for end of life to avoid waste: cradle to cradle certificates can be useful to encourage this. Achieving efficiency savings in housing requires a focus on renovating existing buildings. Life Cycle Analysis is a good tool when designing for future feasible recycling. There are still issues of data availability and different methodologies applied. As a result, cradle to cradle Environmental Product Declarations can be penalized.
Solvay – Mr. M. Bande	The company wanted to build a more sustainable business portfolio, and was aware of the key role the chemicals sector can play in finding new products to solve future sustainability challenges. The volatility of prices and the lack of stability in regulation create uncertainties, such as e.g. the case of electricity contracts, where firms can not sign long term agreements. This is a barrier to companies making long term investment decisions. Waste regulation can act as a barrier to recycling. For instance, due to waste classification, it is hard to transport used PVC. In this regard, the Commission can help by changing waste classification so that waste can be viewed as a raw material, in some cases, and by creating a more predictable business environment. Encouraging better collaboration between companies in the supply chain can also play a valuable role; open collaboration and open platforms can help companies work together for a better general outcome.
Norsk Hydro – Mr. R. Scharf-Bergmann	In 2005 the company set itself the aim of reducing the impact of their resource use with a target of quadrupling recycling over next decade. However, a key issue is the exportation of aluminium waste – 10 twh worth were exported in 2009. Aluminium is a global commodity, and recyclers are exposed to additional costs in Europe. There is no possibility for passing costs through since the international price is set at the London Metal Exchange. For this reason, additional costs have to be absorbed by producers making them less profitable and therefore less competitive in the international market. 75% aluminium ever produced is still in use: urban mining is a reality for aluminium. However, recycling requires the highest quality aluminium. Technology can offer good solutions for sorting aluminium from other materials, but at a higher cost than hand sorting. However, it is important to remember that recycling involves a whole value chain (collection, preparation, re-melting and casting). In order to maximise recycling, industrialists and legislators need to work together: education and legislation have an important role to play. Better co-ordination by legislators can then mean that industry invests to maximise the use of recycled material in the value chain.
Discussion	Attendees discussed recycling, suggesting that collection is the key step to maximise in the recycling value chain. In order to maximise recycling, industrialists and legislators need to work together: education and legislation have an important role to play. Better co-ordination by legislators would induce industry to invest in order to maximise the use of recycled material in the value chain. There was also a wider discussion about the role that recycling plays in achieving greater resource efficiency: there is a need to think about the best use of resources in the widest sense, and only promote recycling where it makes sense from an environmental lifecycle point of view. Attendees also recognised the key role that expert companies can play in offering solutions, for example the Chemicals sector is in a strong position to work with its customers to find solutions.

4. Opportunities for maintaining competitiveness whilst increasing resource efficiency

This session focused on how the enabling industries can help other industry sectors to achieve greater resource efficiency, whilst enhancing their own competitiveness. Examples of what they can offer include better waste management, recycling collection, renewable energy supply and resource efficient solutions. On the next page we summarise some main issues that emerged. For more details please see relevant presentations on the above mentioned DG ENTR Workshop webpage.

Discussion: opportunities for maintaining competitiveness whilst increasing resource efficiency	
CMI Thermline – Mr. M. Boyer	From 2006, the revamping of many furnaces in Europe integrated energy savings and lower emissions as parameters in economic evaluation. Other motivations were increased product quality, flexibility and productivity. There is still scope for energy savings/ emissions lowering through existing technology. However, if the use of BAT is imposed by EU legislation for environmental reasons, this could jeopardise the competitiveness of EU industries, as the payback in energy saving can be too long for producers. Some third countries are better at implementing BAT due the existence of subsidies to state-owned companies. Industry needs financial support to demonstrate and implement customised solutions whilst keeping global competiveness. Positive actions that legislators can take include acknowledging the role of multiple actors, seeking coherency; promoting industrial co-operation (particularly in R&D); supporting ISO standards, using the integrated pollution prevention and control directive; disseminating best practices and anticipating key levers e.g. regulatory reporting. The Eco-design Directive or a components approach may not be a good option due to heterogeneity of products and long deadlines before they have an impact.
Deutsche Telekom – Mr. H-G. Peters	Showed that the ICT industry is enabling other industries to reduce carbon emissions. Their Smart 2020 study looked at Smart logistics, motors, buildings, grid, and dematerialisation (e.g. downloading music). Smart ICT use can directly reduce carbon emissions in 2020 by 13Mt CO_2e tonnes, and indirectly 194Mt CO_2e tonnes: total 207Mt CO_2e, against a national reduction target of 97Mt CO_2e. However, a realistic expectation of how much consumers would use ICT to reduce carbon emissions by 2020 is about 64Mt CO_2e, leaving a gap of 130Mt CO_2e. This gap is caused by social, economic, legal and technical barriers such as information gaps, technical standards, data protection concerns and lack of wide public acceptance. Information campaigns can help to address this, especially those focussed on the consumer-end, along with public financial support for early markets. Levies and legal requirements to enforce environmentally conscious behaviour can also support this shift: for example, in order to mobilise the sector in Germany special taxes were introduced.
Akwadok – Mr. W. Moerman	Depicted that phosphate is crucial to living organisms and food production, but is only found in a few regions of the world. It is a limited resource (peaks at 2030-2050), and Europe is not self-sustainable in terms of food supply as it imports all its phosphate. Akwadok has created a process whereby phosphate can be extracted from wastewater. There are significant potential benefits for the sustainability of companies, along with business to business opportunities. It is an alternative to imported fertiliser, helps companies to achieve cradle to cradle sustainability and reduces transportation emissions. Landfill mining can also recover phosphate in this way. An obligation to recover phosphate could be introduced to address future phosphate shortages, particularly as a critical amount of phosphate is needed to make it economically viable. Other measures include reviewing waste legislation to give a greater focus on waste as a potential resource.
SITA Environment – Mr. F. Van Eijk	Explained that there is a need to do more with less, e.g. by making better use of products that consume less during the production phase; giving waste a second life; and reducing the amount of ultimate waste. It can be useful to implement a waste hierarchy – reduce, reuse, recycle, incinerate. EU companies recycling and waste management turnover is around €95 billion. They are also resource producers/providers as waste increasingly becomes a resource. In order to increase recycling rates, it could be useful to increase producer responsibility schemes; extend Ecodesign, internalise environmental costs, and focus on combined market drivers. Rewards and punishments need to be employed to provide incentives for recycling: recycling certificates (similar to energy certificates) can be useful, along with requiring a minimum rate of recycled product. In a volatile market waste can be very valuable as it results in less dependency on primary raw material.

Discussion: opportunities for maintaining competitiveness whilst increasing resource efficiency	
Discussion	Attendees discussed the importance of separating at source in order to increase the quality of products to be recycled. Information and education can help in this. It is anticipated that once the price of phosphate increases, waste will be used to produce phosphate. However, policy measures are required to push investment faster than the market would otherwise. There was some discussion around how fiscal incentives and recycling/green certificates could be practically implemented. It was signalled that having a single scheme for recycling would be important because different national legislations constitute a barrier for multinationals.

5. Report on the break out sessions

Four break-out sessions took place on the following aspects:

- Drivers for Resource Efficiency,
- Indicators,
- Barriers,
- Potential Policy Solutions

A summary of the discussions in each break-out session is given below.

5.1 Drivers for Resource Efficiency and measures taken

Drivers and measures taken are different for different businesses. These include *energy savings, scarce raw materials and prices, regulatory compliance, corporate image* and *cost of waste generation*.

The **market** is also a driver for Resource Efficiency as price signals are telling companies to innovate. Creating financial incentives for recycling was also mentioned as a driver that would work. Better dissemination of EU funded research/workshops was also mentioned. Product design was also seen as important.

5.2 Indicators

The **reasons** for having indicators are for *monitoring and improving costs*. In general terms, indicators show environmental performance and place a value to this performance "good or bad". Indicators will have to be different for sectors, companies, regions. The **number** of indicators needs to be suitable; enough to support decision/information, not too many to avoid loss of focus. The **issues** with indicators include data availability and comparability as well as the different methodologies used for collection, which might have implications on aggregation

It is important to prevent setting *counter-productive* general indicators e.g. targets for recycled content could be dangerous since in some cases better options include the use of alternative primary materials that cost less than recycling and have higher customer acceptance.
It was suggested to define indicators based on the strategic importance of resources, strategic dependency, environmental criticality and economic need.
The most mentioned indicators were (avoided) tons of CO_2 relative to resource factors and energy consumption.

5.3 Barriers to Resource Efficiency

The top barriers were identified under the following 3 categories; lack of clear **policy**, lack of **incentives** and lack of **information and knowledge**. Several horizontal issues were also identified. The table describes each category in more detail.

Barriers to Resource Efficiency	
Lack of clear Policy	• Lack of coherence between policy signals and too much regulation. • Predictability on policy was the main issue for big companies. • Lack of proper implementation of existing policies and legislation - red tape across Member States is preventing implementation of good legislation and functional efficiency. • There is a perception of a lack of vision ("business plan") by the European Union; National vs. EU interests - resources are managed on a national level rather than in an EU wide market (for instance for recycled materials). National interests can lead to discrimination. • Absence of a global level playing field - standards and costs are lower in third countries, but EU companies are buying and selling on global commodities markets; e.g. EU industry has to face volatile carbon prices
Lack of incentives	• Lack of financial support and drivers (tax breaks, subsidies, pricing) to create push-effect, particularly for SMEs • Recycled materials cost at least the same as raw materials. It is cheaper to export recyclable materials outside the EU than recycling them within the EU. • Reduced profitability due to limits of passing the price signal down the value chain. • Lack of consumer-side demand/information to create a pull effect.
Lack of Information and knowledge	• Lack of Life Cycle Analysis data to understand lifecycle impacts of different materials, products and applications. • Data and methodology to assess material efficiency is missing • Reliable collection and recycling data in Europe is missing – e.g. end of life statistics. • Little transparency to protect best practice technologies and free rider problem. • Knowledge gap; particularly for SMEs • There are opportunities for industry cooperation not being harnessed (e.g. CHP) • Consumption choices are influenced by short-term considerations and habits • Access to technologies and innovation can be improved
Horizontal issues	• Focus on material recovery and recycling but this is not just about increasing collection rates: quality and trade of materials are also important. • Support an EU wide market for recyclable materials • Improve material recovery rates while avoiding generalisation of recycling targets. • Improve quality management in supply chain (e.g. recyclability as a requirement in product design) • Addressing the degradation of resources outside the EU • Missing infrastructure • No 'one size fits all' approach.

5.4 Potential policy solutions to address the Barriers and incentivise investment in Resource Efficiency

There is no consensus on what policy actions should be taken. Nevertheless, the following points were mentioned:

- Need for general objectives and more self-regulation;
- No one size fits all policy possible;
- Stabilization of prices is important, as volatility of commodity prices is an important barrier to investment;
- Promotion of cross-sectoral initiatives to better understand the value chain. Some voluntary business to business initiatives are ongoing. Business to consumer initiatives would also be of value;
- Cohesion/ structural funds could contribute positively;
- Governance structures could be improved - public-private partnerships were seen as valuable.
- Support to R&D&I has high potential to deliver;
- Need to spread good practices;

- Ensuring a level playing field internationally was seen as crucial. Manufacturing is more susceptible to global differences and has a big impact on future prosperity. For instance the lack of reciprocity in trade has meant that the EU lost production in some sectors (such as Manganese). This could be addressed through trade policy (scrap leaving the EU) or State aid rules;
- Address the lack of skills;
- Valorising Waste. Rethink waste regulation and use new approaches to life cycle
- Need to better understand the dynamics playing at the level of the value chain to achieve optimal environmental policy;
- Formal and informal systems should be used to increase Resource Efficiency, including more industry responsibility;
- Access to finance and affordability of measures are seen as issues in particular for SMEs. For bigger companies, the main issue needed was predictability on policy;
- When discussing taxation, the importance of not putting an extra burden on industry was underlined.

6. How policies can incentivise companies to invest in Resource Efficiency

This session focused on discussion around the opportunities, challenges, barriers, recommendations and policy options when incentivizing companies to invest in Resource Efficiency. The discussion session also focused on the long-term vision of Resource Efficiency. Below we summarise some main issues that emerged. For more details please see relevant presentations on the DG ENTR Workshop webpage: http://ec.europa.eu/enterprise/policies/sustainable-business/sustainable-industry/sustainable-industry-forum/index_en.htm.

How policies can incentivise companies to invest in Resource Efficiency	
Resource and Energy Efficiency Partnership – Mr. de Lamberterie	The Partnership is made up of European associations and technology platforms to promote Resource Efficiency in process industries. It argues that coordinated action within process industries is necessary to achieve tangible results in the coming years. Some of the Partnership's recommendations include: creating appropriate framework conditions for R&D, deploying key technologies in the field of resource and energy efficiency, supporting a sustainable approach and demonstration projects, improving provision of and support for skills and training as well as access to finance for dissemination of existing technologies and pilot and demonstration projects, and exploiting the potential of industry in European research and innovation. Some actions are already taking place in the following fields: using waste as a resource, improving industrial synergies on a regional level, developing skills in cross-sectoral domains, disseminating existing technologies in trans-sectoral domains, co-developing new technologies for waste heat recovery, increasing societal value of materials via LCA, providing Ecodesign solutions and making use of industrial water management and ICT.
DG Environment – EC – Mr. P. Misiga	Pavel Misiga presented the latest thinking by DG Environment on the Resource Efficiency Roadmap that will be published in the summer. He focused on opportunities, challenges, barriers, actions and policy options to increase resource efficiency. Resource Efficiency policy can help to address government deficit issues and provide stimuli for innovation. Priorities include: sustaining economic sectors; economic stability; supporting fiscal reform; growth and jobs creation; driving innovation; sustained competitiveness; improve environmental resilience. Policy options should involve working with the market and have a resource life-cycle perspective. They should ensure better coherence and coordination throughout the value chain and creating positive incentives.

How policies can incentivise companies to invest in Resource Efficiency	
Business Europe - Mr A. Affre	Business Europe supports the need to move towards more sustainable use of resources and a resource-efficient EU economy. Priority areas are security of supply; access to raw materials, affordable materials. There are opportunities behind developing new innovative products to reduce resource use. There is also scope in improving production processes and the use phase and increase recycling. On the other hand, a key challenge is that industry is facing constant increase in environmental legislation and complexity in its implementation such as in the ETS and waste framework directives. Successful Resource Efficiency policy needs to be designed to build on EU strengths (e.g. environmental technologies) and to reduce costs i.e. via smart policy. It is equally important to foster global competitiveness in order to reap the benefit of environmentally mindful position. There is a need for an integrated, predictable, stable and coherent policy framework: industrial, trade and environmental policy must avoid overlaps and inconsistency in legislative instruments. Policy should not be based on artificial targets. There are many success stories in innovation as for example in energy efficiency. The development of private public partnership, clusters etc. can stimulate the demand and the market for resource efficiency. It is also essential to boost the conditions for secondary material markets. Eco-design can play an important role. Green Public Procurement policy is a key incentive for innovative markets. Effective use of life-cycle analysis which integrates value chain and the interdependency between sectors is also important.
Discussion	There was discussion around how to ensure companies invested in Europe, and how to achieve a level playing field globally, as many attendees felt that price signals were already high and the Emissions Trading Scheme led to added costs and uncertainty. There were several comments from attendees around overlapping policies coming out of the Commission and lack of agreement about where to focus efforts and which tools to use. Attendees agreed that industry is ready to take on the resource efficiency challenge, but competitiveness needs to be preserved, which can only be achieved if policies are coherent. There was consensus that we need a long-term detailed vision on resource efficiency actions. DG Environment emphasised that the vision for 2050 is to provide a good life for citizens in Europe, with eco-systems supporting it. Targets can be a valuable indicator to assess whether or not objectives are being achieved. The ambition is to make coherent and stable European policy which sets long term targets with no contradictory signals to potential investors. There are still many resources that do not have prices which reflect externalities, for example water. Policy makers need to address those instances where the market gives signals to overuse resources.

7. Conclusion

There was a consensus that industry will take forward Resource Efficiency, which nearly always involves an investment decision. In order to incentivise this, it is necessary to have price signals, not just subsidies, as well as clear, stable, predictable and coherent policy signals. It is necessary to create the right incentives and the right knowledge and information for industry to become both more Resource Efficient and more competitive.

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