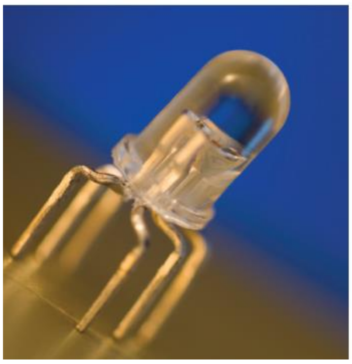


ICF INTERNATIONAL

STUDY ON ENERGY EFFICIENCY AND ENERGY SAVING POTENTIAL IN INDUSTRY AND ON POSSIBLE POLICY MECHANISMS

Contract No. ENER/C3/2012-439/S12.666002

1 December 2015

This page is intentionally blank

STUDY ON ENERGY EFFICIENCY AND ENERGY SAVING POTENTIAL IN INDUSTRY AND ON POSSIBLE POLICY MECHANISMS

Contract No. ENER/C3/2012-439/S12.666002

A report submitted by ICF Consulting Limited

Date: 1 December 2015

ICF Consulting Limited
Watling House
33 Cannon Street
London
EC4M 5SB

T +44 (0)20 3096 4800
F +44 (0)20 3368 6960

www.icfi.com

Document Control

Document Title	Study on Energy Efficiency and Energy Saving Potential in Industry and on Possible Policy Mechanisms
Contract No.	ENER/C3/2012-439/S12.666002
Prepared by	Yeen Chan, Ravi Kantamaneni
Checked by	Mark Allington
Date	1 December 2015

Contents

Abbreviations and definitions

BAU projection	A projection of energy consumption on a Business-As-Usual through to 2050
EE	Energy Efficiency
Energy end use	Manner or kind of application of energy (e.g. boilers, compressors, motors, etc.)
Energy intensity	Energy intensity is expressed as a ratio between energy consumption and production output or economic Gross Value Added of the respective sector.
Energy type	Electricity, Natural Gas, Solid Fuel, Refined Petroleum Product and Other (biomass, renewables, etc.)
EnMS	Energy Management System
ESO	Energy Saving Opportunity
ESOs	Energy Saving Opportunities.
EUROSTAT	Statistical office of the European Union
Final Energy Consumption	Total consumption of 5 energy types (electricity, natural gas, solid fuel, total petroleum products and other) for energy use
HVAC	Heating, Ventilation and Air Conditioning
kTOE	Thousand tonnes of oil equivalent
MS	EU 28 Member States
MTOE	Million tonnes of oil equivalent
NACE	nomenclature statistique des activités économiques in the European Community
Sector	Corresponds with NACE code division level (2-digit numerical code)
Sector group	An aggregated group of NACE code divisions
Solid fuel	Coal products and manufactured gas (coke oven gas, blast furnace gas, etc.)
Sub-sector	Corresponds with NACE code groups level (3-digit numerical code)
TOE	Tonnes of oil equivalent
TPP	Total Petroleum Product (gasoline, diesel, fuel oil, etc.)

Executive summary

The study evaluated eight energy intensive industrial sector groups, and four tertiary sector groups. A detailed bottom-up modelling assessment of the energy consumption trends and energy saving potential through 2050 of the eight industrial sectors was conducted. For the tertiary sectors, due to data limitations, a high-level summary of energy use profiles, energy saving opportunities, implementation barriers and policy options is presented based on literature review.

Industrial sectors

Total final energy consumption in the eight sector groups within EU28 was 272,487 kTOE in 2013. This accounts for 25% of total EU28 final energy consumption (1,103,813 kTOE)[1] in 2013. The eight industrial sector groups analysed in this study account for 98% of industrial final energy consumption (276,638 kTOE) in EU28. Table ES1.1 provides a breakdown of final energy consumed within the respective sector group.

Table ES1.1 Final energy consumption in the eight industrial sector groups

Sector group	Final energy consumption in 2013 [kTOE]	% share of total
Pulp, paper and print	34,265	12.6%
Iron and steel[2]	50,815	18.6%
Non-metallic mineral	34,249	12.6%
Chemical and pharmaceutical	51,485	18.9%
Non-ferrous metal	9,381	3.4%
Petroleum refineries	44,657	16.4%
Food and beverage	28,353	10.4%
Machinery	19,282	7.1%
Total	**272,487**	

Source: Eurostat data, accessed June 2015

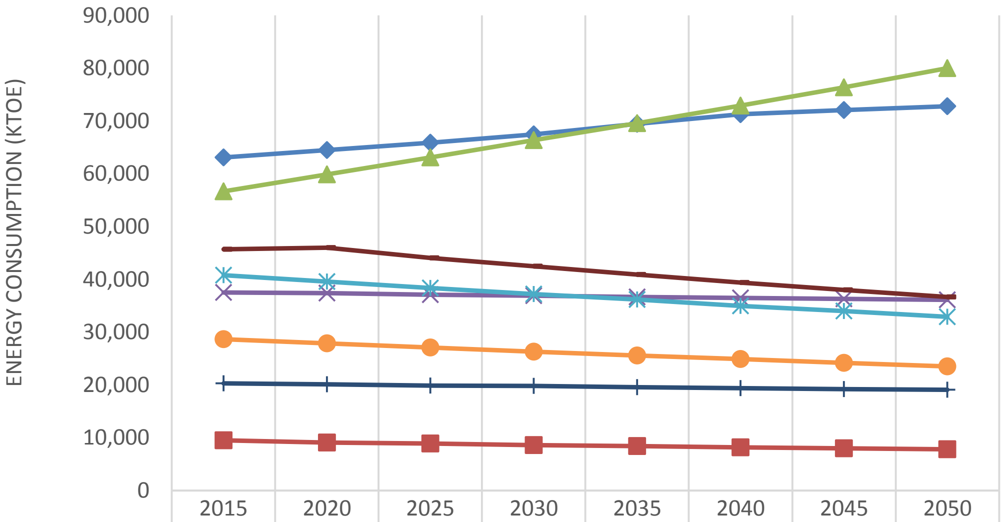
Final energy consumption is projected to reduce for most sector groups

Based on a literature review of economic indicators, market statistics, energy consumption trends; and business strategies, a perspective on the possible, sectoral Business-As-Usual (BAU) energy consumption trends through 2050 were created. Figure ES1.1 presents the expected energy consumption trends across the eight sector groups analysed.

[1] Eurostat data on EU28 final energy consumption in 2013, accessed June 2015

[2] Note that the EUROSTAT data presented for iron and steel sector group only covers the downstream steel making process; upstream iron making process is not reported under this figure.

Figure ES1.1 BAU projections of final energy consumption through 2050



	2015	2020	2025	2030	2035	2040	2045	2050
Iron and steel	63,100	64,500	65,900	67,500	69,500	71,300	72,100	72,800
Non ferrous metals	9,500	9,100	8,900	8,600	8,400	8,200	8,000	7,800
Chemicals	56,700	59,900	63,100	66,400	69,600	72,900	76,400	80,000
Non metallic minerals	37,500	37,400	37,100	36,900	36,700	36,500	36,300	36,100
Paper and pulp	40,800	39,600	38,400	37,200	36,200	35,000	34,000	32,900
Food, drink and tobacco	28,700	27,900	27,100	26,300	25,600	24,900	24,200	23,500
Machinery	20,300	20,100	19,900	19,800	19,600	19,400	19,200	19,100
Petroleum refineries	45,700	46,000	44,100	42,500	40,900	39,400	38,000	36,700

Through 2050, only iron and steel and the chemicals sectors are anticipated to have increasing energy consumption.

For **iron and steel** (Section 3.2.6), production is assumed to increase, as it is assumed that EU steel makers will remain competitive in terms of overall costs and quality, through a continuous process of investments and restructuring, despite increases in energy prices and raw materials, labour and regulatory costs. As such, the production of steel is projected to increase through 2050. Based on the limitations of emerging energy efficient technologies in steelmaking, energy intensity for the sector is expected to improve only marginally up to 2030, resulting an increase in energy consumption from 2011 – 2030; after which the commercialization of breakthrough technologies between 2030 and 2040, improvement in energy intensity trends is expected to 'flatten' the energy consumption trend for the sector with increasing production trends.

EU production in the **chemicals and pharmaceuticals** (Section 3.4.5) sector is assumed to increase through 2050 to meet anticipated global demand for products. In 2050, sales are projected to be nearly 60% greater than 2010 levels. The sector has continuously improved its energy intensity trend considering its historic trend since 1990. However, the rate of energy intensity improvement has significantly slowed down since year 2000, reflecting a limited further improvement potential. As a result, the sector's energy consumption is expected to increase in line with the projected increase in production.

For the other sectors, declines are a result of either declining production and/or improvement in energy intensity. The following provides an overview of the key assumptions.

Pulp and paper (Section 3.1.6): The study projected a gradual increase in pulp, paper and paperboard production through 2050 assumed to be driven by the continual EU innovation delivering higher value products (not necessarily in high volume) and continued growing demands for consumer goods packaging (offsetting declines in print demand). Although energy- and raw materials–intensive, the sector has a good track record in improvement of its energy intensity. This improvement trend is expected to continue as growing number of integrated mills will further improve the sector's energy intensity. As such, the energy consumption is projected to decrease despite a gradual increase in production rates.

Non-metallic minerals (Section 3.3.6): Overall, production in non-metallic minerals sector is projected to remain relatively flat (with slight declined) through 2050; slight declines in lime and ceramics will be offset by stable production in cement and glass. The sector is defined by high capital costs, with long term investment cycles (e.g., kilns have 40 year lifetimes). Consequently, once an investment is made the ability to upgrade and improve energy efficiency is limited. Overall energy intensity for the sector is anticipated to remain flat until 2030 and a marginal improvement through 2050, resulting in a gradual decline in energy consumption trend.

Non-ferrous metals (Section 3.5.5): Production is expected to stagnate with no new EU investment in production capacity and the corresponding expansion of production capacity outside the EU. Although the EU has some of the most efficient aluminium and copper production in the world, the core technology has not gone through any drastic improvement in energy intensity. However, recycling recovery rates within the EU are amongst the highest in the world. As such, the study projects energy intensity to improve marginally at historical rates as the EU continues its strong trend in production of secondary metal through improved waste management schemes in recycling and recovering useful scrap metal. As such, the energy consumption for the sector is expected to remain rather flat (with a slight decline) through 2050.

Petroleum refineries (Section 3.6.5): Overall, production in the petroleum refineries sector is assumed to decline by 23% through 2050. This is a combination of a net decline in coke production, due to an increase in cheap imports, and a reduction in EU plant refinery capacity due to changing product profile, and increasing overseas imports. Between 1992 and 2010, EU refiners have increased energy efficiency by 10%; "low hanging fruits" opportunities have been addressed. However, the energy intensity is anticipated to increase slightly through 2030, as more energy-intensive processing is required to satisfy the increasing demand for lighter and lower sulphur products. This trend is assumed to continue through 2050. In the coking subsector, energy intensity is assumed to remain stable through 2050; however, considering it only accounts for 8% of energy consumption, its impact on the overall trend is negligible.

Food, drink and tobacco (Section 3.7.6): The food and beverage industry is traditionally strong in the EU and has a dominant position in the world market. Consumer demand is expected to grow through 2050 on par with EU's long term economical trend. European companies are technological advanced and at the forefront of product innovation, resulting in continuous improved productivity and high standards for food safety and quality. It is expected that the sector will continue its strong energy intensity improvement trend through 2050, resulting in a declining energy consumption even as production continues to grow.

Machinery (Section 3.8.5): Compared to other manufacturing sectors, the machinery sector is less energy intensive. The sector requires constant change in its production process to respond to evolving consumer demands and technological trends. Consequently, energy consumption is linked to the manufacturing demands of the product specifications. It is assumed that the sector will continue with its strong reduction trend in energy intensity in the longer term, resulting in a relatively flat energy consumption trend as production continues to increase.

Process heating remains the most significant energy use

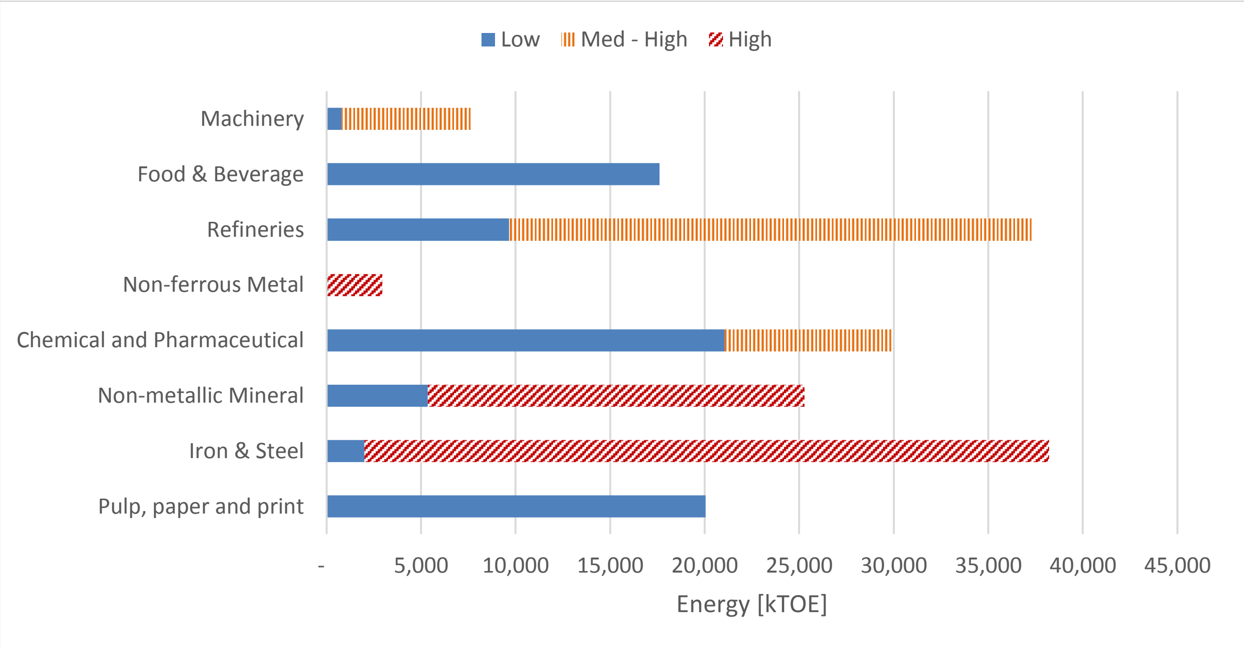
Table ES1.2 provides an estimated breakdown of final energy consumption according to process heating, process cooling and electrical energy use for the respective sector group. Process heating remains the most significant energy use, accounting for approximately 179,000 kTOE (~66% of of total final energy consumption) followed by electrical use, accounting for approximately 70,000 kTOE (~26% of total final energy consumption) for the eight sector groups studied.

Table ES1.2 Estimation of sector group energy consumption breakdown[3]

Sector group	Final energy consumption in 2013 [kTOE]	% energy for process heating [%]	% energy for process cooling [%]	% energy for electrical [%]
Pulp, paper and print	34,265	59%	0.3%	31%
Iron and steel	50,815	75%	0.4%	19%
Non-metallic mineral	34,249	74%	0.2%	17%
Chemical and pharmaceutical	51,485	58%	0.6%	30%
Non-ferrous metal	9,381	32%	-	57%
Petroleum refineries	44,657	84%	0.6%	7%
Food and beverage	28,353	62%	10.0%	34%
Machinery	19,282	40%	1.0%	53%
Total	**272,487**	**66%**	**1%**	**26%**

Although there are no formal temperature bands for differentiation of thermal processes, they can generally be categorised into low (<250°C), medium (250 - 600°C) and high (>600°C). Figure ES1.1 provides an estimated[4] thermal energy consumption categorised according to this heat temperature range. The thermal processes for Machinery, Refineries and Chemical & Pharmaceutical sector groups are presented in a mixture of med – high temperature band (i.e. this band includes all process heat >250°C) as the thermal processes within these sector groups are much more diverse.

Figure ES1.1 Estimation of process heat temperature range



[3] Process heat excludes electrical heating and HVAC. Electrical energy includes electrical heating and HVAC use. Process cooling includes cooling towers, chillers and refrigeration but excludes HVAC use.

[4] Estimates are based on the energy use profile of a typical facility within the sector group.

There are a good range of economically viable Energy Saving Opportunities (ESOs)

The study evaluated over 230 Energy Saving Opportunities (ESOs) and screened each ESO for economic viability based on a simple payback approach. The simple payback approach was applied for economic screening, as it is still a widely utilized metric and easily comparable as it is not subjected the tie-ins with associated discount rates, which differs widely among industries and Member States. The study projected 2 output scenarios *Economic Potential Scenario 1 (high hurdle rate)* projects the energy consumption trend assuming the sector will implement applicable ESOs that satisfy a 2-year simple payback criteria, based on a predefined uptake rate and trend. The study has selected a 2-year simple payback criteria as it represents a closer perspective of what industry might consider to be economically feasible. *Economic Potential Scenario 2 (low hurdle rate)* projects the energy consumption trend assuming the sector will implement applicable ESOs that satisfy a 5-year simple payback criteria, based on a predefined uptake rate and trend. This provides an alternative projection assuming enterprise employs a lower hurdle rate in their criteria for uptake of ESOs. The study selected 5-year payback for the lower hurdle rate scenario as ESOs under this criteria are often shortlisted but not implemented. Table ES1.3 presents the energy saving potential for each scenario analysed in the study. The *Technical Potential Scenario* illustrates the maximum energy saving potential which is technically feasible, regardless of the economic constraints on implementing these opportunities.

Table ES1.3 Economic and technical saving potential of industrial final energy consumption

Sector		BAU energy consumption (MTOE/yr)	Economic potential – 1 (MTOE)	Economic potential – 2 (MTOE)	Technical potential (MTOE)
Pulp and paper	2030	37.3	1.1 (2.9%)	1.4 (3.8%)	7.2 (19%)
	2050	32.9	1.9 (5.8%)	2.3 (7.1%)	5.5 (17%)
Iron and steel	2030	67.5	2.9 (4.3%)	3.1 (4.6%	16.3 (24%)
	2050	72.8	6.2 (8.6%)	6.8 (9.4%)	18.9 (26%)
Non-metallic mineral	2030	36.9	1.2 (3.3%)	1.3 (3.6%)	7.1 (19%)
	2050	36.1	2.4 (6.6%)	2.6 (7.2%)	6.3 (18%)
Chemical and pharmaceutical	2030	66.4	2.6 (4%)	3.2 (4.9%)	16.5 (25%)
	2050	80.1	6.4 (7.9%)	7.4 (9.3%)	17.8 (22%)
Non-ferrous metal	2030	8.6	0.5 (5.5%)	0.5 (5.8%)	1.9 (22%)
	2050	7.8	0.9 (12%)	1.0 (12.7%)	1.6 (21%)
Petroleum refineries	2030	42.5	1.7 (4.0%)	1.9 (4.5%)	10.6 (25%)
	2050	36.7	3.1 (8.5%)	3.5 (9.5%)	8.3 (8.3%)
Food and beverage	2030	26.4	1.4 (5.2%)	1.7 (6.5%)	6.8 (26%)
	2050	23.5	2.4 (10.1%)	3.2 (13.5%)	5.7 (24%)
Machinery	2030	19.8	1.0 (5.2%)	1.3 (6.5%)	5.3 (27%)
	2050	19.0	2.0 (10.5%)	2.5 (13.3%)	4.8 (25%)

Figure ES1.1 Combined sector projections through 2050

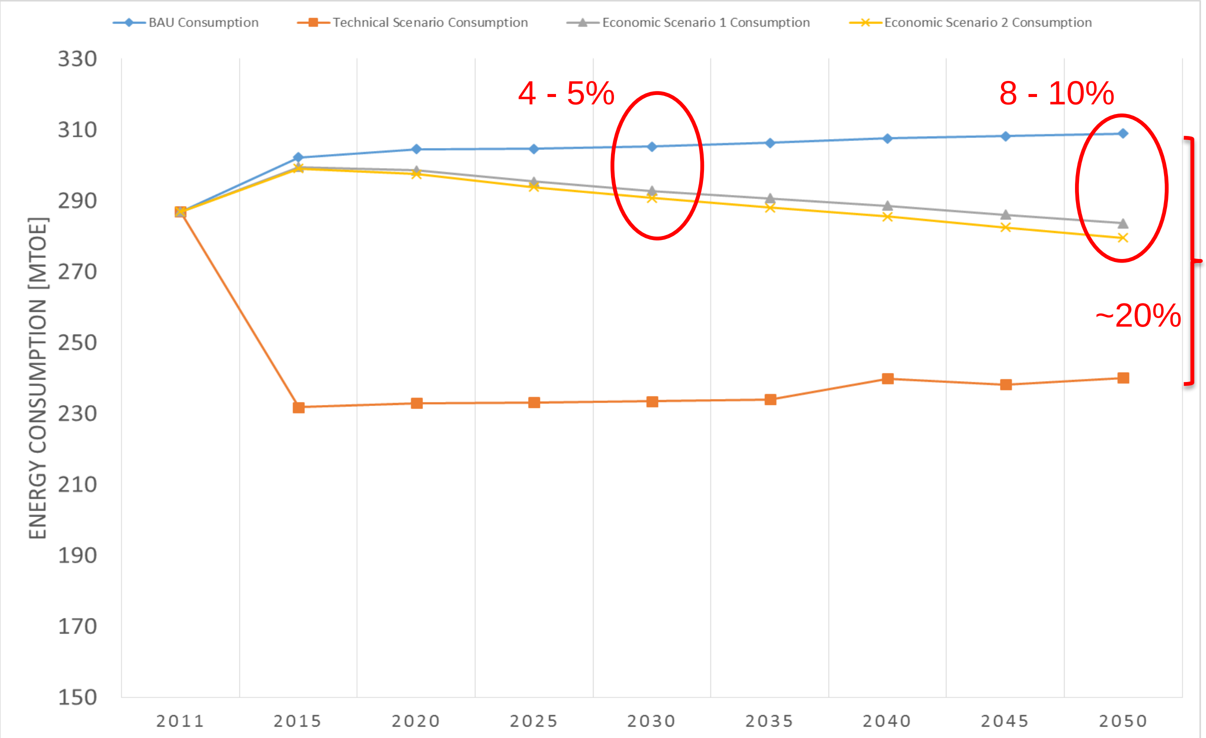


Figure ES1.1 illustrates the study's output projection of the 2 economical potential scenarios; and the technical potential scenario; with reference to BAU scenario for the eight industrial sectors assessed. The average potential reduction of final energy consumption for economic scenario 1 in 2030 and 2050 was 4.3 and 8.8%, respectively. For economic scenario 2, the average reduction potential in 2030 and 2050 was 5% and 10.3%, respectively. The projections reflect a good range of economically viable solutions which is still available to the industrial sectors assessed. For each of the economically viable ESO accounted for within the economic scenarios, an uptake trend is applied to reflect a realistic implementation rate of such ESOs as there are still persisting barriers preventing its immediate and widespread uptake despite it being economically viable, resulting in a gradual decrease in energy consumption for the economic scenarios through 2050. The technical scenario illustrates the energy reduction potential on an immediate basis if all technically feasible ESOs are implemented, regardless of its economic viability, resulting in a steep indicative drop in energy consumption for this scenario.

Table ES1.4 provides a summary of the top economical ESOs satisfying the 2 and 5 year simple payback criteria along with its projected energy saving impact across the sector groups in this study. As these ESOs has varying levels of energy saving potential, the study takes into consideration how each ESO is applied to the industrial sectors to generate the average output projections.

Table ES1.4 Summary of top economic Energy Saving Opportunities across the sector groups

Energy Saving Opportunity	Total energy saving potential by 2030 [%]
ESOs with <2 year simple payback:	
Integrated control system	17.3%
Sub-Metering and Interval Metering	13.8%
Flue gas monitoring (Furnace and boiler)	8.3%
High Efficiency Burner (Furnace)	8.1%

Energy Saving Opportunity	Total energy saving potential by 2030 [%]
Exhaust Gas Heat Recovery (Furnace and kiln)	5.0%
Implementation of Energy Management Systems (EnMS)	4.9%
Advanced Heating and Process Control (Furnace)	4.6%
Combustion Optimization (Furnace)	3.8%
Steam trap survey and repair	1.9%
Preventative Furnace Maintenance	1.6%
ESOs with 2 - 5 year simple payback:	
Premium efficiency controls with automatic speed drives (pumps, fans and other motors)	5.7%
High efficiency non-packaged HVAC equipment	1.3%
Advanced boiler control	0.9%
Process heat recovery to preheat make up water	0.9%
Optimization of pumping system	0.6%
Use of radiant heat instead of convection heating	0.3%
Sequencing control	0.2%
Variable Speed Drive for chiller compressor	0.1%

Significant innovation is required on current and emerging technologies to realise further industrial energy reduction potential

Approximately 100 ESOs evaluated within the study are sector specific and most of which are considered to be economically unviable. The average industrial energy saving technical potential is approximately 20 – 23% of final energy consumption, as presented in Figure ES1.1. This potential is based upon an immediate application of current ESOs available to the respective sector groups which are technically feasible, regardless of its economic viability. This reflects a 10 – 15% higher reduction potential than the economic potential scenarios. As such, significant effort is required to support further improvements in commercialising current available technologies to realize these additional energy saving potential. This also signals the need for further innovation and R&D support on emerging technologies to realise higher industrial energy reduction potential.

Market competitiveness remains the strongest driver for energy efficiency solutions

Historically these industrial sector groups have been improving its energy intensity over a long period of time which is primarily driven by overall market conditions, growth and competitiveness. Despite the disruption in the EU financial crisis, most sectors have recorded increasing growth trends, apart from petroleum refineries and non-metallic mineral sector group. The historic energy intensity trends for the respective sectors are summarised in Table ES1.5.

Table ES1.5 Summary of energy intensity trends

Sector Group	Energy intensity trend
Pulp, paper and print	Steadily reducing since 1991.
Iron and steel	Drastic improvements between 1970 – 1980 due to the switch to BF-BOF [5]and Electric Arc Furnace production route, replacing the less efficient open-hearth production route.
Non-metallic mineral	Minimal improvements observed.
Chemical and pharmaceutical	Reduced by approximately 4% per year between 1990 and 2000, but between 2000 and 2010 the rate has dropped to approximately 1% per year.
Non-ferrous metal	Gradual reductions since 1990 attributed to higher aluminium recycling rates.
Petroleum refineries	Gradual improvements despite a decline in market growth
Food and beverage	Gradual improvements observed over the period of 1995 – 2012
Machinery	(inconclusive due to data limitation)

Internal barriers to uptake of Energy Saving Opportunities are not well understood

The subject of barriers to energy efficiency and energy saving opportunities too often focus on a perspective external to the enterprise. This creates a situation where internal and external perspectives diverge. There are insufficient attention paid to the internal perspective, which consists of many under evaluated behavioural elements, which can lead to irrational choices from an external perspective. Table ES1.6 provides a taxonomy of barriers to energy efficiency and ESOs categorised according to an internal and external perspective.

Table ES1.6 Taxonomy of barriers to Energy Efficiency and Energy Saving Opportunities

Origin	Area	Barriers
External	Market	Energy price distortion
		Low diffusion of technologies
		Low diffusion of information
		Market risks
		Difficulty in gathering external skills
	Government / Politics	Lack of proper regulation
		Distortion in fiscal policies
	Technology / Services suppliers	Lack of interest in energy efficiency
		Technology suppliers not updated
		Scarce communication skills
	Designers and manufacturers	Technical characteristics not adequate
		High initial costs
	Energy suppliers	Scarce communication skills
		Distortion in energy policies

[5] BF: Blast Furnace BOF: Basic Oxygen Furnace

Origin	Area	Barriers
		Lack of interest in energy efficiency
	Capital suppliers	Cost for investing capital availability
		Difficulty in identifying the quality of the investments
Internal	Economic	Low capital availability
		Hidden costs
		Intervention related risks
	Organisational behaviour	Lack of interest in energy efficiency
		Other priorities
		Inertia
		Imperfect evaluation criteria
		Lack of sharing the objectives
		Low status of energy efficiency
		Divergent interests
		Complex decision chain
		Lack of time
		Lack of internal control
	Barriers relating to competences	Identifying the inefficiencies
		Implementing the interventions
	Awareness	Lack of awareness or ignorance

Source: Cagno et al, 2012

Recommended intervention measures

By overlaying the energy saving potentials with the associated economic, organisational and technical barriers, against the current EU energy efficiency policy framework (e.g., Energy Efficiency Directive), the study recommends the following potential intervening measures that could address these barriers and further encourage ESO uptake:

1. Mandatory implementation of Energy Management Systems (EnMS) for large energy intensive enterprises.
2. Mandatory sub-metering requirement for significant energy consuming equipment.
3. Promote the need for energy managers within large energy intensive companies.
4. Facilitate development of insurance products for energy savings guarantee
5. Promote and facilitate further potential for resource sharing among industrial clusters.

Tertiary sectors

Retail and wholesale trade buildings are the largest consumers of energy among non-residential buildings in Europe. Retail and wholesale trade accounted for 28% of total energy consumption in the non-residential building sector, which amounted to approximately 19 Mtoe in 2012. It accounts for approximately 11% of the EU's GDP.[6] Due to limited published data on energy consumption projections, estimates have been developed based on the historic information, and inferences from

[6] http://ec.europa.eu/growth/single-market/services/retail/index_en.htm

market trends. For example, a recent report noted that by 2020, growth of ecommerce will have a significant impact on retail stores. Specifically, the growth of ecommerce will result in town and shopping centre store sales declining by 27%. This will result in 21% less retail space and 31% fewer stores in town centre venues.[7] As such, it is assumed that absolute energy consumption will also decline by 21% by 2020 from 2010 levels (i.e., approximately 2.5% per year) due to both energy efficiency improvements and declining retail space. Furthermore, it is assumed that this will be followed by a continuing, but a slower rate of decline through 2050 of 1% per year, 2030 and 2050 energy consumption for the sector is assumed to be 14 Mtoe, and 11.5 Mtoe respectively. There are many economic benefits associated with a reduction in energy consumption particularly in the retail sector. The biggest energy savings in the retail sector can be made in lighting, heating, ventilation, and air conditioning.

Accommodation and food service activities accounted for 11% of total energy consumption in the non-residential building sector in 2012, amounting to approximately 10.5 Mtoe. In 2000, energy consumption in European hotels was estimated to be 39 TWh (terawatt hours) or 3.4 Mtoe. Assuming current sector trend of energy consumption reduction (~2% per year reduction between 2005 and 2012) continues through 2020, after which it decreases at a slower rate of 1% per year through 2050, coupled with an anticipated decline in EU population, it is projected that sector energy consumption could be on the order of 8 Mtoe and 7 Mtoe in 2030 and 2050, respectively. There is a high amount of energy waste within the accommodation sector, attributed to guest behaviour, which presents significant further opportunity for energy reduction potential. Based on industry benchmarks, a reduction in energy consumption by 10-15% should be achievable using available technology. This equates to reductions on the order of 1 Mtoe in 2030 and 2050. Commercial kitchens not equipped with energy-efficient equipment: Evidence has showed that equipment used in commercial kitchens is only 50% efficient. Thus more energy-efficient equipment could result in significant energy savings.

Information and communications equipment is estimated to consume approximately 14.7 Mtoe of energy in 2012. Studies have estimated that European data centre service market will see a growth of 16% up to 2018 from 2012 levels (i.e., 2.5% per year), due to the growth in enterprise cloud computing, content-heavy applications, and machine-to-machine (M2M) connectivity. It is also estimated that the UK, Germany and France will be the largest data centre markets in Europe. Besides economic growth, the sector also benefits from high levels of technological improvement rates. There are also growing global trend towards green data centres which sees energy performance of the sector steadily improving over time. The average Power Usage Effectiveness (PUE) has improved from 2.50 in 2007 to 1.89 in 2011. In 2014, the PUE has further improved to 1.7, reflecting the fact that the biggest infrastructure efficiency gains have already happened, and further improvements will require significant investment and effort, with increasingly diminishing returns. As such, the improvement rate will taper down through 2050. In consideration of the sector growth and PUE improvement trend, it is projected that the sector will consume approximately 788 PJ (18.8Mtoe) and 1,226 PJ (29.3 Mtoe) of energy in 2030 and 2050 respectively.

Financial and insurance activities. Office buildings are the second largest consumers of energy among non-residential buildings in Europe. Office buildings accounted for 23% of total energy consumption in the non-residential building sector, which amounted to approximately 19 Mtoe in 2013.[8] The study has estimated the energy consumption of this sector based on an assumption of the number of employees employed within the sector and the associated office space required. Thus, of the total energy consumed in offices, it is assumed that financial and insurance activities consume approximately 1.4 Mtoe in 2012. The majority of energy consumption and energy efficiency opportunities occur in heating and lighting.

[7] Javelin Group press release, 31% fewer town centre stores by 2020, says Javelin Group report, October 2011

[8] Survey on the energy needs and architectural features of the EU building stock, iNSPiRe, May 2014. http://www.inspirefp7.eu/wp-content/uploads/2014/08/WP2_D2.1a_20140523_P18_Survey-on-the-energy-needs-and-architectural-features.pdf

1 Introduction

1.1 Context of study

The Commission has published in July 2014 a Communication (COM(2014)520) that reports on the European Union's (EU) progress towards achieving the 20% energy saving target by 2020. Based on the Commission's analysis of Member State action plans, it is forecasted that the EU will only achieve an energy saving of 18-19% by 2020; falling short of the initial headline target of 20% by 20 – 40Mtoe. The Commission has highlighted that Member States should make additional efforts to achieve the original target.

In support of the additional effort required by Member States to meet EU targets, this study aims to develop potential policy measures; additional to current EU policy measures, to further drive energy saving opportunities in key energy intensive industrial sectors and tertiary sectors, which contribute significantly to the EU economy. These policy measures are specifically aimed at encouraging the uptake of both technological and non-technological (e.g. behavioural, energy management, etc.) opportunities which could enhance the untapped potential for further energy savings.

1.2 Study objectives

This study undertakes a comprehensive EU-wide assessment of the energy efficiency and energy saving potentials of key energy-intensive industrial sectors, to evaluate future trends, drivers, barriers, and opportunities, so that possible (soft or regulatory) measures can be identified, defined and assessed for their ability to drive energy efficiency uptake in industry. Additionally, the study presents a high-level overview of the energy use profile, energy saving opportunities, implementation barriers and policy options for four tertiary sectors. In view of the prevailing EU economic climate at time of writing, the study focuses solely on economically viable opportunities, which can drive energy efficiency or energy savings on their own merits based on current industry decision making and organisational practices and current energy and carbon market conditions.

1.3 Scope of the study

This study assesses the energy saving potential of industrial and selected tertiary sectors that make a key GDP contribution to the EU. The main emphasis of the study is energy intensive industries; for which the study presents a bottom-up analysis of eight industrial sectors, which contribute to more than 80% of industrial final energy consumption in the EU28 Member States (as detailed in Table 1.1). The sector groups correspond directly with the industry sector groups reported under EUROSTAT.

Table 1.1 Summary of industrial sectors covered in this Study

Sector group	NACE code	Sector group components
Iron and Steel	C24.1 – 24.3	Iron, steel, ferro-alloys, bars, pipes, tubes, wires
Non-ferrous Metal	C24.4, 24.53 and 24.54	Aluminium, lead, tin, zinc, copper, casting of metals
Chemical and Pharmaceutical	C20, C21	*Chemicals*: Basic chemicals, fertilizers and nitrogen compounds, plastic and synthetic rubber *Pharmaceutical*: Basic pharmaceutical and pharmaceutical preparations
Non-Metallic Mineral	C23	Glass, refractory, ceramic, bricks, cement, concrete, plaster, stone products

Sector group	NACE code	Sector group components
Food and Beverage	C10, C11	*Food Products*: processing and production of meat, fish/crustaceans/molluscs, fruit and vegetable, animal oil and fats, dairy, grain, bakery, animal feed, other *Beverage*: Spirits, wine, non-distilled fermented beverages, beer, malt, soft drinks
Paper, Pulp and Print	C17 and C18	Pulp, paper, paperboard, printing and reproduction of recorded media
Machinery	C25, C26, C27 and C28	*Fabricated metal products*: metal products, tanks, steam generators, metal forming, metal treatment, machining, cutlery and general hardware *Computer/electronics/optical products*: electronic components, computers and peripheral, communication equipment, consumer electronics *Electrical equipment*: motors, generators, transformers, electricity distribution, control equipment *Machinery and equipment*: engines and turbines, ovens, furnaces, burners, hand tools, ventilation and cooling equipment, special purpose machinery
Petroleum refineries	C19	Coke and refined petroleum products

For the tertiary sector, a high-level analysis was conducted. Four sectors that contribute significantly to EU GDP were identified (Table 1.2). Within the EU, the non-residential buildings stock (which includes the sectors presented in Table 1.2) accounts for 25% of the total European building stock. Buildings in the retail and wholesale space comprise 28% of the non-residential stock, while office buildings (which include financial and insurance) are the second biggest category, with 23%. The accommodation and food service sector accounts for 11% of EU non-residential building stock.[9]

Table 1.2 Key service sectors and their associated sub-sectors

	EUROSTAT Sector grouping	NACE Code	Sub-sector components
1	Wholesale and retail sale	G46-47	Wholesale and retail sale of textiles and clothing, food, beverages and tobacco, households goods
2	Information and communications	J62-63	Computer programming, data processing, data hosting and related activities
3	Financial and insurance activities	K64-65	Financial services, insurance, reinsurance and pension funds
4	Accommodation and Food service activities	I55-56	Hotels, holiday accommodation, restaurant and other food serving activities

1.4 Structure of the report

The report consists of 5 main chapters:

Chapter 2 of the report explains the methodology adopted for the study, including the modelling framework.

Chapter 3 presents the projected energy consumption (based on sector profiles presented in Annex 1) and corresponding energy saving potential for the eight sector groupings up to 2050.

[9] BPIE (2011) Europe's buildings under the microscope available at http://www.europeanclimate.org/documents/LR_%20CbC_study.pdf

The chapter is divided into eight sections detailing each sector grouping's structure and economic contribution, key products and associated processes and energy metrics

Chapter 4 presents an overview to the tertiary sectors, their energy use profiles, energy saving opportunities, implementation barriers and policy options.

Chapter 5 discusses the internal and technical barriers for uptake of potential Energy Saving Opportunities (ESOs) within enterprises of the eight sector grouping.

Chapter 6 presents the proposed policy measures in regards to the EU policy context. It presents the benefits and costs of those policies measures.

Annex 1 presents the detailed findings from the literature review, presented in 8 individual sector groupings.

Annex 2 presents a summary of energy price projection methodologies that were evaluated in this study.

Annex 3 presents the cross-sector and sector-specific energy saving opportunities evaluated in the study.

Annex 4 presents the energy saving opportunities which falls within the economic potential scenarios.

2 Methodology

2.1 Overview of methodology

As detailed in Section 1.3, the focus of this study was eight energy intensive industrial sectors. This analysis was conducted in two phases. In Phase 1, sectoral data was collected, compared, and analysed to develop an understanding of the EU28 market; specifically, each sector's business environment, strategy, decision making, energy consumption and mitigation activities, was summarised in a sector profile. The aim was to develop a business-as-usual production and energy consumption trend through 2050. This BAU trend provides the basis for modelling conducted in Phase 2 to assess sectoral ESOs and their associated energy saving potential. Based on this analysis, the potential barriers preventing the uptake of economically viable ESOs are discussed. A list of potential measures are presented to address these barriers, including an overview of their potential costs and benefits. Figure 2.1 provides a summary of the industrial sector methodology.

Figure 2.1 Overview of industrial sector methodology

Phase 1: Collection of data and development of sector profiles

Step 1.1: Data collection and comparative analysis
Step 1.2: Sector profile development
Step 1.3: Development of sector BAU energy consumption projections; fuel mix and end use profile

⇩

Phase 2: Assessment of energy saving potential

Step 2.1: Modelling framework set-up
Step 2.2: Identification of energy saving potential
Step 2.3: Barrier analysis and development of potential measures
Step 2.4: Develop potential measures to drive improvement of industrial energy performance

For the tertiary sectors, unlike the industrial sectors, due to incomplete EU-wide energy data (i.e., data for only a few Member States is available)[10], a high-level summary of energy use profiles, energy saving opportunities, implementation barriers and policy options is presented based on literature review.

The following details the approach and assumptions applied for the industrial sector analyses.

2.2 Phase 1: Collection of data and development of sector profiles

For each sector group, the following data were compiled and reviewed:

1. Key economic indicators at sector and Member State level: number of enterprises; number of persons employed; turnover; value added; personnel costs; and production value
2. Market statistics: products; historic production; trade flows (imports and exports); market developments and drivers; existing and future competitive strengths and weaknesses;

[10] Odyssee database: for most sectors, less than a half of Member States have reported energy data

3. Energy: Sector consumption trends[11]; energy intensity at the sub-sectoral and/or process-level; fuel mix; and facility level energy use
4. Policies: EU and sector/sub-sector policies; description and pertinent measures
5. Mitigation: business strategies to address resource/energy efficiency; existing and future mitigation activities

Information was sourced from EUROSTAT, Member State government reports/databases; sub-sector associations; industry reports; European Commission reports; and ICF data.

These data were used to provide:

- A perspective on the possible, sectoral Business-As-Usual (BAU) energy consumption trend from 2010 through 2050, incorporating existing EU policy.
- Fuel mix (i.e., the type and percentage of fuel used) for each sector group

These outputs, along with pertinent references to the source information, are presented in Section 3 (Projections on Energy Consumption and Energy Saving Potential for the Industrial Sector) and further detailed in Annex 1 (sector profiles).

The study utilized various statistics from various other Member States, EU-level sector associations and assumptions based on literature review to disaggregate the energy consumed by each sector. This was required as the energy consumption data presented in EUROSTAT were aggregated into sector groups, as detailed in section 1.3.

2.3 Phase 2: Assessment of energy saving potential

To project and quantify the energy saving potential at a sectoral level, in line with the study objectives, ICF's Industrial Energy Efficiency Model (IEEM) was used. IEEM is a bottom-up model for accounting energy saving potential based on a defined list of Energy Saving Opportunities (ESOs) applicable to the respective industrial sector grouping.

ICF's Industrial Energy Efficiency Database (IEED) is a comprehensive list of potential ESOs, both in terms of Technical Best Practice (TBP) and Management Best Practice (MBP), described further in section 2.3.3. Each of these ESOs are applied in IEEM to generate 2 potential scenarios as an output; the 'technical potential' scenario and the 'economic potential' scenario for each sector, described further in section 2.3.7.

Figure 2.2 provides an overview of IEEM modelling framework and Figure 2.3 provides the modelling steps for IEEM.

[11] To develop an accurate picture of historic energy consumption various data sources were reviewed and assessed.

Figure 2.2 Overview of IEEM modelling framework

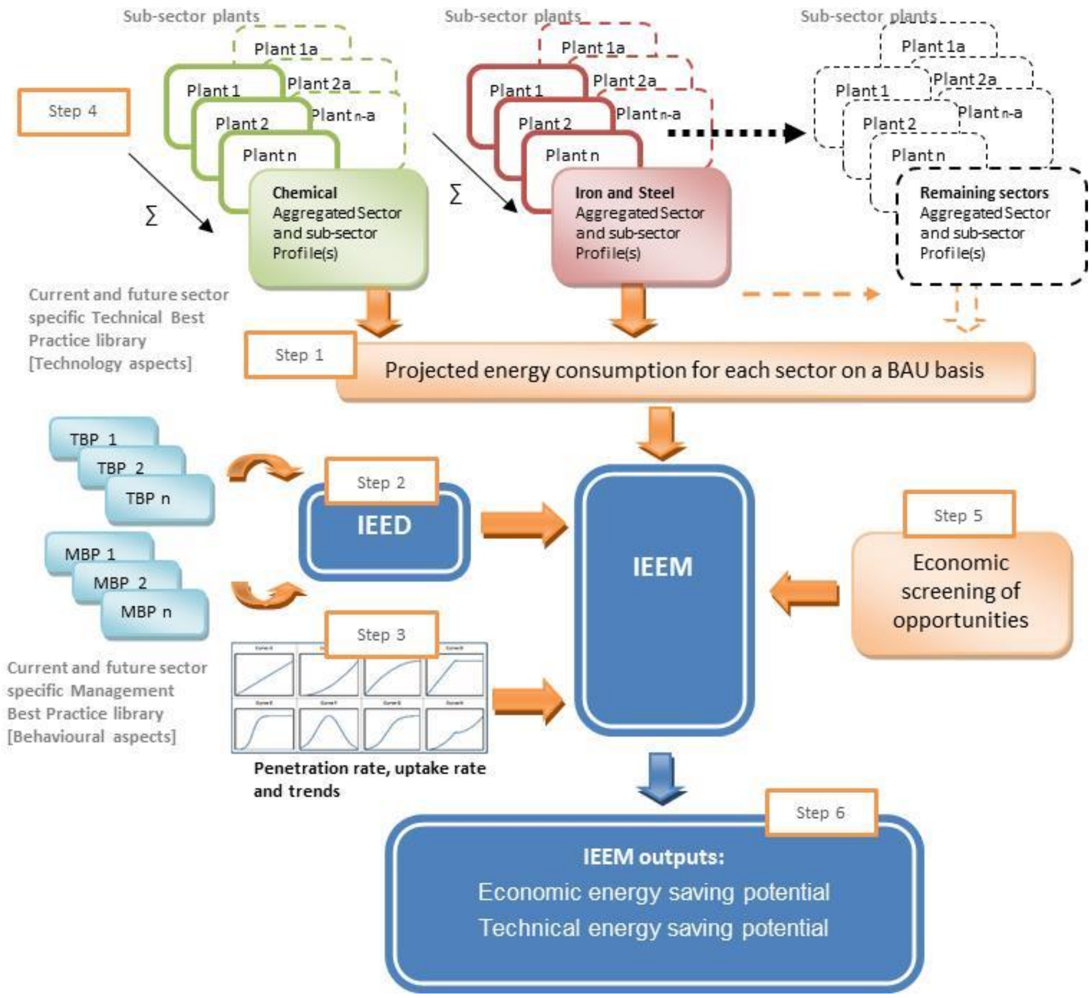
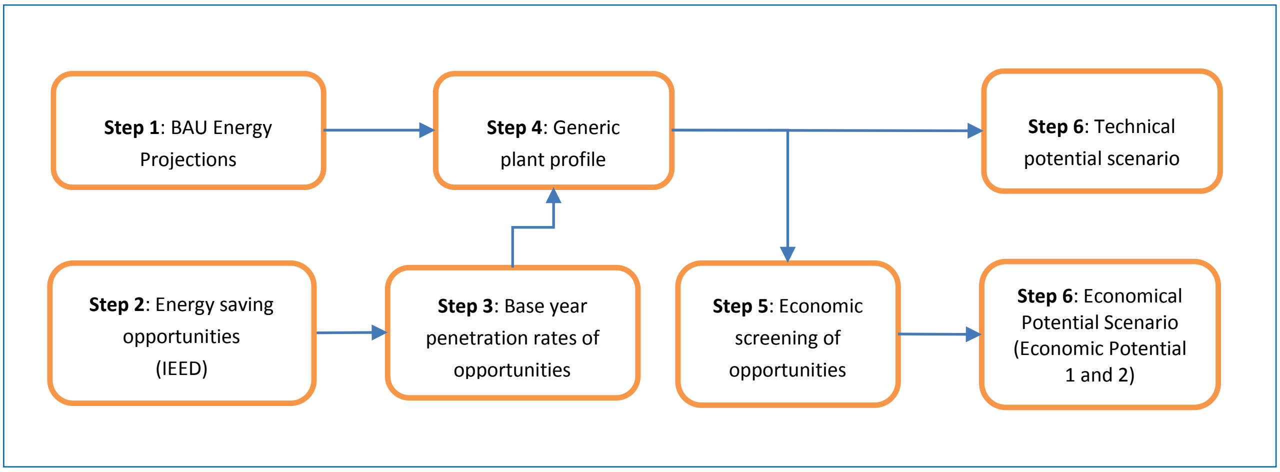


Figure 2.3 Flow diagram of IEEM modelling steps



2.3.2 Step 1: Projection of BAU energy consumption through 2050

For each industrial sector group, a BAU energy consumption was projected through 2050 in Phase 1 (hereafter referred to as 'BAU projection'). The BAU projection (as presented in

Chapter 3) is developed based on key findings from statistical data analysis and literature review (detailed in Annex 1), and accounts for current and upcoming relevant policies on energy efficiency and energy in the industrial sectors.

For each sector group, only the key individual sectors and/or subsectors, with significant economic contribution and share of energy use, are analysed. Based on the analysis of the shortlisted individual sectors, the results are then used as a representative of the BAU projection for the sector group. For example, the pulp, paper and print sector group consist of 2 individual sectors; manufacture of pulp, paper and paperboard (NACE C17) and Printing and reproduction of recorded media (NACE C18). However, the BAU projections for the pulp, paper and print sector group were only based on sector C17 as it contributes to over 70% share of turnover and over 90% share of final energy consumed with reference to the sector group.

The BAU projection is the starting point for the analysis and provides a detailed description of "where" and "how" energy is currently used in the selected sector group, including a breakdown of energy use by end use. The BAU projection is the baseline against which the energy savings are calculated.

The BAU projections for each sector group were quantified considering 2 main parameters: production growth and energy intensity trend. Each of these parameters was assessed separately to develop the projected energy consumption trend. The growth projections were market dependent (based on findings from the literature review) and based on a sector-specific assessment of historic production; trade flows; market developments and drivers; existing and future competitive strengths and weaknesses. The energy intensity trend was analysed on a sector-by-sector basis using available energy statistics and technical literature. For projections beyond 2030, consideration was given to the implementation of emerging technologies which are not yet viable in current markets. Emerging technologies are defined as being at Technology Readiness Level (TRL) 7, which equates to a prototype having been demonstrated in an operational environment.[12] This emerging technology may not be defined yet but an improvement potential rate is factored in as a 'placeholder' for such upcoming technologies.

2.3.2.1 EU Policy implications on the BAU

BAU projection includes policies, measures and legislative provisions adopted by Member States and the European Commission through May 2014. Notably, this includes the Energy Efficiency Directive (EED), EU ETS directive, Ecodesign Framework Directive, and the Industrial Emissions Directive (IED). Furthermore, sector-specific policies have been taken into account, where relevant. For example, in the Pulp and Paper sector, the European Declaration of Paper Recycling identifies measures to optimise the management of paper throughout its value chain, including a 70% recycling rate target of by 2015.

For the key EU level policies that impact energy efficiency, the following assumptions have been applied to the BAU projections:

EED	Articles 7 (MS energy saving targets), 8 (mandatory energy audits), 14 (supply efficiency), 18 (ESCO), and 20 (financing) are directly relevant to the industrial sectors. Although, some of these measures have not been implemented by Member States, or are non-binding, it is assumed that they will play a positive role through incremental energy efficiency improvements over time.
EU ETS	A review of available evidence of the effectiveness of the EU ETS to drive industrial abatement by the UK Government indicated that while some impact can be derived in the first Phase, Phase II results are mixed.[13] In particular, they note that specific results

[12] Technology readiness levels (TRL), HORIZON 2020 – WORK PROGRAMME 2014-2015 General Annexes, Extract from Part 19 - Commission Decision C(2014)4995.

[13] *An evidence review of the EU ETS, focusing on effectiveness of the system in driving industrial abatement*; UK Department of Climate Change; 2012

	for industrial sectors are scarce and difficult to generalise. For example, surveys of pulp and paper manufacturers in Germany, Sweden and Norway noted that market factors were a greater impetus for investments, compared to the EU ETS.[14],[15] Specifically, rising electricity prices were seen as a stronger influence from the EU ETS, and were a driving force for energy efficiency. Consequently, it is assumed that EU ETS impacts are reflected in energy price projections rather than direct investments in the BAU.
Ecodesign	The primary Ecodesign implementing regulations impacting most industrial sectors are power transformers; electric motors; furnaces; compressors; steam boilers, and industrial fans. The BAU assumes that energy efficient products are installed as stock is replaced over time, leading to higher market penetrations of energy efficient equipment.
IED	Since all energy intensive industrial sectors are impacted by the need to meet permit conditions, including Emission Limit Values (ELVs), as defined in 'BAT Conclusions', it is assumed that there will be some related improvement in energy efficiency as higher market penetrations of best available technologies occur.

2.3.3 Step 2: Industrial Energy Efficiency Database (IEED)

ICF's IEED is a database defining the technical and financial performance of Energy Efficiency (EE) technologies and opportunities or bundles of opportunities, referred to as Energy Saving Opportunities (ESOs), applicable within the processes of most industrial sectors. The database has over 230 ESOs, with information compiled from ICF studies, and other technical literature. The ESOs include both generic and sector-specific processes. Further to technological opportunities, ESOs also include management best practices (MBPs). MBPs refer to behavioural actions attributed to respective business management systems and incorporate best practices from various models, such as ISO 50001 – Energy Management System (EnMS), the UK Carbon Trust Energy Management Matrix, Australia and New Zealand Energy Management Guide, USA Energy Star Management Tools, and Natural Resources Canada – Office of EE's Energy Management Tools. The full list of ESOs under IEED are listed in Annex 2.

Each ESO under IEED is defined by the parameters listed in Table 2.1.

Table 2.1 Input parameters for Energy Saving Opportunities

Category	Input Parameters for each Energy Saving Opportunity (ESO)
Characteristics of ESO	Energy type is categorised into the following 5 categories: Electricity, natural gas, refined petroleum products, coal and other (biomass, renewable, etc.) Energy saving potential according to fuel type Availability (immediately or End-of-Life) Lifetime of technology Year first available Capital cost Variable operating cost Fixed operating cost
Uptake of ESO	Base year market penetration rate[16] Maximum achievable penetration potential Application limit/factor Uptake rate and trend (see discussion below)

[14] *The limited effect of EU emissions trading on corporate climate strategies: Comparison of a Swedish and a Norwegian pulp and paper company*; L.H. Gulbrandsen and C. Stenqvist; Energy Policy; 2013

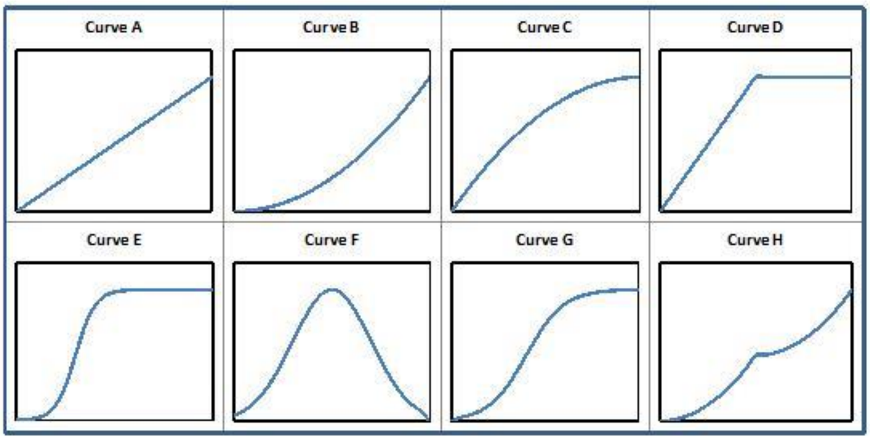
[15] *The role of the regulatory framework for innovation activities: The EU ETS and the German paper industry*; K.S. Rogge, J. Schleich, P. Haussmann, A. Roser, F. Reitze; 2011

[16] The market penetration rates of the opportunities in the Base Year were determined using primary data, which was obtained from prior ICF studies, and literature review.

2.3.4 Step 3: Penetration rate, uptake rate and trend

For each ESO, one of eight “standard” uptake curves are applied by defining a starting point (current market penetration rate) and final point (estimated or target final market penetration rate). Application of the uptake curve takes into consideration the maturity of technology, capital, operating expenditures and complexity in implementation and operation. Each of the curves normally considered is presented in Figure 2.4 and described below.

Figure 2.4 Uptake trend for ESOs



- Curve A represents a steady increase in the expected penetration rate over the study period.
- Curve B represents a relatively slow penetration rate during the first half of the study period followed by a rapid growth in penetration during the second half of the study period.
- Curve C represents a rapid initial penetration rate followed by a relatively slow growth in penetration during the remainder of the study period.
- Curve D represents a very rapid initial penetration rate that results in virtual full saturation of the applicable market during the first half of the study period.
- Curve E is similar to Curve D, except that an extended period of market development activities is anticipated prior to the beginning of market penetration.
- Curve F represents a rapid initial market penetration with maximum potential being attained by the mid portion of the study period.
- Curve G is similar to Curve C, except that an extended period of market development activities is anticipated prior to the beginning of market penetration.
- Curve H represents a significant penetration rate during the first study period, but only among certain market segments, followed by more moderate penetration rates among the remaining markets over the remainder of the study period.

2.3.5 Step 4: Development of “generic” plant profiles

IEEM is organized by major industrial sectors as highlighted at in Figure 2.2. Each industrial sector group is represented by a ‘generic’ plant size with a defined energy end-use profile that is used as a representative of a typical, or archetype, plant within a given industrial sector group. For each generic plant within the sector group, the following input parameters are defined:

- **Fuel mix**: Energy type categorised into electricity, natural gas, coal, refined petroleum products, and other (i.e., biomass, renewables, etc.) and percentage of fuel used in a “generic” plant

- **End-use profile**: Type of processes likely to be present at a subsector-specific plant (e.g., furnaces, kilns; refrigeration), and associated allocation of fuel used (based on results from Phase 1)
- **Hours of use**: estimated hours each process is in operation per day, week and year.
- **Size of plant**: Large, medium and small (varies by sector; based on energy consumption as described above)
- **Number of plants**: number of manufacturing plants in a specific sector in the EU

The change in fuel mix for each sector group is projected forward through 2050 based on historical statistic data linearised trends.

The generic plant size is estimated on a statistical approach; i.e. the overall energy consumed by the sector divided by the number of manufacturing plants within the sector. For example, manufacture of pulp, paper and paperboard sector (NACE C17) is represented by approximately 2000 manufacturing plants with the sector consuming approximately 43,000 kTOE/a in total, resulting in an assumption of each generic plant consuming 21.5kTOE /a. The generic plant size is also checked against available sector data to ensure that it provides the best possible representative of an 'average' sized plant.

The generic plant further defines the energy end-use profile (typical processes likely to be present in a specific sector). These energy end-use profiles have been developed through primary data collected from prior ICF industrial site assessments. Table 2.2 provides a further description of the energy end-use categories applied in the modelling process.

The evaluation of energy saving potential is conducted at the generic plant level, subsequently scaled up to EU-level based on the number of manufacturing plants present in the EU. For sector groups with higher (and diverse) number of sub-sector components, such as Food & Beverage (with 16 subsectors) and Machinery (27 subsectors), the number of plants was established based on assumptions applied to the number of enterprises recorded under EUROSTAT, due to the lack of data in quantifying the exact number of manufacturing plants. This is required because the number of enterprise recorded in EUROSTAT does not necessarily equate to the number of manufacturing plants, i.e. number of plants with significant energy consumption.[17]

Table 2.2 Classification of processes defined within in a generic plant

End use	Description
Machine drives	Motor power equipment, including pumps, fans/blowers, and all other machine drives. Each of these end uses is modelled separately, but reported together
Process heating	Process heating systems, both indirect and direct. Indirect heating refers to systems where an intermediate heat transfer medium is used, such as hot water and steam. Direct heating systems do not have an intermediate heat transfer medium and include ovens, dryers, furnaces and kilns.
Compressed system	Compressed air systems
Process specific	Processes that are not included in the process heating, process cooling, or motive power end uses. For example, electric arc furnace (I&S); prebake cells (aluminium); wet presses (in printing)
Process cooling	Process cooling and refrigeration systems; for example, cooling towers, freezers, chillers and associated refrigeration compressors
Heating, ventilation and air conditioning (HVAC)	Comfort heating and cooling systems, and ventilation systems. Ventilation systems that are included can be associated with a process, such as ventilation

[17] Eurostat defines an enterprise as the smallest combination of legal units that is an organisational unit producing goods or services. An enterprise carries out one or more activities at one or more locations; consequently, it does not equate to the number of manufacturing plants.

End use	Description
	of paint booths, and/or comfort, for example, ventilation of air in production area to maintain adequate air quality levels
Lighting	Indoor and outdoor lighting systems
Gas compressors	Compressors used to compress natural gas.
Other	Electricity uses not included in any of the other categories listed above. Examples include forklifts, battery chargers, and automated doors.

2.3.6 Step 5: Economic screening of opportunities

IEEM evaluates all the defined ESOs individually for economic viability, based on a simple payback approach. While there are many other financial metrics engaged by industry to assess financial viability (including discounted cash flow metrics such as Internal Rate of Return and Net Present Value), the simple payback approach was applied for economic screening, since it is still a widely utilized metric and not subjected the complications associated with discount rates or Weighted Average Cost of Capital (WACC), which differs widely among industries and Member States.

The economic benefit (or revenue) of the ESO accounts only for the direct energy saving benefit, expressed in monetary value. It does not include any other direct or indirect benefits such as avoided carbon taxes, improved production or improved competitiveness, reduced maintenance costs, etc. The ESO cost includes the capital, Operating and Maintenance (O&M), and implementation cost. An energy price outlook is used as a main input to quantify the monetary value of energy savings, since the benefit of the ESO is dependent on the energy price.

For each ESO that meets the economic threshold (e.g. 2-year payback or 5-year payback), IEEM will account for it by subtracting its respective energy saving potential from the BAU projection. The accumulated energy savings for each ESO are added together to present the overall energy saving potential for the sector group, based on economical ESOs being taken up at its respective pre-defined rate and trend (as discussed in section 2.3.4).

In addition, when modelling the impact of various ESOs, each ESO is applied sequentially to avoid double counting of energy savings and to account for the interaction between technologies, i.e. the technology lock-in effects, as some ESOs will limit the savings of other ESOs.

2.3.6.1 Energy price outlook

The energy price outlook is applied to each ESO during the economic screening process to quantify the monetary benefits in implementing the ESO. Three energy price projection methodologies provided by EC, UK Department of Energy and Climate Change (DECC) and IEA were assessed. Annex 2 presents a summary of the price outlooks, describing the projection years assessed; model used to develop the forecasts; the projected fossil fuel prices, industrial growth assumptions, policy assumptions, and macroeconomic assumptions.

Energy price were based on EU average from EUROSTAT database. For the price projection trend, the study utilised DECC's projection trend[18] for Total Petroleum Products (TPP), natural gas and coal, as it has a more robust methodology based on market inputs. The electricity price trend were based on assumptions defined in *European Commission (2014) Commission*

[18] DECC provides energy price trends up to 2030. The study assumes TPP, natural gas and coal price to stagnate at 2030 pricing up to 2050.

Staff Working Document: Energy Prices and Costs report (accompanying document) SWD 20final/2.[19]

2.3.7 Step 6: IEEM output

IEEM generates 2 potential energy saving scenarios: the technical potential and economic potential scenarios.

The *Technical Potential* scenario estimates the level of energy consumption that would occur if all industrial processes, equipment and buildings are upgraded with EE measures that are technically feasible, regardless of any economic constraints. The model addresses technical potential by assuming that the ESO will be implemented when it becomes technically feasible. For many ESOs, this will be almost immediately; however, for others, such as emerging technologies, these are implemented when the currently installed equipment has reached its end of life.

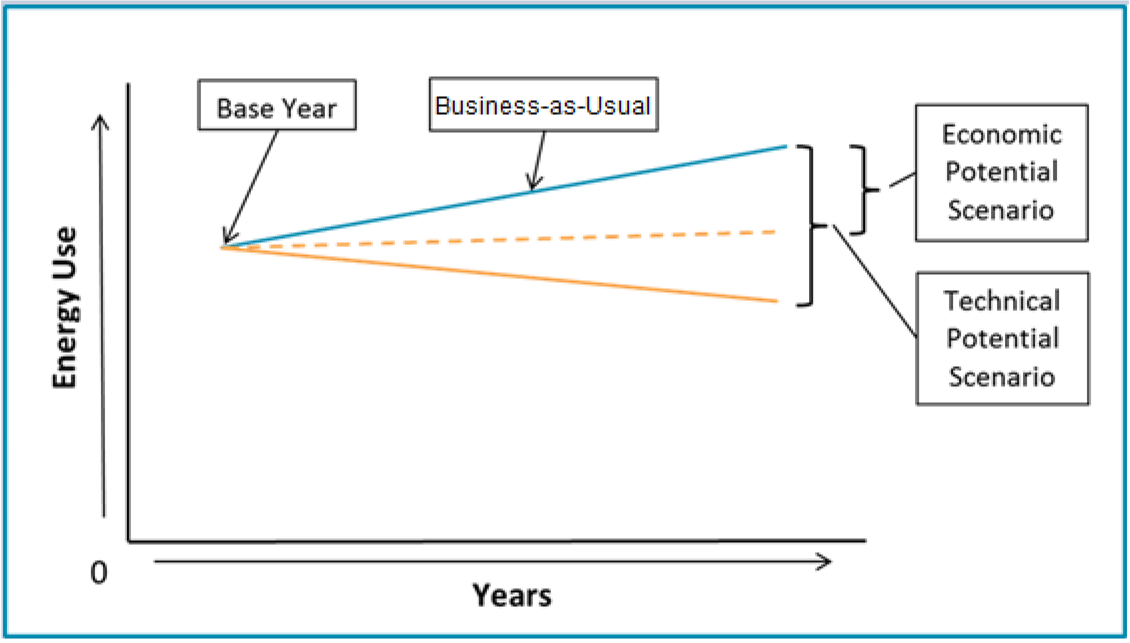
The *Economic Potential* scenario estimates the level of energy consumption that would occur if all industrial processes, equipment and buildings are upgraded with EE measures that are economically feasible, at a predefined uptake rate and trend. This represents a more modest case, since it considers how ESOs are accepted by the industry in terms of how it affects their main business activity and profitability. The study further divides the economic potential into 2 categories; Economic Scenario 1 and Economic Scenario 2:

1. *Economic Scenario 1 (high hurdle rate):* Projects the energy consumption trend assuming the sector will implement applicable ESOs that satisfy a 2-year simple payback, based on a predefined uptake rate and trend. The study has selected a 2-year simple payback criteria as it represents a closer perspective of what industry might consider to be economically feasible.
2. *Economic Scenario 2 (low hurdle rate):* Projects the energy consumption trend assuming the sector will implement applicable ESOs that satisfy a 5-year simple payback, based on a predefined uptake rate and trend. This provides an alternative projection assuming enterprise employs a lower hurdle rate in their criteria for uptake of ESOs. The study selected 5-year payback for the lower hurdle rate scenario as ESOs under this criteria are often shortlisted but not implemented.

The economic and technical potentials are projected up to 2050 (on a 5-year increment), based on the amount of savings achieved with reference to the sector-specific BAU projections (Figure 2.5).

[19] http://ec.europa.eu/energy/doc/2030/20140122_swd_prices.pdf [accessed on 08.10.14]

Figure 2.5 Illustrative economic and technical potential outputs



Based on the modelled outputs for each sector group, a combination of ICF experience and literature review was applied to identify technical, organisational, behavioural, market and competency challenges limiting uptake of the ESOs under the economic scenario. A list of potential policy measures, additional to current EU polices, are developed to overcome these barriers and drive the uptake of ESOs.

3 Projections on Energy Consumption and Energy Saving Potential for the Industrial Sector

3.1 Pulp, Paper and Print

3.1.1 Structure and economic contribution

The pulp, paper and print sector group consists of 2 main NACE divisions (C17 and C18) which contributed 1.9% of the EU's GDP in 2011 (Eurostat; 2013). Key economic contributions were delivered by 3 key groups: Manufacture of pulp, paper and paperboard (NACE C17.1); Manufacture of articles of paper and paperboard (NACE C17.2) and Printing and service activities related to printing (NACE C18.1), as summarised in Figure 3.1 and Table 3.1.

Figure 3.1 Structure and product flow of pulp, paper and print industry (NACE 17 and 18)

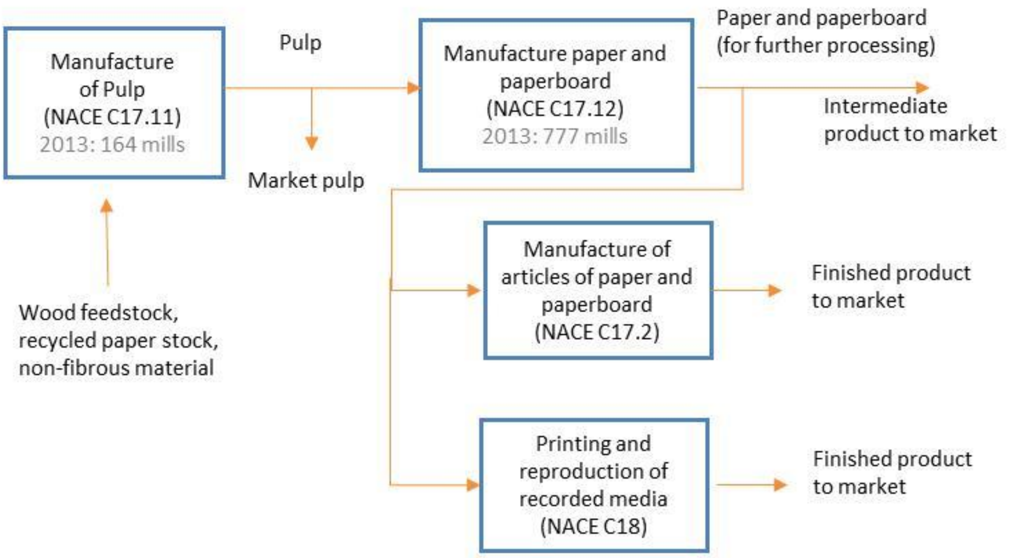


Table 3.1 2012 Key economic indicators on sector division and group level for EU 28

Description	NACE (Div)	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of paper and paper products	C17		19,394	588,500	176,977	41,564	168,216
Manufacture of pulp, paper and paperboard	-	C17.1	2,137	169,818	82,042	16,899	78,783
Manufacture of articles of paper and paperboard	-	C17.2	17,257	418,682	94,935	24,664	89,433
Printing and reproduction of recorded media	C18		109,101	628,786	74,347	27,678	72,974
Printing and service activities related to printing	-	C18.1	104,117	610,612	71,101	26,689	69,946
Reproduction of recorded media	-	C18.2	4,984	18,174	3,246	989	3,028

Source: EUROSTAT, accessed Dec 2014

3.1.2 Subsector share of energy consumption

Table 3.2 provides an estimated overview of the share of energy consumption between the subsectors in EU28 based on statistics analysed from EUROSTAT, the Confederation of European Paper Industry (CEPI)[20], German Federal Statistics Office, National Statistics Institute of Spain and Statistics Finland. It is estimated that manufacturing of pulp, paper and paperboard (C17.1 and C17.2) consumes over 98% of the overall final energy consumption reported under EUROSTAT for the pulp, paper and print sector for EU28. This is mainly attributed to the upstream processes of producing pulp, paper and paperboard, which is much more energy intensive in comparison with the downstream process in of printing and reproduction of recorded media. Based on Spanish statistics[21] in 2011, the split of energy product consumed (expressed in EUR terms) between C17.1 and C17.2 is 73% and 27% respectively.

Table 3.2 Estimated EU28 subsector share energy demand

Sector Description	NACE	Category	Estimated share of final energy demand
Manufacture of pulp, paper and paperboard	C17.1	Energy intensive	90 – 98%
Manufacture of articles of paper and paperboard	C17.2	Non-energy intensive	
Printing and reproduction of recorded media	C18	Non-energy intensive	2 – 10%

Based on the energy significance, the following sections only take into account C17.1 and C17.2 as representation of the sector's future projections.

3.1.3 Key products

3.1.3.1 Pulp (NACE 17.11)

Under NACE (rev. 2) classification, the pulp product category falls under C17.11 'Manufacture of pulp'. This includes:

- Manufacture of bleached, semi-bleached or unbleached paper pulp by mechanical, chemical (dissolving or non-dissolving) or semi-chemical process
- Manufacture of cotton-linters pulp
- Removal of ink and manufacture of pulp from waste paper.

Pulp quality is graded according to the method of production (e.g. mechanical or chemical wood pulp), wood source (e.g. soft or hard wood) and level of processing (e.g. bleached or unbleached). Pulp can be divided into 2 main principal categories; mechanical and chemical pulp.

Mechanical Pulp is produced by mechanically grinding the wood logs in to smaller pieces with water. The heat generated by the grinding process softens the lignin binding the fibres. As a result, the mechanical grinding process separates the fibres from the lignin to form pulp, which consist of whole fibres and fibre fragments of different sizes. The pulp is then screened and graded before further processing. Paper containing high level of mechanical pulp is also termed 'wood containing paper'. In comparison with chemical pulp, mechanical pulp has:

- a high yield (~95%) of pulp from the wood source

[20] Source: Key Statistics European Pulp and Paper Industry 2013, CEPI.

[21] Source: National Statistics Institute of Spain, Energy Consumption Survey, Serie 2009 – 2011.

- lower production cost
- lower paper strength
- higher energy requirements for refining mechanical pulp

Chemical Pulp is produced by 'cooking' the wood chips with chemicals under high pressure. The cooking process separates lignin, resulting in a slurry containing loose fibres and a black liquor of dissolved wood. The black liquor is then separated, and the remaining pulp is washed and screened before further processing. Pulp or paper containing chemical pulp is also termed 'wood-free'. In comparison with mechanical pulp, chemical pulp has:

- lower yield (~45%) of pulp from the wood source
- higher production cost
- higher paper strength and brightness quality
- lower energy requirements for refining due to energy recovered from lignin sulphate or sulphite process.

Semi-Chemical Pulp process involves aspects of the chemical and mechanical pulping process. The pulp is produced by partial cooking of fibres with chemical followed by a mechanical de-fibre process.

- intermediate yield (~55 – 85%) of pulp from the wood source
- intermediate pulp properties (strength and moldability)
- intermediate energy requirements as compared to mechanical and chemical energy consumption

Table 3.3 provides further details on the main categories and other subcategories of pulp.

Table 3.3 Subcategories of pulp

Sub-category	Process overview	Main end-use product
Mechanical:		
Stone Groundwood Pulp (SGW)	The main grinding mechanism for Stone Groundwood (SGW) pulp is stone. Wood feedstock (debarked wood logs) is pressed against water lubricated stones. Heat generated from the grinding process softens the lignin and forces it to separate from the fibres.	Newsprint, wood-containing papers such as Lightweight Coated (LWC) and super-calendared papers.
Refiner Mechanical Pulp (RMP)	The main grinding mechanism for Refiner Mechanical Pulp (RMP) is the disc refiner, made of rotating metal plates. Wood feedstock (primarily softwood chips and sawdust) is fed into the refiner and shredded into fibre which is longer, stronger and bulkier than SGW fibres.	(Same as SGW pulp)
Thermo-mechanical Pulp (TMP)	The main grinding mechanism for Thermo-Mechanical Pulp (TMP) is the disc refiner, made of rotating metal plates (similar to RMP). In this process, the wood feedstock (softwood and certain hardwood sawdust, wood chips) is first pre-treated with pressurised steam to soften the feedstock prior to refining. This heat pre-treatment allows the TMP process to utilize certain hardwood as well as softwood.	(Same as SGW pulp)
Chemi-thermo-mechanical pulping (CTMP)	Chemi-thermo-mechanical pulping (CTMP) adds another step to TMP process. The wood feedstock is pre-treated with small amounts of chemical and pressurised steam prior to the refining process. The chemical treatment produces pulp with higher brightness and marginally greater strength.	Tissue, printing and writing grade paper

Sub-category	Process overview	Main end-use product
Semi-chemical:		
Neutral sulphite semi chemical (NSSC) pulp	Both pulping processes involve aspects of the chemical and mechanical pulping process. Mild chemical treatment causes partial de-lignification, which results in stiffer pulp strength.	Corrugated board, food packaging board, newsprint, magazine, tissues, paper towels
Kraft semi chemical pulp		
Chemical		
Sulphite Pulp	Chemical pulps require the wood feedstock to be pre-cut into wood chips. The wood chips are then cooked in a pressurised vessel containing bisulphite liquor, resulting in Sulphite pulp which could be bleached or un-bleached.	Newsprint, printing and writing papers, tissue, sanitary papers.
Sulphate Pulp (Kraft Pulp)	Sulphate pulp (widely known as Kraft Pulp) is produced by cooking wood chips in a pressurised vessel containing sodium hydroxide (soda) liquor, resulting in Sulphate pulp which could be bleached or un-bleached.	Graphic paper, tissue, carton board, wrapping, sack and bag papers, envelopes and other specialty papers.
Recycled pulp		
De-inked pulp (DIP)	De-inked pulp is a result of recovering pulp from recycled paper. The collected papers would first need to be sorted and then mixed with water, any unwanted materials (staples, wire bands, plastics) are filtered out. Thereafter, the recovered pulp goes through a cleaning process to remove all inks and undesirables from the recovered fibre.	Tissues, printing and writing, fine papers.

Source: CEPI and Carbon Trust

3.1.3.2 Paper and paperboard (NACE 17.12)

Under NACE (rev. 2) classification, the paper product category falls under C17.12 ‘Manufacture of paper and paperboard’. The output of this class of product is intended for further industrial processing before taking form as the end-use product. This includes:

- Further processing of paper and paperboard:
  - Coating, covering and impregnation of paper and paperboard
  - Manufacture of crinkled paper
  - Manufacture of laminates and foils (if laminated with paper or paperboard)
- Manufacture of newsprint and other printing or writing paper
- Manufacture of cellulose wadding and webs of cellulose fibres
- Manufacture of carbon paper or stencil paper in rolls or large sheets
- Manufacture of handmade paper

Paper and paperboard finishing can be coated or uncoated.

3.1.4 Key sector processes

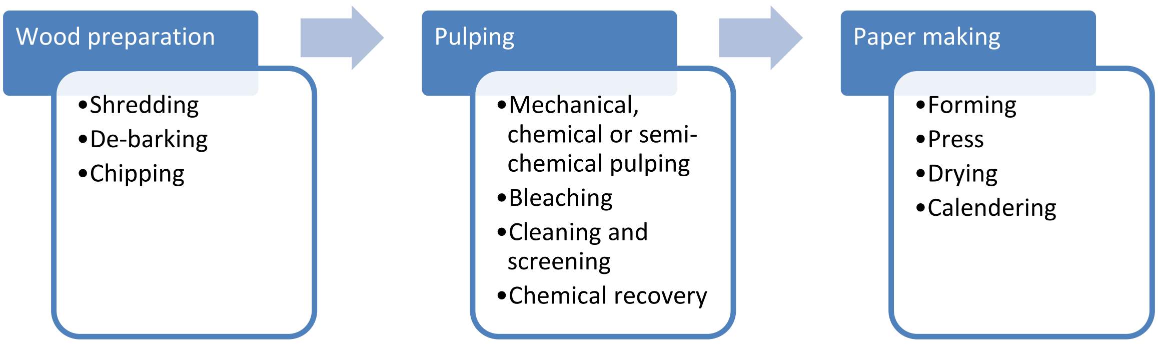
3.1.4.1 Pulp, paper and paperboard production in EU

Production of pulp, paper and paperboard continuously evolves to meet changing market demands, mainly due to stricter policy and environmental requirements. The production mills can be standalone basis, i.e. production of pulp and paper on separate standalone plants, or integrated plants whereby pulp, paper and paperboard are produced on the same plant. Integrated mills are generally larger and more cost-effective than standalone mills. However, smaller non-integrated mills could benefit strategically by being located closer to the consumer. About 30% of mills in EU are integrated mills [BREF, 2001]. The paper and paperboard plants can be broadly categorised as follows:

- Newsprint
- Uncoated printing and writing papers
- Coated printing and writing papers
- Packaging papers
- Packaging paperboards
- Liner and fluting
- Tissue
- Specialty papers

Production of pulp, paper and paperboard is highly integrated and divided mainly into 3 main process categories; wood preparation, pulping and paper making as illustrated in Figure 3.2.

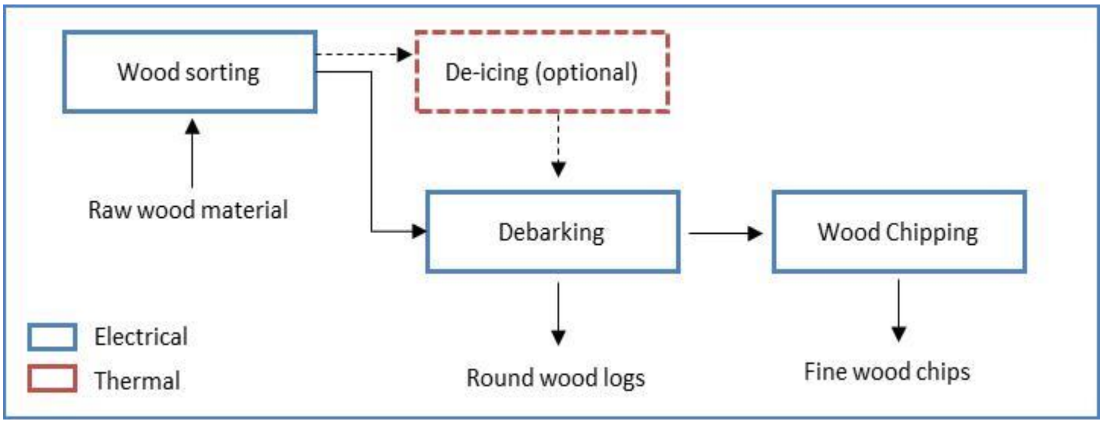
Figure 3.2 Main process categories of pulp, paper and paperboard production



3.1.4.2 *Wood Preparation*

This process converts raw wood material into forms (logs or wood chips) which are suitable for pulping. The raw wood material is first sorted and cut to size. It is then transported to the debarkers, a mechanical process of removing barks from the logs through abrasion. Chain conveyors are typically used to transport the raw wood material. Following this, the wood logs are ready for the chipping process. Wood chippers are typically use discs or knives to break the logs into wood chips. The wood preparation process uses electrical energy almost entirely. The main energy end users are conveyor motors, debarking operational motors and wood chipping motors. Thermal energy is only required in some mills, where hot water is used to de-ice the wood logs before it is debarked. Figure 3.3 provides an overview of the wood preparation process.

Figure 3.3 Wood preparation process



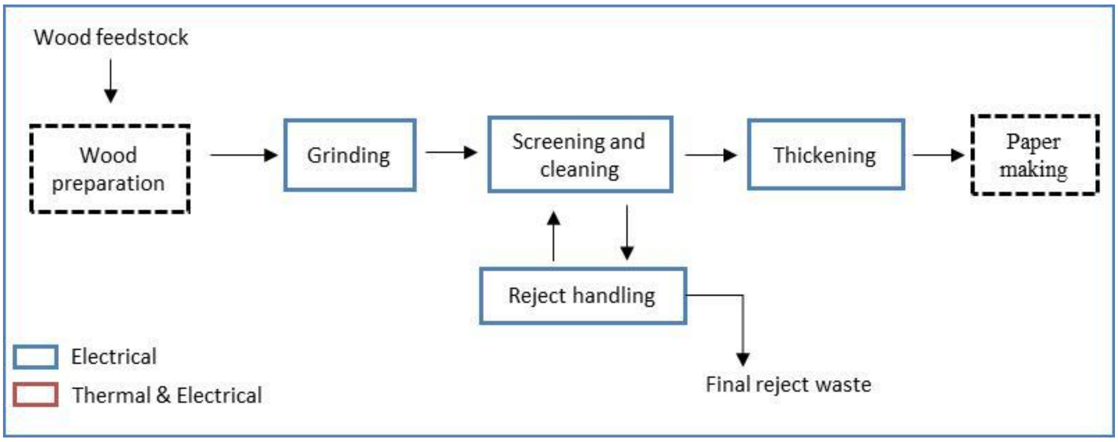
3.1.4.3 *Pulping – Mechanical and Semi-Chemical*

Based on 2012 CEPI statistics, 29% of pulp produced within the EU is made up of mechanical pulp and Semi-Chemical pulp. Mechanical consist of Groundwood pulp and Thermo Mechanical Pulp (TMP) and Chemical Thermo Mechanical Pulp (CTMP).

Groundwood pulp

Groundwood pulping is one of the oldest and simplest form of pulping. Although it has a higher energy demand in comparison with chemical pulping, the yield for mechanical pulping is much higher. Heat generated from the grinding process is cooled with water. The presence of heat and water softens the lignin bond within the wood material and releases the fibres. The grinded fibres then enters a screening and cleaning process. The screening process removes unwanted fragments while retaining valuable long fibres at the reject handling system for further re-processing. The accepted pulp from reject handling system (usually hammer mills) is thereafter returned back to the main fibre line. The screened and cleaned fibres are then thickened (with disc filters or thickening drum) and stored in tanks, in preparation for the papermaking process. The SGW pulping process consumes almost entirely electrical energy. Figure 3.4 provides an overview of groundwood pulping process.

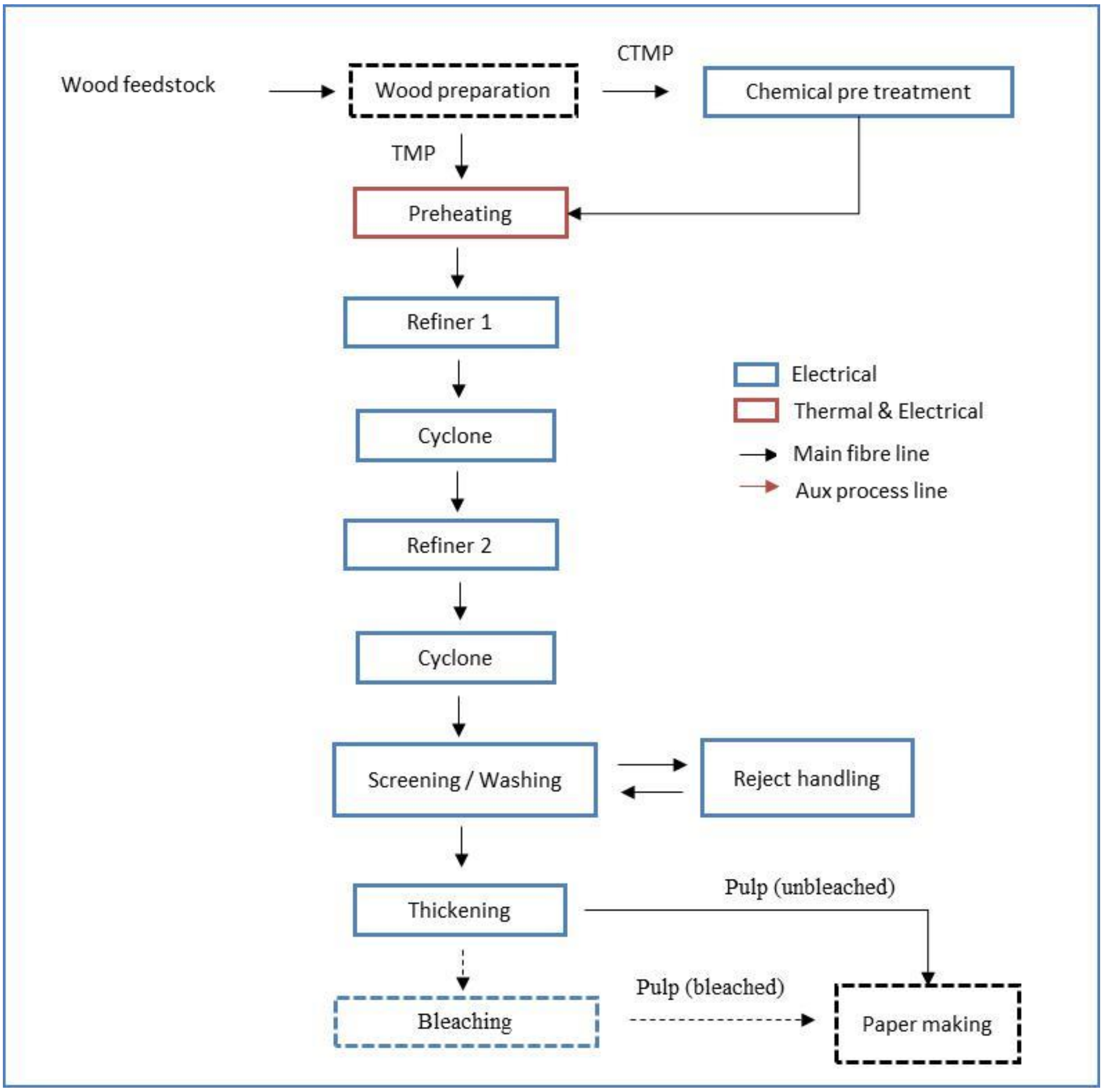
Figure 3.4 Overview of Groundwood pulping process



Refiner Mechanical Pulp - Thermo Mechanical Pulp (TMP) and Chemical Thermo Mechanical Pulp (CTMP)

Refiner Mechanical Pulp (RMP) also uses mechanical grinding mechanism to convert wood feedstock into fibres. RMP process utilizes a mechanical grinding discs which results in longer and stronger fibres than Groundwood pulp. TMP process adds to the RMP process whereby wood feedstock is steamed under pressure before entering the refiners. The CTMP process adds to the TMP process whereby the wood feedstock are pre-treated with small amounts of chemical before being heated up. Almost all EU RMP mills are TMP or CTMP mills. Figure 3.5 provides an overview of the TMP and CMTP process.

Figure 3.5 Overview of TMP / CTMP pulping process



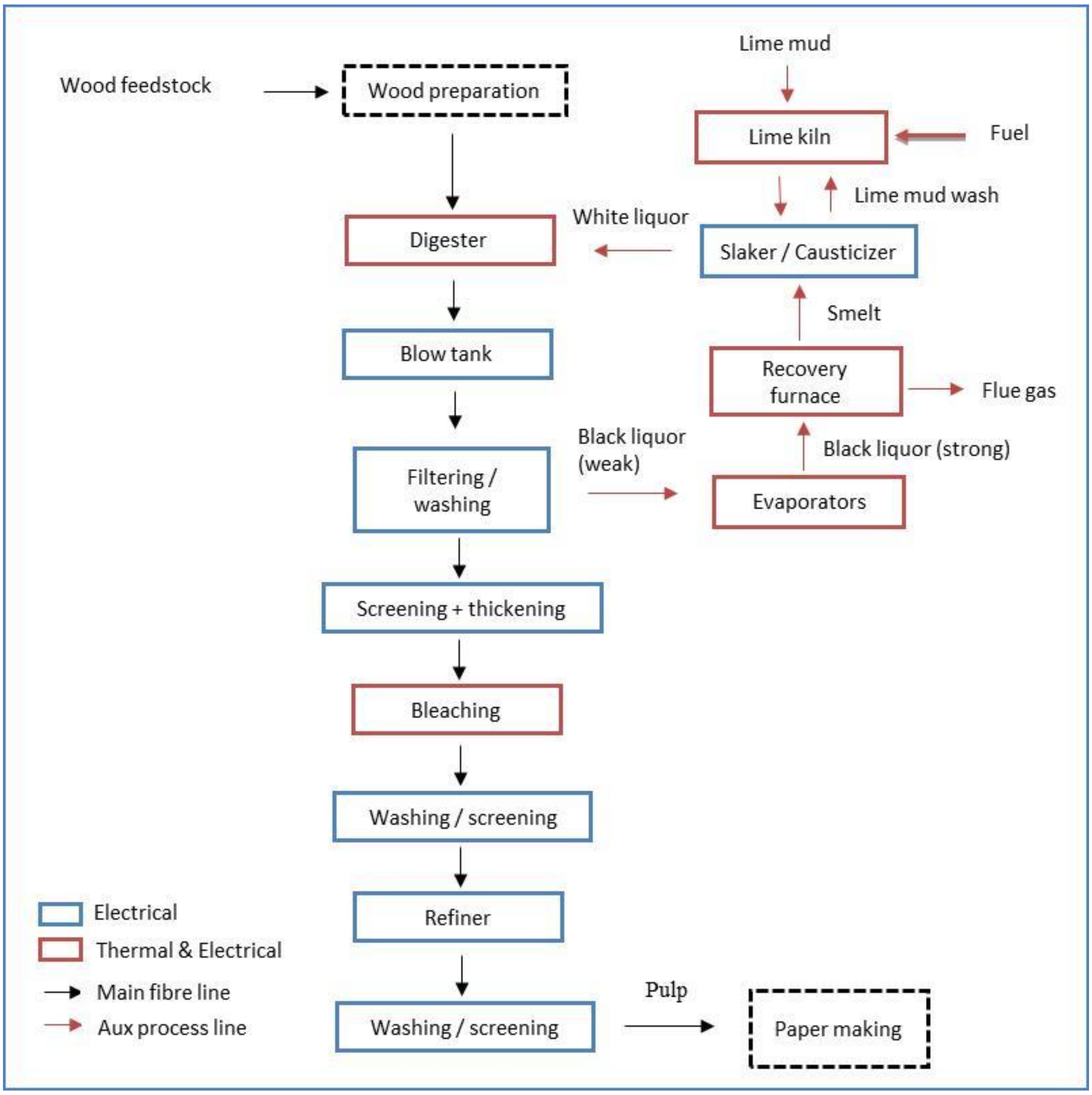
3.1.4.4 Pulping – Chemical

Based on 2012 CEPI statistics, 71% of pulp produced within the EU is made up of Chemical pulp. Of this 71%, 92% are made up of Kraft pulp and remaining 8% are made up of Sulphite pulp. Kraft pulp has surpassed Sulphite pulping mainly because of its limitation in wood feedstock, lower pulp strength and less efficient in chemical recovery.

Sulphate (Kraft) Pulping

Wood chips are fed into a digester where it is ‘cooked’ with steam and white liquor. The cooking time and temperature varies according to fibre source. Digesters could either be based on batch or continuous production. Batch digesters offers higher product flexibility and lower capital cost, while continuous digesters offers lower use of energy, chemical and space. In batch digesters, wood chips are cooked with white liquor at predefined temperature and period. In continuous digesters, the wood chips are impregnated with white liquor at different stages. After the cooking stage, the hot pulp is transferred into a blow tank where softened wood chips disintegrate into fibres upon impact. Thereafter, the pulp is filtered for undigested lump wood fragments, which is either discarded or sent back for digesting. The filtered pulp is then washed to separate the fibres and spent liquor. The washed fibres are then screened again to remove any oversized particles and contaminants and thickened before entering the bleaching and paper making process. Unbleached pulp will be sent for the paper making process, or dried and baled if it's produced as market pulp. The Kraft pulp will have to be bleached when used for production of white paper. Figure 3.6 provides an overview of the Kraft pulping process.

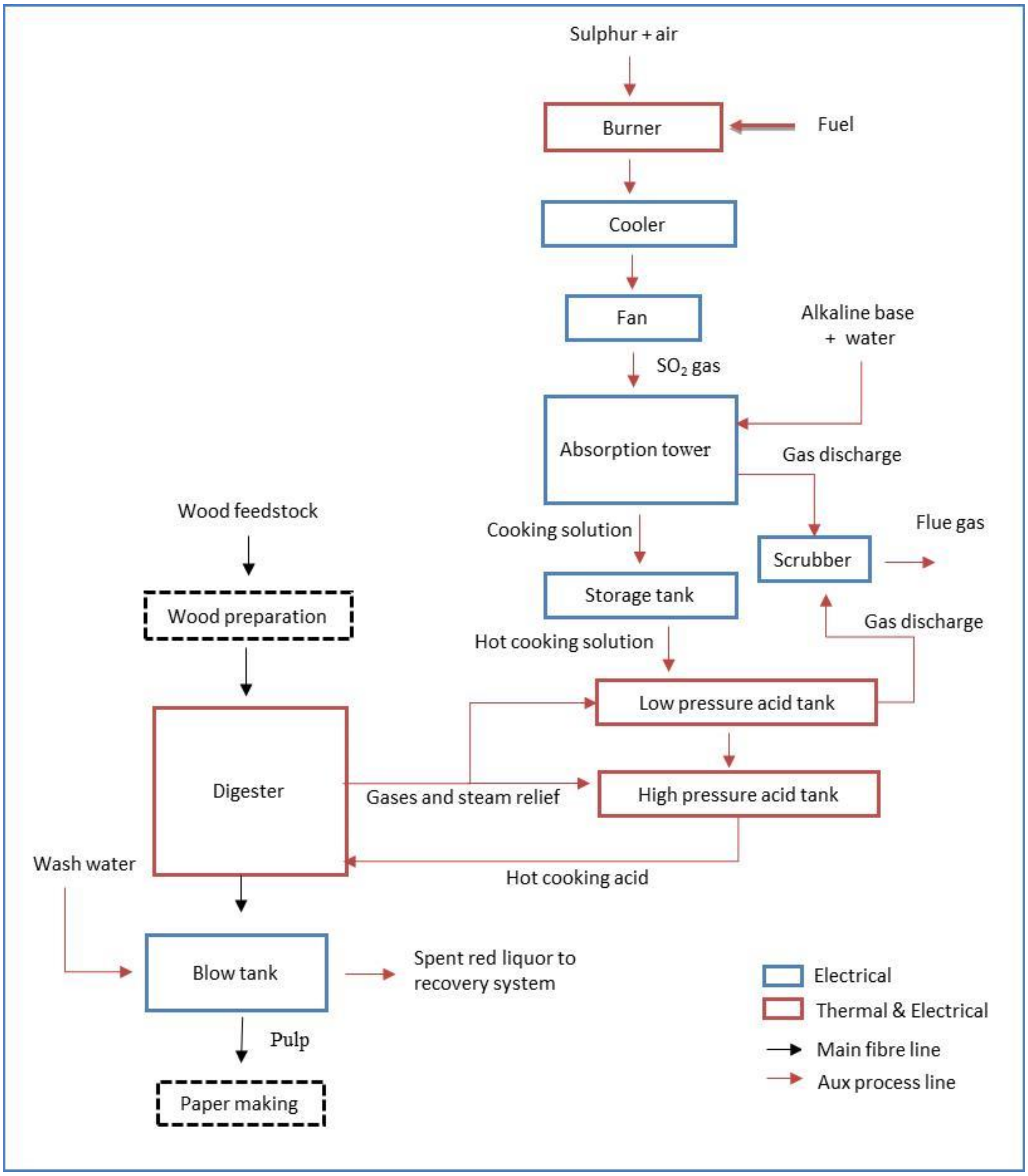
Figure 3.6 Overview of Kraft Pulping Process



Sulphite Pulping

Sulphite pulping process utilizes a cooking liquor which is a mixture of Sulphurous acid (H_2SO_3) and bisulphite ion (HSO_3) to dissolve lignin. The cooking liquor is typically produced on site. Sulphur is burnt to produce Sulphur Dioxide (SO_2) gas, which is cooled and passed through an absorption tower containing alkaline base, resulting in a cooking solution of Sulphurous acid (H_2SO_3) and bisulphite ion (HSO_3). The cooking solution is then heated up under pressure prior to mixing with wood chips in the digester. After the digesting process, the resulting fibres are then screened and washed

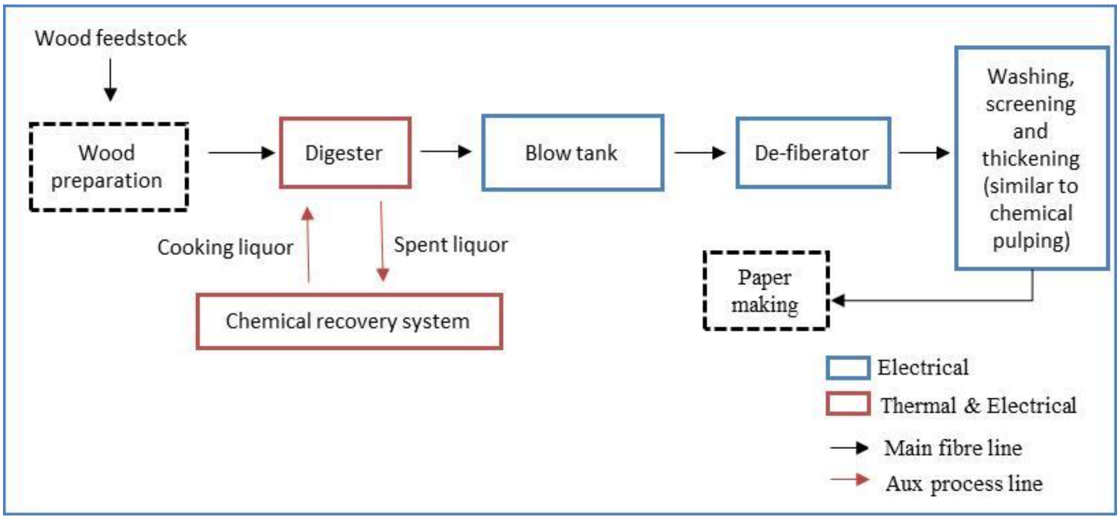
Figure 3.7 Overview of Sulphite pulping process



3.1.4.5 *Pulping – Semi Chemical*

Semi chemical pulping process combines aspects of both mechanical and chemical pulping. The wood feedstock is fed into a digester for mild chemical cooking, a lower temperature and cooking period in comparison with chemical pulping process, which results in partial delignification of the feedstock. Thereafter, the blow tank transfers the feedstock into the mechanical defibering device, usually disc or conical refiners, which separates the partially cooked feedstock. The resulting pulp is then washed, screened and thickened, similar to chemical pulping process.

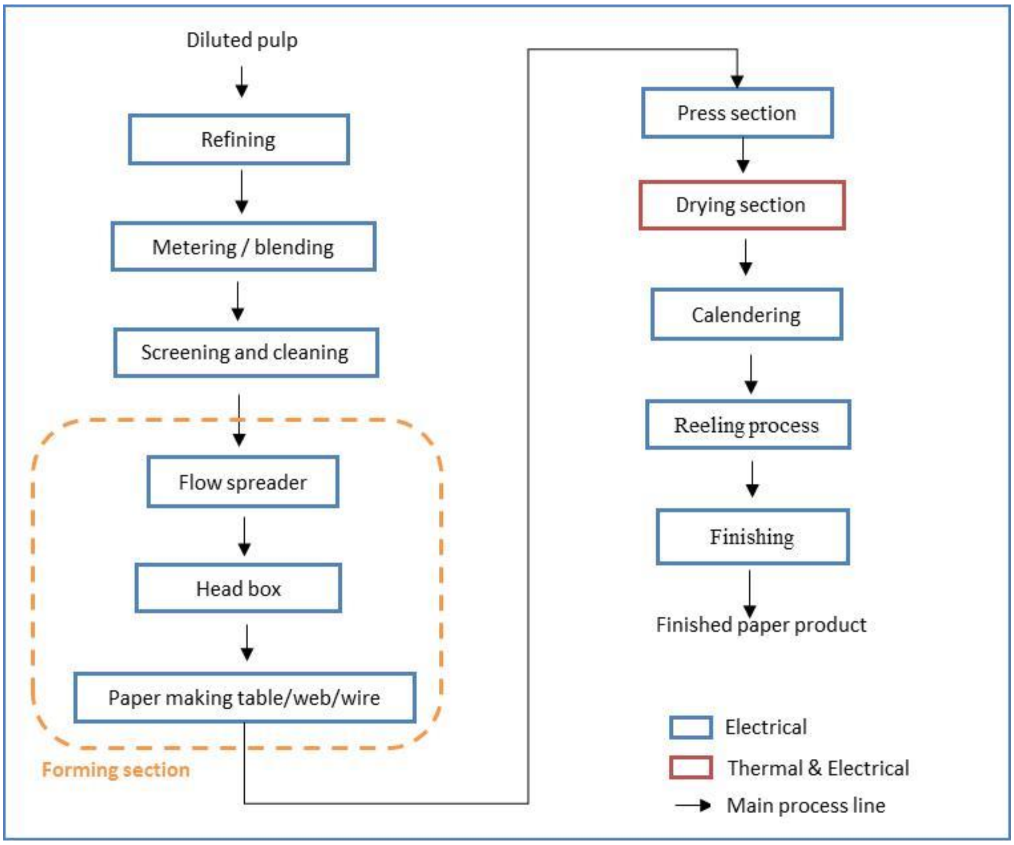
Figure 3.8 Overview of semi chemical pulping process



3.1.4.6 Paper making

Paper making process is where the pulp fibres is processed to take form of paper and paperboard, through blending and processing of other non-fibrous additive. This process is mainly handled by a paper machine which generally consist of a forming, press and drying section. The blending formulae is completely customized to the required type, quality and finishing of the paper or paperboard. The paper making process begins with the pulp fibres being fed into a mechanical refiner, where they are mechanically hammered, de-clustered and cut to improve fibre bonding properties. Thereafter, the fibres are blended with other functional additives (e.g. clay, ground calcium carbonate, precipitating calcium carbonate, etc.). The fibre and non-fibre functional additive is continuously blended to form the paper making stock. The flow spreader evenly distributes the blended mixture through a head box which results in an even form of 'paste' across a moving table, web or wire, forming a continuous layer of web. This layer of web is then fed through a press section, removing the moisture content down to approximately 45 – 55%. Thereafter, the sheet then passes through a drying section where the remaining water content is completely removed via evaporation mainly using steam (<5% moisture). The dried sheet of paper then goes through a calendaring process, a process of pressing the paper sheet with a roll, which results in uniformity in smoothness and thickness of paper. The final part of the paper making process is the reeling process where the paper sheet is wound around a rotating spool and stored for further finishing operations. Finishing operations could refer to rewinding, trimming, sheeting, coating, printing and box making.

Figure 3.9 Overview of paper making process



3.1.5 Energy metrics

3.1.5.1 Energy intensity based on sector energy cost

Table 3.4 provides an indication of the sector's energy intensity for EU28 expressed in 2 ratios[22] from 2008 - 2012. Based on the 5 year period data, the intensity ratios are gradually improving, with both ratios reduced by approximately 8% over the 5 year period. This is in line with the longer term energy intensity trend discussed in section 3.1.6. The pulp, paper and print sector ranks as 5th most energy intensive sector in comparison with the 8 industrial sectors evaluated in this Study in terms of energy cost spent per value added generated.

Table 3.4 Energy cost intensity ratios per unit of VA and Turnover generated*

	Ratio	2008	2009	2010	2011	2012
1	Energy cost/ Value Added	17.5%	17.2%	16.1%	16.7%	16.2%
2	Energy cost/ Turnover	5.0%	5.0%	4.7%	4.7%	4.6%

Source: ICF analysis on EUROSTAT SBS, accessed Dec 2014] Note: Data excludes Luxembourg, Malta, Poland and Slovenia*

3.1.5.2 Energy intensity of key processes

Table 3.5 to Table 3.8 provides a breakdown of thermal and electrical energy intensity in the wood preparation, pulping and paper making processes. These data were obtained from an

[22] (1) Ratio of energy cost per unit of value added and (2) Ratio of energy cost per unit of turnover, i.e. the monetary value paid by manufacturers on energy products for every unit of value added or turnover generated by the sector.

energy benchmark report by the Canadian Industry Program for Energy Conservation (CIPEC) and Pulp and Paper Research Institute of Canada (PAPRICAN). Data were collected in four consecutive quarters for 49 mills, including several mills that had multiple pulping processes and paper types.

Table 3.5 Thermal energy intensity of pulping key processes

Process	Thermal Process Intensity [MJ / t of dried fibre]			
	Range		Median	Modern
	25th percentile	*75th percentile*		
Wood preparation	0	0	0	0
Kraft pulping – continuous	2430	3810	2940	2200
Kraft pulping – batch	4330	5640	4940	3500
Kraft pulping – M&D	5500	6760	6040	N/A
Kraft evaporators – indirect contact	5030	7060	5910	3200
Kraft evaporators – direct contact	2900	3890	2960	N/A
Kraft recausticizing	0	440	140	0
Kraft bleaching – softwood	2570	4650	3410	1700
Kraft bleaching – hardwood	1620	3370	2330	N/A
Sulphite pulping	4110	6480	5000	N/A
Sulphite acid plant	0		-	N/A
Mechanical pulping – TMP for newsprint	390	800	560	0
Mechanical pulping – TMP for paper	30	930	670	0
Mechanical pulping – SGW	0		0	0
Mechanical peroxide bleaching	0	130	0	0
Recycled pulping	0	440	110	0

Source: CIPEC, 2008

Table 3.6 Electrical energy intensity of pulping key processes.

Process	Electrical Energy Intensity [MJ / t of dried fibre]			
	Range		Median	Modern
	25th percentile	*75th percentile*		
Wood preparation	34.2	131.76	79.92	79.2
Kraft pulping – continuous	541.8	796.68	646.2	579.6
Kraft pulping – batch	485.64	829.8	609.48	579.6
Kraft pulping – M&D	597.6	751.32	687.24	NA
Kraft evaporators – indirect contact	0	110.16	56.52	118.8
Kraft evaporators – direct contact	36	160.92	88.2	NA
Kraft recausticizing	83.52	172.44	115.56	201.6
Kraft bleaching – softwood	404.28	866.52	646.2	439.2
Kraft bleaching – hardwood	421.56	855	518.04	NA
Sulphite pulping	815.4	4891.68	2759.04	NA
Sulphite acid plant	0	0	115.2	NA
Mechanical pulping – TMP for newsprint	9030.96	10032.48	9581.76	8820 - 9360
Mechanical pulping – TMP for paper	9311.76	11739.96	10595.52	9540 - 10080
Mechanical pulping – SGW	6086.88		6409.08	5400 - 6480
Mechanical peroxide bleaching	302.76	837	481.68	NA
Recycled pulping	921.96	1542.96	344.2	460

Source: CIPEC, 2008

Table 3.7 Thermal energy intensity of paper machines for various paper type

Process	Thermal Process Intensity [MJ / t of dried fibre]			
	Range		Median	Modern
	25th percentile	*75th percentile*		
Paper Machine – Newsprint	4770	6620	5360	4900
Paper Machine – Uncoated Groundwood	4930	7010	6210	N/A
Paper Machine – Printing and Writing	5740	8310	6320	5100
Paper Machine – Kraft Papers	8470	9110	9100	N/A
Board Machine	6920	7180	6940	3400

Process	Thermal Process Intensity [MJ / t of dried fibre]			
	Range		Median	Modern
	25th percentile	*75th percentile*		
Pulp Machine – Steam Dryer	4140	5260	4590	2300
Pulp Machine – Wet Lap	0	0	0	0
Converting Operation	0	0	0	0

[Source: CIPEC, 2008]

Table 3.8 Electrical energy intensity of paper machines for various paper type

Process	Electrical Energy Intensity [MJ / t of dried fibre]			
	Range		Median	Modern
	25th percentile	*75th percentile*		
Paper Machine – Newsprint	1810.44	2240.64	2034.72	1188
Paper Machine – Uncoated Groundwood	2012.76	2797.56	2437.2	N/A
Paper Machine – Printing and Writing	2144.88	2544.12	2385	1980
Paper Machine – Kraft Papers	2966.04	3991.68	3677.4	N/A
Board Machine	1776.24	2296.44	1998	1854
Pulp Machine – Steam Dryer	428.76	688.68	551.52	507.6
Pulp Machine – Wet Lap	241.92	363.24	256.32	N/A
Converting Operation	207	464.76	313.92	N/A

Source: CIPEC, 2008

3.1.5.3 Final energy demand breakdown of a typical pulp mill

Table 3.9 provides an overview of the final energy consumed by key processes in a typical Kraft pulp mill based in Sweden [BREF, 2001]. The mill produces bleached Kraft pulp and a production capacity of 250,000 t/a. The mill was built in the 1970s and modernised since then. The energy intensity for the plant amounts to 17,136 MJ/t, of which thermal energy attributes to 84% while the remaining 16% is electrical energy.

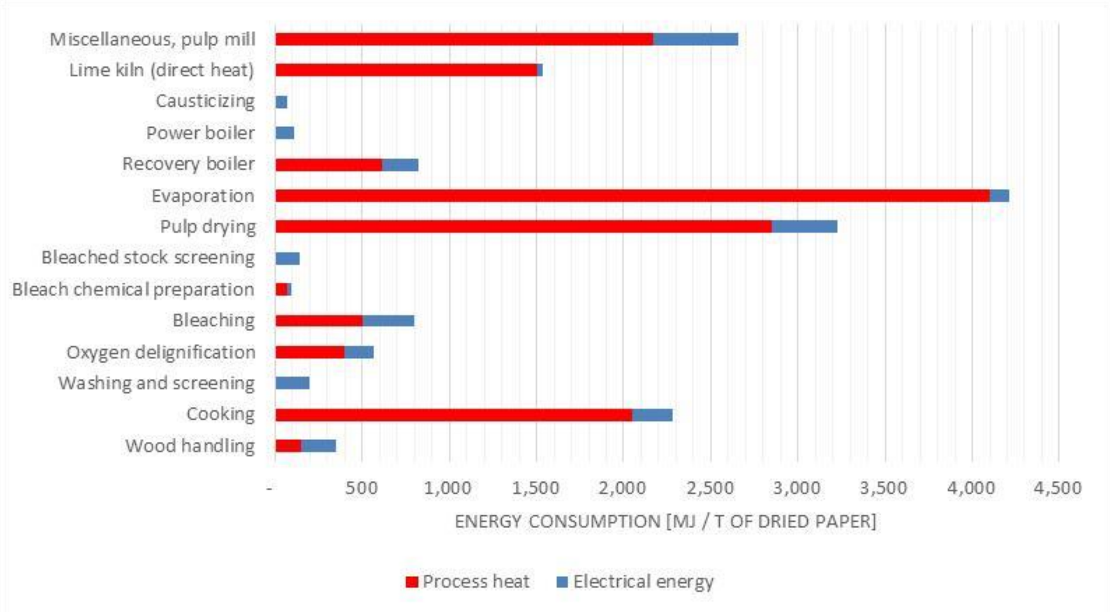
This is very much in line with the EU average intensity and that majority of EU pulp mills are Kraft pulp mills. Based on CEPI statistics, EU average intensity amounts to 16,926 MJ/t of pulp, paper and paperboard produced in 2012, of which 78% attributes to thermal energy while the remaining 22% is electrical energy. Figure 3.10 illustrates the breakdown of thermal and electrical energy consumption in a typical pulp mill.

Table 3.9 Energy intensity for key processes of a Swedish bleached Kraft pulp mill

Process	Process Heat	Electrical Power	Total Energy	% of total
	[MJ / t]	[MJ / t]	[MJ / t]	[%]
Wood handling	150	198	348	2.0%
Cooking	2,050	234	2,284	13.3%
Washing and screening		198	198	1.2%
Oxygen delignification	400	162	562	3.3%
Bleaching	500	299	799	4.7%
Bleach chemical preparation	70	22	92	0.5%
Bleached stock screening	-	144	144	0.8%
Pulp drying	2,850	378	3,228	18.8%
Evaporation	4,100	108	4,208	24.6%
Recovery boiler	610	216	826	4.8%
Power boiler	-	108	108	0.6%
Causticizing	-	72	72	0.4%
Lime kiln (direct heat)	1,500	36	1,536	9.0%
Miscellaneous, pulp mill	2,170	490	2,660	15.5%
Effluent treatment	-	72	72	0.4%
Total per ton of pulp	**14,400 (84%)**	**2,736 (16%)**	**17,136 (100%)**	

Source: BREF, 2001

Figure 3.10 Thermal and electrical energy intensity breakdown of a Swedish Kraft Pulp mill



Source: BREF, 2011

3.1.5.4 EU final energy consumption and energy mix for pulp, paper and print production

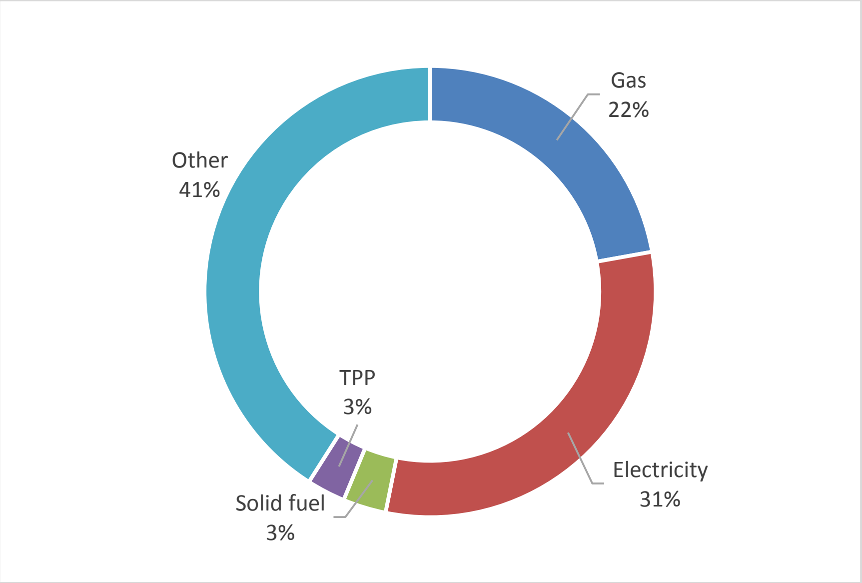
Table 3.10 and Figure 3.11 provides a summary of the final energy consumption and fuel mix for pulp, paper and print sector for EU28 as a whole.

Table 3.10 Final energy consumption for EU Pulp, Paper and Print in 2012

EU primary energy consumption for the sector	kTOE	% of total
Gas	7,556	22%
Electricity	10,561	31%
Solid fuel	1,055	3%
TPP	942	3%
Other	13,961	41%
Total final energy demand	**34,075**	

Source: EUROSTAT, accessed Dec 2014

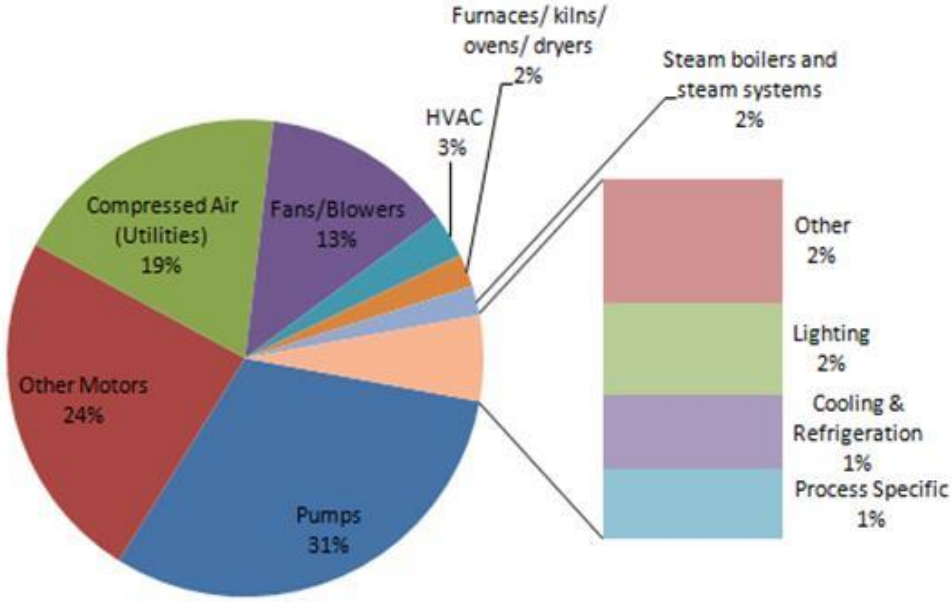
Figure 3.11 Energy mix for EU pulp, paper and print in 2012



3.1.5.5 *Energy end use profile*

Based on the estimated share of energy consumption in the pulp, paper and paperboard sector and the fuel mix, the following figures present an aggregate energy end use profile for the energy sources, including electricity, natural gas, refined petroleum products (i.e., oil, fuel oil), coal, and other sources.[23]

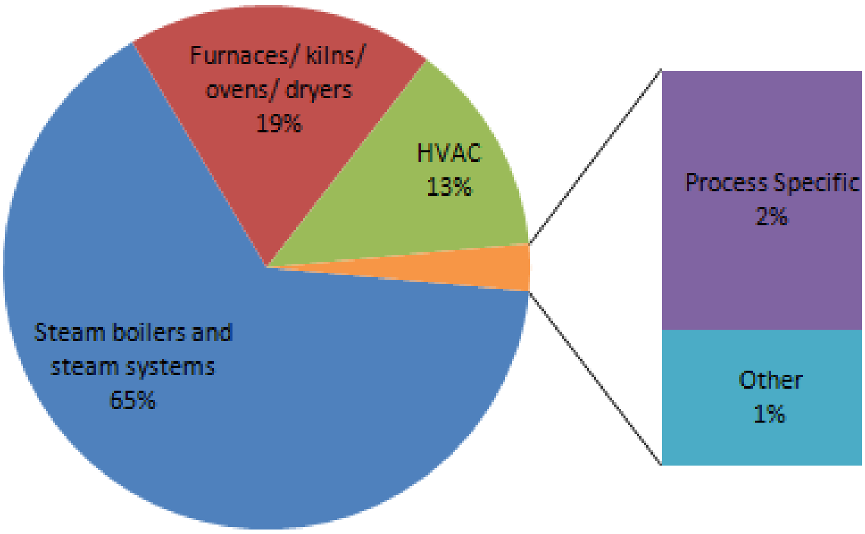
Figure 3.12 Electricity use profile



Source: ICF International

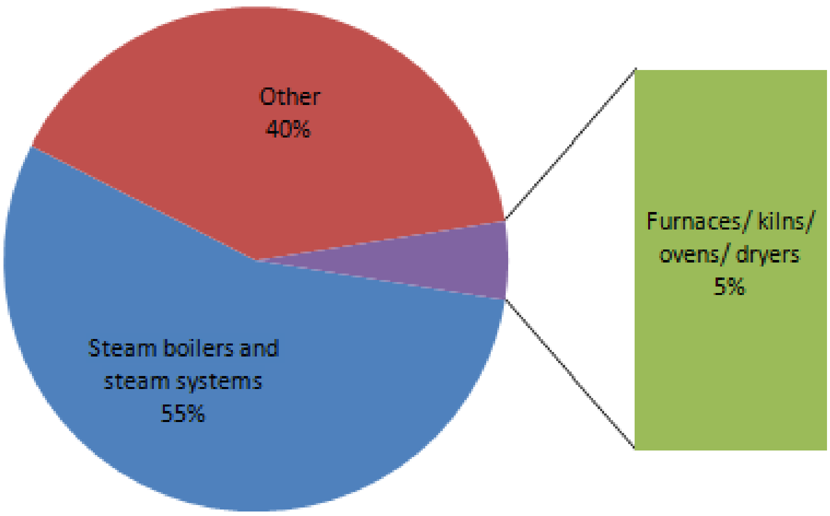
[23] Based on ICF energy efficiency studies within the pulp and paper sector

Figure 3.13 Figure 1: Natural gas use profile



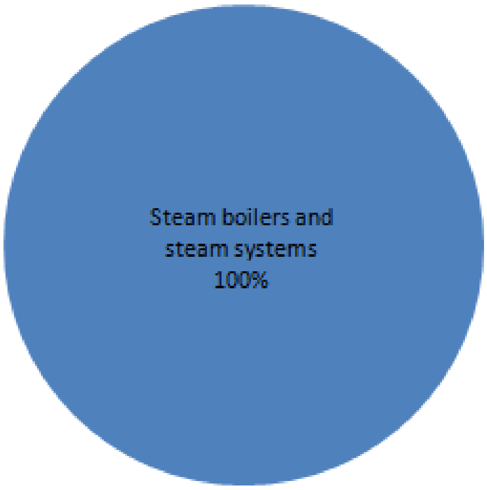
Source: ICF International

Figure 3.14 Total petroleum product use profile



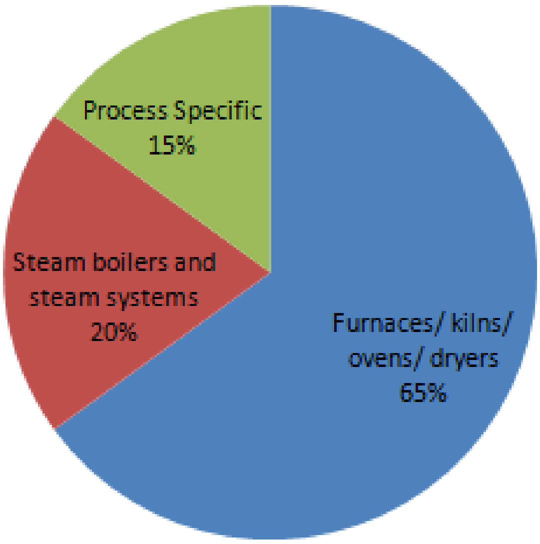
Source: ICF International

Figure 3.15 Coal use profile



Source: ICF International

Figure 3.16 Energy use profile for other sources, including renewable, biomass, and waste heat recovery



Source: ICF International

3.1.6 Projection of energy consumption trend

The following details are an extracted summary of the sector profile in Annex 1. Projections for this sector group was based on CEPI statistics (representing 93% of EU pulp and paper production), which provided better data granularity in comparison to EUROSTAT.

3.1.6.1 Production of pulp

Sweden, Finland, and Germany account for 66% of market (SETIS[24]). The market is distinguished by large companies (i.e., >250 employees). Since 2000, EU production of pulp, paper and paperboard has been gradually increasing until a significant slowdown was experienced in 2007 due to the economic crisis, which continues to affect production in 2012 [CEPI. 2013]. While imports of wood material, as well as competition for wood material from emerging bio-based industries is a potential future threat (Indofur; 2013), it is anticipated that the potential supply from forests and other sources of wood in EU will exceed demand until 2025 [Mantau U et al, 2010] and EU wood supply is anticipated to increase up to 2030 [EFSOS II, 2010]. However, it is unclear if the supply is economically sufficient to fulfil both the forest and non-forest based industries beyond 2025. Although the percentage of virgin pulp in paper is declining, increasing recycling rates within EU are anticipated to offset it. The number of EU pulp mills has been declining significantly over time. CEPI has recorded a drop from 296 pulp mills in 1991 to 171 mills in 2012. Despite this decline, pulp production has gradually increased by 8% over the same period of time. Extra-EU export of pulp has also increased drastically by approximately 3 folds from 2000 to 2012.

3.1.6.2 Production of paper and paperboard

Germany, Italy and France account for 43% of the EU market (Eurostat; 2013). The EU is a net exporter of paper and paper products (Indofur; 2013). Through 2011 there has been a slight increase in production. Significant losses in newsprint production have occurred (and will likely continue); however, these have been offset by increases in packaging and hygienic paper production (due to an aging population). This trend is anticipated to continue. Additionally, new bio-based products are being developed, which will support future growth. The industry is primarily SME based. Similar to pulp mills, the number of EU paper and paperboard mills has been declining significantly over time. CEPI has recorded a drop from 1274 to 791 paper and paperboard mills from 1991 to 2012. Despite this decline, paper and paperboard production has increased drastically by approximately 38% over the same period of time. Extra-EU export of paper and paperboard also recorded a drastic increase of approximately 43% from 2000 to 2012.

3.1.6.3 Print production

Germany, UK, Italy and France are the leading printers (based on employment) (Eurostat; 2013); however, between 2000 and 2011, there has been a 29% decline in employment. This decline reflects a reduction in production of 14% between 2000 and 2011. Significant declines expected moving forward, with a reduction in newspapers, books, with a move towards digital media. Furthermore, the industry is primarily SME and microenterprises (<10), so increasing energy costs as well as labour and material costs are decreasing margins; low cost imports, and structural over capacity, on the order of 30%, will impact future growth (EC; 2013). Relocation of services outside EU expected to increase (EC; 2013).

3.1.6.4 Sector projection summary

Overall, production of pulp, paper and paperboard is expected to increase on a slow gradual pace through 2050. Although it is unclear if the wood supply post 2025 will be sufficient for both forest and non-forest based industries, it is assumed that EU demand is met through progressive policy shifts, improved monitoring of wood balance and increased supply from other alternative sources. The sector growth is also driven by the continual EU innovation delivering higher value products (not necessarily in high volume) and continued growing demands for consumer goods packaging (offsetting the decline in print demand). The number of pulp and paper mills is expected to fall gradually, with non-profitable mills shutting down due to eroding profit margins. The remaining mills are expected to restructure its operation

[24] *Energy efficiency in the Pulp and Paper Industry*; Available at: http://setis.ec.europa.eu/technologies/energy-intensive-industries/energy-efficiency-and-co2-reduction-in-the-pulp-paper-industry

model sustaining reasonably good profit margins and production growth. Table 3.11 presents the anticipated production for the sector.

Table 3.11 Projected production of market pulp, paper and paperboard in EU (million tonnes)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Production (MT)	105*	104*	105	106	107	108	109	110	112	113

**Based on CEPI statistics*

The pulp and paper manufacturing sector is energy- and raw materials–intensive. Based on CEPI statistics data, specific energy intensity for production of pulp, paper and paperboard in 2000 has decreased approximately 6.6% from 1991 levels, and in 2011 it has decreased 8.9% from 2000 levels (despite production decline during 2005 – 2010). The sector has effectively demonstrated a good track record in reduction of energy intensity and consumption (including reduction of emission and water consumption), effectively de-coupling all of these aspects from production growth (EC; 2013). Incremental process efficiency improvements reflecting the uptake of recently developed or commercialised technologies is anticipated to occur as the sector meets existing legislative requirements (e.g., EED, EU-ETS, IED), and further innovates to develop new products to improve margins and market lead. In summary, this trend in reduction of energy intensity and energy consumption is anticipated to continue on par with historical rates. Table 3.12 presents the anticipated energy intensity trend through to 2050.

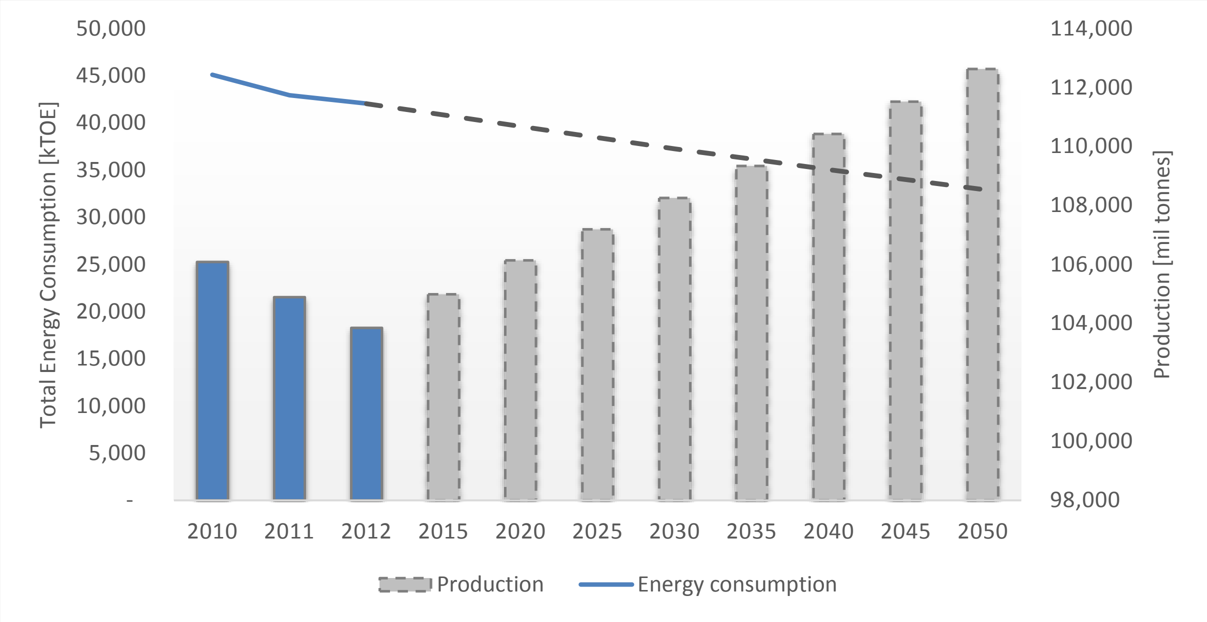
Table 3.12 Projected energy intensity trends for production of pulp, paper and paperboard

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Energy intensity (TOE/dried tonne)	0.409*	0.405*	0.389	0.373	0.359	0.344	0.331	0.317	0.305	0.292

**Based on CEPI statistics*

Figure 3.17 illustrates the BAU projection trends (energy consumption and production) for pulp, paper and paperboard for EU28 over the period 2012 to 2050. Production in 2010 – 2012 illustrates the impact of the EU financial downturn, however it is expected that production will recover and continue its projected growth, on the balance of the above factors considered.

Figure 3.17 BAU projection for EU production of pulp, paper and paperboard *



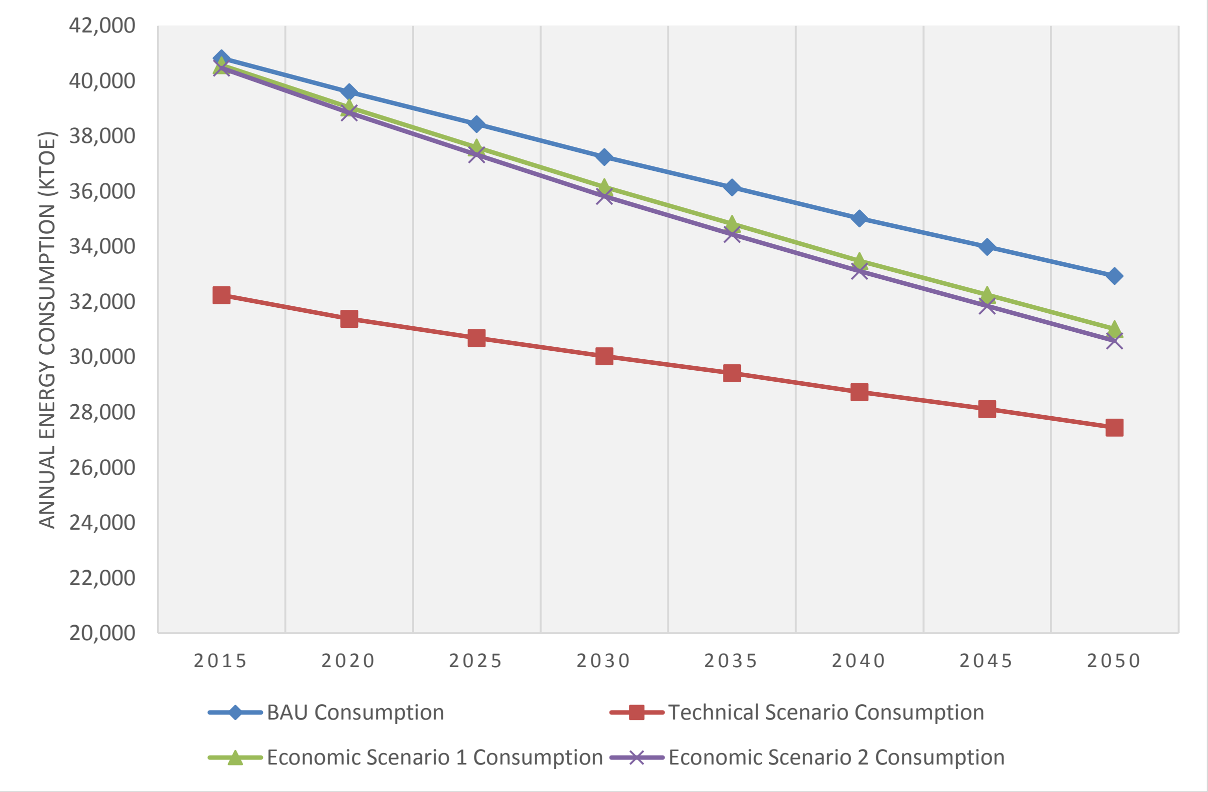
Source: ICF analysis on CEPI statistics, 2013

** Note: The energy consumption data for this sector was based on CEPI statistics, which are higher than the figures presented in EUROSTAT.*

3.1.7 Projection of energy saving potential

Figure 3.18 presents the energy consumption projections from 2011 through to 2050 under the BAU, technical and economic scenarios[25] from the modelling outputs of IEEM.

Figure 3.18 Projected economic and technical potential scenario energy use for EU pulp, paper and print sector



A total of 101 ESOs which are technically feasible to the sector were accounted for in the modelling process. The projected savings under the technical[26] potential scenario is 7.2 million TOE (19% saving) in year 2030 and 5.5 million TOE (17% saving) in year 2050 with reference to the BAU projection.

Of the 101 ESOs, a total of 43 ESOs meet the economic scenario 1 criteria (<2 year payback), resulting a projected saving of 1 million TOE (3% saving) in year 2030 and 1.9 million TOE (6% saving) in year 2050 with reference to BAU projection.

Of the 101 ESOs, a total of 64 ESOs meet the economic scenario 2 criteria (<5 year payback), resulting in a projected saving of 1.4 million TOE (4% saving) in year 2030 and 2.3 million TOE (7% saving) in year 2050 with reference to BAU projection.

The additional 21 ESOs under economic scenario 2 accounted for 21% of the overall savings in comparison with economic scenario 1. The full list of ESOs can be found in Annex 3. The list of ECOs under economic scenario 1 and 2 is presented in Annex 4.

[25] Economic scenario 1 assumes an uptake of energy saving opportunities which fulfils the less than 2 year simple payback criteria, whereas the economic scenario 2 assumes an uptake of energy saving opportunities of less than 5 year simple payback.

[26] Under the technical potential scenario, it is assumed that all technically feasible opportunities relevant to the sector is implemented regardless of economic feasibility.

The following ESOs listed in Table 3.13 represents approximately 54% of the energy saving potential under technical scenario.

Table 3.13 Projected sector ESOs with highest technical potential included in the economic scenarios 1 and 2

Energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Integrated control system	A neural network system is an example of an integrated control system. The information of the sensors is used in control systems to adapt the process conditions, based on artificial intelligence, mathematical ("rule"-based) or neural networks and "fuzzy logic" models of the industrial process.	987	821	14% / 15%
Flue-gas monitoring for boilers and dryers	Stack thermometers, fuel meters, make-up feed water meters, oxygen analyzers, run-time recorders, energy output meters, and return condensate thermometers are required to maintain a proper air-to-fuel ratio to optimize fuel combustion efficiency.	707	625	10% / 11%
Exhaust gas heat recovery (dryer)	Exhaust gas heat recovery increases efficiency because it extracts energy from the exhaust gases and recycles it back to the process, which reduces fuel/steam requirements.	465	438	6% / 8%
Inter-plant Process Integration	Process integration techniques such as pinch analysis can be applied for resource conservation. Several networks or plants may be integrated to maximize resource recovery through inter-plant integration. Requires facilities to be adjacent, and have synergies (such as utilities) which in close enough proximity to be shared.	374	236	5% / 4%
Sub-metering	Sub-meters are used to measure the amount of energy consumed by equipment, or portions of the plant. They communicate with a central system where the information is trended, stored or transferred to a data historian system for archiving.	361	231	7% / 4%
Combined Heat and Power plant	Combined heat and power (CHP) production is the simultaneous generation of heat energy and electrical and/or mechanical energy in a single process referred to as a CHP plant. CHP plants raise the conversion rate of fuel use (fuel efficiency level) from around one-third in conventional power stations to around 80 – 93%.	360	235	5% / 4%
Increased uptake of Energy Management System (EnMS)	A series of systemised interacting processes that enables an organization to obtain relevant energy information and act upon it to maintain and improve energy performance, while reducing environmental emissions as a consequence.	360	298	5% / 5%
Black Liquor Gasification	Chemical pulp plants are favourable for the production of a variety of "green" chemicals as well as biofuels. This extension of a pulp plant into a bio-refinery would allow improved use of wood residues.	225	152	3% / 3%

A significant portion of energy saving potential in Table 3.13 (integrated control system, inter-plant process integration and EnMS) are relevant to 'system level' opportunities, i.e. an interaction between the local and other components is required to result an energy saving benefit.

Referring to CEPI statistics 2013, approximately 96% of total energy generated on-site at pulp and paper mills are CHPs. However, approximately 51% of total electrical energy consumed within the pulp and paper mills are generated on-site, indicating a significant market share is still available for implementation of CHP in this sector.

The following additional ESOs in Table 3.14 are sector specific ESOs which are technically feasible but unaccounted for in the economic scenarios as they did not meet the respective payback criteria.

Table 3.14 Projected technical potential sector specific Energy Saving Opportunities

Sector specific energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
TMP Refiner Heat Recovery	In integrated plants, the waste heat can be used in the paper machine. Depending on the process design and grinding intensity, about 20-40% of the electricity consumed can be recovered in the form of steam, and a further 20-30% in the form of hot water	16	0	0.2% / 0%
Efficient TMP refiner and pre-treatment	Pre-compression of wood feedstock demonstrated results in electrical savings. The use of wood shavings instead of wood chips could also reduce electrical consumption. High efficiency refiners have emerged over the years saving more than 10 – 15% of energy compared to conventional disc refiners.	33	22	0.5% / 0.4%
Efficient Screening of Recovered Fibers	Improvements were made in the field of screening and filtering. Increasing the slurry consistency from 1.5 to 2.5% results in considerable EE improvement. Further optimization of the screening process showed energy savings of 5-30%, depending on the plant characteristics.	8	5	0.1% / 0.1%
Paper Process Heat Recovery and Integration	Heat recovery and the use of waste heat are widespread in the paper industry. Large potentials are found in the use of waste heat from the dryer section in the paper machine and the effluent water. In particular, the use of low temperature heat still shows further potential, but also the steam system is often not adequately optimized.	195	164	2.7% / 3.0%
Paper Drying Section Shoe Press	The shoe press is integrated into the paper machine's press section, improving dewatering of the paper web by an increased pressing surface between the two rollers. This reduces the demand for thermal drying, while the electricity demand increases slightly. As rule of thumb, it is assumed that a 1% increase in the paper web's dry content results in 5% steam savings in the drying section.	120	100	1.7% / 1.8%
Efficient Paper Process Refiners	The reduction of idle running time comprises a large saving potential. They expect that new refining concepts will allow reduction of the idle-running losses.	21	14	0.3% / 0.3%

Sector specific energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Energy efficient vacuum systems for dewatering.	Efficient vacuum systems have an automatic speed control to adapt to changes in speed, grammage and felt age. Recuperation of a large share of the pumping energy by recuperation of the exhaust air heat energy.	16	11	0.2% / 0.2%
Thermo Compressors	Thermo-compressors are used to increase the pressure of the exhaust vapours from separators which enables a recovery of the exhaust vapour to use it again in the drying process.	83	73	1.1% / 1.3%
Heat recovery for the biomass and sludge drying process	Use of excess heat for the drying of biomass and sludge, to heat boiler feedwater and process water, to heat buildings, etc.	11	7	0.2% / 0.1%
Heat recovery from radial blowers used in vacuum system	The hot exhaust air from the vacuum blowers can be passed through air-to-air heat exchangers enabling the recuperation of up to 75% of the power absorbed by the vacuum blowers. Radial blowers are used for wire and felt dewatering across all grades and are normally installed in larger paper machines.	134	127	1.9% / 2.3%
High Efficiency grinding for Mechanical Pulp	Different concepts aim at EE improvement of wood grinding design. One of these is to use fully metallic grinders with optimized grinding surface patterns instead of stone or ceramics.	68	46	0.9% / 0.8%
Enzymatic Pre-treatment for TMP Refiner	Pre-treating wood chips using enzymes reduces the mechanical energy needed for wood processing. New approaches combine the use of enzymes with low-intensity refining to improve the penetration of the enzymes into the wood.	50	34	0.7% / 0.5%

3.2 Iron and Steel

3.2.1 Structure and economic contribution

The EU is the world's second largest steel producer after China, accounting for 10% of global crude steel production in 2013. EU Crude steel production is concentrated in a relatively limited number of Member States. Nine Member States (Germany, Italy, France, Spain, United Kingdom, Poland, Belgium, Austria, and the Netherlands) accounted for 83% of the total EU production in 2013 [EUROFER, 2014]. The sector is made up of 4 main groups, with production of basic iron and steel and of ferro-alloys being the most significant sector. The key economic indicators for the iron and steel sector is detailed in Table 3.15.

Table 3.15 Key economic indicators on iron and steel sector for EU 28 for 2012

Description	NACE (Group)	NACE (Class)	No. of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of basic iron and steel and of ferro-alloys	C24.1		2,394	312,590	140,665	18,023	138,011
Manufacture of basic iron and steel and of ferro-alloys	-	C24.10	2,394	312,590	140,665	18,023	138,011
Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	C24.2		2,019	114,968	32,320	6,821	31,005
Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	-	C24.20	2,019	114,968	32,320	6,821	31,005
Manufacture of other products of first processing of steel	C24.3		2,926	69,827	21,544	3,877	20,603
Cold drawing of bars	-	C24.31	260	6,328	1,929	360	1,898
Cold rolling of narrow strips	-	C24.32	205	12,609	5,185	810	4,965
Cold forming or folding	-	C24.33	1,861	29,295	7,248	1,452	6,973
Cold drawing of wire	-	C24.34	600	21,595	7,182	1,254	6,768
Casting of metals	C24.5		1,961	123,113	18,924	5,680	18,567
Casting of iron	-	C24.51	1,467	93,399	14,747	4,249	14,431
Casting of steel	-	C24.52	494	29,714	4,177	1,431	4,136

Source: EUROSTAT, accessed Dec 2014

3.2.2 Subsector share of energy consumption

Primary fuel is used in the iron and steel sector for onsite power generation, process heat and also as raw material for iron making. In EUROSTAT, the total energy consumed within the iron and steel sector (including the upstream raw material preparation process) is reported under 4 different sections as follows in Table 3.16:

Table 3.16 EUROSTAT classification for total energy consumed within the iron and steel sector

Iron and steel production process	EUROSTAT classification
Sintering and pelleting	Mining
Coke production (Coke Ovens)	Energy transformation
Iron making process (Blast Furnace)	Energy transformation
Steel making process (Basic Oxygen Furnace and Electric Arc Furnace)	Iron and steel
Casting and finishing processes	Iron and steel
On site power generation	Energy

The share of energy figures presented in Table 3.17 is an estimate of the iron and steel subsector share of energy use based on the key energy consuming processes along the production chain and its production output quantity of the respective subsector. The key processes were streamlined more towards the steel making process (Basic Oxygen Furnaces BOF and Electric Arc Furnaces EAF) and casting at foundries which are considered more homogenous while the remaining energy content were then apportioned to the more diverse processes in producing semi-finished and finished products (hot rolling, cold rolling, pipe making, drawing, annealing, etc.). Note that the EUROSTAT energy reported under iron and steel sector only covers the steel making process and does not account for the energy consumed in the overall process from iron ore to metal and on site generation. As such, this study only takes the final energy consumption of downstream steel-making process into consideration its projections in order to harmonize with EUROSTAT data. The final energy consumption for the upstream process (sintering and peletting, coke production, iron making process and on-site power generation) is excluded from the study's projections.

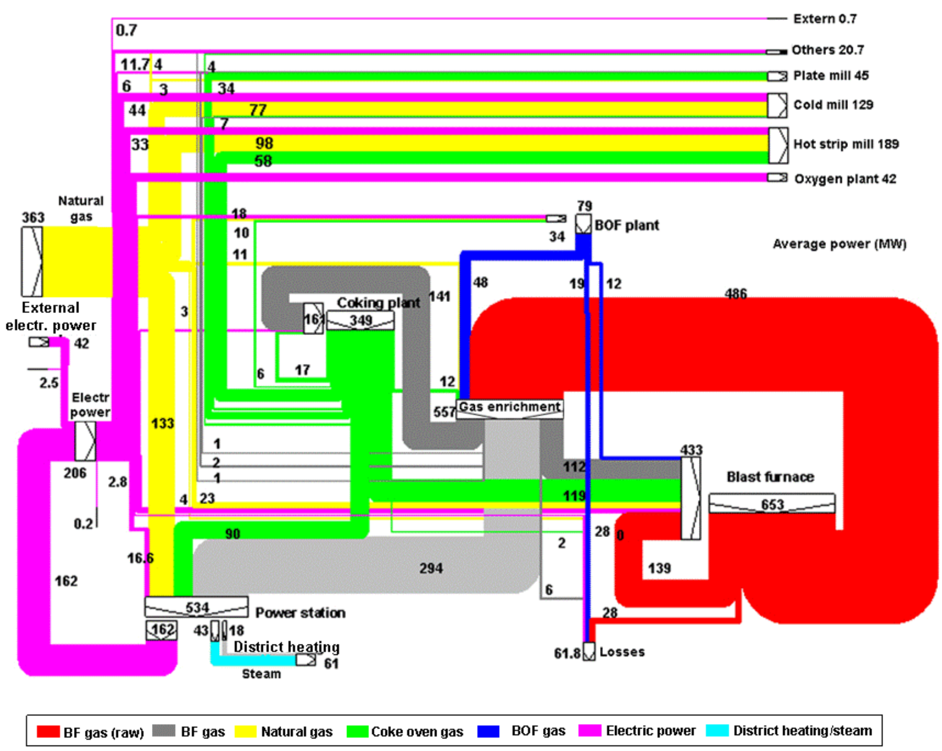
Table 3.17 Estimated EU28 iron and steel subsector share of energy demand in 2012

Sector Description	NACE (Group)	Category	Estimated share of final energy demand	
			[kTOE]	*[%]*
Manufacture of basic iron and steel and of ferro-alloys	C24.1	Energy intensive	37,771	73%
Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	C24.2	Energy intensive	12,465	24%
Manufacture of other products of first processing of steel	C24.3	Non-energy intensive		
Casting of metals (iron and steel)	C24.5	Energy intensive	1,281	2%
Total final energy demand for iron and steel sector for EU28 (2012):			**51,517**	**100%**

3.2.2.2 *Primary fuel for energy and non-energy application*

The interrelationship between primary fuel (coal and heavy oil) as raw material and energy input creates a rather complex energy balance within the iron and steel industry. Firstly, the primary resource input utilized in the coal pyrolysis process produces coke and Coke Oven Gas (COG). Coke is then used as feedstock for the iron making process and COG is utilized as an energy resource after cleaning. Secondly, the coke consumed in the Blast Furnace for iron ore reduction process produces hot metal and Blast Furnace Gas (BFG), which is also utilized as energy resource after cleaning. Thirdly, the gasses produced from the Basic Oxygen Furnace during the hot metal oxidation process produces crude steel and BOF Gas, containing large amounts of Carbon Monoxide rich flue gas which can be cleaned for subsequent use as fuel. The application and quality of these 3 gasses as fuel will vary depending on plant specifics (integrated or non-integrated, technology employed, etc.) and ultimately impact the amount it is able to supplement primary fuel used in the Coke Oven, BF, BOF and on-site generation plants. On-site power generation (captive power plants) plays a crucial role in the iron and steel plants due to the availability of Coke Oven Gas, Blast Furnace Gas and Basic Oxygen Furnace Gas, which could be applied in a power plant to produce electricity or both electricity and heat (steam) in a CHP plant.

Figure 3.19 Typical energy flow for a primary BF-BOF iron and steel plant



Source: BREFF, 2012

3.2.3 Key products

The production of iron and steel could be categorised in the following key categories:

Crude steel. Crude steel is defined as steel in its first solid state after melting (ArcelorMittal, 2014). Crude steel are semi-finished products where further downstream processing is required to form finished products for the consumer market. Crude steel is categorized into 3 main quality levels: non-alloy; other alloy; and stainless steel. In 2013, the production mix consisted of 80.8%, 14.9% and 4.3% of total crude steel production respectively (EUROFER, 2014b). In 2013, approximately 40% of the total crude steel production in Europe was produced by EAF technologies and this share has been rising for years. The remaining 60% is produced by BOF technologies (World Steel Association, 2014).

Semi-finished products. Semi-finished products include steel shapes (blooms, billets or slabs) that are later rolled into finished products such as beams, bars or sheet. Continuous casting is the process whereby molten metal is solidified into a semi-finished billet, bloom, slab or beam blank.

Finished products. Finished products are subdivided into two basic types, flat and long products: Flat products include slabs, hot-rolled coil, cold-rolled coil, coated steel products, tinplate and heavy plate. They are used in automotive, heavy machinery, pipes and tubes, construction, packaging and appliances. Flat products represent approximately 60% of the EU hot rolled steel output; this proportion was constant over the period 2002-2011, meaning that EU countries maintained their solid position in the high added-value portion of the steel market (Ecorys, 2008). Long products: include billets, blooms, rebars, wire rod, sections, rails, sheet piles and drawn wire. The main markets for these products are construction, mechanical engineering, energy and automotive (ArcelorMittal, 2014).

3.2.4 Key sector processes

Figure 3.20 provides an overview of the key processes in EU iron and steel production, which is produced through 2 main routes, primary or secondary. Currently, the primary route involves the production of steel through the Blast Furnace – Basic Oxygen Furnace route while the secondary route involves the recovery of metal from scrap and waste stream by utilizing the Electric Arc Furnace (EAF).

Primary iron and steel making involves the following key stage processes; raw material preparation, iron making and steel making process:

Raw material preparation. During this stage, coal is converted into coke through a pyrolysis process in a coke oven plant, producing coke (solids which are raw material fed into the iron making process), coke oven gas (used as fuel after cleaning) and liquids. The operating temperature of the coke oven gas is between 1150 – 1350 °C. To improve the iron ore reduction process in the next stage, the raw materials goes through a sintering (a process of mixing raw materials with additives before charging into blast furnace) or pelletisation (a process of forming raw material mixture into 9 – 16mm spheres through high temperature process). In the period of 2005 – 2008, there are 34 sintering plants and 6 pellet plants within EU (JRC, 2012a).

Iron making process. The raw material (coke, sinter / pellets, lump ore) is fed into the Blast Furnace (BF) which reduces the iron oxides to metal iron. The liquid iron (hot metal or 'pig iron') is collected and continuously caste. This process also produces BF gas which is collected and treated before utilized as fuel.

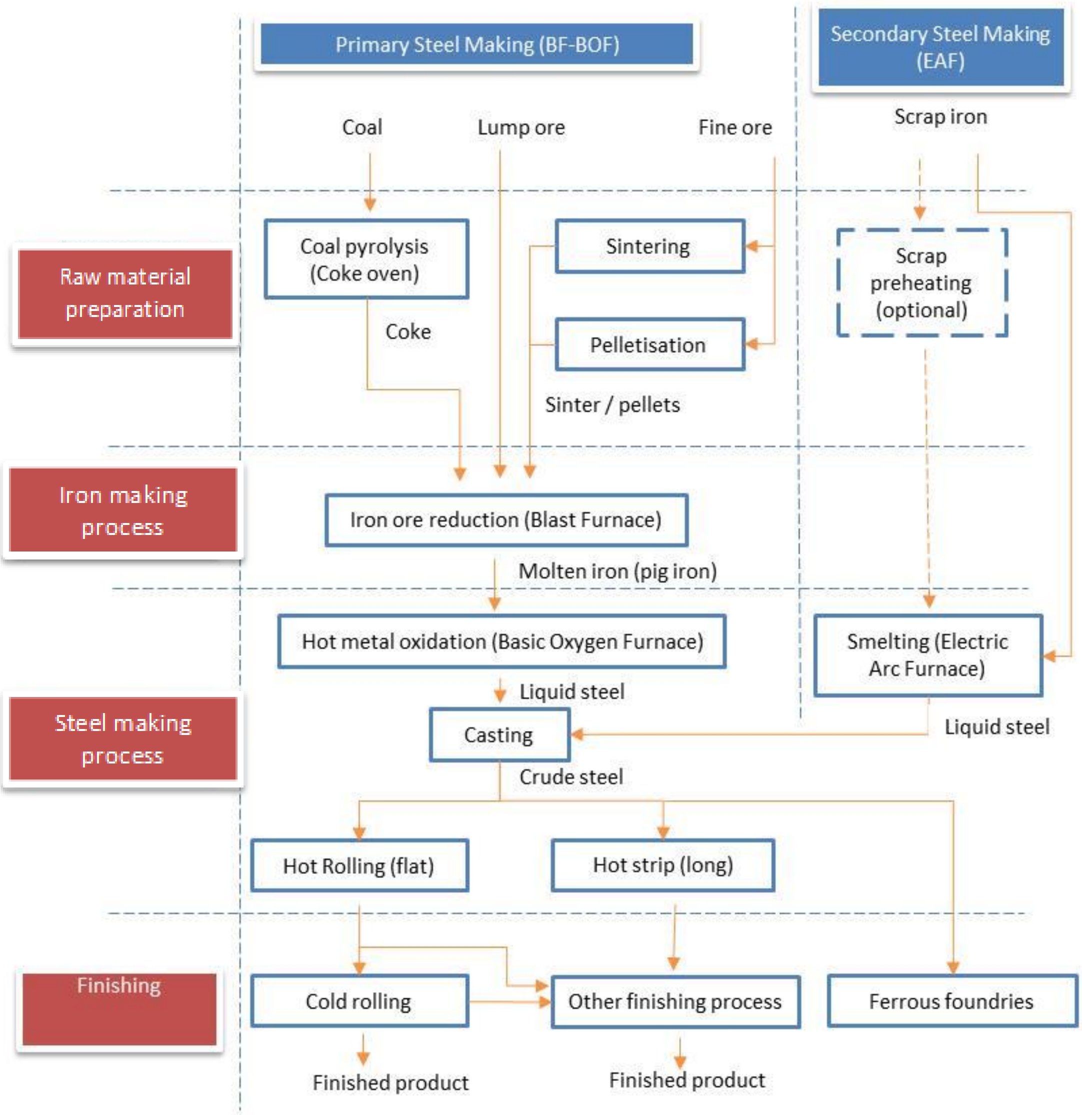
Steel making process. The key objective of this stage is to regulate the impurities within the hot metal feedstock. As a result, carbon content is reduced to a specified level (from 4 – 5% to 0.01 – 0.4%), contents of desirable foreign elements are regulated and undesirable impurities are burned (oxidised) in the Basic Oxygen Furnace (BOF). The liquid molten steel from the BOF is the casted into crude steel forms (slabs, blooms, billets) for further processing.

Secondary steel making process involves direct smelting of materials which contain iron typically from scrap and recycled iron feedstock from waste streams, essentially omitting the energy intensive process of coal pyrolysis and iron ore reduction process, requiring much lower consumption. In this process, the scrap iron is melted and refined utilizing high amounts of electric current carried out in an Electric Arc Furnace (EAF).

Finishing. There are 2 main classification of finished steel products; flat and long. Long products goes through further finishing products to form seamless pipes, bars, rolls and wires. Flat products goes through further finishing process to form cold rolled sheets, steel plates, welded pipes, coated sheets, etc.

In 2006, there were 86 BF installations, 101 BOF installations and 231 EAF installations within EU (JRC, 2012).The BOF and EAF process has since replaced the less efficient Open-Hearth steel making process. Within EU, the BF-BOF and EAF are the only processes being used for steel making. There are only 2 remaining Open-Hearth furnaces operating in the EU, representing 1.6% of total EU production. There are also 2 plants utilizing the emerging method of Direct Reduced Iron – Electric Arc Furnace (DRI – EAF) steelmaking, which represents 0.2% of total EU production. [JRC, 2012]. In 2013, there are a total of 1,992 casting plants (ferrous foundries) within the EU [CAEF, 2014].

Figure 3.20 Overview of the primary and secondary steel production process



3.2.5 Energy metrics

3.2.5.1 Energy intensity based on sector energy cost

Table 3.18 provides an indication of the sector's energy intensity for selected EU Member States expressed in 2 ratios[27] from 2008 - 2012. Based on the 5 year energy intensity ratios, the intensity ratio 1 in 2012 increased by approximately 24% in comparison with 2008. This trend does not reflect the sector's longer term energy trend (discussed in Section 3.2.6) as the data presented here coincides with EU's financial crisis period, whereby production of crude steel was very much effected in 2009 resulting in a distorted trend of the energy intensity. The iron and steel sector ranks 2nd most energy intensive sector (after petroleum refineries) in

[27] (1) Ratio of energy cost per unit of value added and (2) Ratio of energy cost per unit of turnover, i.e. the monetary value paid by manufacturers on energy products for every unit of value added or turnover generated by the sector.

comparison with the 8 industrial sector groups evaluated in this Study in terms of energy cost spent per value added generated.

Table 3.18 Energy cost intensity ratios per unit of VA and Turnover generated for selected MS *

	Ratio	2008	2009	2010	2011	2012
1	Energy cost/ Value Added	29%	43%	36%	33%	36%
2	Energy cost/ Turnover	6%	8%	7%	6%	6%

Source: ICF analysis on EUROSTAT SBS, accessed Dec 2014

** Note: Data covers Belgium, Germany, Greece, Spain, France, Italy, Hungary, Austria, Portugal, Sweden and UK.*

3.2.5.2 Energy intensity of key processes

Table 3.19 and Table 3.20 presents the best practice energy intensity of key processes within the production process of iron and steel production through primary (BF-BOF route) and secondary (EAF route) process. The energy figures present the final energy consumed during the process and the figures are expressed with reference to per tonne of crude steel produced. The final energy consumed takes manufactured gas into account (Coke Oven Gas, BF Gas and BOF Gas).

Table 3.19 World best practice energy intensity of key processes in primary primary iron and steel production (BF-BOF route)

Process	Thermal [GJ / tonne]	Electricity [GJ / tonne]	Final Energy [GJ / tonne]
Material Preparation			
Coke production (Coke Oven)[28]	0.7	0.1	0.8
Sintering	1.7	0.2	1.9
Iron Making Process			
Iron ore reduction (Blast Furnace)	12.1	0.1	12.2
Steel Making Process			
Hot metal oxidation (Basic Oxygen Furnace)	0.12	0.1	0.22
Continuous cast	0.05	0.05	0.1
Hot rolling - strip	1.3	0.3	1.6
Hot rolling - bar	1.6	0.3	1.9
Hot rolling - wire	1.7	0.4	2.1
Cold rolling	0.2	0.3	0.5
Total (based on hot rolled strip)	**15.9**	**0.8**	**16.7**

Source: Adapted from LBNL report[29]

[28] This figure only takes the energy consumption of the coke oven into account and excludes the coking coal raw material input.

[29] Worrell et al, World Best Practice Energy Intensity Values for Selected Industrial Sectors, 2008

Table 3.20 World best practice energy intensity of key processes in secondary steel production (EAF route)

Process	Thermal [GJ / tonne]	Electricity [GJ / tonne]	Final Energy [GJ / tonne]
Steel Making Process			
Smelting of scrap metal (Electric Arc Furnace)	0.9	1.5	2.4
Continuous cast	0.05	0.05	0.1
Hot rolling - strip	1.3	0.3	1.6
Hot rolling – bar	1.6	0.3	1.9
Hot rolling – wire	1.7	0.4	2.1
Cold rolling	0.2	0.3	0.5
Total (based on hot rolled strip)	**2.5**	**1.8**	**4.1**

Source: Adapted from LBNL report

Within the EU-27, the average energy intensity for production through the BF-BOF or EAF route is assumed to be 21 GJ and 4.5GJ per tonne of crude steel in the form of hot rolled products respectively (SETIS, 2010). In 2013, 60.2% of crude steel produced within the EU-27 was produced through the BF-BOF route while the remaining 39.8% was produced through the EAF route (World Steel Association, 2014). Therefore, on average, the EU's energy intensity amounts to 14.4 GJ (0.345 TOE) per tonne of crude steel produced, as detailed in Table 3.21.

Table 3.21 Summary of EU average energy intensity in crude steel production for 2013

Route	Volume [mil tonnes]	% of total volume	Average Energy intensity
BF-BOF	99.9	60.2%	21 GJ / t of crude steel
EAF	66.0	39.8%	4.5 GJ / t of crude steel
EU27 Total	**165.9**	**100%**	**14.4 GJ / t of crude steel**

3.2.5.3 EU final energy consumption and energy mix for iron and steel sector

Table 3.22 and Figure 3.21 provides a summary of the final energy consumption and fuel mix for iron and steel sector for EU28 as a whole.

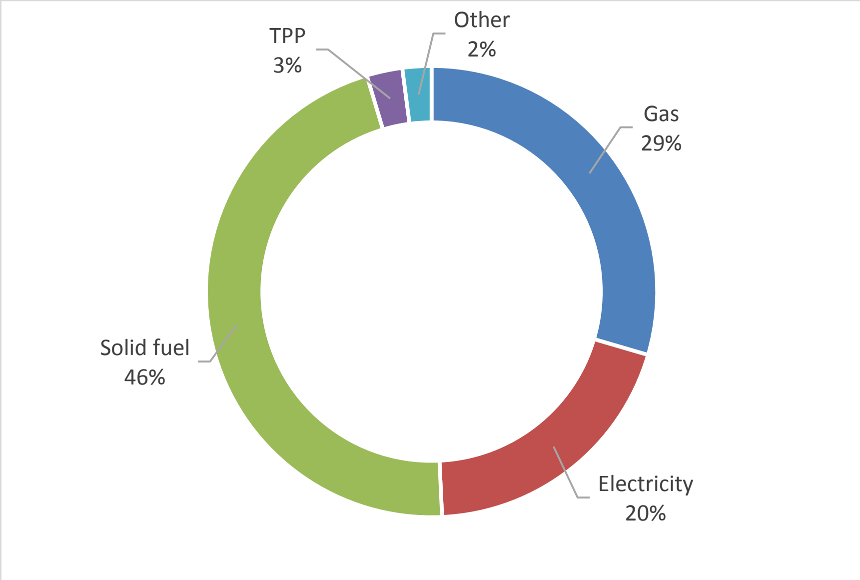
Table 3.22 Primary energy consumption for EU iron and steel sector in 2012

EU primary energy consumption for the sector	kTOE	% of total
Gas	15,213	30%
Electricity	10,163	20%
Solid fuel	23,754	46%
TPP	1,319	3%
Other	1,069	2%

EU primary energy consumption for the sector	kTOE	% of total
Total final energy demand	**51,517**	

[Source: EUROSTAT, accessed Dec 2014]

Figure 3.21 Energy mix for EU iron and steel sector in 2012

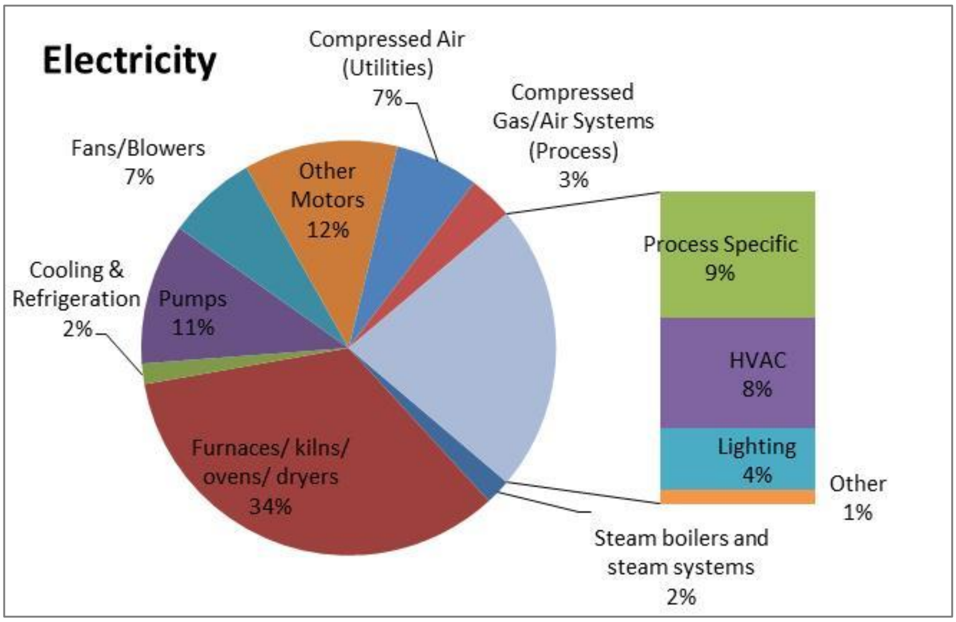


Source: EUROSTAT, accessed Dec 2014

3.2.5.4 Energy end use profile

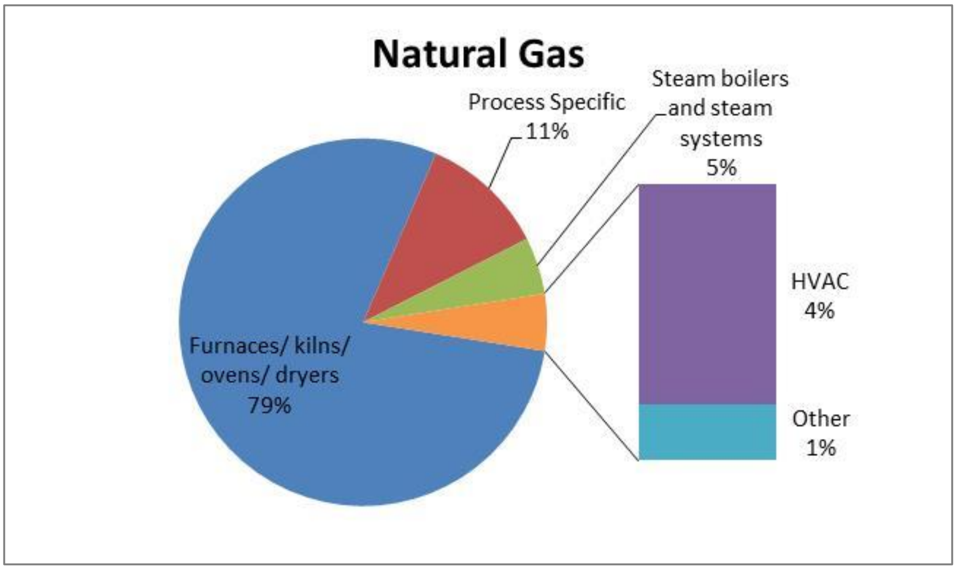
Based on the estimated share of energy consumption amongst the iron and steel sector, the following figures present an aggregate energy use profile for the primary energy sources, including electricity, natural gas, total petroleum products (i.e., oil), coal, and other fuel

Figure 3.22 Electricity use profile



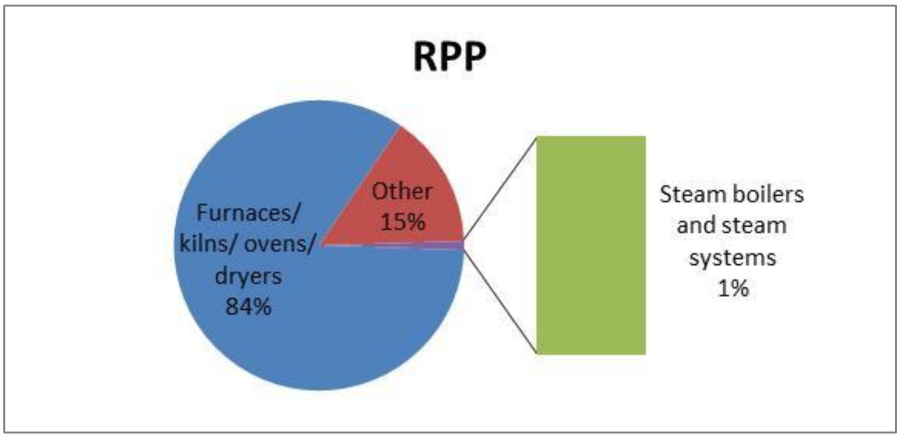
Source: ICF internal data

Figure 3.23 Natural gas use profile



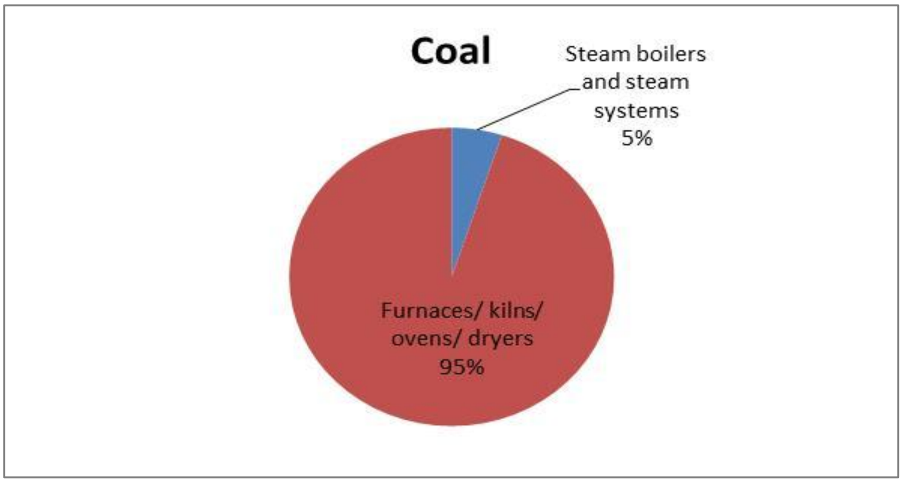
Source: ICF internal data

Figure 3.24 Total Petroleum Products use profile



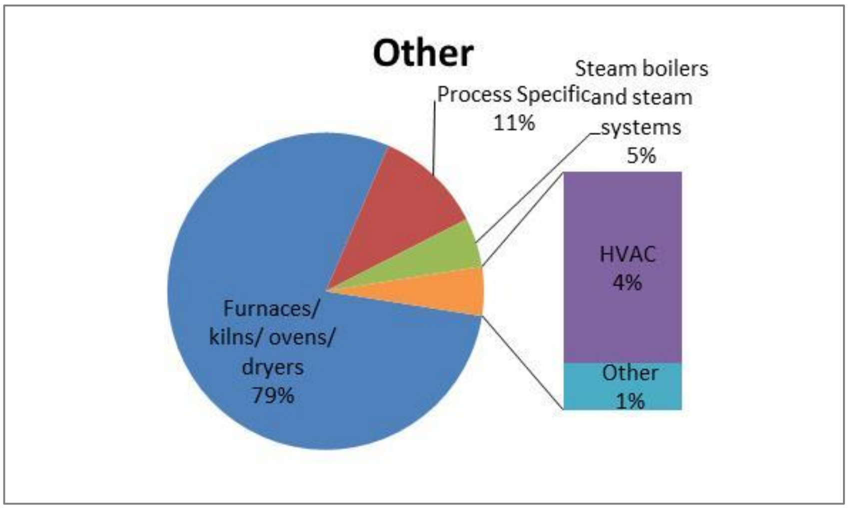
Source: ICF internal data

Figure 3.25 Coal use profile



Source: ICF internal data

Figure 3.26 Other fuel use profile



Source: ICF internal data

3.2.6 Projection of energy consumption trend

The following details are an extracted summary of the sector profile in Annex 1.

EUROFER and Boston Consulting Group provided a forward looking projection of the EU's steel production trend as detailed in Table 3.23. The expected growth in EU crude steel production was for an average annual increase of 0.8% p/a from 2010 – 2050. EU demand for steel use over the short range period (2013 – 2015) was forecasted to grow annually at a rate of approximately 3%. EU steel makers have remained competitive in terms of overall costs and in terms of quality, through a continuous process of investments and restructuring, and this despite energy prices and raw materials, labour and regulatory costs among the highest worldwide (EUROFER, 2013). Global crude steel production reached 1.52 billion tonnes in 2012, 11% of which was produced in EU27. Looking at the longer term statistical trend, EU27 production of crude steel has remained relatively flat throughout the period of 1980 – 2008 whereby the production output was 208 and 199 million tonnes respectively. There was a drastic drop in production to 139 million tonnes in 2009, which coincides with EU's financial crisis, followed by a gradual increase to 166 million tonnes in 2013 (World Steel Association statistics, accessed in 2014). Even if the European steel industry's share of the world market does shrink appreciably, Europe will remain an important steel-producing region, as manufacturing networks with important local customers continue to deliver essential advantages (Deutsche Bank Research, 2009). The steel industry in Europe should continuously maintain and improve its ability to compete with products produced in third countries, facilitate process and product innovation to meet advanced customer demand and continually reduce production costs. However, competitors are also improving their technological capacities and competencies reducing the gap.

Table 3.23 Projected production of crude steel in EU (million tonnes)

	2011	2015	2020	2025	2030	2035	2040	2045	2050
Production (MT)	178	185	191	197	204	213	222	229	236

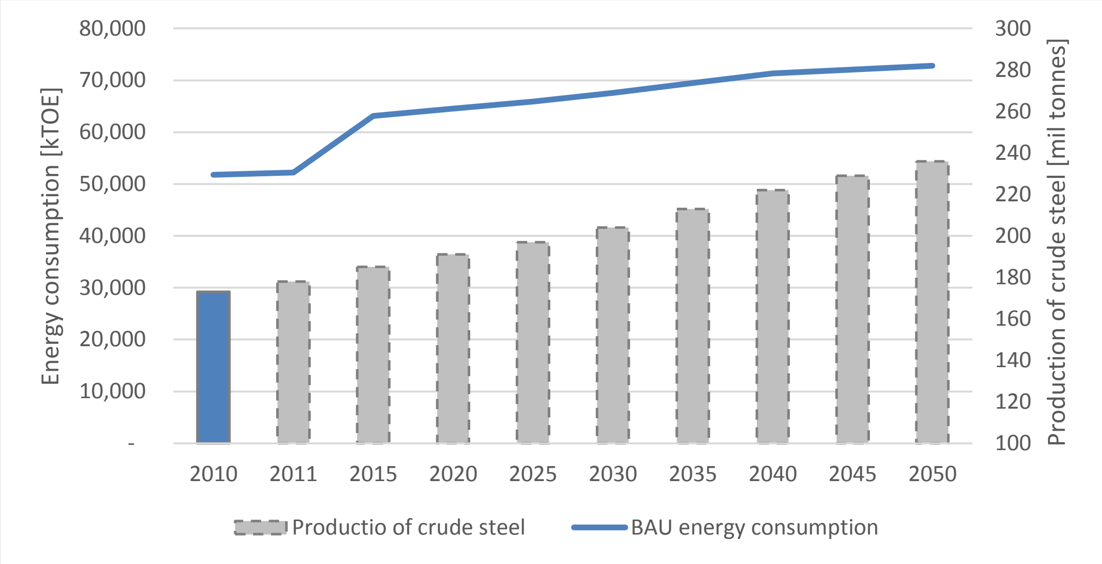
The EU iron and steel industry has been continuously improving its energy intensity over time, primarily driven by commercial factors of increasing energy prices. Taking the UK as an example, the energy intensity reduced from 31.7 GJ/t in 1973 to 19.6 GJ/t in 2013 (EEF, 2013). The improvement trend was drastic in the 1970s and 1980s, primarily due to the uptake of disruptive technology then, i.e. the BF-BOF and EAF production route, replacing the less efficient open-hearth production route. The improvement trend was more gradual from the 1990s to date. Based on the limitations of emerging energy efficient technologies in steelmaking (such as Top Gas Recycle Blast Furnace, ULCORED and HIsarna), the energy intensity is expected to reduce gradually from 2011 – 2030. Upon the commercialization of breakthrough technologies breakthrough, expected in 2030 – 2040, the energy intensity trend will reduce further thereafter. Table 3.24 presents the projected energy intensity trend.

Table 3.24 Projected energy intensity trends for production of iron and steel

	2011	2015	2020	2025	2030	2035	2040	2045	2050
Energy intensity (TOE/dried tonne)	0.345	0.341	0.338	0.334	0.331	0.324	0.318	0.308	0.299

Figure 3.27 illustrates the projected energy consumption and production trend for manufacture of iron and steel in EU27 over the period 2012 to 2050.

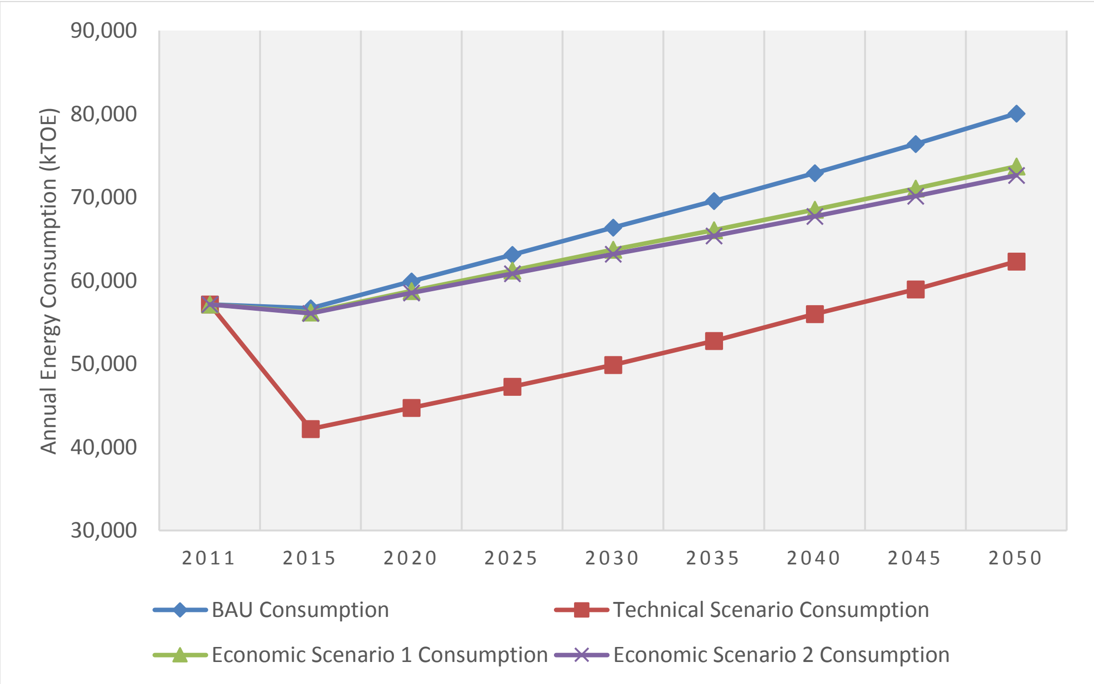
Figure 3.27 BAU projection for EU production of iron and steel



3.2.7 Projection of energy saving potential

Figure 3.28 presents the energy consumption projections from 2011 through to 2050 under the BAU, technical and economic scenarios[30] from the modelling outputs of IEEM.

Figure 3.28 Projected economic and technical potential scenario energy use for EU iron and steel sector



[30] The economic scenario 1 assumes an uptake of energy saving opportunities which fulfils the less than 2 year simple payback criteria, whereas the economic scenario 2 assumes an uptake of energy saving opportunities of less than 5 year simple payback.

A total of 94 ESOs which are technically feasible to the sector were accounted for in the modelling process. The projected saving under the technical[31] potential scenario is 16.3 million TOE (24% saving) in year 2030 and 18.9 million TOE (26% saving) in year 2050 with reference to the BAU projections. The sharp rise from 2011 to 2015 is mainly contributed to the projected recovery of the steel production output due to the EU financial crisis which resulted in a drastic drop back in 2009.

A total of 38 ESOs were included under economic scenario 1, resulting in a projected saving of 2.9 million TOE (4.3% saving) in year 2030 and 6.2 million TOE (8.6% saving) in year 2050 with reference to the BAU projections.

An additional 19 ESOs, i.e. a total of 57 ESOs, were included under economic scenario 2, resulting in a projected saving of 3.1 million TOE (4.6% saving) in year 2030 and 6.8 million TOE (8.6% saving) in year 2050 with reference to BAU projections. This is only an additional of 0.3% savings in 2030 and 0.8% savings in 2050 in comparison with economic scenario 1, because the additional energy saving potential under economic scenario 2 has a much lower energy saving impact, despite a higher payback time and they only accounted for 7% of the overall savings in comparison with ESOs under economic scenario 1. The full list of Energy Saving Opportunities is listed in Annex 3. The list of ECOs under economic scenario 1 and 2 is presented in Annex 4.

The following ESOs listed in Table 3.25 represent approximately 71% of the overall sector energy saving potential.

Table 3.25 Projected sector ESOs with highest technical potential

Energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
State-of-the-art power plant	Most power plants operating on steel plant gases consist of a boiler in combination with a steam turbine which provides the necessary flexibility to operate on different types of gas produced in the steel. The total average efficiency of the conversion of energy of steel plant gases to electricity is currently 32%. This current average efficiency could be increases by replacing older installations with new state-of-the-art steam boiler and turbine technologies.	1621	4314	10% / 23%
Inter-plant Process Integration	Process integration techniques such as pinch analysis can be applied for resource conservation. Several networks or plants may be integrated to maximize resource recovery through inter-plant integration. Requires facilities to be adjacent, and have synergies (such as utilities) which in close enough proximity to be shared.	1941	2010	12% / 11%

[31] Under the technical potential scenario, it is assumed that all technically feasible opportunities relevant to the sector is implemented regardless of economic feasibility.

Energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Integrated control system	A neural network system is an example of an integrated control system. The information of the sensors is used in control systems to adapt the process conditions, based on artificial intelligence, mathematical ("rule"-based) or neural networks and "fuzzy logic" models of the industrial process.	1775	1789	11% / 9%
BOF Waste Heat and Gas Recovery	Two systems can be used to recover energy from the converter gas. In the first one, the combustion of BOF gas takes place in the converter gas duct and, subsequently, the sensible gas is recovered in a waste heat boiler. Alternatively, the BOF gas is cleaned, cooled and stored in a gas holder for further use.	1227	1180	8% / 6%
High Efficiency Burner for furnace	These burners are more efficient at higher-temperature applications. Advancements over the recent years include the commercialization of self-recuperative and self-regenerative burners that use staged combustion to achieve flameless combustion. This results in more uniform heating, lower peak flame temperatures, improved efficiency and lower NOx emissions.	1207	1049	7% / 6%
Flue-gas monitoring (furnace)	Stack thermometers, fuel meters, make-up feed water meters, oxygen analysers, run-time recorders, energy output meters, and return condensate thermometers are required to maintain a proper air-to-fuel ratio to optimize fuel combustion efficiency.	982	850	6% / 5%
Exhaust gas heat recovery (furnace)	Exhaust gas heat recovery increases efficiency because it extracts waste energy from the exhaust gases and recycles it back to the process, which reduces fuel/steam requirements.	900	816	6% / 4%
Sub-metering and interval metering	Sub-meters are used to measure the amount of energy consumed by equipment, or portions of the plant. They communicate with a central system where the information is trended, stored or transferred to a data historian system for archiving.	763	801	5% / 4%
Combustion optimization (furnace)	Combustion efficiency can be improved by frequent adjusting of the air-to-fuel ratio to reduce excess air as too much excess air carries away excessive amounts of heat.	634	549	4% / 3%

Energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Increased uptake of Energy Management System (EnMS)	A series of systemised interacting processes that enables an organization to obtain relevant energy information and act upon it to maintain and improve energy performance, while reducing environmental emissions as a consequence.	611	597	4% / 3%

From these shortlisted ESOs with the highest energy saving impact, most of them are again relevant to system[32] level technical measures. Combustion optimization stands out as one of the opportunities with almost no cost, as it is a best practice for operation and maintenance of a furnace, with significant impact on energy consumption.

The following sector specific ESOs listed in Table 3.26 are technically feasible for the sector but unaccounted for in the economic scenarios as they did not meet the respective payback criteria.

Table 3.26 Projected technical potential of sector specific ESOs

Sector specific energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Coke Dry Quenching (CDQ)	CDQ is an alternative to the wet quenching of hot coke in order to recover thermal energy. A further advantage of CDQ is that it uses less water, not easily available everywhere	523	509	3.2% / 2.7%
Continuous Casting	Continuous casting replaces the primary rolling process, including re-heating by casting the slabs, blooms or billets directly to the right shape for hot rolling.	403	533	2.5% / 2.8%
Scrap Pre-Heating	Scrap preheating is a technology that can reduce the power consumption in the EAF process by utilising the waste heat of the furnace to preheat the incoming scrap charge	36	46	0.2% / 0.2%
Sinter Plant Waste Heat Recovery	Generally, there are two systems that can be used to recover energy from the sintering process. (1) The hot exhaust gas from the sinter bed can be returned to the sinter bed as combustion air, thus reducing energy consumption through savings in coke use. (2) Energy from the hot sintered ore is recovered at the end of the sinter bed using a sintered ore cooling system where air is heated up and can later be used to generate steam.	251	241	1.5% / 1.3%

[32] An interaction between the local and other components is required to result an energy saving benefit

Sector specific energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Optimized Sinter Pellet Ratio (Iron Ore)	The aim is to achieve a sinter-pellet ratio of at least 50/50 for each Blast Furnace in order to reduce CO2 emissions and resulting in increased energy savings.	173	170	1.1% / 0.9%
Top Gas Recovery Turbine (TRT)	The top gas from the Blast Furnace has an over-pressure which can be used to produce additional electricity using a TRT	43	56	0.3% / 0.3%
Stove Waste Gas Heat Recovery	The heat recovery system improves the efficiency of the Hot Blast Stoves, as thermal energy of waste gas discharged from the Hot Blast Stoves is partially recovered in external heat exchangers and typically used to pre-heat the Blast Furnace gas and/or combustion air.	73	70	0.4% / 0.4%

3.3 Non-metallic minerals

3.3.1 Structure and economic contribution

The non-metallic minerals sector contributed to 1.5% of the EU's GDP in 2011 (Eurostat; 2013). Key economic contributions are delivered by 4 key groups: Manufacture of glass (NACE C23.1), ceramic (NACE C23.2; 23.3; 23.4; 23.7; 23.9), cement and lime (NACE 23.5, 23.6). Key economic indicators for the non-metallic minerals sector are summarised in Table 3.27.

Table 3.27 Key economic indicators on sector division and group level for EU 28 for 2012

Description	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of other non-metallic products	C23	97,975	1,259,267	207,520	61,002	193,297
Manufacture of glass and glass products	C23.1	15,711	305,862	45,000	15,000	42,424
Manufacture of refractory products	C23.2	860	30,932	5,899	1,640	5,268
Manufacture of clay building materials	C23.3	3,627	114,974	17,073	5,624	16,196
Manufacture of other porcelain and ceramic products	C23.4	13,288	97,819	8,822	3,314	7,679
Manufacture of cement, lime and plaster	C23.5	1,100	62,680	19,982	6,639	19,520
Manufacture of articles of concrete, cement and plaster	C23.6	23,500	385,483	69,810	17,520	65,239
Cutting, shaping and finishing of stone	C23.7	35,910	164,203	13,800	5,000	12,959

Description	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of abrasive products and non-metallic mineral products n.e.c.	C23.9	3,979	97,314	27,134	6,265	24,011

Source: Eurostat, accessed on Dec 2014

The sector has over 97,000 enterprises in the EU generating €207 billion of revenues. Cement and lime production (C23.5, C23.6) are the largest industries, accounting for nearly 45% of total sector revenues. Glass manufacture (C23.1) is the next largest contributor, with turnover accounting for over 20% of the non-metallic sector.

SMEs as a group dominate the sector in terms of number of enterprises (99% of the EU-27's sectoral total) and persons employed (64% of the EU-27's sectoral total) in 2010. The remaining enterprises (1%) are considered large and accounted for 47% of the value added and 36% of the sector's workforce.

3.3.2 Subsector share of energy consumption

Table 3.28 provides an estimated overview of the share of energy consumption between the subsectors in EU28 based on statistics from various sources, including EUROSTAT, the European Cement Association, Glass Alliance Europe, and the European Lime Association. Cement production accounts for nearly 60% of the energy use in the non-metallic minerals sub-sector. However, the most energy intensive part of the non-metallic minerals industry is the production of ceramic materials (IEA; 2007).

Table 3.28 Estimated EU28 subsector share energy demand in 2012

Sector Description	NACE (Group)	Category	Estimated share of final energy demand	
			[kTOE]	*[%]*
Manufacture of glass and glass products	C23.1	Energy intensive	6,075	17%
Manufacture of ceramics and ceramic products	C23.2; 23.3; 23.4; 23.7; 23.9	Energy intensive	6,790	19%
Manufacture of cement	C23.5, 23.6	Energy intensive	20,726	58%
Manufacture of lime	C23.5, 23.6	Energy intensive	2,144	6%
Total final energy demand for non-metallic minerals sector for EU28 (2012):			**35,735**	**100%**

3.3.3 Key products

Glass (NACE 23.1). The EU-27 is the world's largest glass market, in terms of production and consumption.[33] The majority of glass production is for container packaging (60%); and flat glass for building, automotive and solar-energy panels (30%). The remainder is consumed in the domestic glass market (e.g., tableware, cookware); in glass fibre applications for the automotive and transportation (such as aircrafts), communication, and electronic sectors; and

[33] http://www.glassallianceeurope.eu/en/industries

speciality glass products, such as laboratory glassware, heat-resistant glass, optical and ophthalmic glass.[34]

Ceramics (NACE 23.2; 23.3; 23.4; 23.7; 23.9). Ceramic products include, wall and floor tiles, bricks and roof tiles, household ceramics, refractory products, and expanded clay aggregates. The EU has 1,091 installations producing ceramics, with 80% of energy consumption associated with the production of bricks, wall, floor, and roof tiles.[35]

Cement and Lime (NACE 23.5; 23.6). Cement is widely used in construction and building industry; it is an important component in the production of mortar and concrete. Cements are typically characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water. Portland cement, which is the most common type of cement used in the world, is hydraulic.

3.3.4 Key sector processes

Glass production comprises the six process steps. First, silica (high quality sand), soda (Na2CO3) and potash are mixed with stabilizers, such as lime (CaO), magnesium oxide (MgO) and aluminium oxide (Al2O3), to reduce weathering effects. Following this batch mixing and preparation step, the raw materials are melted, homogenized in a furnace, which operates up to temperatures of 1,600°C. After, the molten glass moves to the forming process, where depending on the final product, it passes through different blowing and pressing methods. Once the glass has formed, it is annealed to remove stresses and treated with coatings or lamination to enhance durability and strength. There are approximately 309 glass manufacturing installations in the EU.[36]

Ceramic production takes place in different types of kilns, with a wide range of raw materials and in numerous shapes, sizes and colours; however, the general process is uniform. All ceramics start as a mixture of powdered base material (Zirconia, etc.), binders and stabilizers. This mixture is "formed" into shapes and then fired (sintered) in kilns at temperatures between 1800°C - 2000°C for days or weeks at a time, depending on the ceramic and process details (e.g., for wall and floor tiles, and household ceramics multiple stage firing is used).

Cement production is a two-step process. First, clinker is produced from raw materials (calcium oxide (65%), silicon oxide (20%), alumina oxide (10%) and iron oxide (5%)) by heating in a rotary kiln at temperatures of up to 1,500°C. This step can be a dry, wet, semi-dry or semi-wet process according to the state of the raw material. After the clinker is produced, the second step involves gypsum (calcium sulphates) and possibly additional materials, such as coal fly ash, natural pozzolanas being added to the clinker. These are then ground to a fine and homogenous powder in a cement grinding mill, after which, the cement is dispatched either in bulk or bagged. There are approximately 268 installations producing clinker in the EU.[37]

Lime production, such as quicklime, dolime, is used in a variety of applications, including filler and bonding agents in building materials, purification agents in steel manufacture, and in soil and water treatment to remove impurities. Most lime producers are vertically integrated, so they undertake mining, crushing/sieving and calcination operations. Calcination is the most energy intensive step in the manufacture of lime. It involves crushed limestone or dolomite being heated to temperatures of 900 to 1200°C in kilns, where the thermal decomposition process produces lime or dolime, respectively.

[34] http://www.glassallianceeurope.eu/en/main-glass-sectors

[35] EUA Allowances allocation - sector report for the ceramics industry; Ecofys, 2009

[36] Methodology for the free allocation of emission allowances in the EU ETS post 2012: Sector report for the glass industry; Ecofys, 2009

[37] Methodology for the free allocation of emission allowances in the EU ETS post 2012: Sector report for the cement industry; Ecofys, 2009

- $CaCO_3$ (limestone) + energy → CaO (lime) + CO_2 (carbon dioxide)
- $CaMg(CO_3)_2$ (dolomite) + energy → $CaMgO_2$, (dolime) + 2 CO_2 (carbon dioxide)

3.3.5 Energy metrics

3.3.5.1 *Energy intensity based on sector energy cost*

Table 3.29 provides an indication of the sector's energy intensity for selected EU Member States expressed in 2 ratios[38] from 2008 - 2012. Based on the 5 year trend of the energy intensity ratios, it has remained flat, consistent with the longer term intensity trend discussed in Section 3.3.6.5. The non-metallic mineral sector ranks 3rd most energy intensive sector (after petroleum refineries and iron and steel) in comparison with the 8 industrial sectors evaluated in this Study in terms of energy cost spent per value added generated.

Table 3.29 Energy cost intensity ratios per unit of VA and Turnover generated for selected MS*

	Ratio	2008	2009	2010	2011	2012
1	Energy cost/ Value Added	23%	22%	21%	22%	23%
2	Energy cost/ Turnover	7%	7%	6%	7%	7%

Source: ICF analysis on EUROSTAT SBS, accessed Dec 2014

** Note: Data excludes Finland, Slovenia, Poland and Luxembourg*

3.3.5.2 *Energy intensity of key processes*

The production of non-metallic minerals (glass, ceramic, cement and lime) is characterised by the use of intense heat to either melt (glass), sinter (ceramics, cement) or thermally decompose (lime) raw materials. As such, the key energy intensive process in these industries is the kiln or furnace, which can operate at temperatures exceeding 1,000°C. Electricity use, in comparison, is minimal (e.g., in lime production it is on the order of 1 to 2%). Table 3.30 to Table 3.33 provides a summary of the energy intensities associated with the production of glass, ceramics, cement and lime.

[38] (1) Ratio of energy cost per unit of value added and (2) Ratio of energy cost per unit of turnover, i.e. the monetary value paid by manufacturers on energy products for every unit of value added or turnover generated by the sector.

Table 3.30 Energy intensity of glass production (Source: Ecofys, 2009)

Product	EU	
	Electricity Use kWh/t (GJ/t)	Production contribution[39]
Flat glass	203 (0.73)	25%
Container packaging	372 (1.34)	70%
Tableware	unknown	2%
continuous filament fiber	1,110 (4)	2%
Specialty glass	unknown	1%

Source: Ecofys, 2009[40]

Glass Alliance Europe notes that in 2009 the total energy intensity of the industry was 8 GJ/tonne.[41] Based on the data in Table 3.30, the weighted average specific electricity consumption in the EU is 1.2 GJ/t; consequently, the split between heat and power is approximately 85% and 15%, respectively.

Table 3.31 Energy intensity of ceramic production

Product	EU	
	Energy Use (GJ/t)	Production contribution
Brick and roof tiles	2.31	38%
Wall and floor tiles	5.6	42%
Refractory products	5.57	7%
Sanitary-ware	21.87	3%
Vitrified clay pipes	5.23	1%
Table and ornamental-ware	45.18	6%
Technical ceramics	50.39	2%

Source: BREF, 2007[42]

Kilns used in the production of brick, roof, wall and floor tiles represent the largest contributor to energy consumption in the EU ceramics industry. Based on the data presented in Table 3.31, the weighted average energy intensity for the EU is estimated to be 8.1 GJ/tonne.

[39] http://www.glassallianceeurope.eu/en/main-glass-sectors

[40] Methodology for the free allocation of emission allowances in the EU ETS post 2012: Sector report for the glass industry; Ecofys, 2009

[41] http://www.glassallianceeurope.eu/en/common-challenges

[42] http://eippcb.jrc.ec.europa.eu/reference/BREF/cer_bref_0807.pdf

Table 3.32 Energy intensity of cement production

Process	Global	
	Energy Use (GJ/t clinker)	Production Contribution
Vertical shaft kilns	5	—
Wet kilns	5.8 – 6.7	—
Long dry process	4.4 – 4.5	4%
Semi wet/semi dry kiln	4.0	5%
Dry kiln (four stages pre-heater)	3.2 – 3.7	92%
Dry kiln (six stages pre-heater and pre-calciner)	2.8 – 3.4	

Source: ABB, 2013; BCG, 2013[43,44]

Dry kilns represent the majority of clinker kilns used in the EU (92%), with 5% semi-dry, and 4% long dry.[45] As such, the specific energy consumption of the EU cement industry is approximately 3.78 GJ/tonne; which aligns closely with estimates reported by IEA (2007), 3.7 GJ/tonne clinker[46].

Table 3.33 Energy intensity of lime production

Process	EU-27		Energy use	
	Heat Use (GJ/t)	Kiln electricity use (kWh/t)	Heat	Electricity
Horizontal kiln				
Long rotary kiln	6 – 9.2	18.25	99%	1%
Rotary kilns with pre-heater	5.1 – 7.8	17.45		
Vertical kilns				
Parallel flow regenerative kilns	3.2 – 4.2	20.40	98%	2%
Annular shaft kilns	3.3 – 4.9	18.35		
Mixed feed shaft kilns	3.4 – 4.7	5.15		
Other kilns	3.5 – 7.0	20.40	98%	2%

Source: UNIDO, 2010[47]

[43] Global Energy Efficiency Trends 2013 – ABB; http://www.enerdata.net/enerdatauk/press-and-publication/publications/the-state-global-energy-efficiency.php

[44] The Cement Sector: A Strategic Contributor to Europe's Future; Boston Consulting Group, 2013

[45] ibid

[46] Tracking Industrial Energy Efficiency and CO2 Emissions; IEA, 2007

[47] Global Industrial Energy Efficiency Benchmarking; UNIDO, 2010

There are approximately 449 lime kilns in the EU; 7% are horizontal, 72% are vertical, and 21% are "other" kilns.[48] The European Lime Association (EuLA) indicates that the average fuel consumption in 2010 was 4.25 GJ/tonne quicklime, which aligns with the information presented by UNIDO.

3.3.5.3 EU final energy consumption for non-metallic mineral production

Furnaces used in the production of glass consume natural gas and/or oil as the primary fuel source. Solid fuels, such as coal or lignite are not typically used as they would result in the production of molten ash in the glass phase, which would reduce product quality[49]. In the ceramics industry, natural gas is the primary energy source for kiln firing; accounting for approximately 85% of total energy consumption. The remainder is made up electricity[50]. Table 3.34 and Figure 3.29 provides a summary of the final energy consumption and fuel mix for non-metallic mineral sector for EU28 as a whole.

Table 3.34 Final energy consumption for EU non-metallic mineral sector in 2012

EU primary energy consumption for the sector	kTOE	% of total
Gas	13,766	39%
Electricity	5,987	17%
Solid fuel	5,238	15%
TPP	7,483	21%
Other	3,263	9%
Total final energy demand	35,735	

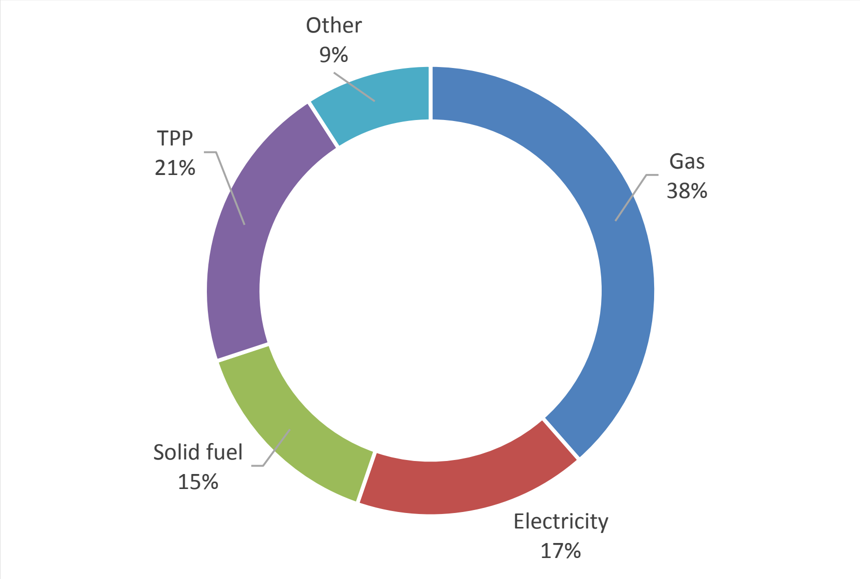
Source: EUROSTAT, accessed Dec 2014

[48] A Competitive and Efficient Lime Industry Cornerstone for a Sustainable Europe; EuLA, 2014

[49] Glass production: Guidebook 2013; Jeroen Kuenen

[50] Paving the way to 2050: The Ceramic Industry Roadmap; Cerame-Unie; 2012

Figure 3.29 Energy mix for EU non-metallic mineral sector in 2012

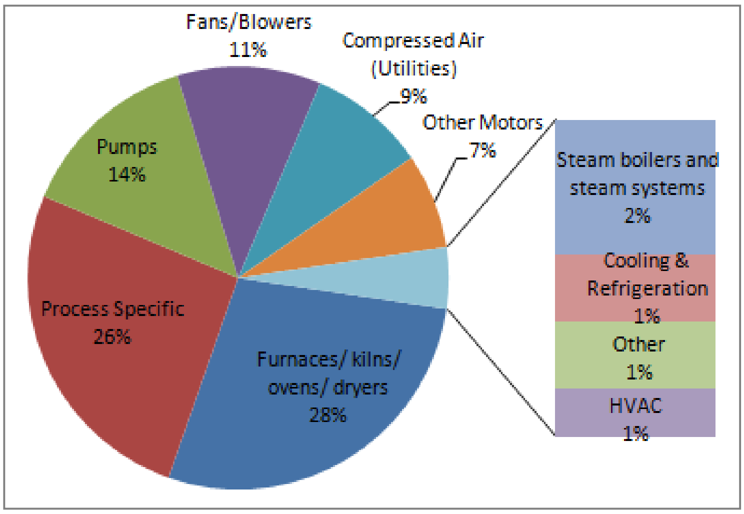


Source: EUROSTAT, accessed Dec 2014

3.3.5.4 Energy end use profile

Based on the estimated share of energy consumption amongst the glass, ceramic, cement and lime manufacturing industries, and the fuel mix profiles discussed, the following figures present an aggregate energy use profile for the primary energy sources, including electricity, natural gas, total petroleum products, coal, renewables, waste heat, and biomass.[51]

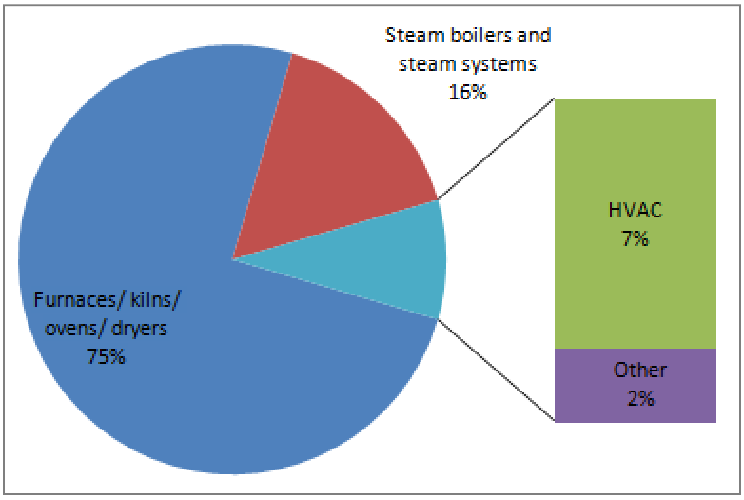
Figure 3.30 Electricity use profile



Source: ICF internal data

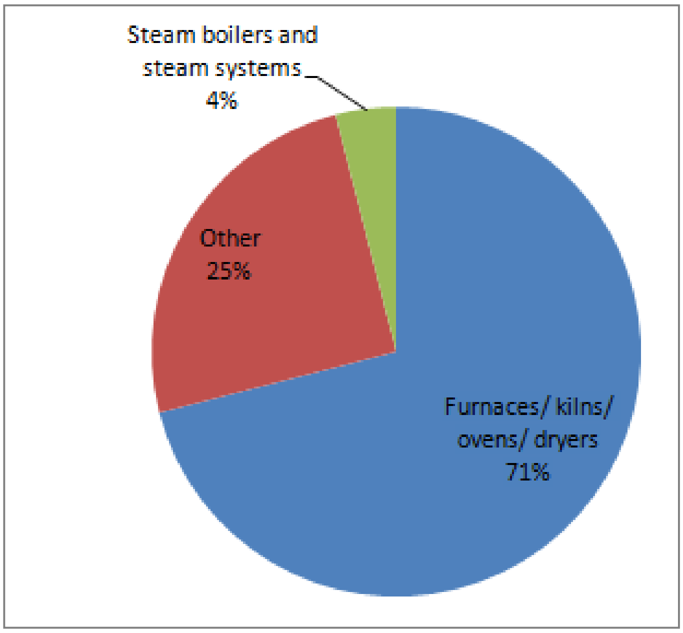
[51] Based on ICF energy efficiency studies within the non-metallic minerals sector

Figure 3.31 Natural gas use profile



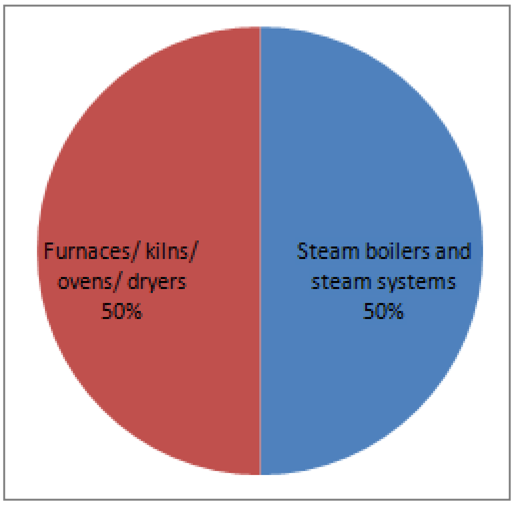
Source: ICF internal data

Figure 3.32 Total petroleum product use profile



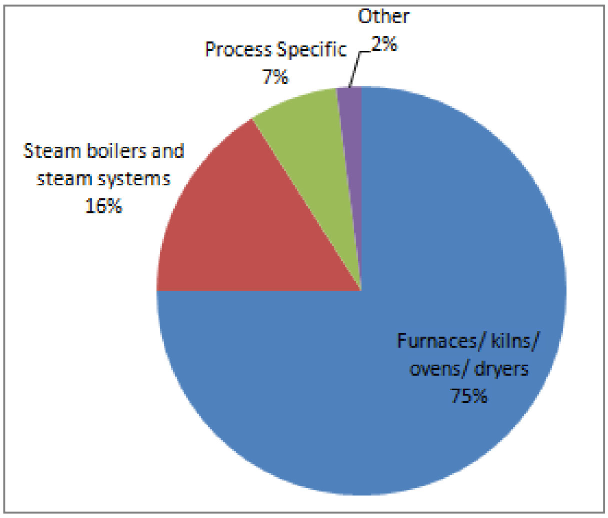
Source: ICF internal data

Figure 3.33 Coal use profile



Source: ICF internal data

Figure 3.34 Energy use profile for other sources, including renewable, biomass, and waste heat recovery



Source: ICF internal data

3.3.6 Projection of energy consumption trend

The following details are an extracted summary of the sector profile in Annex 1.

The non-metallic minerals sector contributes four primary outputs: glass; ceramics, cement and lime which in 2011, contributed to 1.5% of the EU's GDP (Eurostat; 2013). It is a mature and energy–intensive sector, with energy costs accounting for a significant portion of production costs (i.e., >30%).[52,53] The non-metallic minerals sector accounts for 13% of total EU industrial energy consumption in 2011.[54]

[52] The role of cement in the 2050 low carbon economy; CEMBUREAU; 2013

[53] Paving the way to 2050: The Ceramic Industry Roadmap; Cerame-Unie; 2012

[54] Energy, transport and environment indicators; Eurostat; 2013

3.3.6.1 Glass production

EU-27 is the world's largest glass market, in terms of production and consumption, with 80% of production traded within the EU.[55] Foreign imports do not play a dominant role, with export to import ratio being 1.26 in 2012.[56] The market is dominated by less than a dozen multinationals that produce over 80% of the total glass produced in the EU. Between 2004 and 2012, production declined by approx. 5%, primarily as a result of large decreases in demand for domestic, specialty glass and glass fibres due to low cost foreign imports. In 2012, glass production totalled 33 million tonnes.[57] However, container and flat glass production remained relatively constant. Demand for these products is driven by consumer industries, where packaging is required, and the construction and automotive industries. While future growth could be driven by access to new markets, such as the Middle East and Asia, and new EU provisions for buildings energy performance (i.e., glass insulation), it is anticipated that glass production will follow historic trends and remain relatively stable.

3.3.6.2 Ceramic production

Six member states dominate ceramics production (Germany, France, Italy, UK, Portugal and Poland), accounting for nearly 80% of total EU production. In 2000, EU production was 55 million tonnes[58], which remained relatively constant through 2007. However, since 2007, across all ceramic sub-sectors, production value has declined by 36% through 2012.[59] As such, it is estimated that EU production was around 35 million tonnes in 2012. Demand for bricks, wall, roof, and floor tiles are influenced by new builds and renovation; as such population growth and the rising number of households is important to future growth. However, recent declines have been due to significant competition from low cost imported products; and a reliance on raw materials from outside markets (e.g., China) where costs are rising. This is anticipated to continue; as such, production is assumed to continue declining slowly into the future.

3.3.6.3 Cement production

Between 1998 and 2007, cement production increased by 23%; however, since the economic crisis, production has been declining. In 2012, cement production declined by 13% compared to 2011, reaching 228.4Mt, which was a record low. Major European markets recorded sharp drops, including Spain (-39.5%) and Italy (-20.8%), whereas more moderate falls were in Germany (-4.8%) and France (-7.3%).[60] Demand is cyclical and driven by building and civil engineering works. It is expected that the overall EU cement consumption per capita will remain around 450 kg per capita with local variations per country. Assuming these average values, cement production in Europe will be about 234 Mt by 2030, i.e., relatively constant.[61]

3.3.6.4 Lime production

Lime is a heavy product with a low sales price, so transport costs dictate consumption patterns. Consequently, exports are minimal, and only to neighbouring countries. Germany, France, Poland, Belgium, Spain and Italy are the largest producers of lime in the EU-27. Between 2006 and 2011, EU lime production declined from 28 million tonnes[62] to 22 million tonnes[63],

[55] http://ec.europa.eu/enterprise/sectors/metals-minerals/non-metallic-mineral-products/index_en.htm

[56] http://www.glassallianceeurope.eu/

[57] ibid

[58] EUA Allowances allocation - sector report for the ceramics industry; Ecofys, 2009

[59] Paving the way to 2050: The Ceramic Industry Roadmap; Cerame-Unie; 2012

[60] The cement industry is exposed to carbon leakage regardless of the assessment method used and the relevant product level; CEMBUREAU, 2013

[61] http://setis.ec.europa.eu/cement-energy-efficiency

[62] http://ec.europa.eu/enterprise/sectors/metals-minerals/non-metallic-mineral-products/index_en.htm

[63] A Competitive and Efficient Lime Industry Cornerstone for a Sustainable Europe; EuLA, 2014

reflecting a 20% decline. Demand is driven by the environmental and construction industries; however, access to raw material, calcium carbonate, and competition from producers on the periphery of EU is the primary threats. Future production is anticipated to continue to decline, but at a lower rate.

3.3.6.5 Sector projection summary

Overall, production in the non-metallic minerals sector is assumed to remain relatively flat through 2050; slight declines in lime and ceramics will be offset by stable production in cement and glass. Table 3.35 presents the anticipated production profile for the sector.

Table 3.35 Projected production of non-metallic minerals in EU (million tonnes)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Production (MT)	318.2	318.2	317.2	316.6	316.1	315.6	315.3	315.0	314.9	314.8

The non-metallic minerals sector is energy- and raw materials–intensive, with energy costs contributing to significant part of production costs. The sector is defined by high capital costs, with long term investment cycles (e.g., kilns have 40 year lifetimes). Consequently, once an investment is made the ability to upgrade and improve energy efficiency is impacted. 2050 sector roadmaps have been developed for all sectors, and energy efficiency is listed as a key objective. However, many of the sectors are dependent on breakthrough technologies that are not available today. As such, overall energy intensity for the sector is anticipated to remain stable for the near future and then decline slowly through 2050. Table 3.36 presents the anticipated energy intensity trend through 2050.

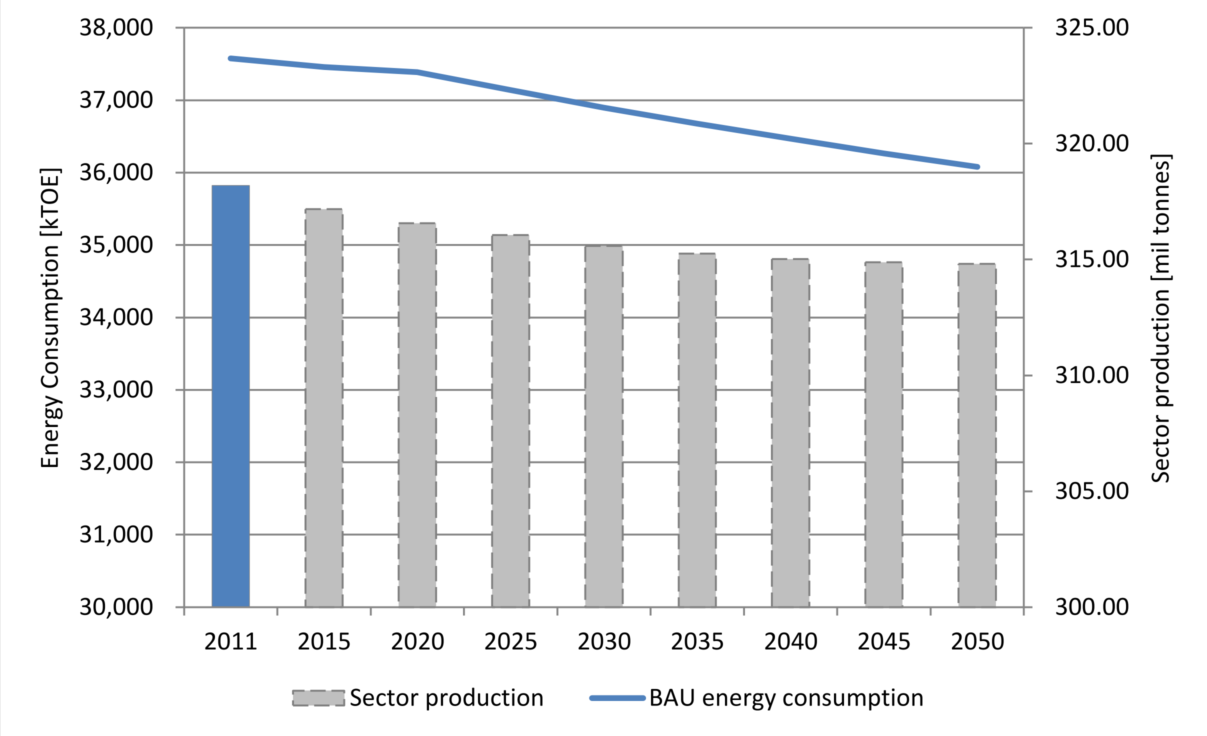
Table 3.36 Projected energy intensity trends for production of non-metallic minerals (Thousand tonnes oil equivalent per dried metric tonne)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Energy intensity (TOE/ tonne)	0.118	0.118*	0.118	0.118	0.118	0.117	0.116	0.116	0.115	0.115

**Base year energy intensity based on: Glass – Glass Alliance Europe (2014); Ceramics - Ecofys (2009), Cement – BCG (2013) and Lime – EuLA (2014)*

Figure 3.35 illustrates the BAU projection trend (energy consumption and production) of non-metallic minerals in EU28 over the period 2012 to 2050.

Figure 3.35 BAU projection for EU production of non-metallic minerals



3.3.7 Projection of energy saving potential

Figure 3.36 presents the energy consumption projections from 2011 through to 2050 under the BAU, technical and economic scenarios[64] from the modelling outputs of IEEM.

A total of 83 ESOs which are technically feasible to the sector were accounted for in the modelling process. The projected savings under the technical[65] potential scenario is 7.2 million TOE (19% saving) in year 2030 and 6.3 million TOE (18% saving) in year 2050 with reference to the BAU projections. The sharp increase in technical potential by the first milestone, 2015, is based on the assumption that if technically feasible options are available, they will be implemented immediately. For some ESOs, such as those that are emerging technologies, it is assumed that they will be implemented when the currently installed equipment has reached its end of life.

A total of 33 ESOs were included under economic scenario 1, resulting in a projected saving of 1.2 million TOE (3.3% saving) in year 2030 and 2.4 million TOE (6.6% saving) in year 2050 with reference to the BAU projections.

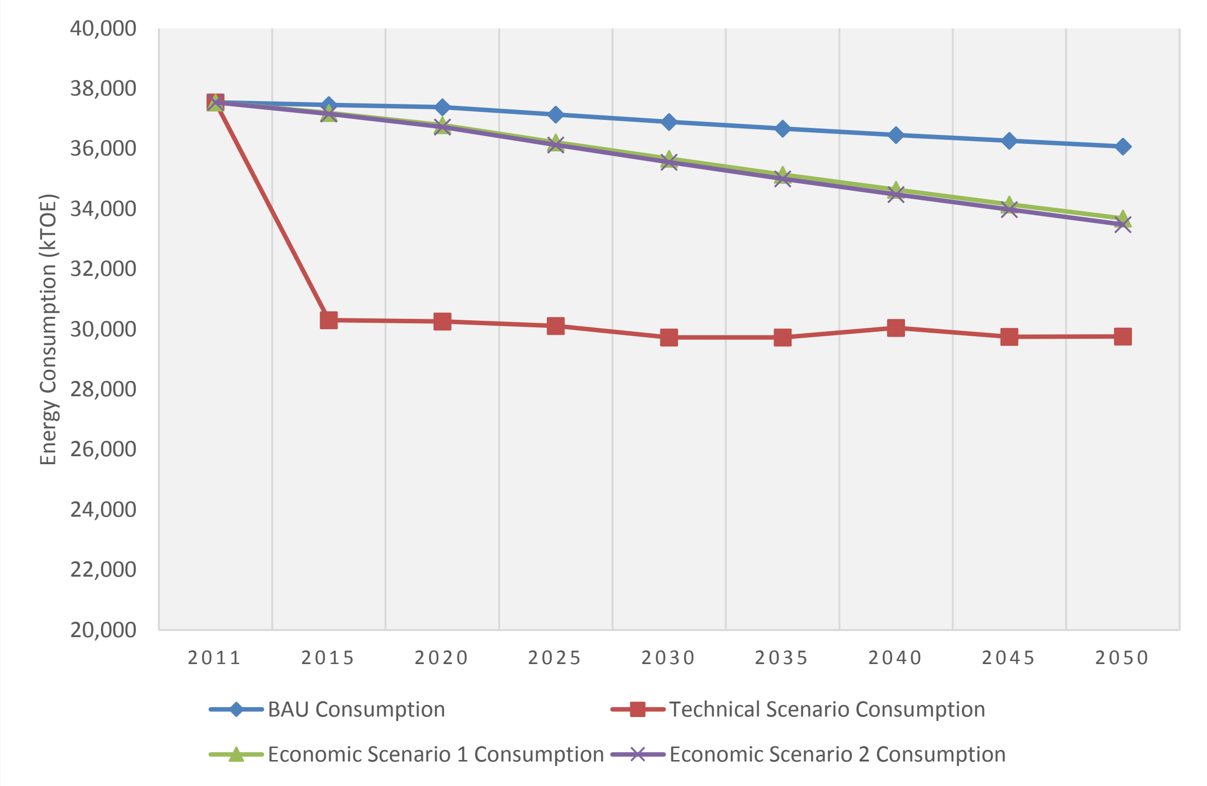
An additional 19 ESOs, i.e. a total of 52 ESOs, were included under economic scenario 2, resulting in a projected saving of 1.3 million TOE (3.6% saving) in year 2030 and 2.6 million TOE (7.2% saving) in year 2050 with reference to BAU projections. This is only an additional of 0.3% savings in 2030 and 0.5% savings in 2050 in comparison with economic scenario 1. Similar to the other sectors, the additional ESOs under economic scenario 2 have a much lower energy saving impact, despite a higher payback time and they only accounted for 8% of the overall savings in comparison with ESOs under economic scenario 1. The full list of Energy

[64] The economic scenario 1 assumes an uptake of ESOs which fulfils the less than 2 year simple payback criteria, whereas the economic scenario 2 assumes an uptake of ESOs of less than 5 year simple payback.

[65] Under the technical potential scenario, it is assumed that all technically feasible ESOs relevant to the sector is implemented regardless of economic viability.

Saving Opportunities are listed in Annex 3. The list of ECOs under economic scenario 1 and 2 is presented in Annex 4.

Figure 3.36 Projected economic and technical potential scenario energy use for the non-metallic minerals sector



The following ESOs listed in Table 3.37 represents approximately 77% of the overall sector energy saving potential.

Table 3.37 Projected sector energy saving opportunities with highest technical potential

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Integrated control system	A neural network system is an example of an integrated control system. The information of the sensors is used in control systems to adapt the process conditions, based on artificial intelligence, mathematical (“rule”-based) or neural networks and “fuzzy logic” models of the industrial process.	998	925	14% / 15%
Exhaust gas heat recovery (kiln and furnace)	Exhaust gas heat recovery increases efficiency because it extracts waste energy from the exhaust gases and recycles it back to the process, which reduces fuel/steam requirements.	904	872	13% / 14%

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Low temperature heat recovery for power generation	Additional waste heat is available from kiln gasses and cooler exhaust gas. Principally, this heat can be used for drying other materials like slag or secondary fuels or production of steam / power.	900	859	13% / 14%
Sub-metering and interval metering	Sub-meters are used to measure the amount of energy consumed by equipment, or portions of the plant. They communicate with a central system where the information is trended, stored or transferred to a data historian system for archiving.	457	405	6% / 6%
Material substitution and alteration of product design	This opportunity involves use of materials which are less energy intensive to process, and product designs which are less energy intensive to produce. This includes a shift towards using more clinker additives (clinker substitution) and different cement blends. Optimizing shapes of products (e.g. ceramic shapes) allows faster heat treatment and reducing the heat requirements.	420	405	6% / 6%
Flue-gas monitoring (kiln and furnace)	Stack thermometers, fuel meters, make-up feed water meters, oxygen analysers, run-time recorders, energy output meters, and return condensate thermometers are required to maintain a proper air-to-fuel ratio to optimize fuel combustion efficiency.	358	320	5% / 5%
Advanced Heating and Process Control (kiln and furnace)	Advanced heating and process controls reduces energy losses by governing aspects such as material handling, heat storage and turndown.	351	304	5% / 5%
High Efficiency Burner (kiln and furnace)	These burners are more efficient at higher-temperature applications. Advancements over the recent years include the commercialization of self-recuperative and self-regenerative burners that use staged combustion to achieve flameless combustion. This results in more uniform heating, lower peak flame temperatures, improved efficiency and lower NOx emissions.	306	222	4% / 4%
Optimization of kiln efficiency	Energy savings are possible through the use of optimized designs of kilns, including the selection of the best melting/heating techniques for the specific application. Involves redesigning of entire equipment.	375	286	5% / 5%
Combustion optimization (kiln and furnace)	Combustion efficiency can be improved by frequent adjusting of the air-to-fuel ratio to reduce excess air as too much excess air carries away excessive amounts of heat.	240	218	3% / 3%

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Increased uptake of Energy Management System (EnMS)	A series of systemised interacting processes that enables an organization to obtain relevant energy information and act upon it to maintain and improve energy performance, while reducing environmental emissions as a consequence.	212	192	3% / 3%

From these shortlisted Energy Saving Opportunities with the highest energy saving impact, most of the measures are highly focused on kilns, as this takes up almost the entire energy consumed within the sector.

From the above ESOs, only 3 of the measures (low temperature heat recovery, material substitution and alteration of product design and optimization of kiln efficiency) did not fall within the criteria of economic scenario 1 or 2.

The following sector-specific energy saving opportunities listed in Table 3.38 are technically feasible for the sector but unaccounted for in the economic scenarios as they did not meet the respective payback criteria.

Table 3.38 Projected technical potential sector specific ESOs

Sector specific energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Coke Dry Quenching (CDQ)	CDQ is an alternative to the wet quenching of hot coke in order to recover thermal energy. A further advantage of CDQ is that it uses less water, not easily available everywhere	523	509	3.2% / 2.7%
Continuous Casting	Continuous casting replaces the primary rolling process, including re-heating by casting the slabs, blooms or billets directly to the right shape for hot rolling.	403	533	2.5% / 2.8%
Scrap Pre-Heating	Scrap preheating is a technology that can reduce the power consumption in the EAF process by utilising the waste heat of the furnace to preheat the incoming scrap charge	36	46	0.2% / 0.2%
Sinter Plant Waste Heat Recovery	Generally, there are two systems that can be used to recover energy from the sintering process. (1) The hot exhaust gas from the sinter bed can be returned to the sinter bed as combustion air, thus reducing energy consumption through savings in coke use. (2) Energy from the hot sintered ore is recovered at the end of the sinter bed using a sintered ore cooling system where air is heated up and can later be used to generate steam.	251	241	1.5% / 1.3%

Sector specific energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Optimized Sinter Pellet Ratio (Iron Ore)	The aim is to achieve a sinter-pellet ratio of at least 50/50 for each Blast Furnace in order to reduce CO2 emissions and resulting in increased energy savings.	173	170	1.1% / 0.9%
Top Gas Recovery Turbine (TRT)	The top gas from the Blast Furnace has an over-pressure which can be used to produce additional electricity using a TRT	43	56	0.3% / 0.3%
Stove Waste Gas Heat Recovery	The heat recovery system improves the efficiency of the Hot Blast Stoves, as thermal energy of waste gas discharged from the Hot Blast Stoves is partially recovered in external heat exchangers and typically used to pre-heat the Blast Furnace gas and/or combustion air.	73	70	0.4% / 0.4%

3.4 Chemical and Pharmaceutical

3.4.1 Structure and economic contribution

The chemicals and pharmaceutical sector contributed to 5% of the EU's GDP in 2011 (Eurostat; 2013). Key economic contributions are delivered by 2 key groups: Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms (NACE C20.1), and Manufacture of pharmaceutical preparations (NACE 21.2), which accounted for 70% of total production value. Key economic indicators for the chemicals and pharmaceutical sector are summarised in Table 3.39.

Table 3.39 Key economic indicators on sector division and group level for EU 28 in 2012

Description	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of chemicals and chemical products	C20	28,306	1,096,562	552,704	106,210	486,986
Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	C20.1	8,886	549,289	348,952	61,631	313,064
Manufacture of pesticides and other agrochemical products	C20.2	623	25,977	15,077	3,002	11,470
Manufacture of paints, varnishes and similar coatings, printing ink and mastics	C20.3	4,100	133,767	40,817	10,501	35,993

Description	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	C20.4	8,283	199,056	61,394	14,232	54,531
Manufacture of other chemical products	C20.5	6,104	164,880	78,465	16,843	64,463
Manufacture of man-made fibres	C20.6	310	23,593	8,000	n/a	7,464
Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21	4,072	479,333	227,879	83,808	206,066
Manufacture of basic pharmaceutical products	C21.1	900	49,577	29,795	11,150	28,810
Manufacture of pharmaceutical preparations	C21.2	3,172	429,756	198,084	72,658	177,256

Source: 2012 Eurostat data

The sector has over 28,000 enterprises in the EU generating €552 billion of revenues. Over 65% of organisations in the chemicals sector are microenterprises, while 70% of pharmaceutical organisations are SMEs; however, both industries are dominated by large enterprises, which contribute 65% and 78% of value added, respectively.

3.4.2 Subsector share of energy consumption

Table 3.40 provides an estimated overview of the share of energy consumption between subsectors in the manufacture of chemicals and chemical products (NACE 20) in EU28. The petrochemicals and basic inorganic subsectors account for 72% of the energy use in the chemicals sector and reflect the high energy requirements to produce the primary feedstock for the downstream subsectors (polymers, specialty and consumer chemicals).

Table 3.40 Estimated EU28 chemicals and pharmaceuticals sector share of energy demand in 2012

Subsector Description	NACE (Group)	Category	Estimated share of final energy demand	
			[kTOE]	[%]
Petrochemicals	C20.1	Energy intensive	26,596	47%
Basic inorganic	C20.1; 20.5	Energy intensive	14,147	25%
Polymers	C20.1; 20.6	Non-energy intensive	6,791	12%
Specialty chemicals	C20.2; 20.3	Non-energy intensive	4,527	8%
Consumer chemicals	C20.4	Non-energy intensive	1,132	2%
Pharmaceutical products	C21	Non-energy intensive	3,395[66]	6%
Total energy demand for chemicals and pharmaceuticals sector for EU28 (2011):			**56,588[67]**	**100%**

Source: CEFIC, 2013; US EPA, 2005[68],[69]

3.4.3 Key products

3.4.3.1 *Petrochemicals (NACE 20.1)*

The petrochemical subsector produces the organic building blocks of the chemical industry, which feed the production of many consumer and industrial products. The organic chemicals with the largest production volume in the EU are ethylene, propylene, butadiene (olefins), methanol (alcohols), benzene, toluene and xylenes (aromatics).[70]

Because the petrochemical subsector covers numerous products, the manufacturing processes will vary from one product to another. Sometimes the same products will use different raw materials, technological processes, or equipment. As such, energy is used in varying amounts. Nonetheless, the petrochemical subsector is defined by two major energy intensive processes: “cracking” (either steam or catalytic), which is the process where large hydrocarbon molecules are broken down into smaller ones; and “reforming”, where heat, pressure and/or catalyst are used to restructure hydrocarbons (e.g., converts naphtha to benzene, toluene and xylene). There are approximately 55 petrochemical plants in the EU with steam crackers and reformers.[71]

3.4.3.2 *Basic inorganics (NACE 20.2; 20.5)*

The industrial inorganic chemical industry manufactures a variety of products, such as chlor-alkalis, sulphuric acid, sulphates; and fertilizers (potassium, nitrogen, and phosphorus products). Many of these products are used as reagents or feedstock in high-tech industries, pharmaceuticals or electronics, as well as in the preparation of inorganic specialties such as catalysts, and pigments.

[66] ICF assumption: Energy costs per unit sales for pharmaceuticals are assumed to be 1% (US EPA; 2005), which is similar to consumer chemicals (CEFIC, 2013). As such, pharmaceutical subsector energy consumption was estimated by applying ratio of energy consumption to production value for consumer chemicals to pharmaceutical subsector production value.

[67] Eurostat; 2013

[68] European chemistry for growth: Unlocking a competitive, low carbon and energy efficient future; CEFIC; 2013

[69] Energy efficiency improvement and cost saving opportunities for the pharmaceutical industry; US EPA, 2005

[70] European chemistry for growth: Unlocking a competitive, low carbon and energy efficient future; CEFIC; 2013

[71] Methodology for the free allocation of emission allowances in the EU ETS post 2012: Sector report for the chemical industry; Ecofys, 2009

The energy consumed to produce different inorganic products can vary significantly; however, a few products dominate energy consumption, such as ammonia and chlorine production.[72] Ammonia is produced in the Haber process where nitrogen and hydrogen, is formed by reacting natural gas and steam at high temperatures, react in the presence of an iron catalyst to form ammonia. There are approximately 42 ammonia plants in the EU.[73] Chlorine (and caustic soda) is produced through electrolysis where an electric current is passed through a brine solution. There are approximately 70 chlorine manufacturing locations in the EU.[74]

3.4.3.3 *Polymers (NACE 20.1; 20.6)*

Polymers are large molecules formed during three basic reaction types, polymerisation, polycondensation and polyaddition. The primary operations/processes are 1) preparation; 2) reaction; and 3) separation of products.

Depending on the product, assorted combinations of heat, pressure and catalysts are used during the reaction stage to alter the chemical bonds that hold monomers together, causing them to bond with one another forming chains of monomers. The most widely used feedstock in polymer production is ethylene and propylene which, once reacted, make polyethylene (PE) and polypropylene (PP), respectively.

3.4.3.4 *Consumer chemicals (NACE 20.4)*

The manufacture of soaps, detergents, perfumes involve a broad range of processing and packaging operations. For soaps, the primary process steps are: 1) saponification (hydrolysis of an ester, under basic conditions (e.g., 80^{o}C)); 2) drying; 3) amalgamator (mixer, in which the soap pellets are blended together with fragrance, colorants and all other ingredients; 4) rolling mills (to blend and create a uniform texture); and 5) cutting/pressing (to create final shape). Similar to soap, detergents are produced through a combination of agglomeration, spray drying, dry mixing steps. Perfume production involves two main steps. The first step, extraction, is primary energy consumer and involves the removal of oils from plant substances by steam distillation, solvent extraction, etc. Step two involves blending the collected oils with other substances based on predetermined formulas.

3.4.3.5 *Specialty chemicals (NACE 20.2; 20.3)*

Resin, pigment and additive agents are generally major components of paint. There are two main process steps; the first involves mixing the components to form a paste. If the paint is to be for industrial use, it usually is then routed into a milling machine, which is a large cylinder that agitates tiny particles of sand or silica to grind the pigment particles, making them smaller and dispersing them throughout the mixture. In contrast, commercial use paint is processed in a high-speed dispersion tank, which agitates the mixture and blends the pigment into the solvent.

Pesticides are manufactured by the chemical reaction of two or more raw materials (organic or inorganic) in the presence of solvents, catalysts and reagents. Manufacturing can vary from a one-step reaction, followed by packaging the product, or multi-step reaction, followed by fractionation, separation, drying, and packaging. Alternately, production can occur through formulation, with no reaction occurring. Instead raw materials are mixed, blended, diluted with solvents, inert materials, pigments, and packaged.

3.4.3.6 *Pharmaceuticals (NACE 21)*

The three key steps in pharmaceutical production are: 1) research and development; 2) conversion of natural substances to pharmaceutical substances; and 3) formulation of final products. Step 2 is the primary energy consuming stage, where chemical synthesis, extraction,

[72] European chemistry for growth: Unlocking a competitive, low carbon and energy efficient future; CEFIC; 2013

[73] For a study on composition and drivers of energy prices and costs in energy intensive industries: the case of the chemical industry – Ammonia; Centre for European Policy Studies, January 2014

[74] Best Available Techniques (BAT) Reference Document for the Production of Chlor-alkali; JRC, 2014

and fermentation processes can be used to produce the pharmaceutical substances. Chemical synthesis involves: reaction; separation; crystallization; purification; and drying stages. Extraction uses precipitation, purification, and solvent extraction methods are used to recover active ingredients from natural sources. Fermentation involves seed preparation; fermentation; and product recovery.

Chemical synthesis is used to produce antihistamines, cardiovascular agents, and hormones, while enzymes and digestive aids, allergy relief medicines, insulin, anti-cancer drugs, and vaccines are types of products developed through extraction. Fermentation is typically used to manufacture steroids, antibiotics, and vitamins.

3.4.4 Energy metrics

3.4.4.1 Energy intensity based on sector energy cost

Table 3.41 provides an indication of the sector's energy intensity for selected EU Member States expressed in 2 ratios[75] from 2008 - 2012. Based on the 5 year trend of the energy intensity ratios, it has remained flat, consistent with the longer term intensity trend discussed in Section 3.4.5. The chemical and pharmaceutical sector ranks 6th most energy intensive sector in comparison with the 8 industrial sectors evaluated in this Study in terms of energy cost spent per value added generated.

Table 3.41 Energy cost intensity ratios per unit of VA and Turnover generated for selected MS *

	Ratio	2008	2009	2010	2011	2012
1	Energy cost/ Value Added	13%	12%	11%	12%	12%
2	Energy cost/ Turnover	3%	3%	3%	3%	3%

Source: ICF analysis on EUROSTAT SBS, accessed Dec 2014

** Note: Data covers Czech Rep, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Lithuania, Hungary, Austria, Portugal and UK*

3.4.4.2 Energy intensity of key processes

The chemicals subsector is characterised by the considerable use of fossil fuels and biomass for energy and feedstock. The bulk of energy and feedstock use occurs in a few key production processes. Steam cracking; ammonia production; and chlorine production, which occur in the petrochemicals and basic inorganics upstream manufacturing subsectors, are estimated to account for over 30% of energy use in the chemicals and pharmaceutical sector[76]. Table 3.42 presents a summary of the energy intensities associated with each manufacturing subsector.

Table 3.42 Chemicals and pharmaceutical sector energy intensities

Product	EU		
	NACE (group)	Energy use[77] (MJ/€ sales)	Energy use[78] (GJ/tonne)
Petrochemicals	C20.1	12.5	15

[75] (1) Ratio of energy cost per unit of value added and (2) Ratio of energy cost per unit of turnover, i.e. the monetary value paid by manufacturers on energy products for every unit of value added or turnover generated by the sector.

[76] European chemistry for growth: Unlocking a competitive, low carbon and energy efficient future; CEFIC; 2013

[77] Ibid (CEFIC (2013) intensities are presented for illustrative purposes only, since final fuel use includes heat related input into combined heat and power installations, which is excluded from Eurostat energy demand statistics)

[78] Aggregated estimate based on ICF site assessments

Product	EU		
	NACE (group)	Energy use[77] (MJ/€ sales)	Energy use[78] (GJ/tonne)
Basic inorganic	C20.1; 20.5	12	—
Polymers	C20.1; 20.6	3.25	3
Specialty chemicals	C20.2; 20.3	2	—
Consumer chemicals	C20.4	0.75	—
Pharmaceuticals	C21	0.74[79]	

Source: CEFIC, 2013; ICF

As expected, petrochemicals and basic inorganics have the highest energy intensity within the chemicals subsector. Unlike downstream manufacturing, which requires energy to support reactions and mechanical processes (e.g., drying, mixing, rolling), upstream production requires significant quantities of energy (heat) to break and transform organic and inorganic molecules. For example, polymer production is approximately 5 times less energy intensive per unit of production than petrochemical.[80] This compares reasonably with CEFIC (2013) results, which note a fourfold difference in energy intensity between polymers and petrochemicals when assessed per unit of sales.[81]

Based on the sector energy demand energy presented in Table 3.40 and production values in Table 3.39, the overall sector energy intensity is estimated to be 0.08 kTOE/€ (million) in 2011.[82]

3.4.4.3 EU final energy consumption for chemical and pharmaceutical production

Figure 3.37 presents the average fuel mix for EU chemical and pharmaceutical plants in 2012.

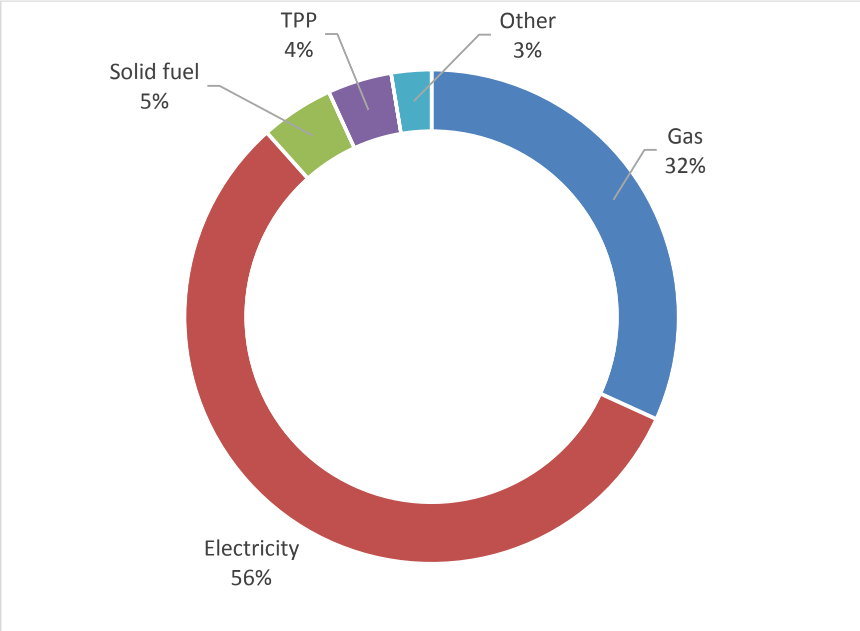
[79] Calculated based on estimated energy demand Table 3.40 and production value Table 3.39

[80] Ibid

[81] European chemistry for growth: Unlocking a competitive, low carbon and energy efficient future; CEFIC; 2013

[82] PRODCOM statistics are incomplete and alternate sources of production data are limited; as such, production value has been used as a proxy for sector output.

Figure 3.37 Fuel mix profile for EU chemical and pharmaceutical sector

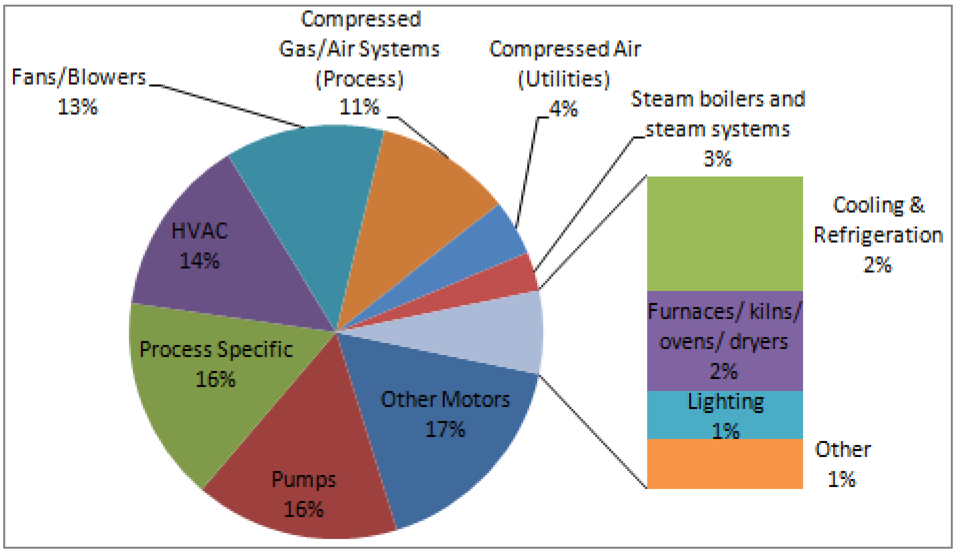


Source: EUROSTAT, accessed Dec 2014

3.4.4.4 Energy end use profile

Based on the estimated share of energy consumption amongst the chemical and pharmaceutical sector, and the fuel mix profiles, the following figures present an aggregate energy use profile for the primary energy sources, including electricity, natural gas, total petroleum products (i.e., oil), coal, and other categories.[83]

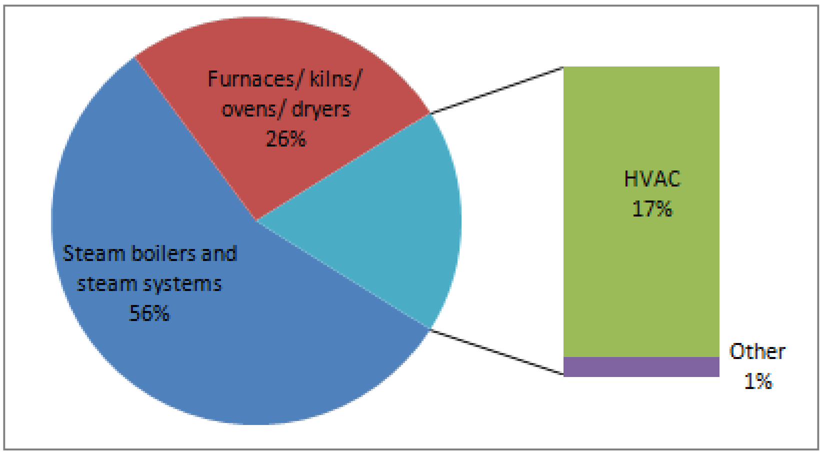
Figure 3.38 Figure : Electricity use profile



Source: ICF International

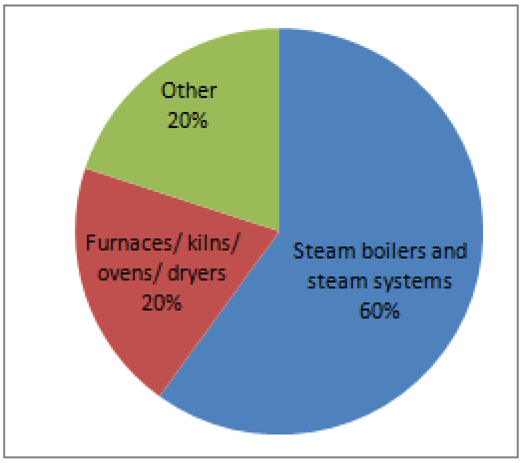
[83] Based on ICF energy efficiency studies within the chemicals sector

Figure 3.39 Natural gas use profile



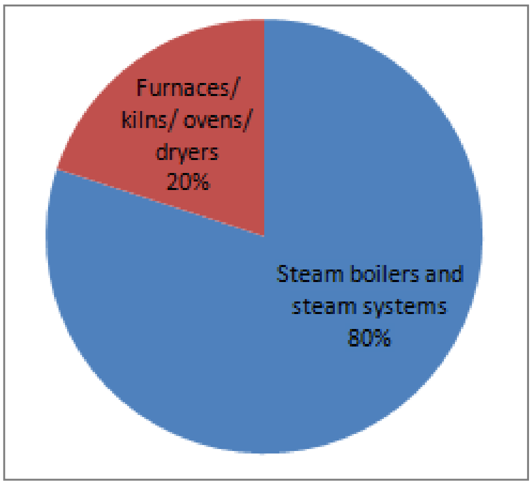
Source: ICF International

Figure 3.40 Total petroleum product (e.g., oil) use profile



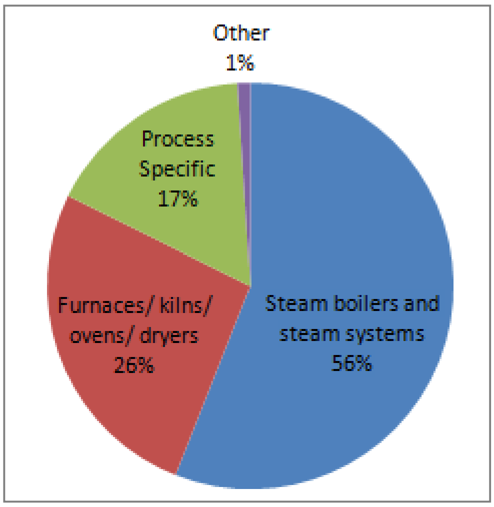
Source: ICF International

Figure 3.41 Figure : Coal use profile



Source: ICF International

Figure 3.42 Figure : Energy use profile for other sources; i.e., biomass



Source: ICF International

3.4.5 Projection of energy consumption trend

The following details are an extracted summary of the sector profile in Annex 1.

The chemical and pharmaceutical sector contributed to 5% of the EU's GDP in 2011.[84] There are over 30,000 enterprises in the EU generating >€175 billion of value added. Both industries are strong and successful players in the world market. In 2011, the chemicals and pharmaceuticals sector accounted for 19.4% of total industrial energy consumption in the EU.[85]

3.4.5.1 Chemicals

The chemicals sector incorporates the manufacture of numerous products, including base chemicals (e.g., plastics, polymers, fertilizers, industrial gases); specialty chemicals (e.g., paint, ink, dyes); and consumer chemicals (e.g., soaps, detergents, cosmetics). Germany, France, the Netherlands, Italy, UK, Spain and Belgium constituted 85% of EU chemicals sales in 2011.[86] Production in the chemicals sector grew by 0.6% per year between 2000 and 2012; however, the average was strongly impacted by production declines during the economic recession in 2008 and 2009.[87] In 2013, the sector reported zero growth[88], with declines in petrochemicals, offset by growth in basic inorganics, polymers, consumer chemicals and specialty products. Nonetheless, the EU has remained the world's top exporter and importer of chemicals (38.1% of global trade in 2012), with future growth anticipated. Global demand for chemicals is forecast to grow on average by 4.5% annually until 2030[89], driven by population growth in emerging markets, and rising demand for chemicals in industrialized countries (i.e., demand from automobiles, electronics, textiles, construction industries). The EU is a key exporter, and is expected to support this need (e.g., Germany predicts that its chemical exports will grow by 2.6% annually on average to 2030).[90]

[84] *Manufacture of chemicals and chemical products statistics - NACE Rev. 2*; Eurostat, 2013a

[85] Ibid

[86] The European chemical industry. Facts & Figures 2013; Cefic, 2013

[87] Ibid

[88] Chemicals Trends Report; Monthly Summary, March 2014; Cefic, 2014

[89] VCI; 2012; Basic chemicals production 2030

[90] VCI; 2012b; The German Chemical Industry in 2030 A summary of the VCI Prognos study

3.4.5.2 Pharmaceuticals

Pharmaceutical products include drugs intended for human or veterinary use. Germany, Italy, UK, Ireland and France accounted for 66% of EU-28 total production. Between 1990 and 2010, the pharmaceuticals sector has grown by an average 5% per year[91], with the recession creating little impact in 2008/2009. In 2012 Europe accounted for 26.7% of world pharmaceutical sales[92]. Although there are various threats to growth, including leakage of research/production activities overseas, and counterfeiting of medicines, demand is anticipated to grow to address population growth (emerging markets), the composition of the population (EU), higher risk of pandemics, emergence of new diseases, etc.

3.4.5.3 Sector projection summary

Overall, EU production in the chemical and pharmaceutical sector is assumed to increase through 2050 to meet anticipated global demand for products. Although, pharmaceutical sector growth trends have been historically greater than the chemicals sector, it accounts for only 25% of total sector revenues; consequently, future trends assume a conservative growth rate ranging from 1.1 to 1.3% per year through 2050[93]. Table 3.43 presents the anticipated sales trend for the sector. In 2050, sales are assumed to be nearly 60% greater than 2010 levels.

Table 3.43 Projected sales trend of chemicals and pharmaceuticals in EU (billion €)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Sales (bil €)	672*	672	707	754	800	848	896	947	1,000	1,056

**Based on Eurostat statistics*

In EU-28, final energy consumption in the chemical and pharmaceutical sector decreased by 4% in 2011 compared to 2000.[94] This reflects continuing efforts by the sector to improve energy efficiency by reducing its fuel and power energy consumption per unit of production.[95] However, the rate of improvement has been decreasing as plant-level efficiency is maximised, making it more difficult to make further improvements. This is illustrated by the sector reducing its energy intensity by approximately 4% per year between 1990 and 2000, but between 2000 and 2010 the rate has dropped to approximately 1% per year[96]. Reflecting this trend, it is assumed that sector intensity will decrease by 0.5% per year through 2020, and then by 0.25% through 2050 as further incremental process efficiency improvements are made to improve margins, and meet existing legislative requirements (e.g., EED, IED). Table 3.44 presents the anticipated energy intensity trend through 2050.

Table 3.44 Projected energy intensity trends for chemicals and pharmaceuticals

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Energy intensity (kTOE/ million €)	0.081	0.081	0.080	0.079	0.079	0.078	0.078	0.077	0.076	0.076

**Base year energy intensity determined from Eurostat (2013)*

Figure 3.43 illustrates the BAU projection trend (energy consumption and production) for manufacture of chemicals and pharmaceuticals in EU28 over the period 2012 to 2050.

[91] EC; 2011; *EU industrial structure 2011 Trends and Performance*

[92] Efpia; 2013; The Pharmaceutical Industry in Figures

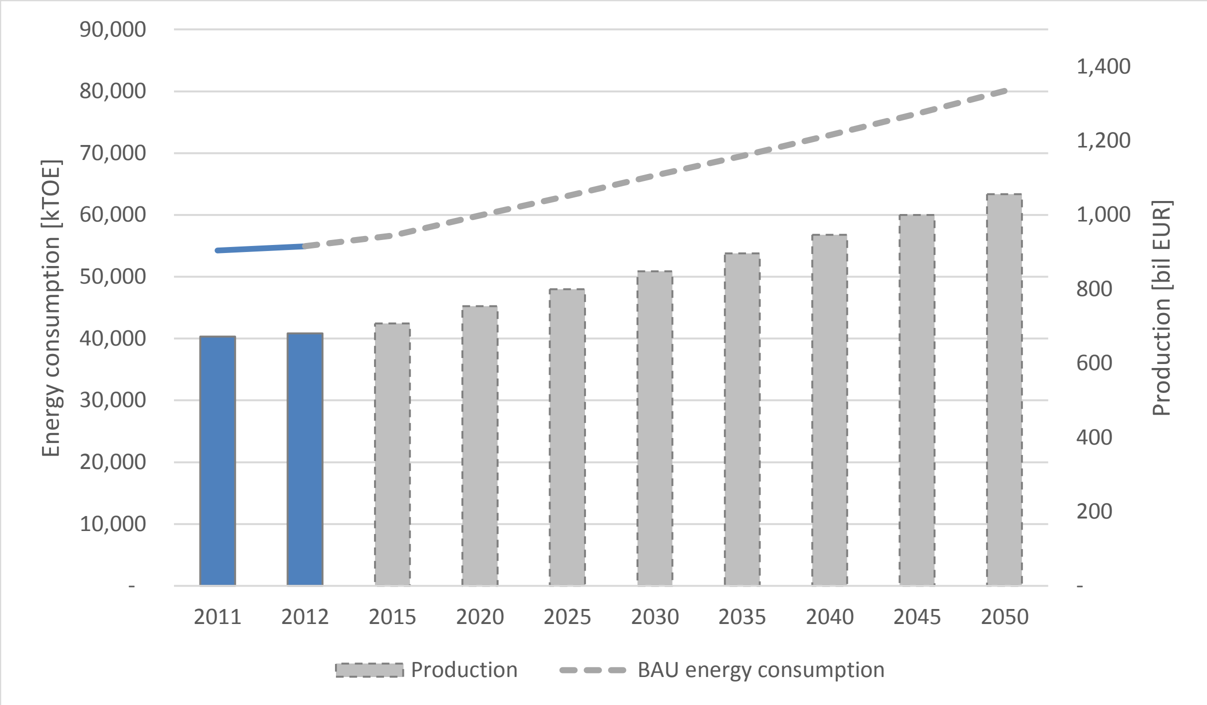
[93] Similar to Cefic Roadmap (2013) projected trends (continued fragmentation scenario)

[94] Eurostat; 2013c; Energy, transport and environment indicators; Luxembourg: Publications Office of the European Union

[95] The European chemical industry. Facts & Figures 2013; Cefic, 2013

[96] Ibid

Figure 3.43 BAU projection for manufacture of chemicals and pharmaceuticals in EU



3.4.6 Projection of energy saving potential

Figure 3.44 presents the energy consumption projections from 2011 through to 2050 under the BAU, technical and economic scenarios[97] from the modelling outputs of IEEM.

A total of 99 ESOs which are technically feasible to the sector were accounted for in the modelling process. The projected savings under the technical[98] potential scenario is 16.5 million TOE (25% saving) in year 2030 and 18 million TOE (22% saving) in year 2050 with reference to the BAU projections.

A total of 49 ESOs were included under economic scenario 1, resulting in a projected saving of 2.7 million TOE (4% saving) in year 2030 and 6.4 million TOE (7.9% saving) in year 2050 with reference to the BAU projections.

An additional 17 ESOs, i.e. a total of 66 ESOs, were included under economic scenario 2, resulting in a projected saving of 3.2 million TOE (4.9% saving) in year 2030 and 7.4 million TOE (9.3% saving) in year 2050 with reference to BAU projections. The additional savings for economic scenario 2 are mainly attributed to the following additional ESOs:

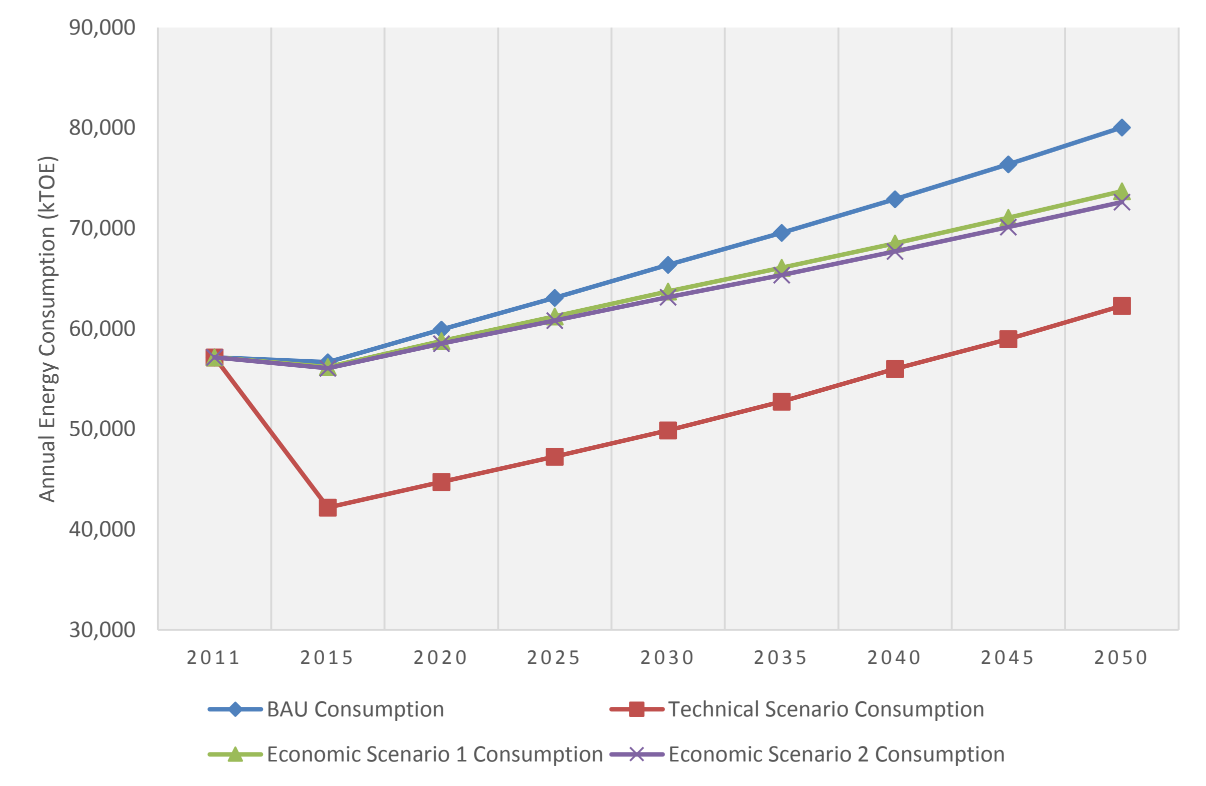
- High efficiency burner (boiler)
- Inter-plant process integration
- High efficiency non-packaged HVAC equipment
- Premium efficiency control with Adjustable Speed Drives (for pumps and motors)
- Advanced boiler controls
- Process heat recovery to preheat makeup water

[97] The economic scenario 1 assumes an uptake of ESOs which fulfils the less than 2 year simple payback criteria, whereas the economic scenario 2 assumes an uptake of ESOs of less than 5 year simple payback.

[98] Under the technical potential scenario, it is assumed that all technically feasible ESOs relevant to the sector is implemented regardless of economic viability.

The full list of Energy Saving Opportunities are listed in Annex 3. The list of ECOs under economic scenario 1 and 2 is presented in Annex 4.

Figure 3.44 Projected economic and technical potential scenario energy use for the chemical and pharmaceutical sector



The following energy saving opportunities listed in Table 3.45 represents approximately 66% of the overall sector energy saving potential.

Table 3.45 Projected sector energy saving opportunities with highest technical potential

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
More efficient low grade waste heat recovery technologies (emerging)	Technology is available to take advantage of even the low grade waste heat, which remains after other more efficient uses of waste heat have been exhausted. Organic Rankine Cycles can be used to produce power from heat as low as 80°C, and hence are a “new heat sink” to utilize this waste heat.	1946	2182	12% / 12%
Improved catalyst	Catalysts are continually being improved to increase process performance and reduce energy consumption.	1627	1869	10% / 11%

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Integrated control system	A neural network system is an example of an integrated control system. The information of the sensors is used in control systems to adapt the process conditions, based on artificial intelligence, mathematical ("rule"-based) or neural networks and "fuzzy logic" models of the industrial process.	1579	1797	10% / 10%
Inter-plant Process Integration	Process integration techniques such as pinch analysis can be applied for resource conservation. Several networks or plants may be integrated to maximize resource recovery through inter-plant integration. Requires facilities to be adjacent, and have synergies (such as utilities) which in close enough proximity to be shared.	1441	1312	8% / 7%
Flue-gas monitoring	Stack thermometers, fuel meters, make-up feed water meters, oxygen analysers, run-time recorders, energy output meters, and return condensate thermometers are required to maintain a proper air-to-fuel ratio to optimize fuel combustion efficiency.	1049	1189	6% / 7%
Sub-metering and interval metering	Sub-meters are used to measure the amount of energy consumed by equipment, or portions of the plant. They communicate with a central system where the information is trended, stored or transferred to a data historian system for archiving.	1045	1075	6% / 6%
Increased uptake of Energy Management System (EnMS)	A series of systemised interacting processes that enables an organization to obtain relevant energy information and act upon it to maintain and improve energy performance, while reducing environmental emissions as a consequence.	481	539	3% / 3%
Improved design of distillation column	This measure involves the replacement of existing distillation technology with a new higher efficiency distillation/separation reaction. This could include advanced separations such as Divided Wall Column distillation or Heat Integrated Distillation Column (HIDiC).	373	464	2% / 2%
Advanced Heating and Process Control	Advanced heating and process controls reduces energy losses by governing aspects such as material handling, heat storage and turndown.	358	421	2% / 2%

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Optimization of distillation column operation	This measure includes operational improvements that can be made by plant operators to reduce distillation energy consumption. (reflux ratios, avoid over-puryfying products, pressure adjustment, etc.)	339	380	2% / 2%
Combined Heat and Power plant	Combined heat and power (CHP) production is the simultaneous generation of heat energy and electrical and/or mechanical energy in a single process referred to as a CHP plant. CHP plants raise the conversion rate of fuel use (fuel efficiency level) from around one-third in conventional power stations to around 80 – 93%.	299	296	2% / 2%
High Efficiency Burner	These burners are more efficient at higher-temperature applications. Advancements over the recent years include the commercialization of self-recuperative and self-regenerative burners that use staged combustion to achieve flameless combustion. This results in more uniform heating, lower peak flame temperatures, improved efficiency and lower NOx emissions.	271	248	1.5% / 1.5%

Of the ESOs listed in Table 3.45, three of the measures (more efficient low grade waste heat recovery technologies, improved design of distillation column and CHP) did not fall within the criteria of economic scenario 1 or 2.

The following sector specific Energy Saving Opportunities listed in Table 3.46 are technically feasible for the sector but unaccounted for in the economic scenarios as they did not meet the respective payback criteria.

Table 3.46 Projected technical potential sector specific energy saving opportunities

Sector specific energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Improved reactor design	This opportunity represents improved reactor designs for energy efficient operation. One technology would include the mixed-phase fixed bed reactor, which is more efficient than a standard fixed bed reactor.	261	255	1.5% / 1.5%
Process optimisation and improved process design	This measure involves major process overhauls/replacements with new more efficient processes that have been developed to produce the same products.	177	217	1% / 1%

Sector specific energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Novel separation processes (emerging)	This opportunity involves novel separation methods that are being developed (or adapted for new reactions) to replace distillation with less energy intensive processes.	122	152	1% / 1%
Optimized heating in furnace (cracking) and pre-heating feed	This opportunity includes significant retrofits to improve the cracking furnace efficiency by improving/saving energy on the feed conditions	63	60	0.5% / 0.3%
Membrane and other pharmaceutical process developments	This opportunity involves process improvements specific to the pharmaceutical sub-sector. This includes membrane related improvements, such as their use for more efficient water treatment.	7	7	negligible

3.5 Non Ferrous Metal

3.5.1 Structure and economic contribution

The Non Ferrous Metal (NFM) sector primarily consist of upstream base metal production (aluminium, copper, lead, zinc, tin) and precious metal production (silver, gold, palladium, other platinum group metals). The downstream activity includes secondary processing and fabrication activities of light metals (semi-finished products of aluminium, magnesium, titanium, zinc, etc.) and other non-ferrous metals (heavy metal, precious metal and die casting). The NFM sector had an annual turnover of over EUR 118bn in 2012. The largest economic contributions are delivered by 2 classes: Aluminium production (NACE C24.42) and copper production (NACE 24.44), contributing to approximately 70% and 64% of annual turnover and value added of NFM sector respectively in 2012. Key economic indicators for the chemicals and pharmaceutical sector are summarised in Table 3.47.

Table 3.47 Key economic indicators on sector division and group level for EU 28 for 2012

Description	NACE (Group)	NACE (Class)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of basic precious and other non-ferrous metals	C24.4		3,600	199,617	118,271	15,000	168,216
Precious metal production	-	C24.41	738	8,762	11,045	960	10,590
Aluminium production	-	C24.42	1,510	97,598	40,222	6,019	38,632
Lead, zinc and tin production	-	C24.43	243	15,559	8,016	1,346	7,750

Description	NACE (Group)	NACE (Class)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Copper production	-	C24.44	368	33,676	42,114	3,560	38,682
Other non-ferrous metal production	-	C24.45	713	13,337	8,381	1,444	7,805
Processing of nuclear fuel	-	C24.46	N/A	N/A	N/A	N/A	N/A
Casting of metals	C24.5		6,200	250,568	38,965	11,341	38,446
Casting of light metals	-	C24.53	2,038	82,644	12,841	3,951	12,731
Casting of non-ferrous	-	C24.54	1,672	28,368	6,176	1,396	6,095

Source: EUROSTAT, accessed on Dec 2014

3.5.2 Key products

Non Ferrous Metals (NFM) are non-magnetic and generally more resistant to corrosion than ferrous metals; several NFM are also good conductors of electricity. There are three key groups that make up the NFM industry, these primarily include:

- Base metals (aluminium, copper, zinc, lead, nickel, tin) => NACE 24.42 – 24.44
- Precious metals (silver, gold, palladium, other platinum group metals) => NACE 24.41
- Minor metals including refractory metals (e.g. tungsten, molybdenum, tantalum, niobium, chromium) and specialty metals (e.g. cobalt, germanium, indium, tellurium, antimony, gallium) => NAC 24.45

The NFM sector also involves the following casting activities:

- Casting of light metals (semi-finished products of aluminium, magnesium, titanium, zinc, etc.)
- Casting of other non-ferrous metals (heavy metal, precious metal, die casting)

3.5.2.1 Aluminium product scope

Alumina (also known as aluminium oxide) is produced from bauxite ore which is the primary source of aluminium. Alumina is extracted from bauxite ore through the Bayer[99] chemical process, which takes the form of white powder. Alumina is the main raw material for primary production of aluminium through the smelting process. In addition to production of aluminium, alumina is also used as filler for plastic, production of automotive paint. A large scale of alumina is also used in refineries for conversion of dangerous hydrogen sulphide into elemental sulphur [The Aluminum Association]. The European Aluminium Association (EAA) recorded a total of 12 plants within Europe producing alumina in 2011.

Primary Aluminium is produced through smelting (or reduction) plants, where pure aluminium is extracted from alumina through the Hall-Héroult electrolysis process[100], whereby the reduction of alumina into liquid aluminium is operated at >950 °C under a high intensity electrical current. For this reason many aluminium production plants are located near to

[99] The Bayer process is the primary chemical process of extracting alumina from bauxite ore, which was developed in 1887 and still used in nearly all of the world's alumina supply

[100] The Hall-Héroult process involves dissolving alumina into a molten cryolite bath and passing current through the mixture causing the oxygen atoms to separate from the alumina and resulting in aluminium.

dedicated, low cost, hydropower supplies to avoid energy losses (examples are Fort William in Scotland, Karmoy in Norway, Krasnoyarsk in Russia) – the layout and shape of the 'busbars' that carry the current is an important factor in reducing energy losses. EAA recorded a total of 31 plants within Europe in producing aluminium through the primary process and approximately 50% of aluminium produced within EU are produced through primary smelters in 2011.

Secondary Aluminium is produced from re-melting aluminium material recovered from waste streams and recycling process. The collected material is fed into a melting furnace operating at temperatures ranging from 700 – 760 °C. EAA recorded a total of 283 plants within Europe producing aluminium through secondary process in 2011 and approximately 50% of aluminium produced within EU are produced through the secondary smelters in 2011.

Processing of aluminium are downstream activities of converting primary and secondary aluminium into final products. Processing of molten aluminium or semi-finished aluminium product can be categorised into the following key processes:

Casting is the most widely used method of forming aluminium into final products within EU. Molten aluminium is shaped to the desired forms through the casting process. The resulting product could be an intermediate product (ingots, billets, etc.) for further processing or it could also take form of finished product. EAA recorded >2400 casting plants operating within EU delivering approximately 27% of the total output of aluminium processing in 2011.

Extrusion is a deformation process in which solid aluminium (billets or ingots) is forced through a die opening through a forced compression. The solid aluminium feedstock are typically preheated to facilitate the deformation process. EAA recorded 55 extrusion plants operating within EU delivering approximately 25% of the total output of aluminium processing in 2011.

Rolling involves passing aluminium between 2 rollers under pressure resulting in thinner and longer form, which is the basic process of producing aluminium plate, sheets or foil. Aluminium ingots are preheated and fed into the rolling mill, whereby the slab is rolled until the desired thickness is achieved. Optional heat treatments are also applied at this stage to improve the final product's strength. EAA recorded 55 rolling plants operating within EU delivering approximately 38% of the total output of aluminium processing in 2011.

3.5.2.2 Copper product scope

Blister is an intermediate copper product containing 98.5 – 99.5% copper. Copper ore and concentrates go through a roasting process prior to being fed into a smelter resulting in a copper matte, containing 50 – 70% copper. The molten matte then follows a conversion process to produce blister copper.

Copper anode is a product of the copper refining process containing around 99% pure copper. Blister copper is fire refined (anode furnace) through traditional process route, and progressively re-melted and cast into anodes for electro-refining.

Copper Cathode is a result of the electro-refining process and contains 99.99% pure copper. An electrolytic cell is used and consists of a cast copper anode and a cathode, made out of pure copper to act as a starter sheet, placed in an electrolyte that contains copper sulphate and sulphuric acid. High current density is applied through the solution and pure copper is deposited on the cathode.

3.5.3 Key sector processes

3.5.3.1 Aluminium production

Figure 3.45 provides an overview of the primary and secondary aluminium production process.

Refining of bauxite (Bayer's process). Bauxite ore is crushed and dissolved in hot sodium hydroxide. The iron and other oxides are removed (as insoluble 'red mud'). The solution is then precipitated and goes through a calcination[101] process to produce a dry white powder, alumina.

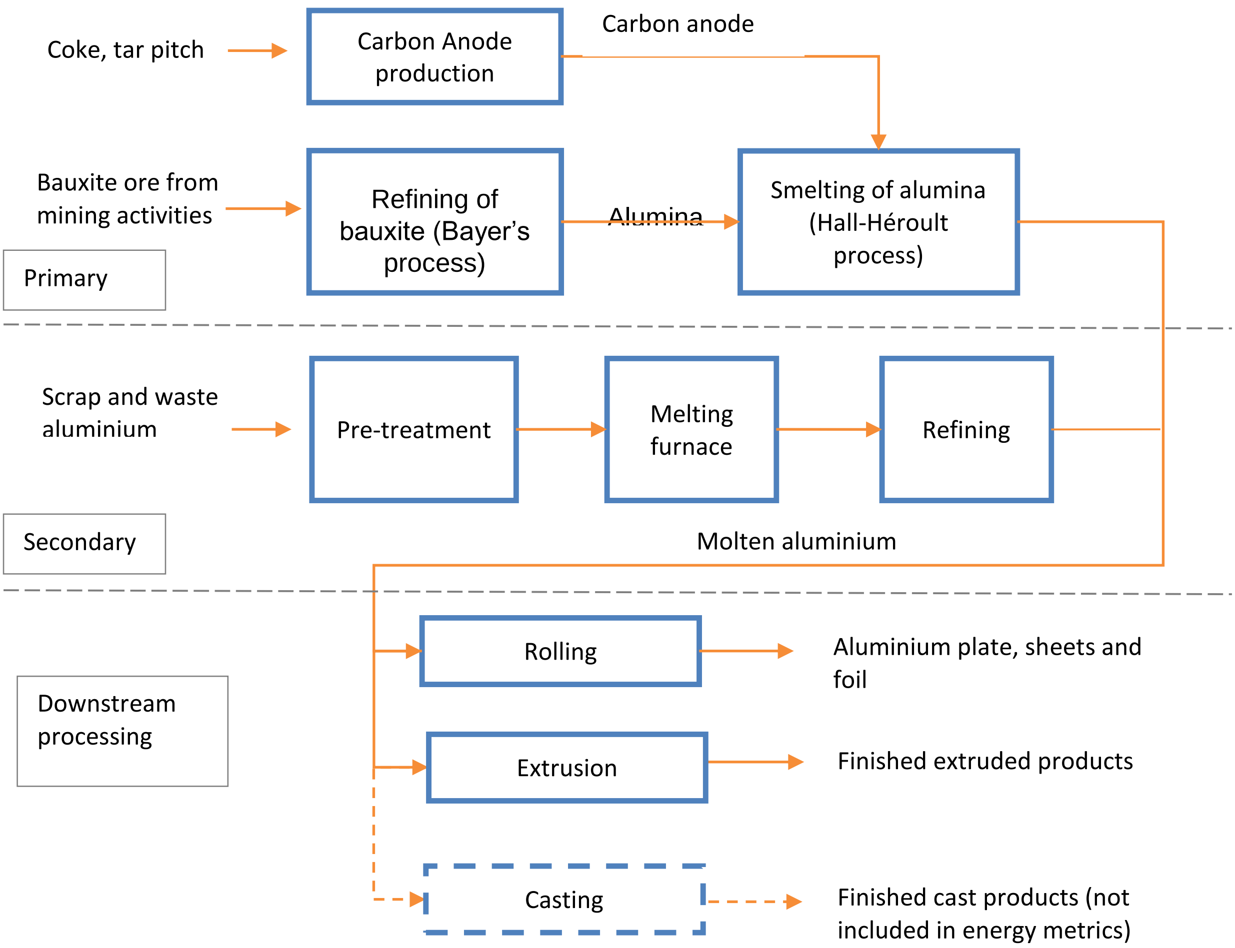
Anode manufacturing. All commercial manufacturing of aluminium utilizes a carbon anode in the smelting (Hall-Héroult) process as it results in much lower energy Consumption. The carbon is consumed during the electrolytic process therefore a constant supply is required for the smelting process. Carbon anodes are produced by heating up of coke or tar pitch.

Smelting (Hall-Héroult process). The Hall-Héroult process is the primary process for commercial aluminium production. The process takes place in an electrolytic cell or pot, consisting of two electrodes, anode and cathode. Alumina is dissolved into a cryolite bath and serves as an electrolyte for the process. High amounts of current is passed through the molten bath and which reduces alumina to form liquid aluminium at the bottom of the cell or pot.

Secondary aluminium production involves using recovered or recycled aluminium from waste streams as raw material to produce aluminium. Secondary aluminium production uses far less energy than primary aluminium production process due to the lower heating temperature. The process starts with sorting and pre-treatment of the scrap feedstock according to their quality and characteristics. Various furnace types are available for the melting process, including reverbatory, induction furnaces and emerging technologies such as rotary arc and plasma furnaces. The choice of furnace would depend on the characteristics of the scrap feedstock.

[101] Calcination is an oxidation process by exposure to intense heat

Figure 3.45 Overview of primary and secondary aluminium production



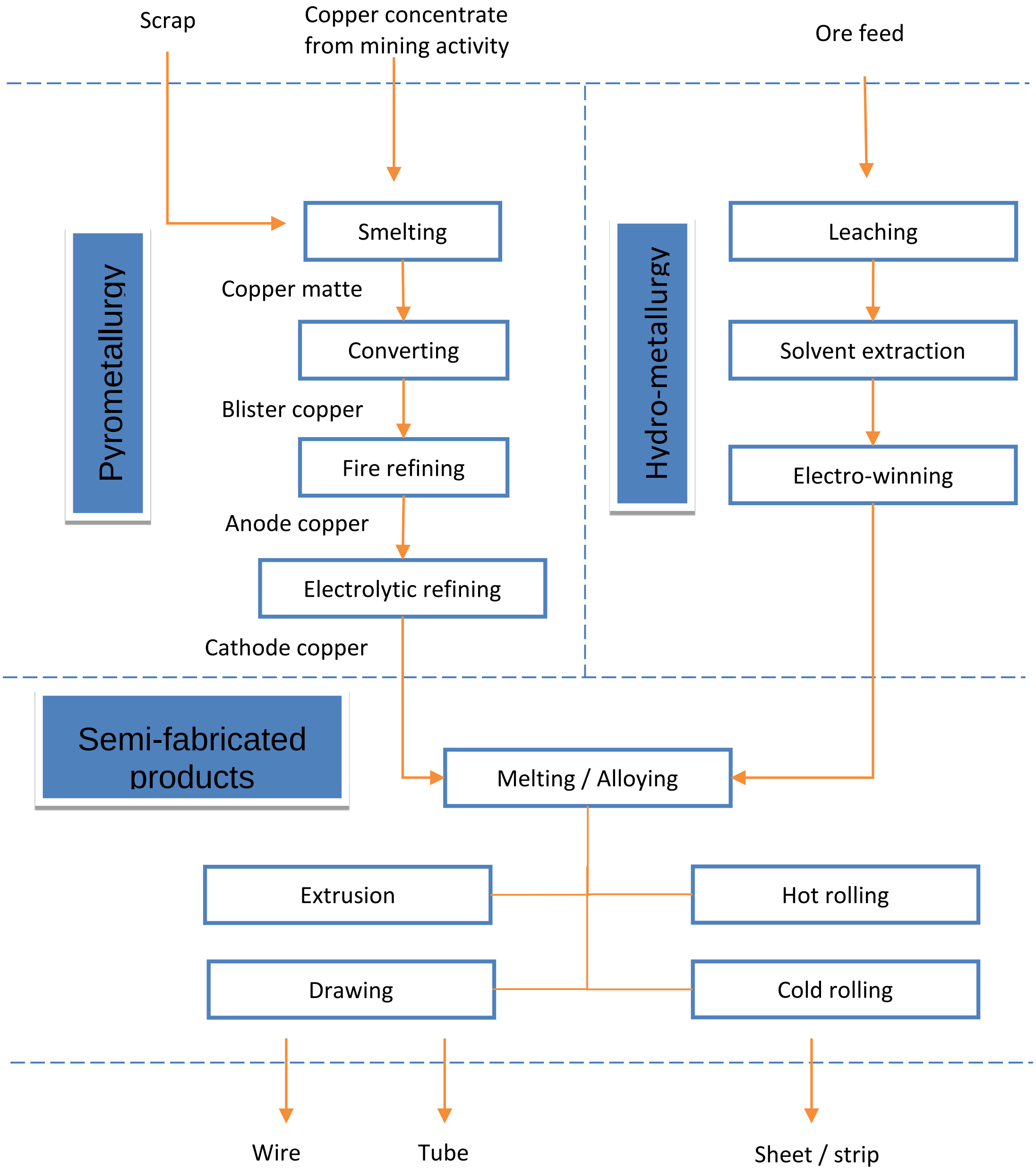
3.5.3.2 Copper production

Figure 3.46 provides an overview of the key processes in primary and secondary copper production.

There are 2 main routes in production of copper; the pyro-metallurgical or hydro-metallurgical route. Approximately 80% of primary copper is produced through pyrometallurgy process and the remaining 20% with hydro-metallurgy process. The hydro-metallurgical route is particularly suitable for ores which are difficult to concentrate by conventional means and does not contain precious metal.

Pyrometallurgy. Copper concentrate are dried, typically from 7 – 8% moisture to 0.2% before being fed into the smelting furnace. The drying and smelting process typically carried out simultaneously in a single furnace to produce melt that can be separated into matte (copper sulphide typically containing 60 – 65% copper) and a slag rich in iron and silica. The matte produced in the smelting furnace is then grinded before being fed into the conversion process. The conversion process converts matte into blister copper (typically 98.5% copper) by oxidising the copper sulphide with an air/oxygen mixture. The blister copper then goes through a fire refining process, i.e. fed into an anode furnace where sulphur is oxidised in a short oxidation period and finally cast into anodes. The cast anodes are then placed into an electrolyte bath which separate other metals to produce copper cathode.

Figure 3.46 Overview of primary and secondary copper production (source: ECI)



Hydro-metallurgy. The hydro-metallurgical process is carried out with much lower temperatures, therefore eliminating the production of sulphur dioxide emission, but produces effluent which must be treated. Crushed ores are mixed with a leaching solution, typically sulphuric acid, which dissolves the copper and leaves a residue of precious metals. The leach solution then undergoes a purification process to remove dissolved iron and other impurities and concentrating of copper in smaller volumes by the solvent extraction process. The stripped solution, containing mainly copper sulphate, is then sent to the electro-winning stage. Electro-winning consists of the recovery of copper metal from the stripped solution (electrolyte) in a unique electro-winning cell. As current is passed, copper is then deposited at the cathode forming copper cathode.

Secondary copper is produced through pyro-metallurgical process. Production of secondary copper depends heavily on the copper content of secondary raw material and its size distribution. It follows a similar process as of production of primary copper in removing impurities and copper recovery.

3.5.4 Energy metrics

3.5.4.1 Energy intensity based on sector energy cost

Table 3.48 provides an indication of the sector's energy intensity for selected EU Member States expressed in 2 ratios[102] from 2008 - 2012. Based on the 5 year trend of the energy intensity ratios, it has remained flat, consistent with the longer term intensity trend discussed in Section 3.5.5. The NFM sector ranks 4th most energy intensive sector in comparison with the 8 industrial sectors evaluated in this Study in terms of energy cost spent per value added generated.

Table 3.48 Energy cost intensity ratios per unit of VA and Turnover generated for selected MS *

	Ratio	2008	2009	2010	2011	2012
1	Energy cost/ Value Added	24%	26%	20%	23%	23%
2	Energy cost/ Turnover	4%	5%	3%	3%	3%

Source: ICF analysis on EUROSTAT SBS, accessed Dec 2014

** Note: Data covers Belgium, Bulgaria, Germany, Greece, Spain, France, Italy, Hungary, Austria, Portugal, Slovakia, Sweden and UK*

3.5.4.2 Energy intensity of key processes

Table 3.49 provides a breakdown of energy intensity for the various processes of aluminium production whereby the figures are expressed in per metric tonne of aluminium produced at the respective processes.

Table 3.49 Energy intensity of aluminium production processes

Process	Thermal [GJ / tonne]	Electricity [GJ / tonne]
Primary aluminium		
Refining of bauxite (Bayer's process) Digesting Calcine kiln	 12.1 6.5	1.4
Carbon anode production	1.0	0.21
Smelting process (Hall-Héroult process)	-	49.0
Secondary aluminium	3 – 9	-
Aluminium processing		
Primary ingot casting	2.8	0.8
Secondary ingot casting	7.2	0.45
Cold rolling	1.0	1.3
Hot rolling	1.3	0.9

[102] (1) Ratio of energy cost per unit of value added and (2) Ratio of energy cost per unit of turnover, i.e. the monetary value paid by manufacturers on energy products for every unit of value added or turnover generated by the sector.

Process	Thermal [GJ / tonne]	Electricity [GJ / tonne]
Extrusion	4.0	0.4
Other shape casting	9.2	0

Source: Worrell et. al, 2008

Based on 2009 statistics from EAA, the EU produced 8.27 million tonnes of aluminium metal, of which 4.75 million tonnes were produced by primary smelters and the remaining 3.52 million tonnes were produced by secondary refiners and re-melters. In consideration of the thermal and electrical energy consumption reported (for production of alumina, primary aluminium, secondary aluminium, rolling and extruded products), the weighted average energy intensity for EU's aluminium production is **23,037kWh/t (0.198 TOE/kt)**, whereby **14,399 kWh (63%)** is attributed to electrical energy and **8,638kWh/t (37%)** is attributed to thermal energy. Table 3.50 provides a breakdown of EU's final energy consumption for the aluminium industry.

Table 3.50 EU energy consumption for aluminium production

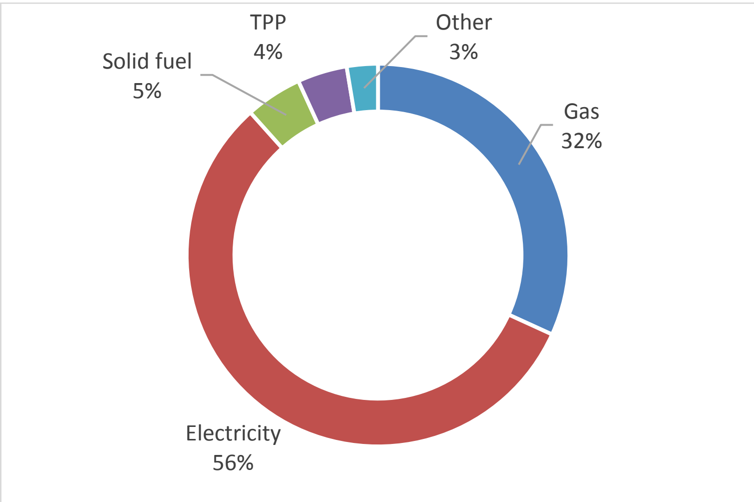
Product	Output [kt]	% of total output	Electrical Energy [GWh]	Thermal Energy [GWh]	Total Energy [GWh]	% of total energy
Alumina	4,748	26%	-	13,734	13,734	13%
Primary	4,091	22%	61,590	16,759	78,349	76%
Rolling	3,514	19%	1,850	2,090	3,940	4%
Extrusion	2,394	13%	1,904	1,946	3,850	4%
Recycling	3,520	19%	-	3,412	3,412	3%
Total	18,267	100%	65,344	37,941	103,285	

Source: ICF analysis on EAA 2010 Sustainability Report

3.5.4.3 *EU final energy consumption for non-ferrous metals chemical and pharmaceutical production*

Figure 3.47 presents the average fuel mix for EU chemical and pharmaceutical plants in 2012.

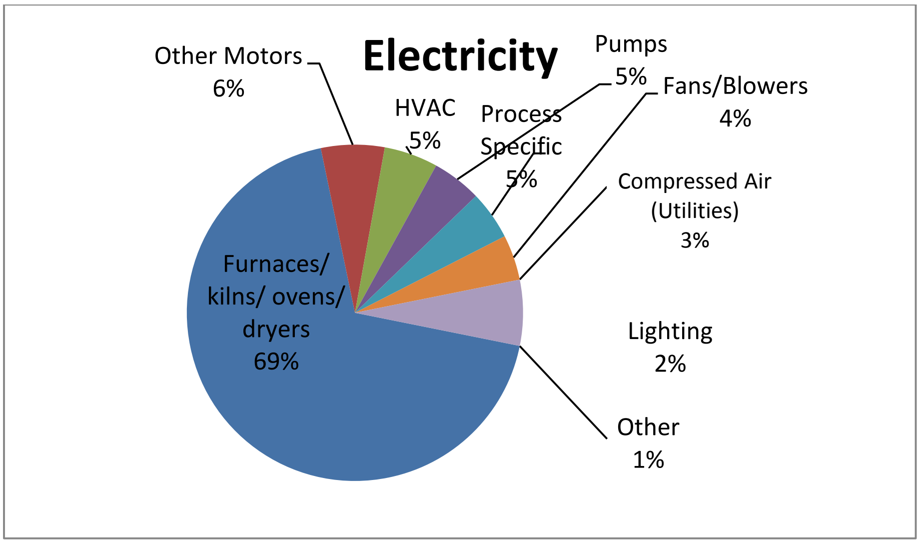
Figure 3.47 Fuel mix profile for EU chemical and pharmaceutical sector



3.5.4.4 *Energy end use profile*

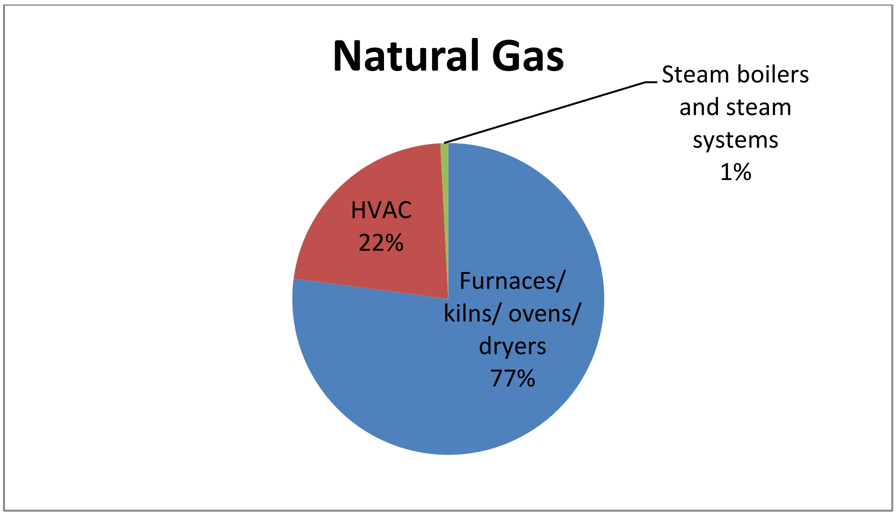
Based on the estimated share of energy consumption amongst the NFM sector, and the fuel mix profiles, the following figures present an aggregate energy use profile for the primary energy sources, including electricity, natural gas, total petroleum products (i.e., oil), coal, and other categories.[103]

Figure 3.48 Electricity use profile



Source: ICF International

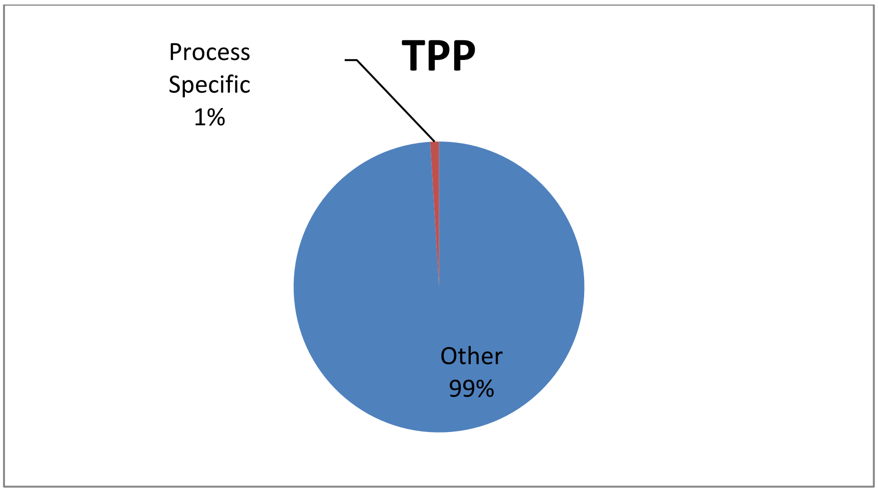
Figure 3.49 Natural gas use profile



Source: ICF International

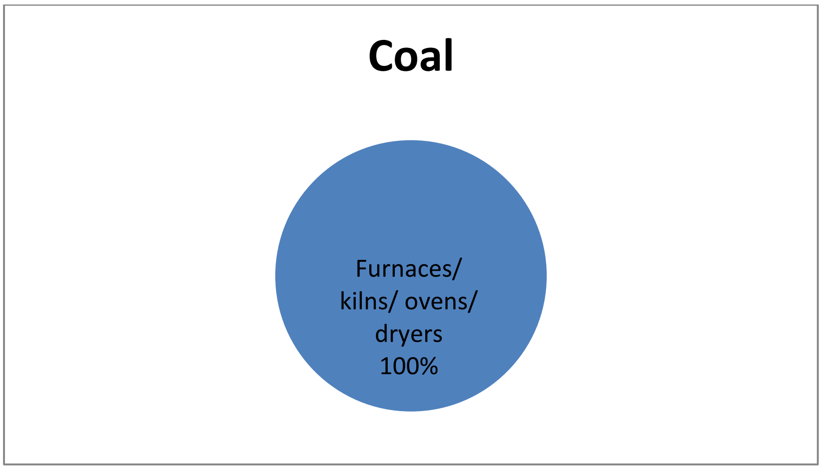
[103] Based on ICF energy efficiency studies within the NFM sector

Figure 3.50 Total petroleum product (e.g., oil) use profile



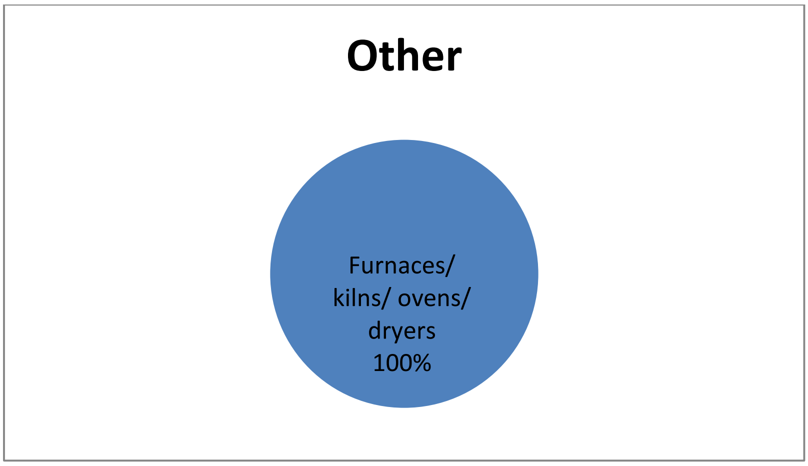
Source: ICF International

Figure 3.51 Coal use profile



Source: ICF International

Figure 3.52 Energy use profile for other sources; i.e., biomass



Source: ICF International

3.5.5 Projection of energy consumption trend

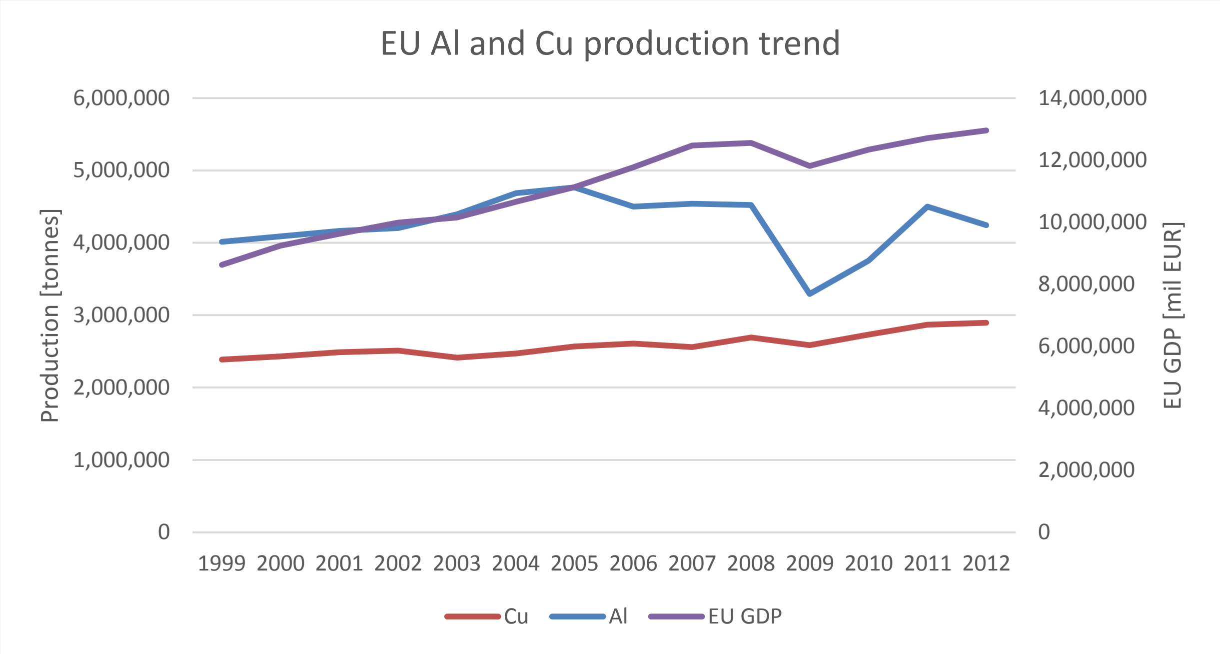
The following details are an extracted summary of the sector profile in Annex 1.

The NFM industry is mature and technologically advanced with a skilled labour force with the ability to produce high quality products. NFM producers provide vital inputs for high-tech industries and are therefore considered to be of great economic importance for emerging technologies. The EU NFM sector is technologically is at forefront in many sub-sectors and segments; particularly in higher value added (e.g. precious metals) and high quality tailor made products. Therefore this provides an important incentive for many companies to retain their production capacity and R&D activities in the EU. The EU has strong value chain integration which has contributed greatly to the strength of the sector. The most demanding consumers of NFM, in terms of quality and specialised material needs are based in the EU. As such, EU NFM producers have worked with clients (in manufacturing, aerospace and transport sectors) and developed the ability to produce tailored, high quality and technologically advanced solutions. The strong integrated value chain has also allowed scrap metals to enter the value chain during the refining and processing stages, significantly reducing energy and resource use to benefit the environment and enhance competitiveness. The EU recycling industry is one of the most advanced in the world, even compared to industries in developed countries such as the US, Canada and Japan.

On the other hand, primary metal producers in the EU will be at risk of closing down if there is not an improvement in power market conditions; since current electricity prices reduce EU producer margins to an unsustainable level. EU is also facing growing threats from extra EU countries. Although EU has high recycling rate of scrap metals, growing competition from low labour cost countries (for the sorting of scrap metal using labour intensive methods) is driving scrap handlers to export unprocessed scrap rather than sort it in the EU as this may be a more profitable route. As such, this would lead to the loss of scrap for EU producers to countries that have lower recovery rates and lower environmental and labour standards.

Figure 3.53 provides a historic EU production trend (excluding Norway) for aluminium and copper from 1999 – 2012. The EU's production has been relatively flat throughout this period (apart from a dip in primary aluminium production during the recession) despite an increase of 50% in EU GDP. The EU is also heavily reliant on NFM import. Environmental regulations in the EU have added pressure on the NFM industry both in terms of regulatory compliance and increased energy costs. The EU ETS in particular has a significant impact because it increases direct production costs compared to producers outside of the EU. Additionally, the industry also faces indirect CO2 costs due to increased electricity prices (as the power sector passes on its ETS costs) as well as cost burdens related to self-generation. Smelting from primary raw material in the NFM industry is extremely energy intensive. For example approximately 15 MWh are needed to produce one tonne of aluminium and 4 MWh are required for one tonne of copper. Electricity costs represent a third of total production costs for the EU primary aluminium industry, making it a key factor impacting the competitiveness of the sector. On the balance of the above factors, it is expected that the trade deficit will continue to increase as the economy grows and production as a whole will continue to stagnate with no increased production capacity due to the lack of evidence in new investment within the sector and expansion of upstream production of NFM is likely to occur outside of EU.

Figure 3.53 EU aluminum and copper production vs. EU GDP trend

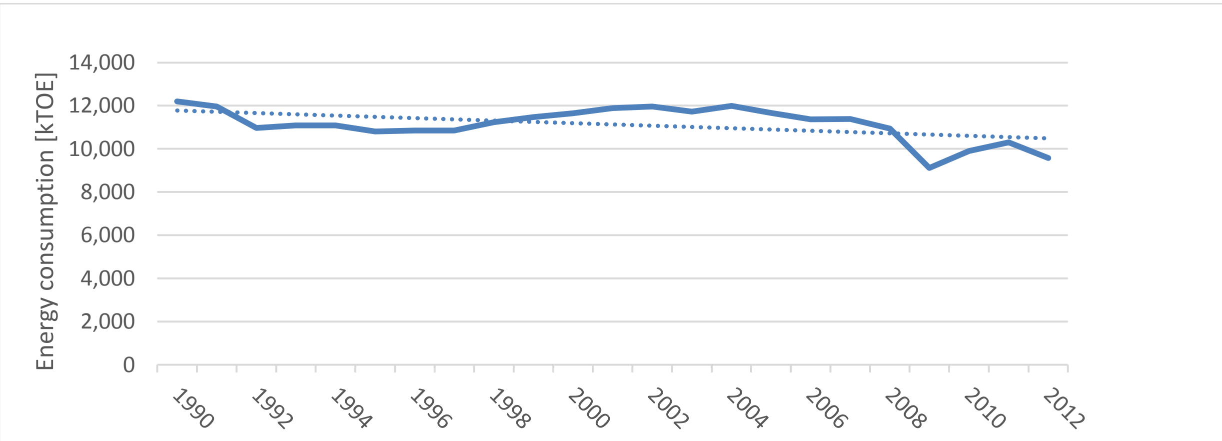


Source: ICF analysis on EU Mineral Statistics 1999 - 2012

** Note: Production figures for aluminium only includes primary aluminium. Aluminium produced from secondary sources (scrap or recycled) are excluded.*

Although the aluminium industry has reduced their CO_2e emissions by 50% since 1990, this is mainly attributed to process improvements which have reduced PFC emissions and the closure of poorly performing smelters. Although the EU has some of the most efficient NFM production in the world, the core technology in production of NFM, aluminium and copper in particular, hasn't gone through any drastic improvement in energy intensity. However, recycling recovery rates within the EU are amongst the highest in the world. For example, the average share of re-cycled metal in Europe is 40%, whereas the global average is 30%. From 1980 – 2002, the production of secondary aluminium increased by over 4 times (from approximately 1 mil tonnes to 4 mil tonnes p/a). As production of secondary aluminium is far less energy intensive than primary aluminium production, this is expected to improve the overall NFM sector's energy intensity trend. Figure 3.54 provides a historic trend of the energy consumption for NFM sector from 1990 – 2012.

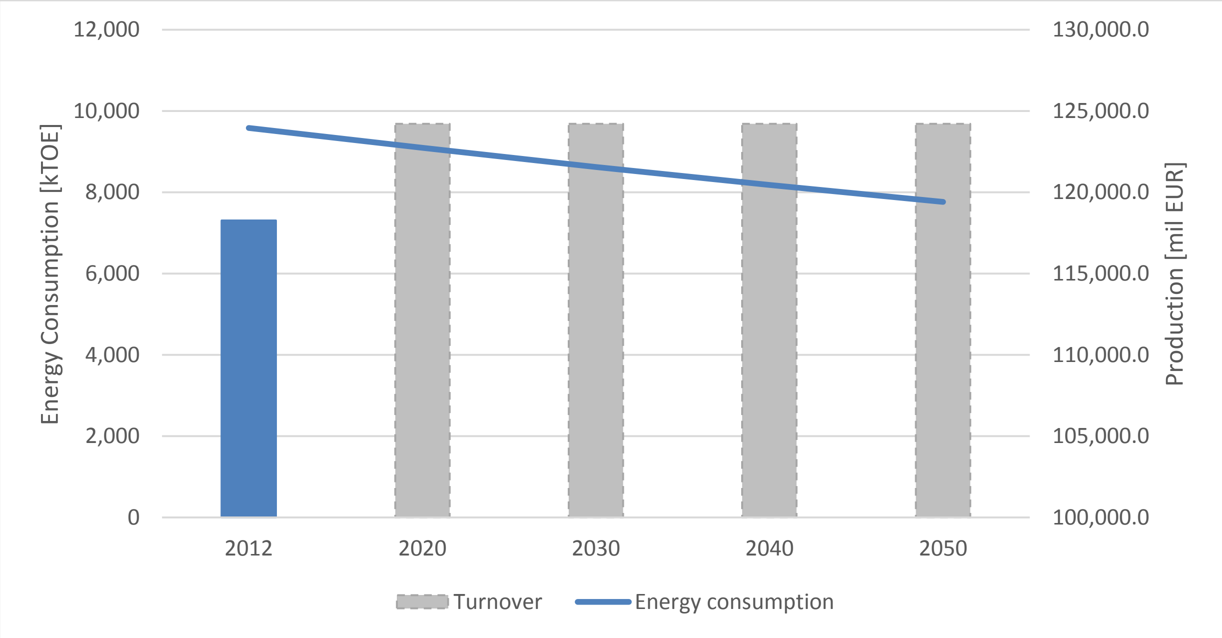
Figure 3.54 Historical trend of Energy consumption for NFM sector



Source: EUROSTAT, accessed on Dec 2014

Over this 22 year period, the energy consumption trend has been gradually reducing by an approximate rate of 0.5% p/a while production of aluminium and copper has been relatively constant over the same period). This gradual reduction trend is expected to continue as the EU continues its strong growth in production of secondary metal through improved waste management schemes in recycling and recovering useful scrap metal, resulting in a continual reduction in energy consumption as projected in Figure 3.55.

Figure 3.55 BAU projection for EU NFM sector



3.5.6 Projection of energy saving potential

Figure 3.56 presents the energy consumption projections from 2011 through to 2050 under the BAU, technical and economic scenarios[104] from the modelling outputs of IEEM.

A total of 97 ESOs which are technically feasible to the sector were accounted for in the modelling process. The projected savings under the technical[105] potential scenario is 1.9 million TOE (22% saving) in year 2030 and 1.6 million TOE (21% saving) in year 2050 with reference to the BAU projections.

A total of 42 ESOs were included under economic scenario 1, resulting a projected saving of 0.47 million TOE (5.5% saving) in year 2030 and 0.9 million TOE (12% saving) in year 2050 with reference to the BAU projections.

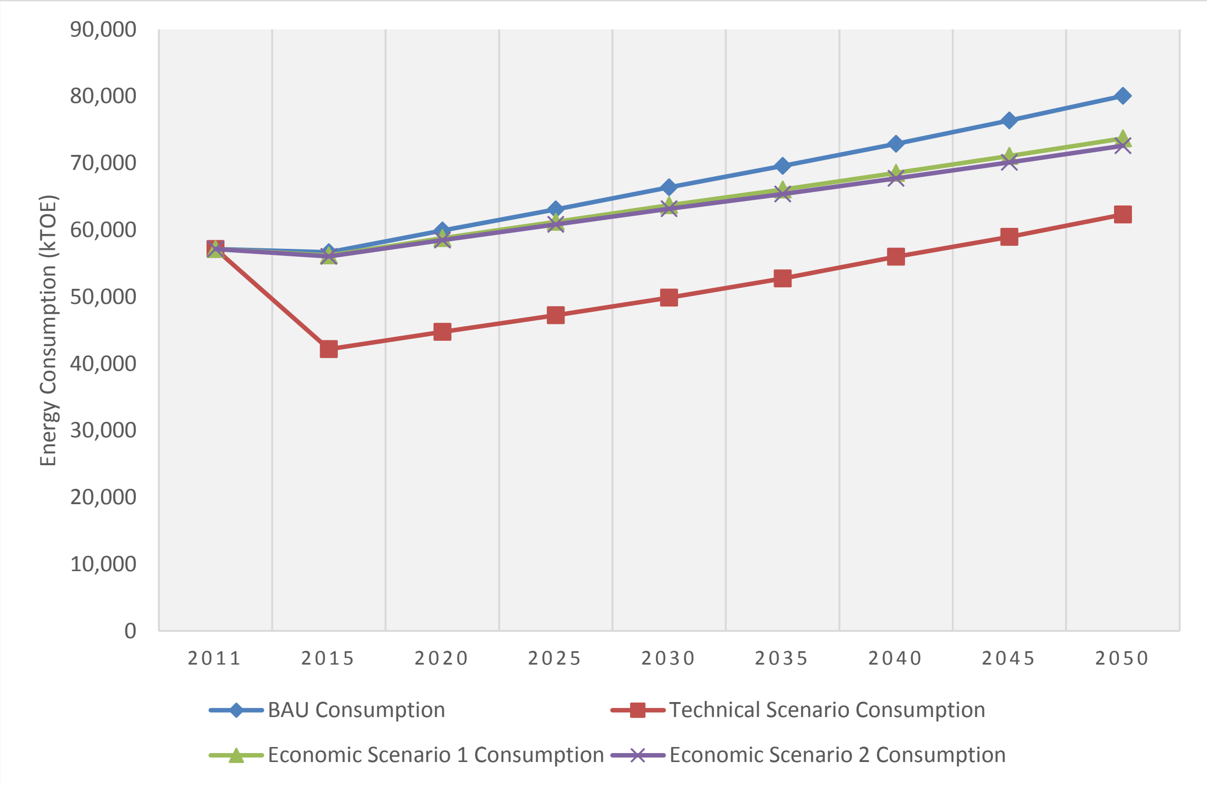
An additional 19 ESOs, i.e. a total of 61 ESOs, were included under economic scenario 2, resulting in a projected saving of 0.5 million TOE (6% saving) in year 2030 and 1 million TOE (13% saving) in year 2050 with reference to BAU projections. The energy saving impact of the additional ESOs in economic scenario 2 made very little impact on the additional energy saving potential, as they only accounted for 6% of the overall savings in comparison with economic

[104] The economic scenario 1 assumes an uptake of ESOs which fulfils the less than 2 year simple payback criteria, whereas the economic scenario 2 assumes an uptake of ESOs of less than 5 year simple payback.

[105] Under the technical potential scenario, it is assumed that all technically feasible ESOs relevant to the sector is implemented regardless of economic viability.

scenario 1, even after considering the higher payback period. The full list of ESOs are listed in Annex 3. The list of ECOs under economic scenario 1 and 2 is presented in Annex 4.

Figure 3.56 Projected economic and technical potential scenario energy use for the NFM sector



The following energy saving opportunities listed in Table 3.51 represents approximately 70% of the overall sector's technical saving potential.

Table 3.51 Projected sector energy saving opportunities with highest technical potential

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Integrated control system	A neural network system is an example of an integrated control system. The information of the sensors is used in control systems to adapt the process conditions, based on artificial intelligence, mathematical ("rule"-based) or neural networks and "fuzzy logic" models of the industrial process.	235	201	13% / 13%
Sub-metering and interval metering	Sub-meters are used to measure the amount of energy consumed by equipment, or portions of the plant. They communicate with a central system where the information is trended, stored or transferred to a data historian system for archiving.	199	170	11% / 11%
Increased recycling	Recycling aluminum (secondary aluminum production) consumes approximately one third	150	130	8% / 8%

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
	(or less) of the energy required to produce primary aluminium.			
Inert anode technology (emerging)	Unlike carbon anodes, inert anodes are not corroded during the aluminium reduction process and will not release CO2 but pure oxygen, improving energy efficiency through reduced downtime period in replacing the anodes.	121	105	6% / 6%
Advanced Heating and Process Control (furnace)	Advanced heating and process controls reduces energy losses by governing aspects such as material handling, heat storage and turndown.	94	77	5% / 5%
Preventive furnace maintenance	Preventive maintenance is repair work done on a piece of equipment, in advance of failure or performance degradation. Preventive furnace maintenance can include insulation maintenance and cleaning of heat exchanger surfaces, and combustion efficiency testing.	93	80	5% / 5%
High Efficiency Burner (furnace)	These burners are more efficient at higher-temperature applications. Advancements over the recent years include the commercialization of self-recuperative and self-regenerative burners that use staged combustion to achieve flameless combustion. This results in more uniform heating, lower peak flame temperatures, improved efficiency and lower NOx emissions.	89	706	5% / 5%
Increased uptake of Energy Management System (EnMS)	A series of systemised interacting processes that enables an organization to obtain relevant energy information and act upon it to maintain and improve energy performance, while reducing environmental emissions as a consequence.	87	74	5% / 5%
Flue-gas monitoring (furnace)	Stack thermometers, fuel meters, make-up feed water meters, oxygen analysers, run-time recorders, energy output meters, and return condensate thermometers are required to maintain a proper air-to-fuel ratio to optimize fuel combustion efficiency.	86	84	5% / 5%
Exhaust gas heat recovery (furnace)	Exhaust gas heat recovery increases efficiency because it extracts waste energy from the exhaust gases and recycles it back to the process, which reduces fuel/steam requirements.	70	70	4% / 5%
Low temperature waste heat recovery for power generation	Additional waste heat is available from kiln gasses and cooler exhaust gas. Principally, this heat can be used for drying other materials like slag or secondary fuels or production of steam / power.	41	32	2% / 2%
Combustion optimization (furnace)	Combustion efficiency can be improved by frequent adjusting of the air-to-fuel ratio to	57	56	3% / 3%

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
	reduce excess air as too much excess air carries away excessive amounts of heat.			

From these shortlisted energy saving opportunities with the highest energy saving impact, most of the measures are focused on systematic savings rather than the furnace itself. Preventive maintenance appears to be one of the no-cost/low-cost measure providing highest energy saving potential as well. Opportunities involving furnace optimization remains a priority as expected. All above measures seems to fall within the criteria of economic scenario 1 or 2.

The following sector specific Energy Saving Opportunities listed in Table 3.52 are technically feasible for the sector but unaccounted for in the economic scenarios as they did not meet the respective payback criteria.

Table 3.52 Projected technical potential sector specific energy saving opportunities

Sector specific energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Waste Heat Recovery for Pre-heating (Combustion Air and Charge Material)	The advantage of preheating combustion air used in burners is results in better combustion and reduced energy consumption. As for preheating of charge metal, theoretically 8% energy savings can be obtained for every 100 °C preheat, and in practice it is claimed that preheating to 400 °C leads to 25 % energy savings while a preheat of 500 °C leads to 30 % energy savings.	32	11	1.7% / 0.7%
Selection of Optimal Furnace Design	This opportunity involves the installation of a new high efficiency furnace at the end-of-life for existing equipment.	15	14	0.8% / 0.8%
Oxygen Enrichment of Combustion Air	Oxygen enrichment of combustion air for smelting decreases the consumption of fossil fuels and associated direct emissions. Balance must be achieved as oxygen enrichment requires energy.	15	15	0.8% / 0.9%
Improvements to Alumina production from Bauxite	This measure involves the use of the most energy efficient techniques for the production of bauxite need in the primary aluminium stream. While some of these technique s might be possible to implement as retrofits, they tend to be significant changes, so more relevant for new plants.	8	7	0.4% / 0.4%
Recovery and Combustion of Carbon Monoxide	Carbon monoxide produced in an electric or blast furnace is collected and burnt as a fuel for several different processes or to produce steam, e.g. for district heating or other energy purposes.	5	5	0.3% / 0.3%

3.6 Petroleum Refineries

3.6.1 Structure and economic contribution

The petroleum refineries sector contributed to 0.8% of the EU's GDP in 2011.[106] Key economic contributions are delivered by 2 key groups: manufacture of coke oven products (NACE C19.1) and refined petroleum products (NACE C19.2). Key economic indicators for the petroleum refineries sector are summarised in Table 3.53.

Table 3.53 Key economic indicators per sector and subsector for EU 28 in 2011

Description	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of coke and refined petroleum products	C19	412	36,641	118,891	2,822	96,743
Manufacture of coke oven products	C19.1	41	5,127	2,835	294	2,121
Manufacture of refined petroleum products	C19.2	371	31,514	116,056	2,528	94,621

Source: EUROSTAT, accessed Apr 2014

The sector has over 400 enterprises in the EU generating nearly €97 billion of revenues. Refined petroleum products (C19.1) are the largest subsector, accounting for nearly 98% of total sector revenues.

The coking subsector is heavily concentrated in Poland, which accounted for more than two thirds of the total EU value added and close to three fifths of the workforce. In 2012 there were 83 mainstream petroleum refineries in the EU, with 703.2 million tonnes of primary refining capacity.107 Germany, Italy, UK, France, Spain and the Netherlands account for over 70% of total EU refining capacity.

3.6.2 Subsector share of energy consumption

Table 3.54 provides an estimated overview of the share of energy consumption between the subsectors in EU28 based on EUROSTAT statistics. The manufacture of petroleum products accounts for 92% of the energy use in the sector.

Table 3.54 Estimated EU28 subsector share energy demand in 2011

Sector Description	NACE (Group)	Category	Estimated share of final energy demand	
			[kTOE]	*[%]*
Manufacture of coke oven products	C19.1	Energy intensive	4081	8%
Manufacture of refined petroleum products	C19.2	Energy intensive	47,948	92%
Total final energy demand for petroleum refineries sector for EU28 (2011):			**52,028**	**100%**

Source: EUROSTAT, accessed on Apr 20114

[106] Energy, transport and environment indicators; Eurostat; 2013

[107] Concawe; 2013; *Oil refining in the EU in 2020; with perspectives to 2030*

3.6.3 Key products

3.6.3.1 *Coke (NACE 19.1)*

About 90% of the coke consumed in the EU is used in the production of iron from blast oven furnaces. The remainder is used in iron foundries, non-ferrous smelters, and the chemical industry. Since 1990's, production has been declining, with capacity closures at their peak in 2009-10 due to low commodity prices, with China now accounting for over 70% of global coke production.[108] Furthermore, despite coke being important to the iron production process, to increase cost effectiveness steel-makers are adopting new technologies that aim at reducing the quantity of coke required. For example, injecting pulverised coal, waste plastic, natural gas or oil directly injected in blast furnaces rather than in the coke oven.

Coke is produced by processing low-ash low sulphur bituminous coal. Pulverised coal is heated in a coke oven, in the absence of oxygen, at high temperatures (1200-1300°C). The necessary heat is provided by external combustion of fuels and recovered gases. Coke is the solid material remaining in the oven. There are approximately 1,900 coke oven installations in the EU.[109]

3.6.3.2 *Refined petroleum products (NACE 19.2)*

Refined petroleum products are derived from crude oils through processes such as catalytic cracking and fractional distillation. The type of crude oil a refinery can process depends on the processing units operated (i.e., complexity) as well as the desired product slate. All refineries have crude oil fractional distillation, where crude oil is distilled into a number of fractions; e.g., petroleum gases, light and heavy naphtha, asphalts and residue. However, depending on the level of the refinery's complexity, these fractions can be upgraded to commercially viable products through additional processes; such as hydrodesulphurization and hydrotreating to produce fuels with reduced sulphur content; catalytic cracking for higher yields of kerosene and gasoline; and catalytic reforming to increase the octane number of the gasoline.

In 2012, there were 83 petroleum refineries in EU-28.[110] Of these, approximately half of Member States have "complex" refineries, with the remainder considered "simple".[111] The level of complexity defines whether a refiner can effectively respond to changes in product supply and demand by shifting its product slate. For example, refineries may produce more gasoline during the spring and summer months when demand is high, than they do during the winter when demand for heating oil is high.

3.6.4 Energy metrics

3.6.4.1 *Energy intensity based on sector energy cost*

Table 3.55 provides an indication of the sector's energy intensity for selected EU Member States expressed in 2 ratios[112] from 2008 - 2012. The petroleum refinery sector is the most energy intensive sector in comparison with the 8 industrial sectors evaluated in this study in terms of energy cost spent per value added generated.

[108] Jones Andrew; 2013; *Coke Markets – European Perspective*; Presentation at the Eurocoke conference, April 2013

[109] https://www.quandl.com/c/energy/consumption-by-use-coke-ovens-un-by-country

[110] Concawe; 2013; *Oil refining in the EU in 2020; with perspectives to 2030*

[111] IEA; 2013; *Recent developments in EU Refining and Product Supply*; Presentation at EU Refining Forum, 12 April 2013

[112] (1) Ratio of energy cost per unit of value added and (2) Ratio of energy cost per unit of turnover, i.e. the monetary value paid by manufacturers on energy products for every unit of value added or turnover generated by the sector.

Table 3.55 Energy cost intensity ratios per unit of VA and Turnover generated for selected MS*

	Ratio	2008	2009	2010	2011	2012
1	Energy cost/ Value Added	57%	41%	28%	38%	44%
2	Energy cost/ Turnover	2%	2%	1%	1%	1%

Source: ICF analysis on EUROSTAT SBS, accessed Dec 2014

** Note: Data covers Belgium, Czech Rep, Germany, Estonia, Greece, Spain, Italy, Hungary, Netherlands, Portugal and UK*

3.6.4.2 *Energy intensity of key processes*

The production of coke and refined petroleum products is characterised by the use of intense heat to carbonise coal (coke), or distil, crack and hydro-treat crude oil and its fractions (petroleum products). JRC (2012) estimates that the energy intensity of coking operations is 6.83 GJ/tonne (or 0.16 TOE/tonne)[113].

Table 3.56 provides a summary of the energy intensities associated with the production of refined petroleum products. As illustrated, the crude distillation unit (CDU), reforming, and hydro-treatment processes account for the majority of energy consumption within a refinery (i.e., nearly 60%), and are the most energy intensive processes.

Table 3.56 Refined petroleum production energy intensity

Process	Fuel[114] (%)	Steam (%)	Electricity (%)	Energy intensity[115] (TOE/t)
Crude distillation unit	26.2	26.2	8.5	0.015
Vacuum distillation unit	7.9	13.5	1.9	0.006
Thermal cracking	8.5	-1.1	10.1	0.003
Fluid Catalytic Cracking	7.5	0.1	15.3	0.004
Hydrocracking	4.7	3.9	12.8	0.004
Reforming	14.4	10.9	7.4	0.008
Hydrotreating	17.6	28.9	34.4	0.016
Deasphalting	1.1	0.0	0.5	0.000
Alkylation	0.9	12.9	6.1	0.004
Aromatics	0.8	0.4	0.6	0.000
Asphalt	4.1	0.0	1.6	0.001
Isomerisation	6.2	4.3	0.8	0.003
Total	100%	100%	100%	0.063
% usage	49.7%	34.1%	16.2%	

Source: LBNL, 2004; CONCAWE, 2013[116]

[113] JRC, 2012; *Prospective Scenarios on Energy Efficiency and CO2 Emissions in the EU Iron & Steel Industry*

[114] Fuel consumption in processes includes, natural gas, petroleum products (e.g., refinery gas), waste heat, (see Figure 3.57).

[115] Derived from Concawe; 2013; *Oil refining in the EU in 2020; with perspectives to 2030*

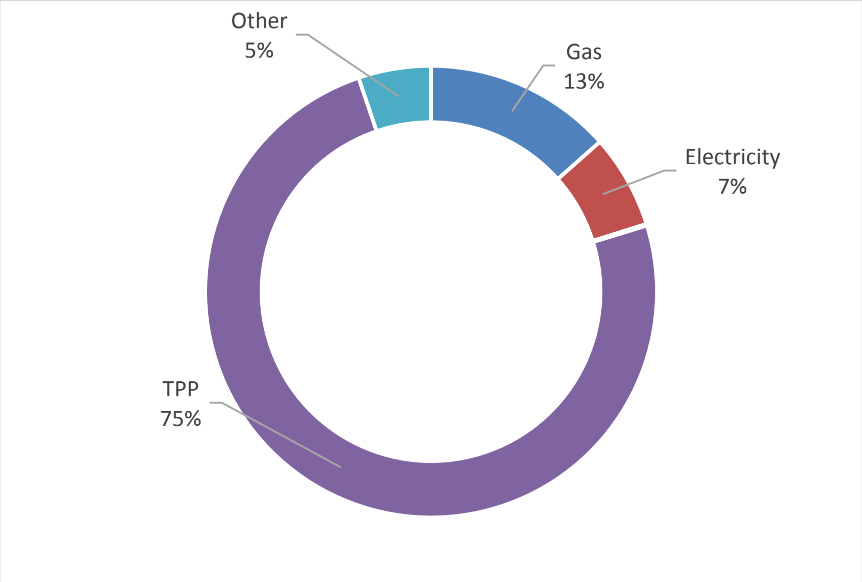
[116] Worrel, E., and Galitsky, C., “Profile of the Petroleum Refining Industry in California,” Lab Report LBNL-55450, Lawrence Berkeley National Laboratory, Berkeley, Calif., 2004

3.6.4.3 Energy mix of final energy consumption for EU petroleum refineries sector

The pyrolysis of coal in the coking process requires intense heat, which is generated by gas combustion in the flues between the coke ovens. Coke oven gas, which is a product of the coking operation, is the common fuel used for firing ovens at most plants, but blast furnace gas (from a steel mill, if integrated), and natural gas are used as well.

Refineries have complicated utility systems with many different fuels, sources and users. In order to produce the required energy and hydrogen, refineries use a combination of external and internal energy sources; such as coke from fluid catalytic cracking units). Internally generated fuel is the largest energy source, which is supplemented with additional purchases of fuel (primarily natural gas), electricity and steam. Also, approximately 5-10% of the crude throughput of refineries is used for the refining process[117]. Figure 3.57 presents the average energy mix of final energy demand for EU petroleum refineries in 2012.

Figure 3.57 Energy mix for final energy demand of EU petroleum refineries in 2012



Source: EUROSTAT, accessed on Dec 2014

3.6.4.4 Energy end use profile

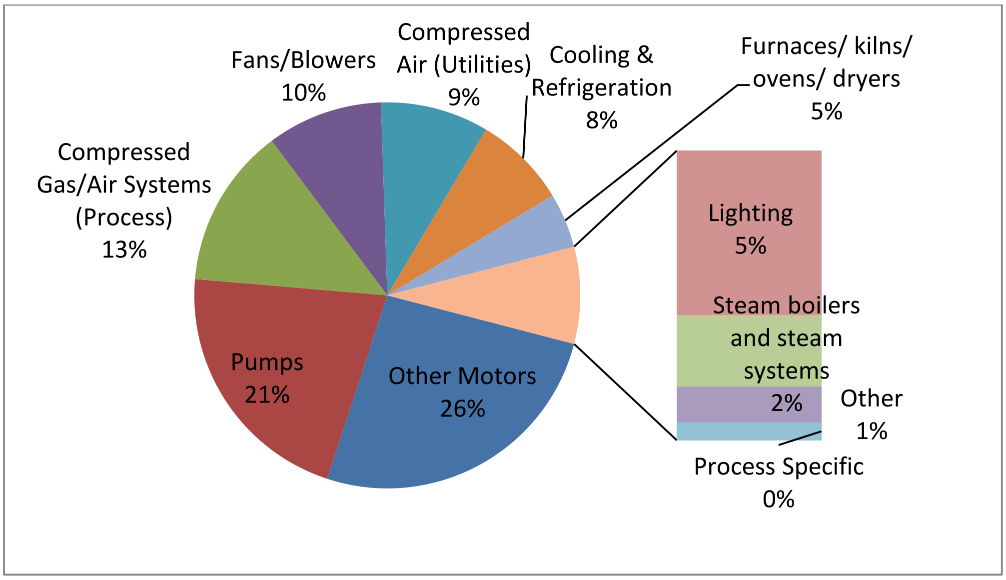
Within the processes, the furnaces/boilers, which are used for the production of power, steam and heat to support the separation processes (i.e., distillation), are the largest energy users. Other large users are gas compressors (and air blowers) in the Fluid Catalytic Cracker (FCC), reformer, hydro-processing units. The following figures present aggregate profiles of energy use within a typical refinery.[118]

[117] IEA (2005); The European Refinery Industry under the EU Emissions Trading Scheme: Competitiveness, trade flows

and investment implications

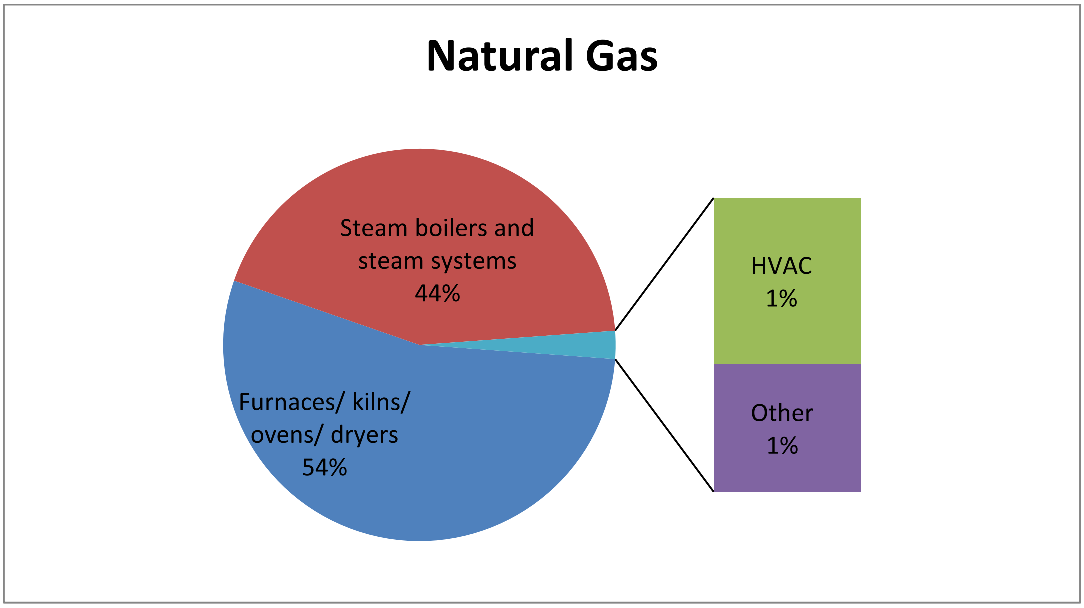
[118] Based on ICF energy efficiency studies within the refining sector

Figure 3.58 Electricity use profile



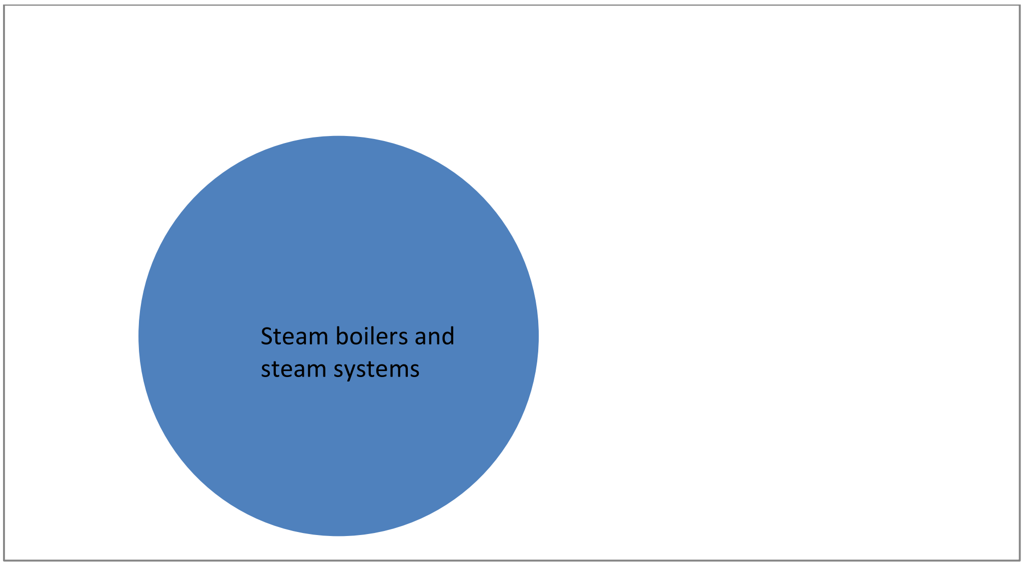
Source: ICF International

Figure 3.59 Natural gas use profile



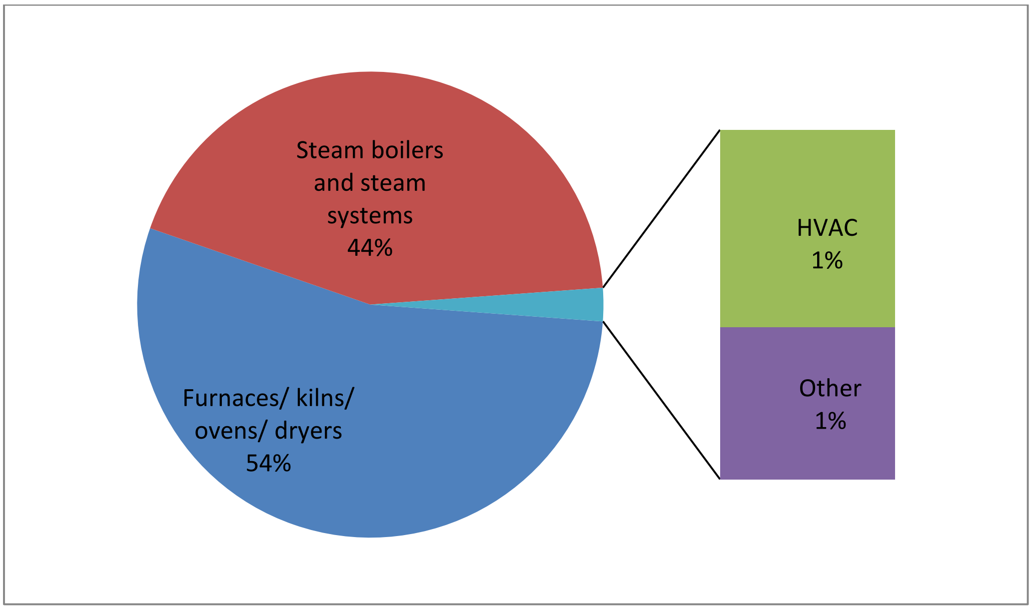
Source: ICF International

Figure 3.60 Energy use profile for coal



Source: ICF International

Figure 3.61 Energy use profile for other sources, including renewable, biomass and waste heat



Source: ICF International

3.6.5 Projection of energy consumption trend

The following details are an extracted summary of the sector profile in Annex 1.

The petroleum refineries sector contributes coke and refined petroleum products, which contributed 0.02% and 0.8% to the EU's GDP, respectively.[119] The coke and refined petroleum products manufacturing sector is energy–intensive, with high capital costs and long investment cycles. The sector accounted for over 18% of total industrial energy consumption in 2011.[120]

[119] Energy, transport and environment indicators; Eurostat; 2013

[120] Ibid

3.6.5.1 Coke production

Coke production in Europe was high in 1980s, yet since the 1990s it has been declining (ca. -3.3%/a). Recently, production has stabilised at a typical level of around 40 million tonnes/ annum. Through most of the past decade, coke demand in Europe has exceeded production. Europe had a net deficit of coke of 4-7 Mt per year in 2001-05, while in 2009 and 2012 they almost equalized. Utilization of capacity in Europe was around 90% until 2007, but through 2010 has been about 80-85%.[121] Since 2012, coke commodity prices have been falling, as global economic growth has slowed, and increasing quantities of low priced coke from China flood the market. Between 2012 and 2013, coke prices declined by 10-15%.[122] These declines in price and demand have fuelled EU capacity closures, which were at their peak during the last economic crisis (2009-10). A net decline is anticipated in the future, as no major investments are in the pipeline.[123] By 2050, production is assumed to decline by nearly 60% from current levels, as cheap imports increasingly address local demand.

3.6.5.2 Refined petroleum products

In 2011, 17% of global refining capacity was based in Europe.[124] Crude oil derived products will continue to play a role in the EU through 2050, although demand is likely to drastically change.[125] Currently, there is too much refining capacity since most EU refineries have been primarily designed for gasoline production. With the increasing shift to diesel and cleaner fuels (e.g., biofuels); gasoline surplus, diesel deficits and tightening margins have led to increasing plant closures[126]. Furthermore, increased refinery capacity in overseas markets will put pressure on exports, and increase EU's import dependence. To address some of these issues will require significant investment; on the order of $51 billion through 2020.[127] Considering these issues, production is assumed to continue declining into the future at a rate of 1% per year.[128] By 2050, production is assumed to be 21% below current levels.

3.6.5.3 Summary of sector projections

Overall, production in the petroleum refineries sector is assumed to decline by 23% through 2050. Table 3.57 presents the anticipated production trend for the sector.

Table 3.57 Projected trend for production of coke and refined petroleum products in EU

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Production (Mil tonnes)	700	700	696	685	657	625	601	580	560	540

Source: Concawe (2013); DG ENER (2011)[129]

The petroleum refining sector is energy and raw material intensive, with energy costs contributing to significant part of production costs (i.e., energy costs account for 60% of operating costs in refineries)[130]. Between 1992 and 2010, EU refiners have increased energy

[121] Jones Andrew; 2013; *Coke Markets – European Perspective*; Presentation at the Eurocoke conference, April 2013

[122] Ibid

[123] Ibid

[124] Europia, 2013; Annual Report 2012

[125] Europia; 2011; *2030-50 Europia contribution to EU Energy Pathways to 2050*

[126] Between 2008 and 2013, 15% of EU refineries shut down (IEA, 2013; Recent developments in EU Refining and Product Supply; Presentation at EU Refining Forum, 12 April 2013)

[127] Concawe; 2013; *Oil refining in the EU in 2020; with perspectives to 2030*

[128] Rate of decline aligns with Concawe (2013) projections for fixed demand scenario

[129] DG Ener, 2011; *The Market for Solid Fuels in the European Union in 2010 and the Outlook for 2011*

[130] DG Ener; 2013; *Summary and conclusions of the first meeting of the EU Refining Forum held on the 12th of April 2013*

efficiency by 10%; "low hanging fruits" opportunities have been addressed. Further opportunities are present, but are assumed difficult to achieve due to not being cost-effective. Considering this, the total energy requirement of EU refineries is forecasted to decrease from 45 million TOE/annum in 2008 to 39 million TOE/annum in 2030.[131] However, the energy intensity is anticipated to increase slightly from 6.3% of total feed in 2008 to 6.6% in 2030, as more energy-intensive processing is required to satisfy the increasing demand for lighter and lower sulphur products. This trend is assumed to continue through 2050. In the coking subsector, energy intensity is assumed to remain stable through 2050; however, considering it only accounts for 8% of energy consumption, its impact on the overall trend is negligible. Table 3.58 presents the anticipated energy intensity trend through 2050.

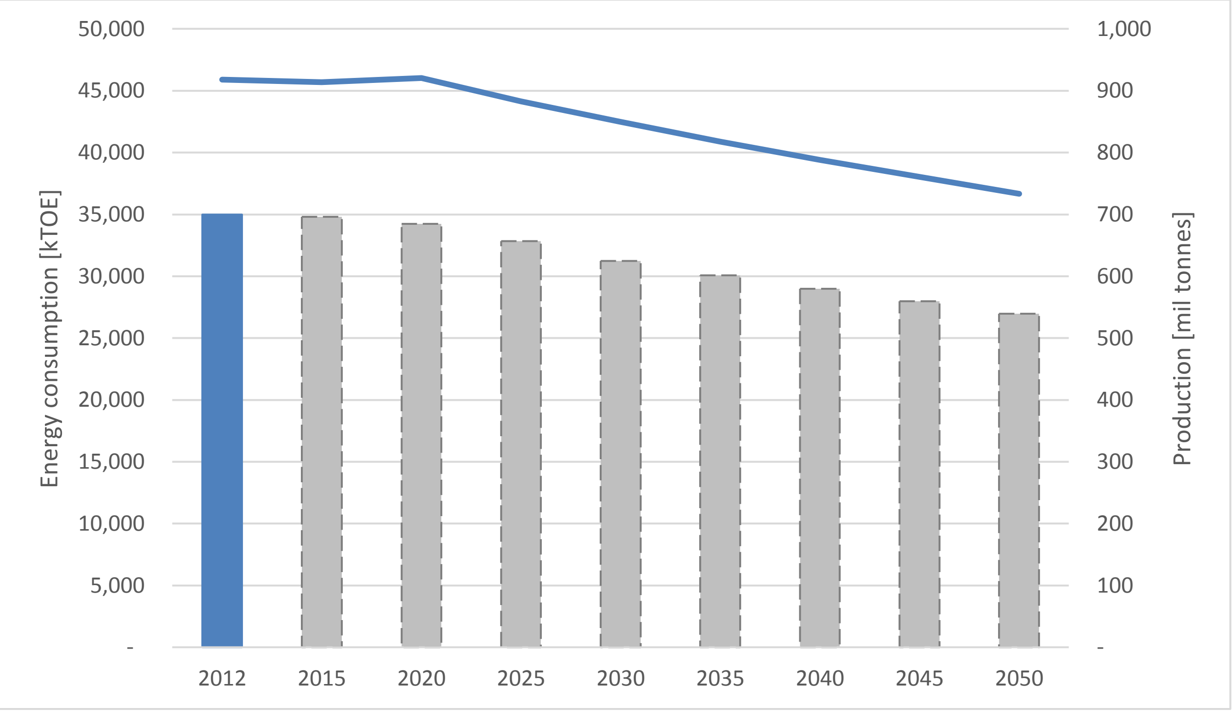
Table 3.58 Projected energy intensity trends for production of coke and refined petroleum products (TOE/tonne of output)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Energy intensity (TOE/ tonne)	0.066	0.066*	0.066	0.067	0.067	0.068	0.068	0.068	0.068	0.068

Source:Concawe data (2013)

Figure 3.62 illustrates the BAU projection trends (energy consumption and production) for the petroleum refineries sector in EU28 over the period 2012 to 2050.

Figure 3.62 BAU projection for manufacture of coke and refined petroleum products

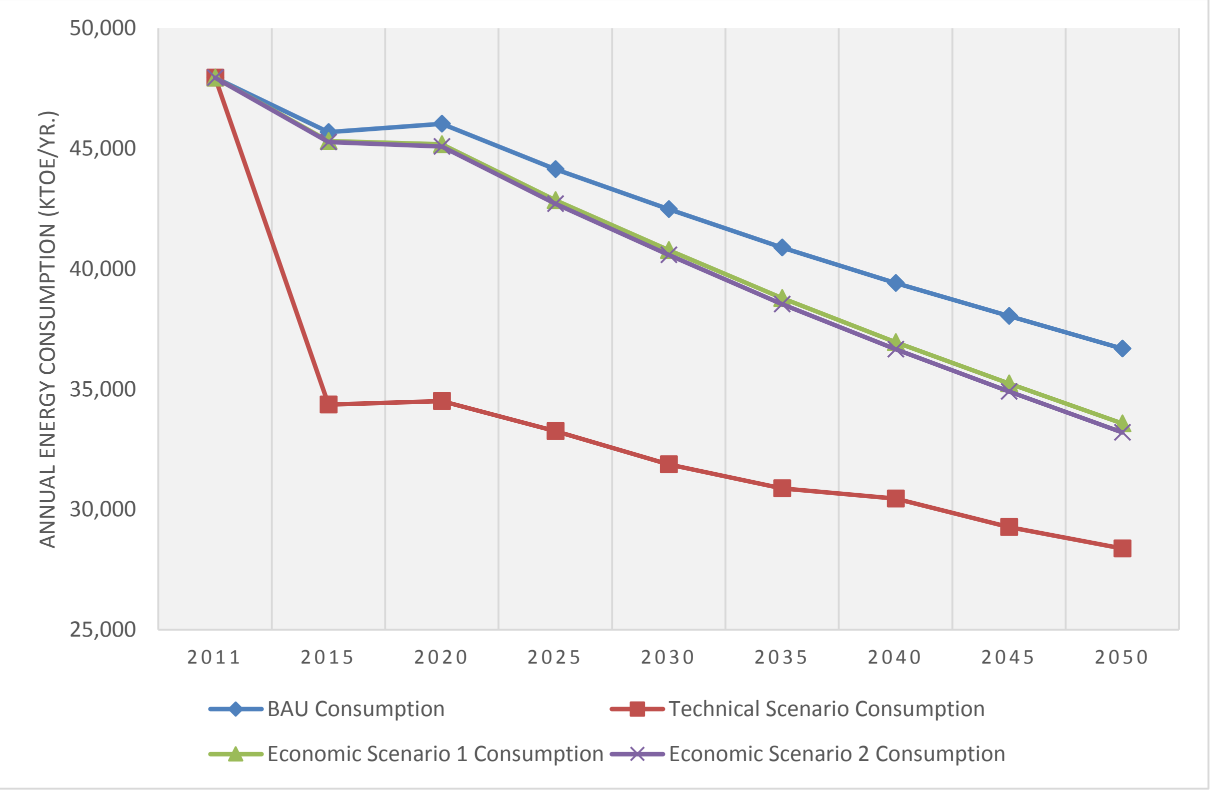


[131] Concawe; 2013; *Oil refining in the EU in 2020; with perspectives to 2030*

3.6.6 Energy Saving Potential Opportunities

Figure 3.63 presents the energy consumption projections from 2011 through to 2050 under the BAU, technical and economic scenarios[132] from the modelling outputs of IEEM.

Figure 3.63 Projected economic and technical potential scenario energy use for the NFM sector



A total of 99 energy saving opportunities which are technically feasible to the sector were accounted for in the modelling process. The projected savings under the technical[133] potential scenario is 10.6 million TOE (25% saving) in year 2030 and 8.3 million TOE (23% saving) in year 2050 with reference to the BAU projections.

A total of 42 energy saving opportunities were included under economic scenario 1, resulting a projected saving of 1.7 million TOE (4% saving) in year 2030 and 3.1 million TOE (9% saving) in year 2050 with reference to the BAU projections.

An additional 17 ESOs, i.e. a total of 59 ESOs, were included under economic scenario 2, resulting in a projected saving of 1.9 million TOE (4.5% saving) in year 2030 and 3.5 million TOE (10% saving) in year 2050 with reference to BAU projections. The energy saving impact of the additional ESOs in economic scenario 2 made very little impact on the additional energy saving potential, as they only accounted for 10% of the overall savings in comparison with economic scenario 1, even after considering the higher payback period. The full list of ESOs are listed in Annex 3. The list of ECOs under economic scenario 1 and 2 is presented in Annex 4.

The following ESOs listed in Table 3.59 represents approximately 71% of the overall sector's technical saving potential.

[132] The economic scenario 1 assumes an uptake of energy saving opportunities which fulfils the less than 2 year simple payback criteria, whereas the economic scenario 2 assumes an uptake of energy saving opportunities of less than 5 year simple payback.

[133] Under the technical potential scenario, it is assumed that all technically feasible opportunities relevant to the sector is implemented regardless of economic feasibility.

Table 3.59 Projected sector ESOs with highest technical potential

Energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Integrated control system	A neural network system is an example of an integrated control system. The information of the sensors is used in control systems to adapt the process conditions, based on artificial intelligence, mathematical ("rule"-based) or neural networks and "fuzzy logic" models of the industrial process.	1044	847	10% / 10%
Improved catalyst	Catalysts are continually being improved to increase process performance and reduce energy consumption.	989	738	9% / 9%
Inter-plant Process Integration	Process integration techniques such as pinch analysis can be applied for resource conservation. Several networks or plants may be integrated to maximize resource recovery through inter-plant integration. Requires facilities to be adjacent, and have synergies (such as utilities) which in close enough proximity to be shared.	737	475	8% / 7%
Advanced Heating and Process Control (furnace)	Advanced heating and process controls reduces energy losses by governing aspects such as material handling, heat storage and turndown.	686	522	7% / 6%
High Efficiency Burner (furnace)	These burners are more efficient at higher-temperature applications. Advancements over the recent years include the commercialization of self-recuperative and self-regenerative burners that use staged combustion to achieve flameless combustion. This results in more uniform heating, lower peak flame temperatures, improved efficiency and lower NOx emissions.	639	447	6% / 5%
Flue-gas monitoring (furnace)	Stack thermometers, fuel meters, make-up feed water meters, oxygen analysers, run-time recorders, energy output meters, and return condensate thermometers are required to maintain a proper air-to-fuel ratio to optimize fuel combustion efficiency.	599	451	6% / 6%
Exhaust gas heat recovery (furnace)	Exhaust gas heat recovery increases efficiency because it extracts waste energy from the exhaust gases and recycles it back to the process, which reduces fuel/steam requirements.	484	376	4% / 5%
Sub-metering and interval metering	Sub-meters are used to measure the amount of energy consumed by equipment, or portions of the plant. They communicate with a central system where the information is trended, stored or transferred to a data historian system for archiving.	424	448	4% / 5%

Energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Advanced Predictive Process and Maintenance Control Systems	This opportunity includes advanced refinery control systems which will use the latest predictive modelling capabilities to continuously adjust plant operations for efficient performance, and will track the performance of critical components and schedule maintenance to reduce upsets/failures causing plant shutdowns.	421	330	4% / 4%
More efficient low grade waste heat recovery technologies (emerging)	Technology is available to take advantage of even the low grade waste heat, which remains after other more efficient uses of waste heat have been exhausted. Organic Rankine Cycles can be used to produce power from heat as low as 80°C, and hence are a "new heat sink" to utilize this waste heat.	406	364	4% / 4%
Combustion optimization (furnace)	Combustion efficiency can be improved by frequent adjusting of the air-to-fuel ratio to reduce excess air as too much excess air carries away excessive amounts of heat.	401	300	4% / 4%
Fouling mitigation in the crude distillation preheat train and fired heater	Fouling deposited Crude Oil Distillation Units pre-heat train heat exchangers reduces energy recovery and increased energy consumption. Replacement of heat exchangers with alternative design can improve efficiency through reduced fouling.	343	199	3% / 2%
Increased uptake of Energy Management System (EnMS)	A series of systemised interacting processes that enables an organization to obtain relevant energy information and act upon it to maintain and improve energy performance, while reducing environmental emissions as a consequence.	329	260	3% / 3%

The following sector specific Energy Saving Opportunities listed in Table 3.60 are technically feasible for the sector but unaccounted for in the economic scenarios as they did not meet the respective payback criteria.

Table 3.60 Projected technical potential sector specific ESOs

Sector specific energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Distillation columns operational optimization	Distillation unit operation could be optimized to improve its energy performance. Factors which effects energy performance include reflux ratios, product purification levels and operating pressure adjustments.	135	120	1.3% / 1.4%
Cogeneration using gas turbine exhaust gas as combustion air for heating furnace	Combustion exhaust gas from the gas turbine is used as combustion air for the tubular heating furnace and recovers steam with the exhaust heat boiler from the exhaust gas of the heating furnace.	307	235	2.9% / 2.8%

Sector specific energy saving opportunity	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Upgrading of existing distillation columns	This opportunity includes replacing out-of-date internal distillation unit internals, trays and components with new ones with higher efficiency.	9	7	0.1% / 0.1%
Advanced Distillation Column Designs	Replacement of existing distillation technology with a new higher efficiency distillation/separation reaction. This could include advanced separations such as Divided Wall Column distillation or Heat Integrated Distillation Column (HIDiC).	137	130	1.3% / 1.6%
Progressive crude distillation	Redesign of crude preheater and the distillation column improving energy performance. The crude preheat train is separated in several steps to recover fractions at different temperatures. The distillation tower works at low pressure and the outputs were changed to link to other processes.in the refinery and product mix of the refinery. The design leads to reduced fuel consumption and improved heat integration.	292	181	2.8% / 2.2%
Combined Heat and Power plant	Combined heat and power (CHP) production is the simultaneous generation of heat energy and electrical and/or mechanical energy in a single process referred to as a CHP plant, with raised combined efficiency raised to around 80 – 93%. Combine Cycle Gas Turbines are commonly used in refineries.	84	70	0.8% / 0.8%
Integrated Gasification Combined Cycle (IGCC)	IGCC is a highly integrated efficient process to produce steam, power and hydrogen from low-grade fuel types such as cleaned up hot gasses and heavy residues.	257	258	2.4% / 3.1%
Novel Desulphurization Technologies (Emerging)	Improved technologies on desulphurization such as bio-desulphurization, deep gasoline desulphurization and non-H2 desulphurization which lowers energy consumption in consequence.			

3.7 Food and Beverage

3.7.1 Structure and economic contribution

The EU food and beverage sector group has over 280,000 enterprises, over 4.3 million persons employed and contributed to over €1,000 billion in turnover and over €200 billion in value added for 2012. The sector group represents 14.6% turnover and 12.5% value added of EU's manufacturing sector [EU Food and Drink, 2014] and 10.4% of final energy consumption by the eight sector goups under the scope of this study. SMEs accounted for 51.6% and 64.3% of the sector's turnover and number of persons employed respectively. The EU food and drink sector accounts for 16.1% share of global exports in 2013. Key economic indicators for the food and beverage sector are summarised in Table 3.61. Although EUROSTAT includes manufacture of tobacco products (NACE C12) under the same grouping of energy statistics, this sector is excluded from the remaining parts of the study as it is not economically significant in and the energy consumption is estimated to be less than 1% in comparison with production of food and beverage, based on national statistics from other Member States.

Table 3.61 Key economic indicators on food and beverage sector division and group level for EU 28 in 2012

Description	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of food products	**C10**	**264,699**	**4,096,033**	**914,000**	**170,000**	**837,000**
Processing and preserving of meat and production of meat products	C10.1	39,012	936,213	216,977	30,688	205,325
Processing and preserving of fish, crustaceans and molluscs	C10.2	3570	109,487	24,672	3,988	22,873
Processing and preserving of fruit and vegetables	C10.3	10,500	257,525	64,119	12,912	59,384
Manufacture of vegetable and animal oils and fats	C10.4	8,100	60,359	55,509	3,917	45,673
Manufacture of dairy products	C10.5	11,998	354,079	140,000	20,000	130,000
Manufacture of grain mill products, starches and starch products	C10.6	6,000	105,852	45,718	7,167	42,186
Manufacture of bakery and farinaceous products	C10.7	155,219	1,530,972	114,523	39,524	108,199
Manufacture of other food products	C10.8	25,100	599,926	171,869	42,505	155,170
Manufacture of prepared animal feeds	C10.9	5,100	122,339	77,500	9,530	66,000
Manufacture of beverages	**C11**	**23,956**	**384,849**	**148,000**	**36,700**	**140,855**
Distilling, rectifying and blending of spirits	C11.01	5,077	39,432	23,845	7,087	23,005
Manufacture of wine from grape	C11.02	11,039	95,707	29,797	6,328	29,637
Manufacture of cider and other fruit wines	C11.03	619	4,307	1,835	369	1,738
Manufacture of other non-distilled fermented beverages	C11.04	175	585	143	27	433
Manufacture of beer	C11.05	3,050	108,371	43,620	11,955	40,394
Manufacture of malt	C11.06	146	3,586	3,944	533	3,733
Manufacture of soft drinks; production of mineral waters and other bottled waters	C11.07	3,851	134,829	44,010	10,375	41,914
Manufacture of tobacco products	**C12**	**260**	**41,800**	**44,762**	**7,335**	**-**

Source: EUROSTAT, accessed on Dec 2014

3.7.2 Subsector share of energy consumption

The final energy consumption data reported in EUROSTAT is aggregated for all 3 NACE divisions, i.e. production of food, beverage and tobacco (C10, C11 and C12) are reported as an aggregated figure. Due to the diversity of products and processes involved within the sector, it is extremely difficult to estimate the share of subsector energy consumption without reliable statistical sources.

Table 3.62 provides a breakdown share of energy consumption between manufacture of food products (C10) and manufacture of beverages (C11) based on national statistics in Germany, Spain and Finland. Table 3.63 provides further details on the energy intensity within the sub-groups based on Spanish data.

Table 3.62 Share of energy consumption between food and beverage sector *

Sector	NACE (group)	Germany	Spain	Finland
Manufacture of food products	C10	89%	89%	84%
Manufacture of beverages	C11	11%	11%	16%

Source: German Federal statistics, National Statistics Institute of Spain and Statistics Finland

** Note: Germany and Finland (2013 statistics), Spain (2011 statistics)*

The National Statistics Institute of Spain provides statistics for energy statistics provided data on energy cost (in million EUR) expensed by each of subclass of the Spanish food sector. Table 3.63 provides a summary of the energy intensity, expressed in a ratio of energy cost per value added generated, for the subclasses within the food sector in Spain. In comparison, EU's average energy intensity for the food sector ranges from 9 – 12% (see Section 3.7.5.1). The intensity for the subclasses of the Spanish food sector falls around the same range, apart from Manufacture of grain mill products, starches and starch products (C10.6), manufacture of prepared animal feeds (C10.9) and Manufacture of vegetable and animal oils and fats (C10.4) with a higher intensity range of 15 – 16%.

Table 3.63 Spanish subsector energy intensity expressed in a ratio of energy cost per value added generated (Energy Cost / Value Added) in 2011.

Sector Description	NACE	Energy cost [mil EUR]	Value added [mil EUR]	Ratio [%]
Manufacture of food products	**C10**	**1,676**	**15,992**	**10%**
Processing and preserving of meat and production of meat products	C10.1	362	3605	10.0%
Processing and preserving of fish, crustaceans and molluscs	C10.2	73	768	9.4%
Processing and preserving of fruit and vegetables	C10.3	222	2037	10.9%
Manufacture of vegetable and animal oils and fats	C10.4	136	916	14.9%
Manufacture of dairy products	C10.5	209	1926	10.9%
Manufacture of grain mill products, starches and starch products	C10.6	89	546	16.3%
Manufacture of bakery and farinaceous products	C10.7	205	2480	8.3%
Manufacture of other food products	C10.8	245	2866	8.6%

Sector Description	NACE	Energy cost [mil EUR]	Value added [mil EUR]	Ratio [%]
Manufacture of prepared animal feeds	C10.9	134	847.5	15.9%
Manufacture of beverages	**C11**	**209**	**4,558**	**4.6%**

Source: EUROSTAT, National Statistics Institute of Spain

3.7.3 Key products

The food sector is categorised into 9 groups and the following section here highlights the product scope of the key groups extracted from the EUROSTAT statistical classification [NACE rev2, 2008].

Processing and preserving of meat and production of meat products (NACE C10.1). The activity of this group involves slaughtering of livestock for the production of fresh meat and poultry in cuts, which could be chilled or frozen. This also includes rendering of animal fats and production of non-edible products (originating from the slaughterhouse) like hide, skin, wool, feathers and down.

Processing and preserving of fish, crustaceans and molluscs (NACE C10.2). The activity of this group involves preparation, processing and preserving of fish, crustaceans and molluscs. The processes include freezing, drying, cooking, smoking, canning and etc for human consumption or animal feed.

Processing and preserving of fruit and vegetables (NACE 10.3). The activity of this group is categorized into 3 classes. (1) Processing and preserving of potatoes, which includes production of frozen potatoes, dehydrated mashed potatoes, potato snacks, crisp, potato flour and meal. (2) Manufacture of fruit and vegetable juice. (3) other processing and preserving of fruit and vegetables or food products primarily containing fruit and vegetable (salads, jam, marmalade, nuts, paste, bean curd, etc.)

Manufacture of vegetable and animal oils and fats (NACE 10.4). The activity of this group involves manufacture of crude and refined (blowing, boiling, dehydration, hydrogenation, etc.) oils and fats from vegetable and animal feedstock (olive oil, soya bean oil, palm oil, sun flower seed oil, cotton seed oil, rape, linseed, extracted fish and marine mammal oil, margarine, spreads, compound of cooking fats, etc.). This also includes non-edible animal oils and fats.

Manufacture of dairy products (NACE 10.5). The activity of this group involves manufacture of dairies and cheese products including fresh liquid milk (pasteurized, sterilized, homogenized or heat treated), milk based drinks, cream from fresh liquid milk, dried concentrated milk, solid milk or cream, butter, yogurt, cheese, whey, curd, casein and lactose). This group also includes the manufacture of ice cream and edible such as sorbet.

Manufacture of grain mill products, starches and starch products (NACE 10.6). The activity of this group involves milling of flour or meal from grains of vegetables, production (milling, cleaning and polishing) of rice and flour mixes or doughs from these products. This group also includes wet milling of corn and vegetable and production of starch and starch products (glucose, glucose syrup, maltose, inulin, gluten and tapioca.

Manufacture of bakery and farinaceous products (NACE 10.7). The activity of this group is categorized into 3 classes. (1) Manufacture of bread, fresh pastry goods and cakes (bread, rolls, pastry, cakes, pies, tarts, pancakes, waffles, etc). (2) Manufacture of rusks and biscuits, preserved pastry goods and cakes. (3) Manufacture of macaroni, noodles, couscous and other farinaceous products.

Manufacture of other food products (NACE 10.8). The activity of this group includes production of sugar, confectionary, prepared meals, coffee, tea, spices, perishable and specialty food products. This is categorized into 7 classes. (1) Manufacture of sugar. (2) Manufacture of coca, chocolate and sugar confectionery. (3) Processing of tea and coffee. (4)

Manufacture of condiments and seasoning (spices, sauces, mayonnaise, mustard, vinegar, salt, etc). (5) Manufacture of prepared meals and dishes. (6) Manufacture of homogenized food preparations and dietetic food (infant formulae, baby foods, low energy food intended for weight control, gluten-free food, foods intended to meet the expenditure of intense muscular effort, etc.). (7) Manufacture of other food products (soups, broth, perishable prepared foods, food supplement, yeast, extracts of meat / fish / crustaceans or molluscs, non-dairy milk, cheese substitutes and artificial concentrates.

Manufacture of prepared feeds for farm animals (NACE 10.9). The activity of this group is the production of prepared feeds for farm animals, including concentrated animal feed, feed supplement, preparation of unmixed feeds and treatment of slaughter waste to produce animal feeds.

The beverage sector is categorized into 7 of the following groups:

Distilling, rectifying and blending of spirits (NACE 11.01). The activity of this group includes manufacture of distilled and potable alcoholic beverages (whisky, brandy, gin, liqueurs, etc.), manufacture of drinks mixed with distilled alcoholic beverages, blending of distilled spirits and production of neutral spirits.

Manufacture of wine from grape (NACE 11.02). The activity of this group involves manufacture of wine, sparkling wine, wine from concentrated grape must and low or non-alcoholic wine. This includes blending, purification and bottling of wine.

Manufacture of cider and other fruit wines (NACE 11.03). The activity of this group includes manufacture of fermented but non-distilled alcoholic beverages (sake, cider, perry and other fruit wines), mead and mixed beverages containing fruit wines.

Manufacture of other non-distilled fermented beverages (NACE 11.04). The activity of this group includes manufacture of vermouth and like.

Manufacture of beer (NACE 11.05). The activity of this group includes manufacture of malt liquors (beer, ale, porter and stout). It also includes low or non-alcoholic beer.

Manufacture of soft drinks, mineral waters and other bottled waters (NACE 11.07). The activity of this group includes manufacture of non-alcoholic beverages including production of natural mineral water, other bottled waters, soft drinks and non-alcoholic flavored or sweetened waters (lemonade, cola, fruit drinks, tonic waters, etc.)

3.7.4 Key sector processes

The key energy intensive processes in production of food and beverage can be categorised into the following 9 categories extracted from IPPC Best Available Techniques Reference Documents (BREF) in food and beverage sector.

Materials reception and preparation. This includes materials handling and storage, sorting and screening, peeling, washing and thawing.

Size reduction, mixing and forming. This includes cutting, clicing, chopping, mincing, pulping, pressing, mixing, blending, homegenisation, conching, grinding, milling, crushing, forming, moulding and extruding.

Separation. This includes extraction, de-ionisation, fining, centrifugation and sendimentation, filtration, membrane separation, crystallisation, removal of free fatty acids by neutralisation, bleaching, deodorisation by steam stripping, decolourisation and distillation.

Product processing. This includes soaking, dissolving, solubilisation/alkalising, fermentation, coagulation, germination, brining, curing, pickling, smoking, hardening, sulphitation, carbonation, coating, spraying, enrobing, agglomeration and ageing.

Heat processing. This includes melting, blanching, cooking and boiling, baking, roasting, frying, tempering, pasteurisation, sterilisation and Ultra High Temperature processing.

Concentration by heat. This includes evaporation (liquid-to-liquid), drying (solid-to-solid) and dehydration (solid-to-solid).

Chilling processes. This includes cooling, chilling, cold stabilisation, freezing, cryoextraction, concentration (through chilling), freeze drying and lyophilisation.

Post processing operations. This includes packing, filling, gas flushing and storage under gas.

3.7.5 Energy metrics

3.7.5.1 Energy intensity based on sector energy cost

Table 3.64 provides an indication of the sector's energy intensity for selected EU Member States expressed in 2 ratios[134] from 2008 - 2012. The food and beverage sector ranks 7th most energy intensive, second least energy intensive sector in comparison with the 8 industrial sectors evaluated in this Study in terms of energy cost spent per value added generated

Table 3.64 Energy cost intensity ratios per unit of VA and Turnover generated for selected MS *

	Ratio	2008	2009	2010	2011	2012
1	Energy cost/ Value Added	12%	11%	9%	10%	10%
2	Energy cost/ Turnover	2%	2%	2%	2%	2%

Source: ICF analysis on EUROSTAT SBS, accessed Dec 2014

** Note: Data covers Bulgaria, Germany, Estonia, Spain, France, Italy, Hungary, Netherlands and Portugal.*

3.7.5.2 EU final energy consumption for production of food and beverage

Table 3.65 and Figure 3.64 provides a summary of the final energy consumption and fuel mix for manufacture of food and beverage in EU28 as a whole. As detailed in 3.7.4, electrical energy appears to be the second largest energy type consumed within the sector as most of the key processes are powered by electrical energy, as expected for food processing and utility equipment (ovens, chillers, pumps, electrical machinery). Natural gas consists of almost half of the sector's final energy requirement.

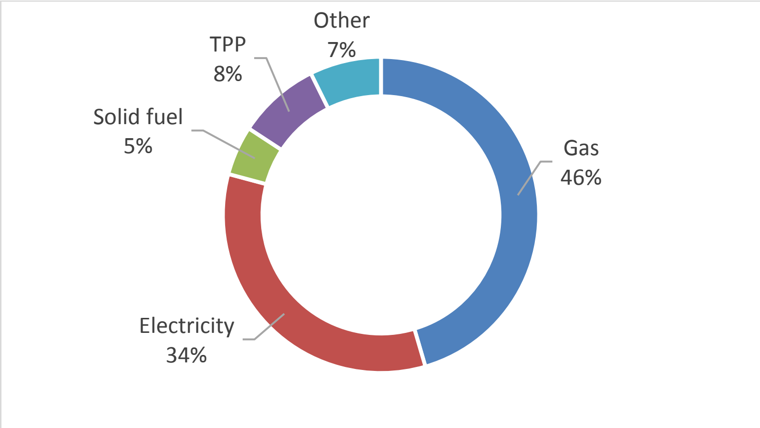
Table 3.65 Final energy consumption for EU food and beverage sector in 2012

EU primary energy consumption for the sector	kTOE	% of total
Gas	12,755	45%
Electricity	9,457	34%
Solid fuel	1,416	5%
TPP	2,373	8%
Other	2,055	7%
Total final energy demand	28,056	

Source: EUROSTAT, accessed Dec 2014

134 (1) Ratio of energy cost per unit of value added and (2) Ratio of energy cost per unit of turnover, i.e. the monetary value paid by manufacturers on energy products for every unit of value added or turnover generated by the sector.

Figure 3.64 Energy mix for EU food and beverage sector in 2012

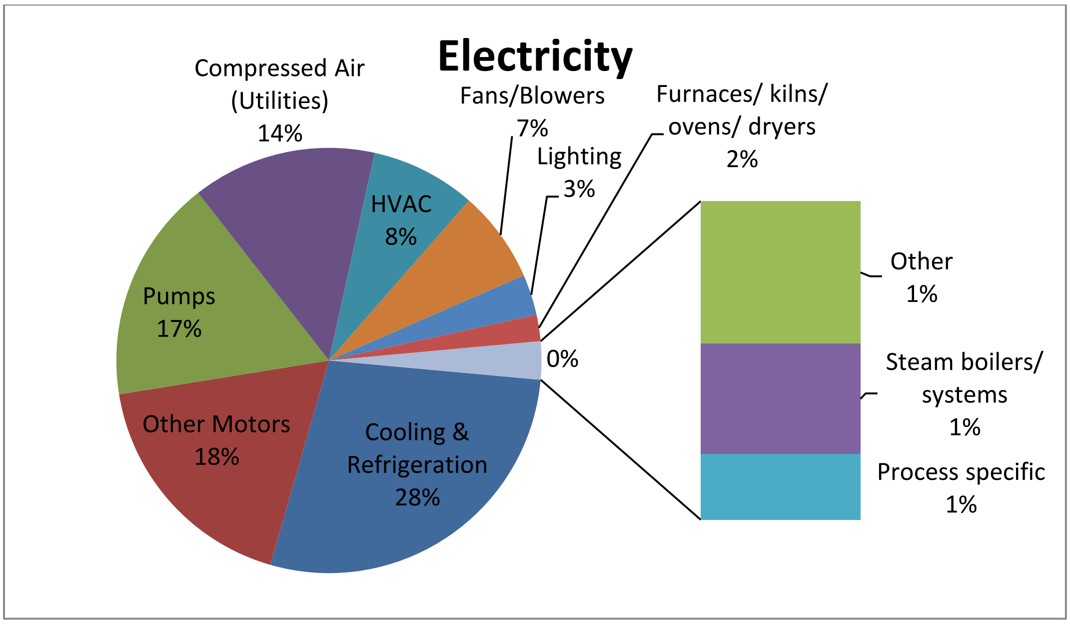


Source: EUROSTAT, accessed Dec 2014

3.7.5.3 Energy end use profile

Based on the estimated share of energy consumption amongst the food and beverage sector, and the fuel mix profiles, the following figures present an aggregate energy use profile for the primary energy sources, including electricity, natural gas, total petroleum products (i.e., oil), coal, and other categories[135].Referring to the processes as detailed in Section 3.7.4, cooling and refrigeration consumes the largest share of electrical energy, followed by pumps and compressed air. The main power consumers for natural gas are steam boilers and ovens for heat processes.

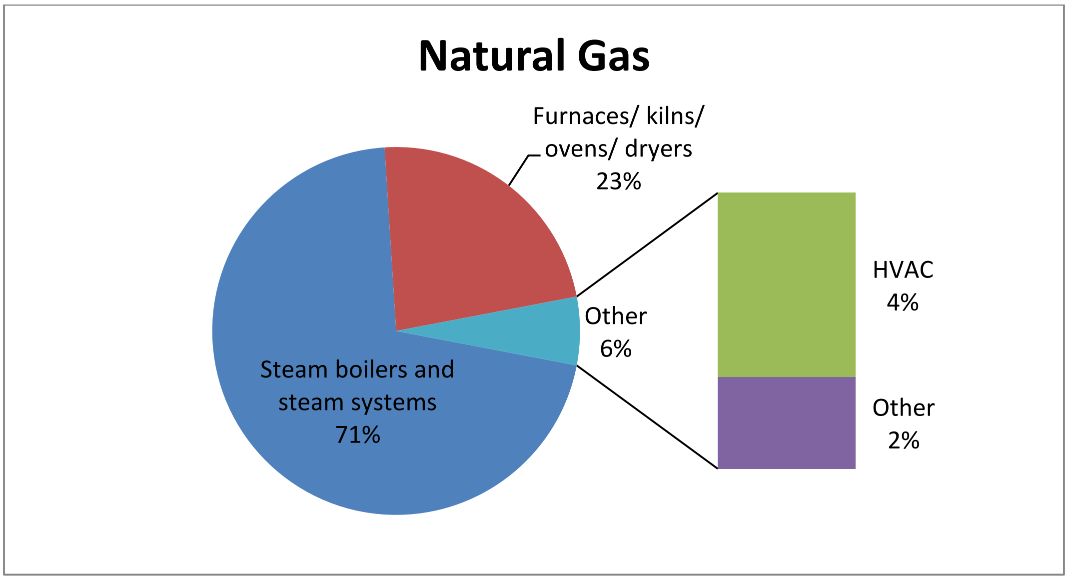
Figure 3.65 Electricity use profile



Source: ICF International

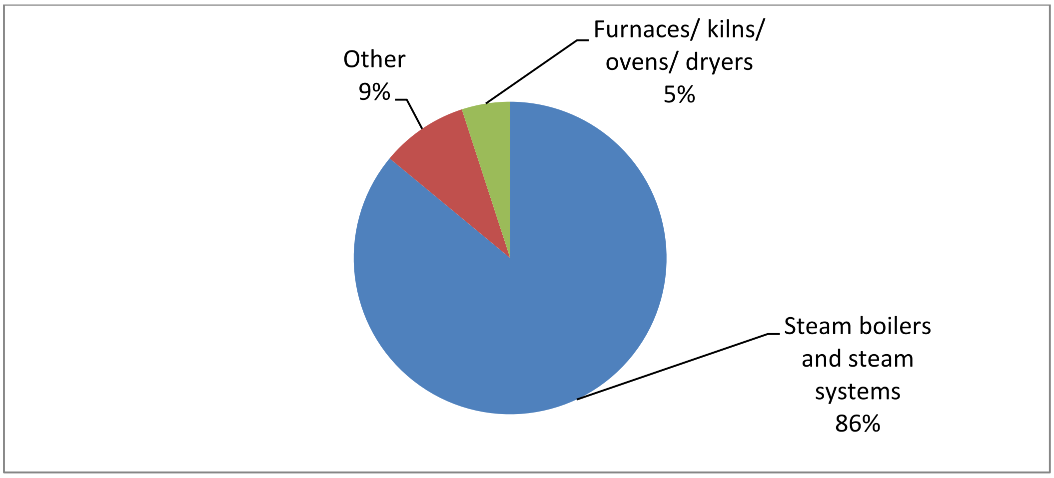
[135] Based on ICF energy efficiency studies within the food and beverage sector

Figure 3.66 Natural gas use profile



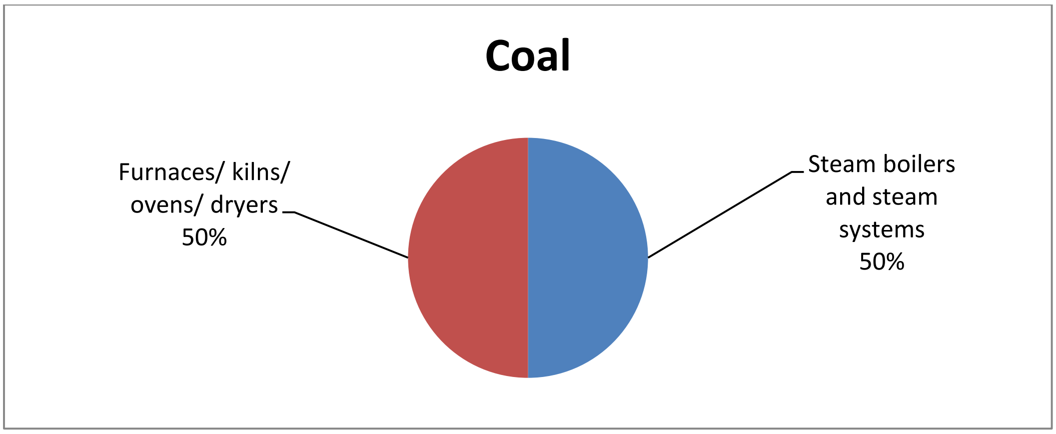
Source: ICF International

Figure 3.67 Total petroleum product (e.g., oil) use profile



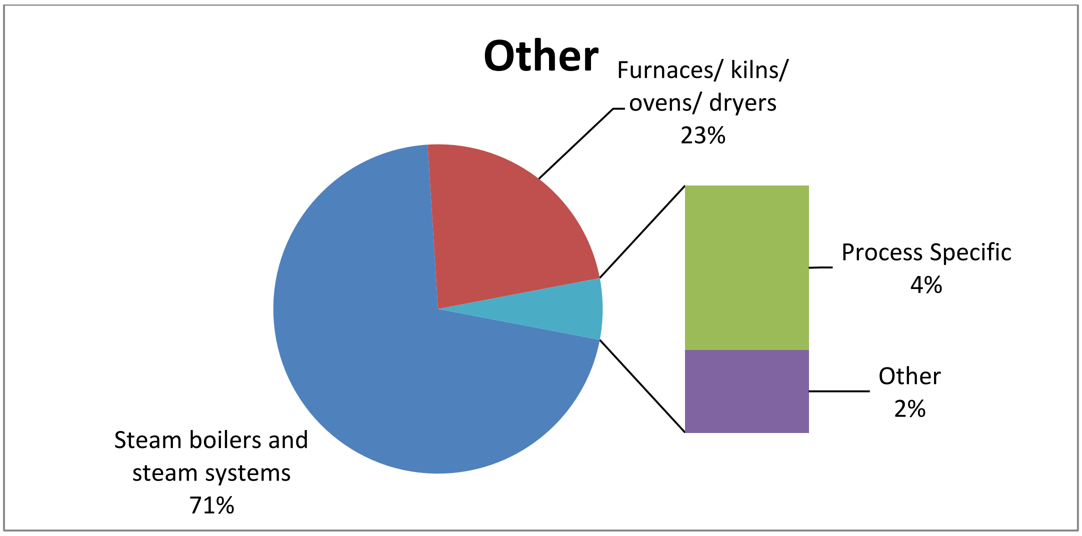
Source: ICF International

Figure 3.68 Coal use profile



Source: ICF International

Figure 3.69 Energy use profile for other sources; i.e., biomass



Source: ICF International

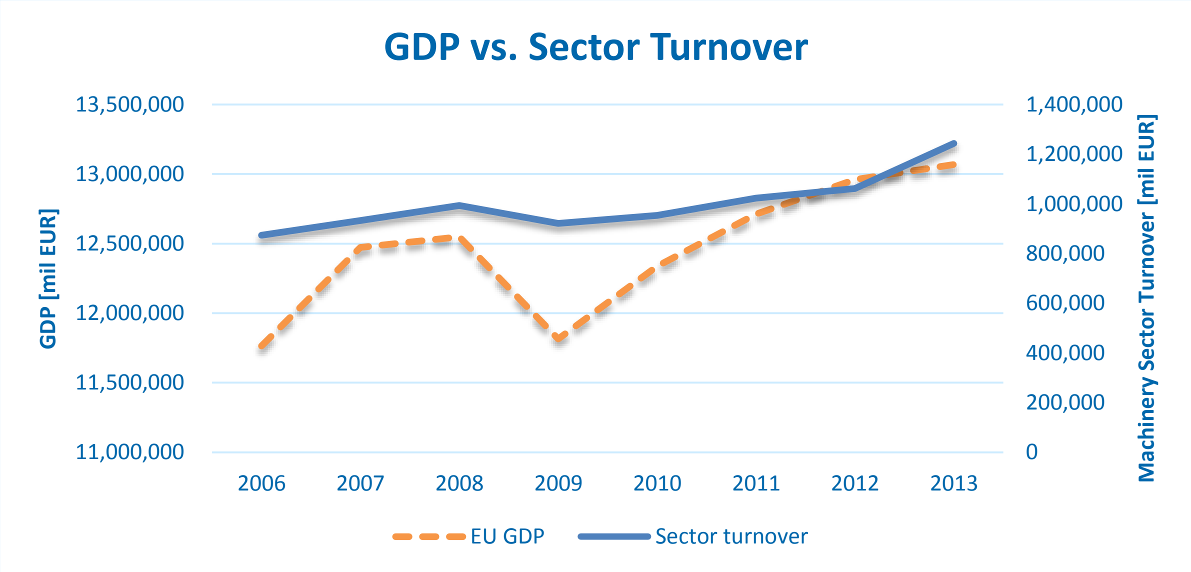
3.7.6 Projection of energy consumption trend

The following details are an extracted summary of the sector profile in Annex 1.

The food and beverage industry is traditionally strong in the EU and has a dominant position in the world market. As the EU market is mature, it benefits from positive, long term relationships across the value chain and fully developed integrated processes, from agriculture sector to production and quality assurance systems. Regulation on food and drink sector will become more stringent pressuring the sector to further innovate on their production processes. The demand in high value-added, niche markets such as natural foods and convenience foods continues its strong growth. The high fragmentation of consumer segments continues to increase a wide range of food enterprises to operate, ranging from multinational, multiproduct manufacturers to one-product micro enterprises. However, the medium, small, and micro enterprises will not be able to compete on cost to the same extent as large companies, and therefore the only option for these companies is product innovation. Growing consumer demand for locally sourced products will retain the growth of the 2 largest group (in terms of turnover), which is production of meat and dairy products. In summary, the sector will continue to grow on par with EU's long term economical trend.

Figure 3.70 provides a comparison of EU GDP trend vs. the sector's turnover for the period of 2006 – 2012. While EU's GDP fluctuates over the financial crisis period, the sector's turnover trend maintains a relatively steady growth. The sector's historical linear growth trend, limited to available statistics from 2006 to 2013, indicates a growth rate of 4.86% p/a.

Figure 3.70 EU GDP trend vs. Food sector turnover from 2006 - 2012



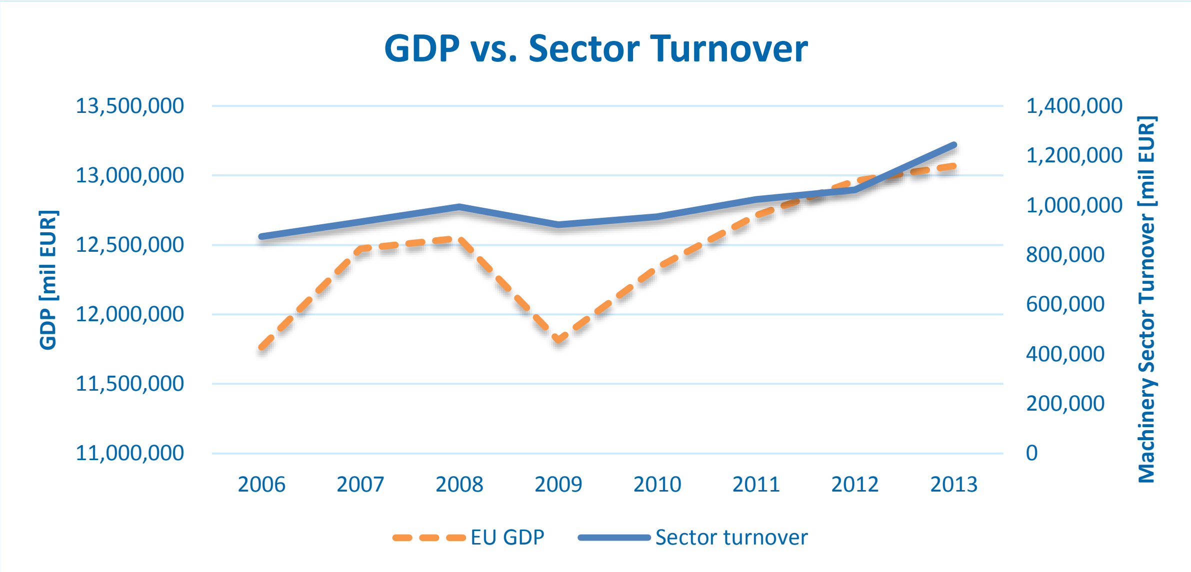
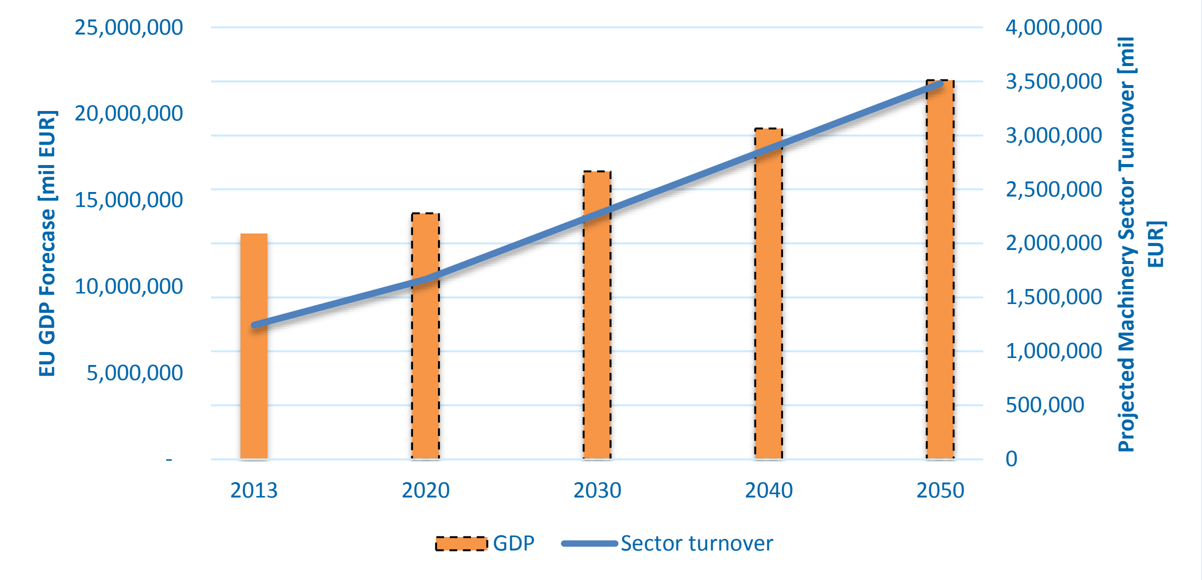


Figure 3.71 provides a projection of EU's food and drink sector turnover assuming this growth rate maintains on par with the Commission's reference scenario of EU's GDP growth of approximately 1% p/a to 2050 [EC, 2013].

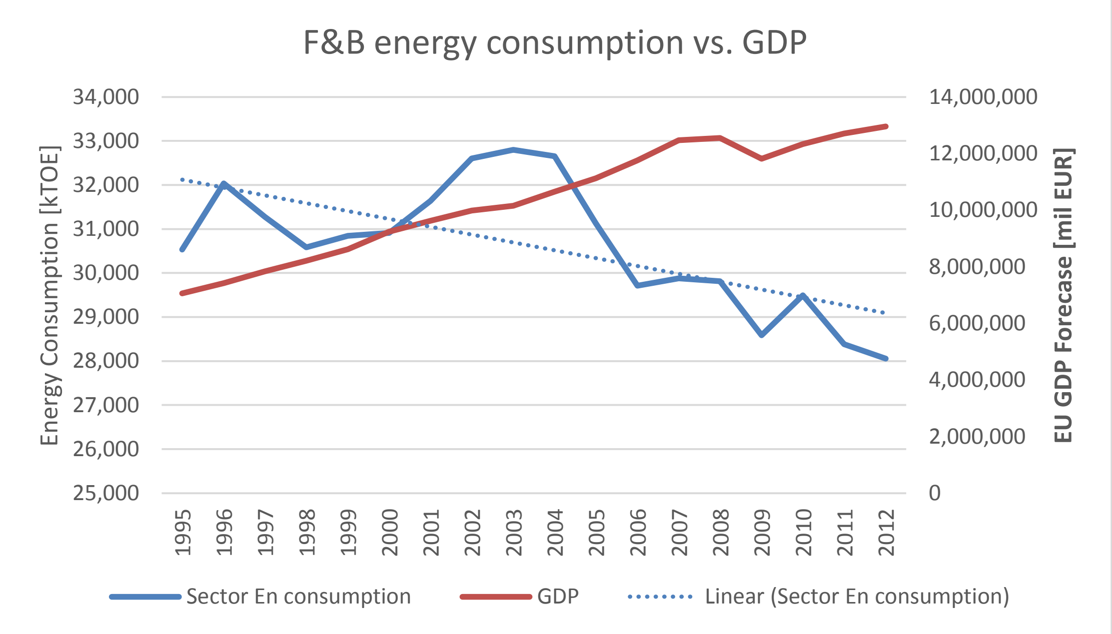
Figure 3.71 Projected EU food and drink sector turnover vs. EU GDP trend



European companies are technological advanced and at the forefront of product innovation, resulting in continuous improved productivity and high standards for food safety and quality. This becomes increasingly important as incomes rise across the world in emerging economies, such as China, India and Central and Eastern European countries. Consumer choices are shifting towards higher quality, healthier products, organic, locally sourced, fair trade and sustainably produced products, driving enterprises to further improve on its production process.

Figure 3.72 provides a historical trend for energy consumption and EU GDP for the past 17 years (1995 – 2012). The energy consumption trend fluctuates year-on-year primarily due to the production fluctuation in the wide range of product scope within the sector, in which the specific energy intensity and energy consumption is fully dependent on the product output type and the associated processes in manufacturing the finished product to the specification as dictated by the consuming market on the specific year. However, analysing the longer term linear trend line, it can be observed that energy consumption has reduced by approximately 0.6% despite an increase of 85% in EU GDP over the same 17-year period. The sector has demonstrated a good track record in reduction of energy intensity and consumption, effectively de-coupling all of these aspects from production growth. There are also very limited emerging technologies within the sector and energy intensity is primarily driven by innovation of new products and quality, which may not necessarily result in lower energy consumption.

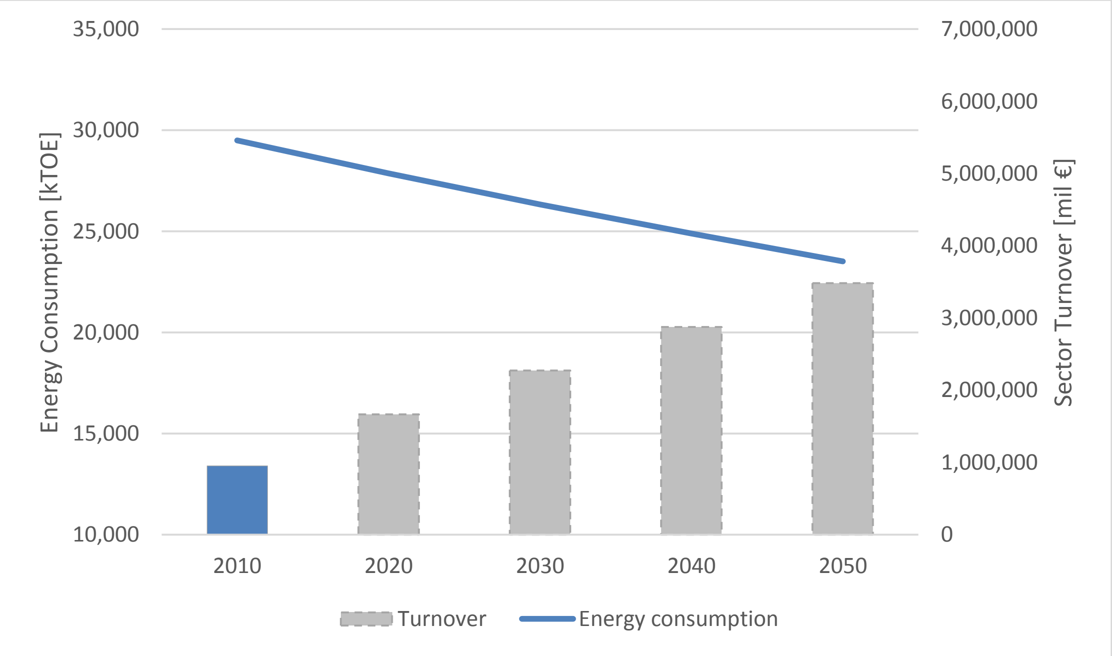
Figure 3.72 Historical trend of Energy consumption for Food and Beverage sector vs. EU GDP



Source: ICF analysis on EUROSTAT, accessed Dec 2014

On the balance of the above factors, the energy consumption will remain volatile but it is expected that the sector will continue its strong reduction trend in energy intensity in the longer term, resulting in a constant reduction in energy consumption trend as production continues to increase as projected in Figure 3.73.

Figure 3.73 BAU projection for food and beverage sector



3.7.7 Projection of energy saving potential

Figure 3.74 presents the energy consumption projections from 2011 through to 2050 under the BAU, technical and economic scenarios[136] from the modelling outputs of IEEM.

A total of 93 ESOs which are technically feasible to the sector were accounted for in the modelling process. The projected savings under the technical[137] potential scenario is 6.8 million TOE (26% saving) in year 2030 and 5.7 million TOE (24% saving) in year 2050 with reference to the BAU projections.

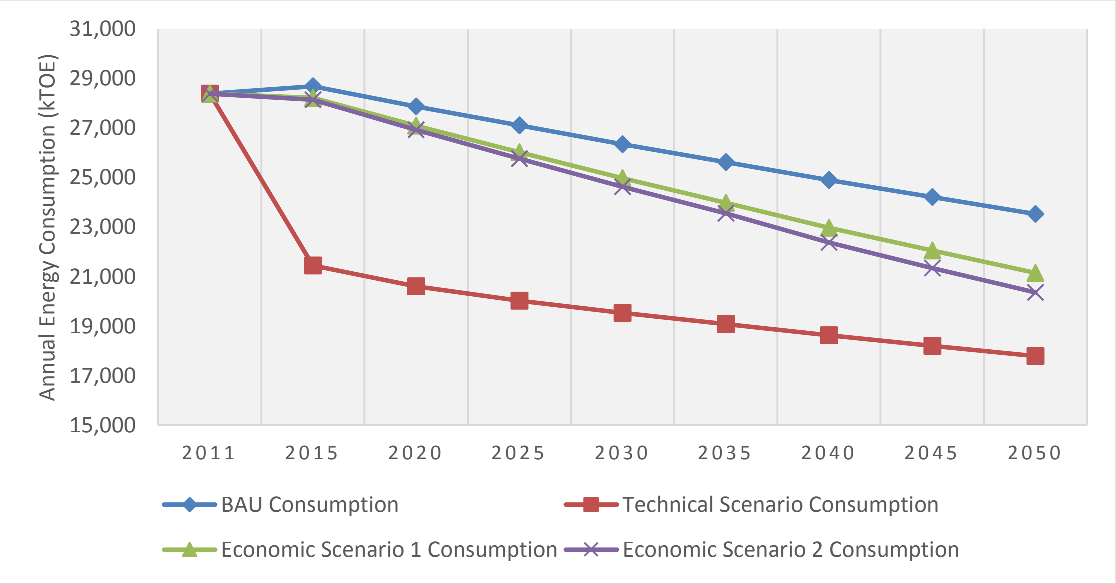
A total of 42 ESOs were included under economic scenario 1, resulting a projected saving of 1.4 million TOE (5% saving) in year 2030 and 2.4 million TOE (10% saving) in year 2050 with reference to the BAU projections.

An additional 19 ESOs, i.e. a total of 61 ESOs, were included under economic scenario 2, resulting in a projected saving of 1.7 million TOE (6.5% saving) in year 2030 and 3.2 million TOE (13.5% saving) in year 2050 with reference to BAU projections. The additional savings for economic scenario 2 is mainly attributed to the following additional ESOs:

- Premium efficiency control with Adjustable Speed Drives (for pumps and motors)
- High efficiency burner
- Advanced heating and process control (oven)
- Process heat recovery
- Variable Speed Drives on chiller compressors

The full list of Energy Saving Opportunities are listed in Annex 3. The list of ECOs under economic scenario 1 and 2 is presented in Annex 4.

Figure 3.74 Projected economic and technical potential scenario energy use



[136] The economic scenario 1 assumes an uptake of ESOs which fulfils the less than 2 year simple payback criteria, whereas the economic scenario 2 assumes an uptake of ESOs of less than 5 year simple payback.

[137] Under the technical potential scenario, it is assumed that all technically feasible ESOs relevant to the sector is implemented regardless of economic viability.

The following energy saving opportunities listed in Table 3.66 represents approximately 60% of the overall sector's technical saving potential.

Table 3.66 Projected sector energy saving opportunities with highest technical potential included in economic scenarios

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Sub-metering and interval metering	Sub-meters are used to measure the amount of energy consumed by equipment, or portions of the plant. They communicate with a central system where the information is trended, stored or transferred to a data historian system for archiving.	680	603	10% / 10.5%
Integrated control system	A neural network system is an example of an integrated control system. The information of the sensors is used in control systems to adapt the process conditions, based on artificial intelligence, mathematical ("rule"-based) or neural networks and "fuzzy logic" models of the industrial process.	676	563	10% / 10%
Inter-plant Process Integration	Process integration techniques such as pinch analysis can be applied for resource conservation. Several networks or plants may be integrated to maximize resource recovery through inter-plant integration. Requires facilities to be adjacent, and have synergies (such as utilities) which in close enough proximity to be shared.	528	449	8% / 8%
Premium efficiency control with ASDs (motors, pumps)	Adjustable Speed Drives (ASDs) match the motor speed to load requirements for motor operations resulting in significant energy savings, especially in applications that require variable load. Energy savings vary between 7% and 60% depending on the application.	270	252	4.0% / 4.4%
Flue-gas monitoring (boiler)	Stack thermometers, fuel meters, make-up feed water meters, oxygen analysers, run-time recorders, energy output meters, and return condensate thermometers are required to maintain a proper air-to-fuel ratio to optimize fuel combustion efficiency.	266	199	3.9% / 3.5%
Combined Heat and Power plant	Combined heat and power (CHP) production is the simultaneous generation of heat energy and electrical and/or mechanical energy in a single process referred to as a CHP plant, with raised combined efficiency raised to around 80 – 93%. [What type of CHP is used in food and beverage? How much is now the coverage, how much is the potential still?].	258	232	3.8% / 4.0%

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
High Efficiency Burner (oven and boiler)	These burners are more efficient at higher-temperature applications. Advancements over the recent years include the commercialization of self-recuperative and self-regenerative burners that use staged combustion to achieve flameless combustion. This results in more uniform heating, lower peak flame temperatures, improved efficiency and lower NOx emissions.	227	189	3.6% / 3.3%
Improved cleaning, washing and sterilising equipment efficiency	Optimized cleaning process (eg. efficient nozzles on hoses, use water at ideal temperature instead of steam, optimize flushing operations, ingredient spills treated as waste instead of flushing them)	227	177	3.3% / 3.1%
Increased uptake of Energy Management System (EnMS)	A series of systemised interacting processes that enables an organization to obtain relevant energy information and act upon it to maintain and improve energy performance, while reducing environmental emissions as a consequence.	188	151	2.8% / 2.6%
Boiler air preheat	The efficiency benefit is roughly 1% for every 5°C increase in the combustion air temperature. Changes in combustion air temperature directly affect the amount of combustion air supplied to the boiler and may increase or decrease the excess air.	178	140	2.6% / 2.4%
Steam trap survey and repair	Traps provide for condensate removal with little or no steam loss. If the traps do not function properly, excess steam will flow through the end-use device or the condensate will back up into it.	170	130	2.5% / 2.3%
Exhaust gas heat recovery (oven)	Exhaust gas heat recovery increases efficiency because it extracts waste energy from the exhaust gases and recycles it back to the process, which reduces fuel/steam requirements.	139	118	2.2% / 2.1%
Advanced Heating and Process Control (oven and boiler)	Advanced heating and process controls reduces energy losses by governing aspects such as material handling, heat storage and turndown.	118	93	1.7% / 1.6%

The following sector specific energy saving opportunities listed in Table 3.67 are technically feasible for the sector but unaccounted for in the economic scenarios as they did not meet the respective payback criteria.

Table 3.67 Projected technical potential sector specific energy saving opportunities

Sector specific energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Adsorption Chillers and Trigeneration to Meet Cooling Requirements	Tri-generation technology is a technology that can provide simultaneously three forms of output energy; electrical power, heating and cooling. In essence, trigeneration systems are CHP (Combined Heat and Power) or co-generation systems, integrated with a thermally driven refrigeration system to provide cooling as well as electrical power and heating.	70	65	1.0% / 1.1%
Fuel switching, subsititution, and combustion of waste gases	Fuel switching – has taken place at many sites by the use of their own processing waste (dry and wet) to convert to energy (thermally or biologically). Biogas from wet wastes has recently become a key discussion feature for deployment by linking with the wider food supply chain.	80	63	1.2% / 1.1%
Optimization of Operating Practices for Refrigeration	This measure captures operating practices which can be used to save energy in the refrigeration system. E.g. avoid overcooling of products and overcool products in the evening when electrical tariffs are lower.	46	41	0.7% / 0.7%1212

3.8 Machinery

3.8.1 Structure and economic contribution

The machinery sector is made up of 4 NACE divisions; C25 (Manufacture of fabricated metal products, except machinery and equipment); C26 (Manufacture of computer, electronic and optical products); C27 (Manufacture of electrical equipment) and C28 (Manufacture of machinery and equipment not elsewhere classified).

The machinery sector group has over 560,000 enterprises, and over 6.9 million persons employed and contributed to a turnover of over 1,600 billion in revenue in 2012. Manufacture of machinery and equipment (C28) is the largest division accounting for approximately 40% of the sector's turnover and persons employed. The sector mainly comprises of SMEs, with most enterprises either family owned or employing less than 50 people. The sector plays a crucial role in the supply chain between raw material supply (ferrous and non-ferrous metal production) and metal related manufacturing (automotive, infrastructure and engineering, etc.). Key economic indicators for machinery sector are summarised in Table 3.68.

Table 3.68 Key economic indicators on machinery sector for EU 28 in 2012

Description	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of fabricated metal products, except machinery and equipment	**C25**	**382,611**	**3,561,858**	**468,042**	**159,211**	**448,141**
Manufacture of structural metal products	C25.1	117,645	1,016,128	119,486	38,052	114,868

Description	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of tanks, reservoirs and containers of metal	C25.2	5,454	131,101	20,381	6,146	18,662
Manufacture of steam generators, except central heating hot water boilers	C25.3	946	27,522	8,157	2,070	7,290
Manufacture of weapons and ammunition	C25.4	1,184	59,719	13,657	5,007	13,555
Forging, pressing, stamping and roll-forming of metal; powder metallurgy	C25.5	14,300	296,324	57,567	15,939	55,898
Treatment and coating of metals; machining	C25.6	140,889	1,010,834	106,109	43,495	104,282
Manufacture of cutlery, tools and general hardware	C25.7	52,000	409,979	50,685	20,702	47,986
Manufacture of other fabricated metal products	C25.9	50,193	610,251	92,000	27,800	85,600
Manufacture of computer, electronic and optical products	**C26**	**41,473**	**1,013,222**	**252,280**	**70,252**	**219,405**
Manufacture of electronic components and boards	C26.1	9,986	261,388	58,734	16,437	51,846
Manufacture of computers and peripheral equipment	C26.2	6,200	71,252	22,800	5,867	20,020
Manufacture of communication equipment	C26.3	6,310	153,201	54,740	8,558	38,556
Manufacture of consumer electronics	C26.4	2,681	47,609	24,380	3,583	22,513
Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	C26.5	11,300	381,237	70,000	28,000	66,000
Manufacture of irradiation, electromedical and electrotherapeutic equipment	C26.6	2,039	52,437	12,291	4,047	11,623
Manufacture of optical instruments and photographic equipment	C26.7	2,503	44,763	9,005	3,690	8,582
Manufacture of magnetic and optical media	C26.8	454	1,335	330	70	265
Manufacture of electrical equipment	**C27**	**50,347**	**1,391,070**	**289,795**	**83,748**	**264,224**
Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	C27.1	22,900	642,421	130,000	40,927	121,045
Manufacture of batteries and accumulators	C27.2	500	28,195	9,000	1,532	7,423

Description	NACE (Group)	Number of enterprises [n]	No. of persons employed [n]	Turnover [mil EUR]	Value added [mil EUR]	Production value [mil EUR]
Manufacture of wiring and wiring devices	C27.3	4,370	199,630	48,673	11,936	46,078
Manufacture of electric lighting equipment	C27.4	7,545	137,701	27,726	8,526	23,974
Manufacture of domestic appliances	C27.5	3,632	202,274	43,703	10,750	36,617
Manufacture of other electrical equipment	C27.9	11,400	180,849	30,693	10,077	29,087
Manufacture of machinery and equipment (not elsewhere classified)	**C28**	**92,930**	**2,868,762**	**631,419**	**190,673**	**581,862**
Manufacture of general-purpose machinery	C28.1	11,734	849,422	207,000	62,000	180,000
Manufacture of other general-purpose machinery	C28.2	36,500	919,360	184,000	56,700	170,000
Manufacture of agricultural and forestry machinery	C28.3	7,307	171,126	43,419	9,973	38,862
Manufacture of metal forming machinery and machine tools	C28.4	8,572	225,248	40,000	13,000	40,000
Manufacture of other special-purpose machinery	C28.9	28,817	703,606	157,000	49,000	153,000

Source: EUROSTAT, accessed on Dec 2014

3.8.2 Subsector share of energy consumption

The final energy consumption data reported in EUROSTAT is aggregated for all 4 NACE divisions, i.e. C25, C26, C27 and C28 are reported as one aggregated figure. Due to the diversity of products and processes involved within the sector, it is extremely difficult to estimate the share of subsector energy consumption without reliable statistical sources.

Table 3.69 provides a breakdown share of energy consumption between the four subgroups of machinery based on national statistics in Germany, Spain and Finland. Share of energy consumption between food and beverage sector *

Table 3.69 Breakdown of energy consumption in selected Member States

Sector	NACE (division)	Germany	Spain	Finland
Manufacture of fabricated metal products, except machinery and equipment	C25	40%	57%	40%
Manufacture of computer, electronic and optical products	C26	12%	4%	10%
Manufacture of electrical equipment	C27	16%	20%	14%
Manufacture of machinery and equipment n.e.c	C28	32%	19%	36

Source: German Federal statistics, National Statistics Institute of Spain and Statistics Finland)

** Note: Germany and Finland (2013 statistics), Spain (2011 statistics)*

The National Statistics Institute of Spain provided statistics for energy statistics provided data on energy cost (in million EUR) expensed by each of the subgroup of the Spanish machinery sector. Table 3.70 provides a summary of the energy intensity, expressed in a ratio of energy cost per value added generated, for the subgroups within the machinery sector in Spain. EU's average energy intensity (see section 3.8.4.1) for the machinery sector falls in the range of 3 – 4% from 2008 – 2012. Spanish data seems to fall in line with this average range, apart from Forging, pressing, stamping and roll-forming of metal; powder metallurgy (C25.1), Manufacture of other fabricated metal products (C25.9) and Manufacture of wiring and wiring devices (C27.3).

Table 3.70 Spanish machinery subgroup energy intensity expressed in a ratio of energy cost per value added generated (Energy Cost / Value Added) in 2011.

Sector Description	NACE [group]	Energy cost [mil EUR]	Value added [mil EUR]	Ratio [%]
Manufacture of fabricated metal products, except machinery and equipment	**C25**	**431**	**10,801**	**4.0%**
Manufacture of structural metal products	C25.1	73.1	3,326	2.2%
Manufacture of tanks, reservoirs and containers of metal	C25.2	19	587	3.2%
Manufacture of steam generators, except central heating hot water boilers	C25.3	2	105	1.8%
Manufacture of weapons and ammunition	C25.4	5	107	4.6%
Forging, pressing, stamping and roll-forming of metal; powder metallurgy	C25.5	86	1,353	6.4%
Treatment and coating of metals; machining	C25.6	108.4	2,444	4.4%
Manufacture of cutlery, tools and general hardware	C25.7	26.3	1,070	2.5%
Manufacture of other fabricated metal products	C25.9	110.9	1,809	6.1%
Manufacture of computer, electronic and optical products	**C26**	**32.0**	**1530**	**2.1%**
Manufacture of electronic components and boards	C26.1	9.6	329	2.9%
Manufacture of computers and peripheral equipment	C26.2	1.8	100	1.8%
Manufacture of communication equipment	C26.3	6.2	284	2.2%
Manufacture of consumer electronics	C26.4	0.9	37	2.4%
Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	C26.5	9.9	632	1.6%

Sector Description	NACE [group]	Energy cost [mil EUR]	Value added [mil EUR]	Ratio [%]
Manufacture of irradiation, electro medical and electrotherapeutic equipment	C26.6	3.6	148	2.4%
Manufacture of optical instruments and photographic equipment	C26.7			
Manufacture of magnetic and optical media	C26.8			
Manufacture of electrical equipment	**C27**	**155.4**	**3,787**	**4.1%**
Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	C27.1	39.9	1,597	2.5%
Manufacture of wiring and wiring devices	C27.3	34.7	412	8.4%
Manufacture of electric lighting equipment	C27.4	14.2	427	3.3%
Manufacture of domestic appliances	C27.5	26.9	822	3.3%
Manufacture of batteries and accumulators	C27.2	39.7	529	2.4%
Manufacture of other electrical equipment	C27.9			
Manufacture of machinery and equipment (not elsewhere classified)	**C28**	**145.1**	**5,852**	**2.5%**
Manufacture of general-purpose machinery	C28.1	40.3	1,050	3.8%
Manufacture of other general-purpose machinery	C28.2	48.2	2,533	1.9%
Manufacture of agricultural and forestry machinery	C28.3	14.7	384	3.8%
Manufacture of metal forming machinery and machine tools	C28.4	8.3	440	1.9%
Manufacture of other special-purpose machinery	C28.9	33.6	1,445	2.3%

Source: EUROSTAT, National Statistics Institute of Spain

3.8.3 Key products

The Machinery sector covers an extremely wide range of diverse range of products within the 4 NACE division covered, with a total of 35 groups and 58 classes of product and activities covered. The following section here highlights the product scope of the shortlisted key groups within the respective divisions extracted from the EUROSTAT statistical classification [NACE rev2, 2008].

3.8.3.1 Manufacture of structural metal products (NACE 25)

The key outputs and activities within this division is made up of 3 main groups:

Manufacture of structural metal products. The main activity for this group is manufacture of metal frameworks or skeletons used in infrastructure construction or metal industry production use. This includes metal structure for buildings, towers, mast, bridges, cranes, lifting equipment, metal doors and window frames.

Treatment/coating/machining of metals. Treatment and coating of metals involves plating, anodising, heat treatment, deburring, sandblasting, tumbling, cleaning, colouring engraving and non-metallic coating, hardening and polishing of metals. Machining involves a wide range of mechanical processes on metal including boring, milling, eroding, planing, lapping, broaching, levelling, sawing, grinding, sharpening, polishing, welding and etc. of metal material.

Forging/ pressing/ stamping/ roll-forming of metal and powder metallurgy. Forging are high strength metal material produced as a result of a high pressure compression process by a locally applied force. Forging is applied in response to stringent engineering performance or safety requirements, which includes production of automotive parts, jet engine blades and fasteners (nuts and bolts). Forging process could be carried out cold or at hot working temperature. Pressing is the process of metal work piece shaping through an application of high pressure. Roll forming is also a shaping process through the constant feeding of metal work strips through consecutive series of rolls or stands, each playing an incremental part in the final shape of the metal product.

3.8.3.2 Manufacture of computer, electronic and optical products (NACE 26)

The key outputs and activities within this division is made up of 3 main groups:

Manufacture of electronic components and boards. The main activity for this group is manufacture of semi-conductors and other components for electronic application. This includes the production of bare standalone components such as capacitors, resistors, electronic connectors, diodes, transistors, inductors and LEDs. They also include integrated products such as microprocessors, electron tubes, printed circuit boards, integrated circuit boards, switches, transducers and display components. These electronic products are integral components for production of consumer electronics.

Manufacture of communication equipment. The main product of this group includes the manufacture of telephone and data communications equipment used to move signals electronically over wires or through air (such as radio and television broadcast) and wireless communication equipment. This includes telephones, central office switching equipment, modems, routers, bridges, gateways, cable television equipment, antennas, cellular phones, mobile communication equipment, radio and television broadcasting/transmitting equipment and communication devices using infrared.

Manufacture of instruments and appliances for measuring, testing and navigation. The main product of this group includes the manufacture of instrument such as automatic controls and regulators (for application such as heating, air conditioning, refrigeration and appliances), instruments and devices for measuring, displaying, indicating, recording, transmitting and controlling (temperature, humidity, pressure, vacuum, combustion, flow, level, viscosity, density, acidity, concentration and rotation). It also includes manufacture of instruments for search, detection, navigation, guidance, aeronautical and nautical system.

3.8.3.3 Manufacture of electrical equipment (NACE 27)

The key outputs and activities within this division is made up of 3 main groups:

Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus. This group involves manufacture of transformers, electric motors, generators and motor generator sets. For transformers, this includes distribution transformers, substation power transformers, distribution and voltage regulators, arc welding transformers and fluorescent ballast. For generators, this includes both power generator and motor generators sets.

Manufacture of wiring and wiring device. The group involves manufacture of current-carrying wiring devices and non-current carrying devices for wiring electrical circuits regardless of material. The wiring devices include bus-bars, electrical conductors, Ground Fault Circuit Interrupters, lamp holders, lightning arrestors, switches for electrical wiring, electrical sockets and boxes for electrical wiring. This group also includes non-current carrying devices the manufacture of electrical conduits, transmission poles, plastic junction boxes, wire insulation and fibre optic cables.

Manufacture of domestic appliances. The group includes the manufacture of electric and non-electric domestic appliances. Electric appliances include refrigerators, freezers, dishwashers, washing and drying machines, vacuum cleaners, floor polishers, other small kitchen appliances (grinders, blenders, juice squeezers, etc.), electric personal care devices (shavers, electric toothbrushes and etc.) and ventilation or recycling hoods. Electro-thermic devices include electric water heaters, electric blankets, electric dryers, electric iron, space heaters, household type fans, electric/ microwave ovens, cookers and hotplates, toasters, coffee or tea makers and electric heating resistors.

3.8.3.4 Manufacture of machinery and equipment not elsewhere classified (NACE 28)

The key outputs and activities within this division is made up of 2 main groups:

Manufacture of general-purpose machinery. This is the largest class within the division and entire sector. It involves the manufacture of engines and turbines (except aircraft, vehicle and cycle engines), fluid power equipment, pumps and compressors, sanitary taps, valves, bearings, gears, mechanical power transmission equipment. Engines and turbines include internal combustion engines, mechanical parts of an internal combustion engine, gas turbines, steam turbines, wind turbines, hydraulic turbines, boiler-turbine sets, turbine generator sets and engines for industrial application.

Manufacture of other general-purpose machinery. This class involves the manufacture of ovens, furnaces, burners, lifts, escalators, moving walkways, mechanical conveyor system, office machinery and equipment (cash registers, calculators, binging equipment, stationery) except computers and peripheral equipment, power driven hand tools, non-domestic cooling/ventilation equipment and other general purpose machinery such as weighing machines, equipment for projecting/dispersing/spraying liquids or powders (spray guns, fire extinguisher, sandblasting machines, steam cleaning machine, etc), packing and wrapping machinery, gas generators, gaskets, automatic goods vending machine, hand tools, non-electrical welding and soldering equipment and cooling towers.

3.8.4 Energy metrics

3.8.4.1 Energy intensity based on sector energy cost

Table 3.71 provides an indication of the sector's energy intensity for selected EU Member States expressed in 2 ratios[138] from 2008 - 2012. Based on the 5 year trend of the energy intensity ratios, it has remained flat, consistent with the longer term intensity trend discussed in Section 3.8.5. The machinery sector is the least energy intensive sector in comparison with the 8 industrial sectors evaluated in this study in terms of energy cost spent per value added generated.

[138] (1) Ratio of energy cost per unit of value added and (2) Ratio of energy cost per unit of turnover, i.e. the monetary value paid by manufacturers on energy products for every unit of value added or turnover generated by the sector.

Table 3.71 Energy cost intensity ratios per unit of VA and Turnover generated for selected MS *

	Ratio	2008	2009	2010	2011	2012
1	Energy cost/ Value Added	4%	4%	4%	3%	3%
2	Energy cost/ Turnover	1%	1%	1%	1%	1%

Source: ICF analysis on EUROSTAT SBS, accessed Dec 2014

** Note: Data excludes Croatia, Cyprus, Luxembourg, Malta, Poland, Slovenia*

3.8.4.2 EU final energy consumption for production of machinery sector

Table 3.72 provides a summary of the final energy consumption and fuel mix for machinery sector in EU28 as a whole. Electrical energy appears to be the largest energy type consumed within the sector as most of the key processes are powered by electrical energy. Natural gas consist of almost 1/3 of the sector's final energy requirement.

Table 3.72 Final energy consumption for EU machinery sector in 2012

EU primary energy consumption for the sector	kTOE	% of total
Gas	6,623	34%
Electricity	10,446	54%
Solid fuel	109	1%
TPP	1,285	7%
Other	820	4%
Total final energy demand	**19,283**	

Source: EUROSTAT, accessed Dec 2014

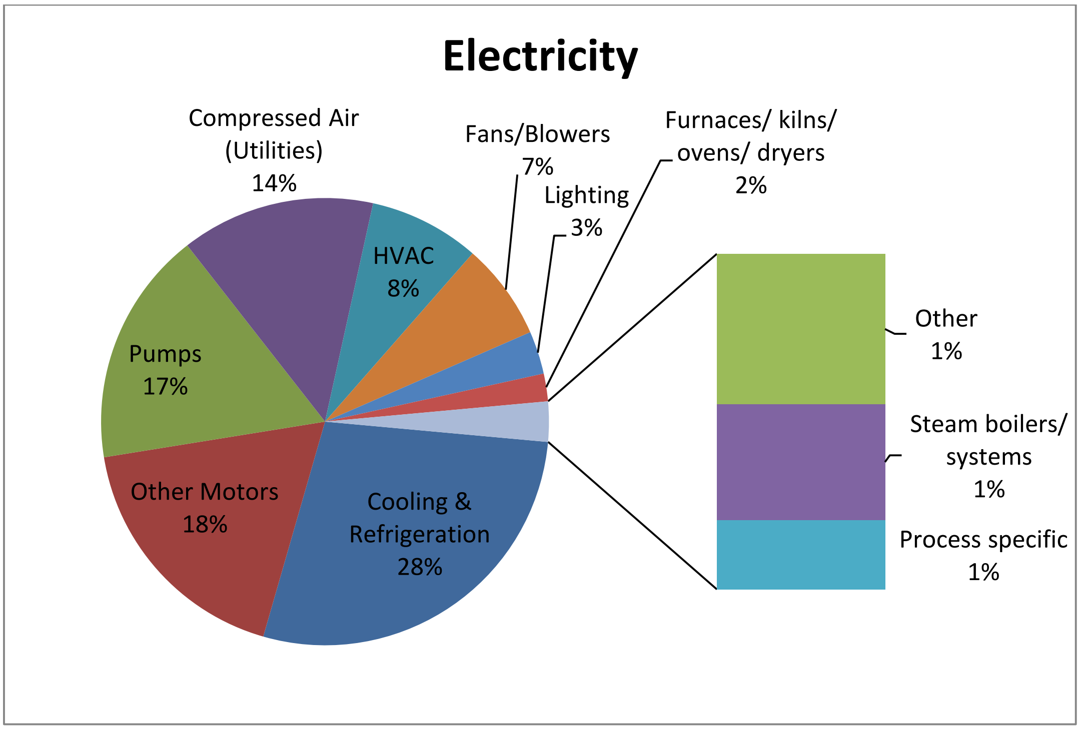
3.8.4.3 Energy end use profile

Based on the estimated share of energy consumption in the machinery sector, and the fuel mix profiles, the following figures present an aggregate energy use profile for the primary energy sources, including electricity, natural gas, total petroleum products (i.e., oil), coal, and other categories[139].

The key processes within the machinery sector is extremely diverse and bespoke to the product produced. However, these machine tools mainly consist of motors and pumps (bespoke machines , conveyor belts, hand tools, Computer Numerical Controls, lifting equipment and other electrical utility equipment like compressors and chillers), which consumes almost half of the sector's total electrical energy. Natural gas consist of 1/3 of the sector's final energy demand, mainly attributed to more heat intensive groups like forging, pressing, stamping and roll-forming of metal; powder metallurgy (C25.5) and treatment and coating of metals (C25.6), consisting of key thermal processes like forging furnaces, heat treatment furnaces, thermal quenching, tempering and washing processes.

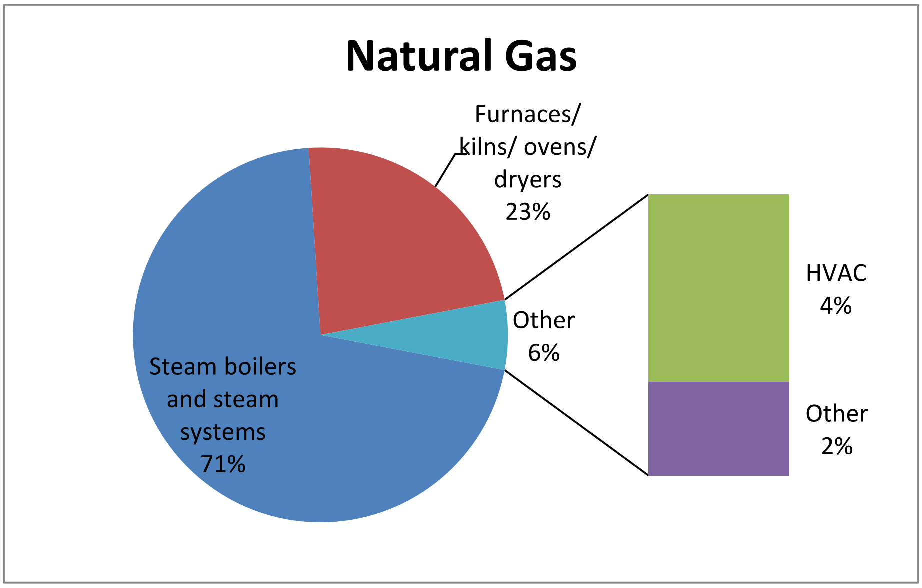
[139] Based on ICF energy efficiency studies within the machinery sector

Figure 3.75 Electricity use profile



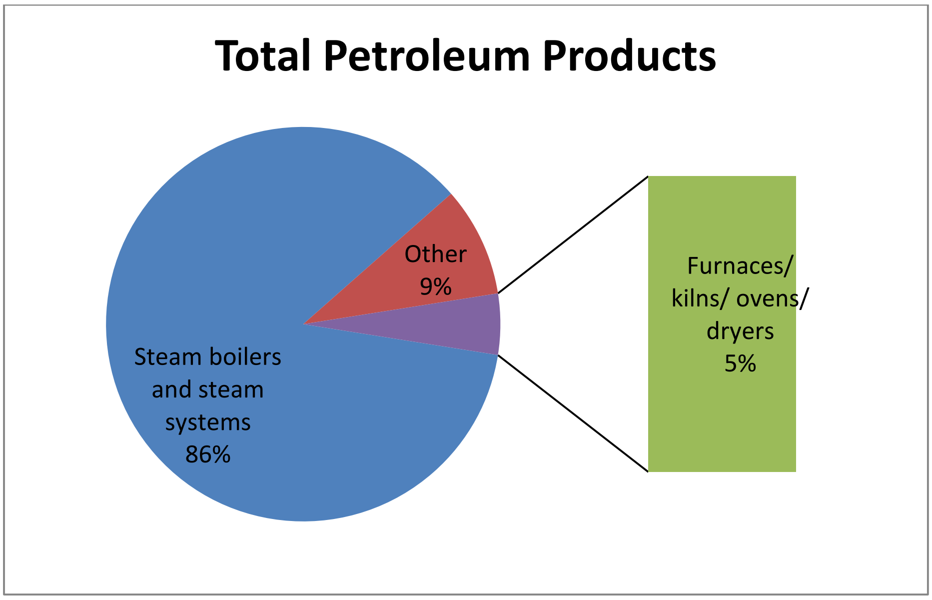
Source: ICF International

Figure 3.76 Natural gas use profile



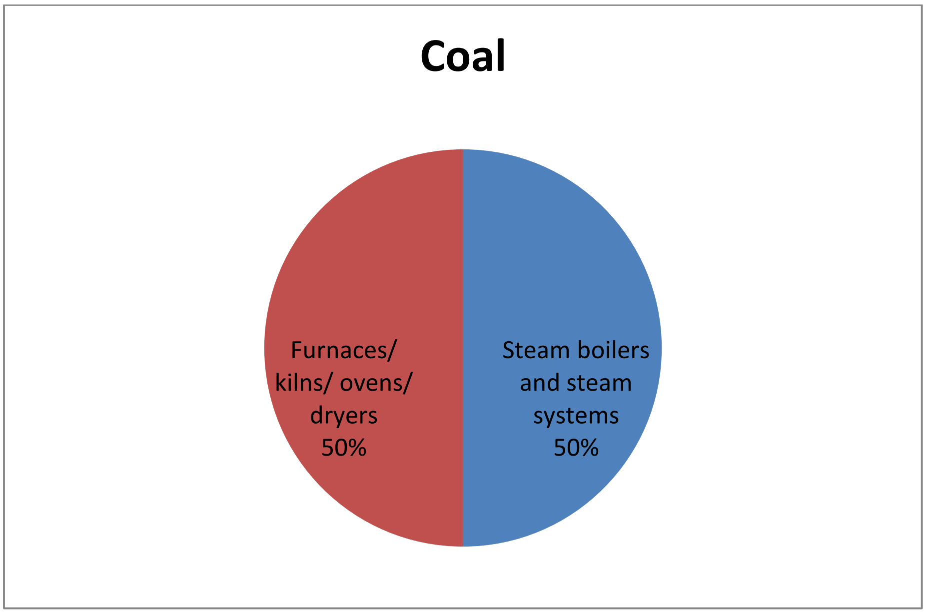
Source: ICF International

Figure 3.77 Total petroleum product use profile



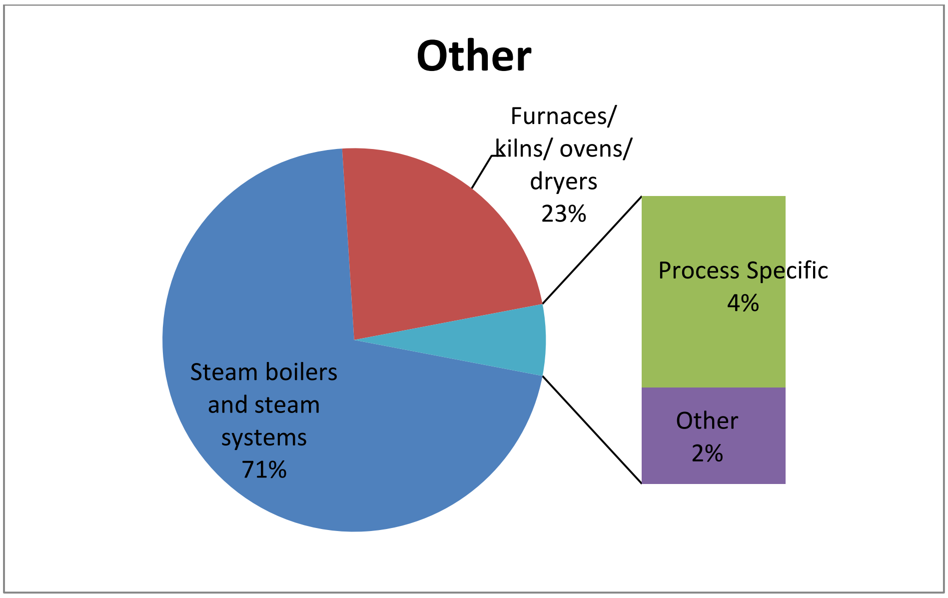
Source: ICF International

Figure 3.78 Energy use profile for coal



Source: ICF International

Figure 3.79 Energy use profile for other sources, including renewable, biomass, and waste heat



Source: ICF International

3.8.5 Projection of energy consumption trend

The following details are an extracted summary of the sector profile in Annex 1.

Metal working and metal articles industry

The industry continues to play a crucial role in the supply chain between producers of raw material and manufacturing of finished goods due to the sectors flexibility and consolidated resource sharing effort. The relationship between this sector and its customers is expected to improve as the manufacturing sector is competing on providing high value goods as opposed to just cost alone. Due to the relatively weak representation of SMEs, innovation within the sector is limited but is expected to improve as policy makers develop a stronger approach to support EU SMEs. However, the industry is facing a shortage of highly skilled workforce due to the sector's visibility in comparison with other industry despite strong continued effort in engaging with education institutes.

Electrical and electronic production

In the near term, the EU will maintain its lead as a provider of electrical and electronic goods. The electrical goods production has seen a steady increase between 2000 – 2008, and will remain competitive in the long run. EU companies will continue to produce high value chain items within the EU, while assembling or manufacturing of final product shifted abroad. However, the prevailing threats of low-cost countries, lack of innovation and extra-EU trade restrictions poses a negative impact on the growth. The EU electronic goods sectors currently lagging behind US and Japan. The sector will lose further market ground to China, Japan and South Korea. EU energy policies continues to play a crucial role in driving moderate innovation for the electrical goods sector but will have less impact on the electronic goods sector where energy efficiency is much less of a concern. Overall, the electrical goods sector will see modest growth while the electronic sector's growth will stagnate or decline.

Machinery and equipment production

The EU's machinery and equipment trade will continue to perform well in the international trades (despite higher cost structure) due to growing Asian demands and higher trends of EU machinery exports. Structural reforms (mergers and acquisitions) within the sector continue to strengthen the sector's turnkey offering, increasing share of engineering services provision further to increase in product trade. The EU will also continue its technological and innovation effort and dominance against competing US and Japanese market. However, the price competitiveness remains weak as EU wages will continue to rise and the sector's employment trend continues to decline, forcing further consolidation within the sector.

Figure 3.80 provides a comparison of EU GDP trend vs. the EU machinery sector's turnover over the period of 2006 – 2012. We can observe a direct correlation between the sector's turnover and EU GDP. Given the sector's retaining strength within the internal EU market, the sector is expected to grow in direct correlation to the projected GDP growth. Assuming this correlation is consistent, Figure 3.81 provides a projection of EU's machinery sector turnover based on the Commission's projected GDP trends to 2050 [EC, 2013].

Figure 3.80 EU GDP trend vs. machinery sector turnover from 2006 - 2012

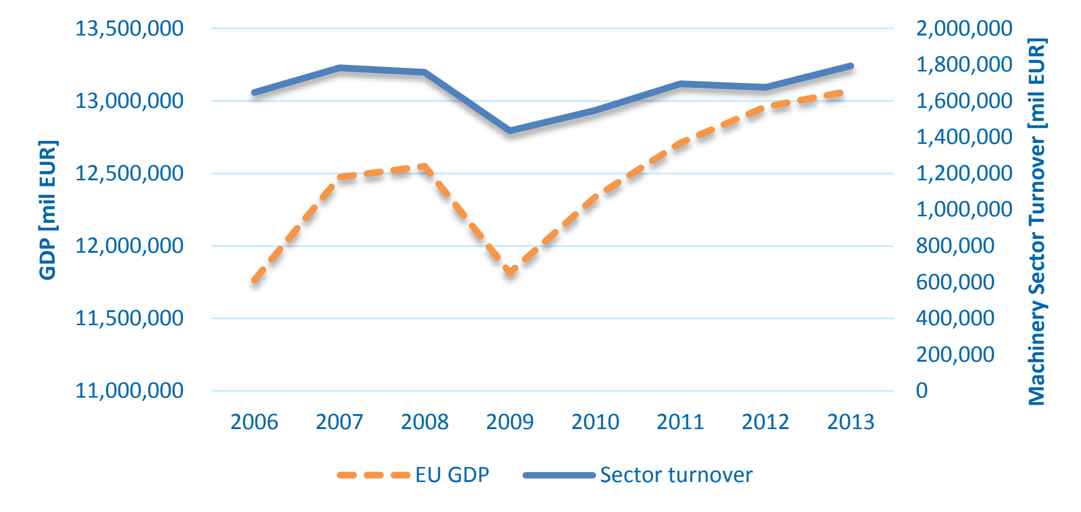
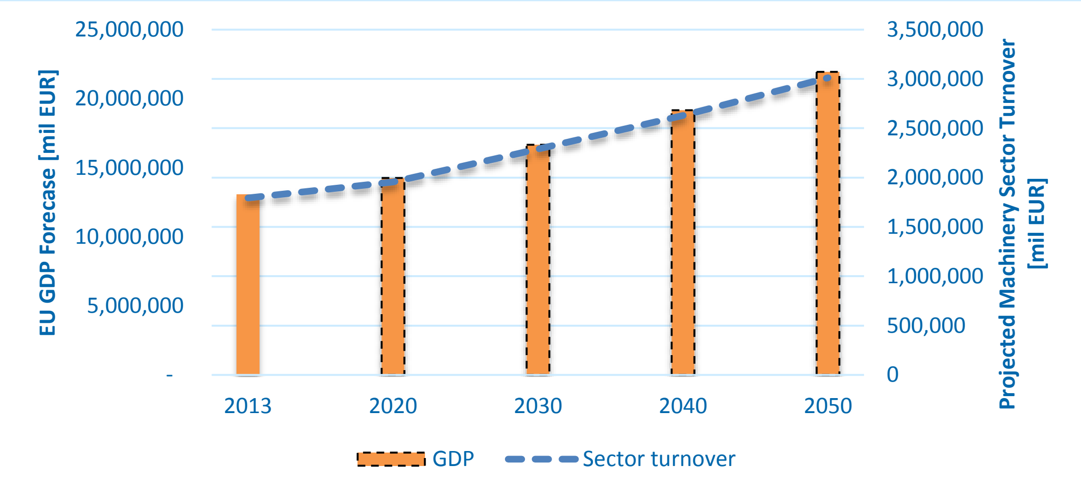
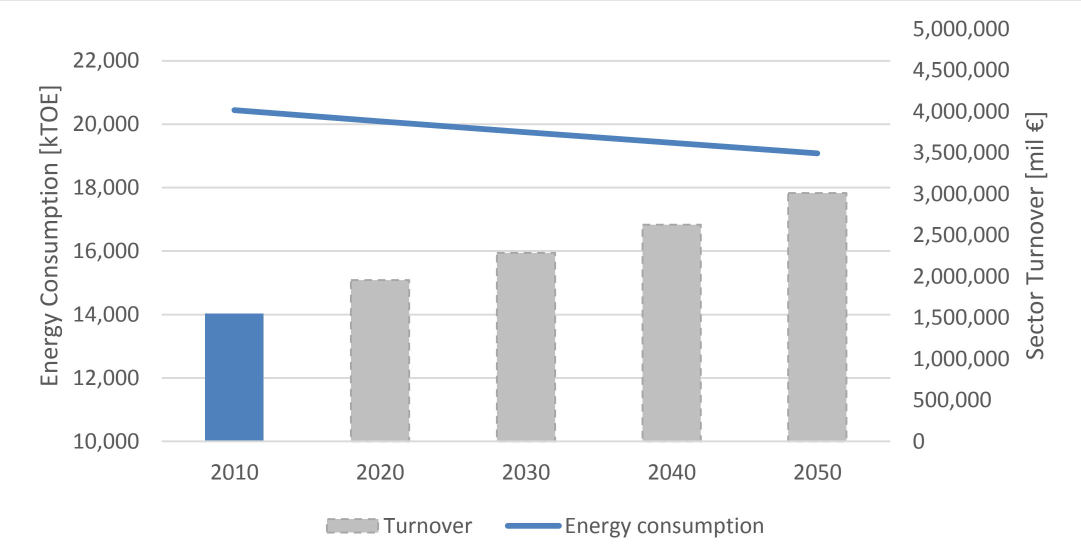


Figure 3.81 Projected EU machinery sector turnover trend vs. EU GDP



In general, the machinery sector is a non-energy intensive sector in comparison with other manufacturing sectors. The sector's year-on-year energy consumption trend fluctuated tremendously from 1995 - 2012. This is primarily due to the wide range of product scope within the sector, in which the specific energy intensity and energy consumption is fully dependent on the product output type and the associated processes in manufacturing the finished product to the specification as dictated by the consuming market on the specific year. However, the longer term linear trend line indicates that energy consumption has reduced by 2.9% despite an increase of 85% in EU GDP over the same 17-year period. The sector requires constant change in their production process in responding to evolving consumer demands and technological trends, presenting opportunities for constant improvement of its manufacturing process through uptake of existing or emerging technologies. However, it may also be likely that newer product specification could demand higher energy requirements. On the balance of the above factors, the energy consumption will remain volatile on a year-on-year basis, however it is expected that the sector will continue with its strong reduction trend in energy intensity in the longer term, resulting in a relatively flat energy consumption trend as production continues to increase as illustrated in Figure 3.82.

Figure 3.82 BAU projection for machinery sector



3.8.6 Energy Saving Potential Opportunities

Figure 3.83 presents the energy consumption projections from 2011 through to 2050 under the BAU, technical and economic scenarios[140] from the modelling outputs of IEEM.

A total of 91 energy saving opportunities which are technically feasible for the sector were accounted for in the modelling process. The projected savings under the technical[141] potential scenario is 5.3 million TOE (27% saving) in year 2030 and 4.8 million TOE (25% saving) in year 2050 with reference to the BAU projections.

A total of 39 energy saving opportunities were included under economic scenario 1, resulting in a projected saving of 1 million TOE (5% saving) in year 2030 and 2 million TOE (10.5% saving) in year 2050 with reference to the BAU projections. An additional 21 ESOs, i.e. a total of 60 energy saving opportunities, were included under economic scenario 2, resulting in a projected saving of 1.3 million TOE (6.5% saving) in year 2030 and 2.5 million TOE (13.3% saving) in year 2050 with reference to BAU projections. The additional savings for economic scenario 2 are mainly attributed to the following additional ESOs:

- Premium efficiency control with Adjustable Speed Drives (for pumps and motors)
- Advanced heating and process control (furnace)

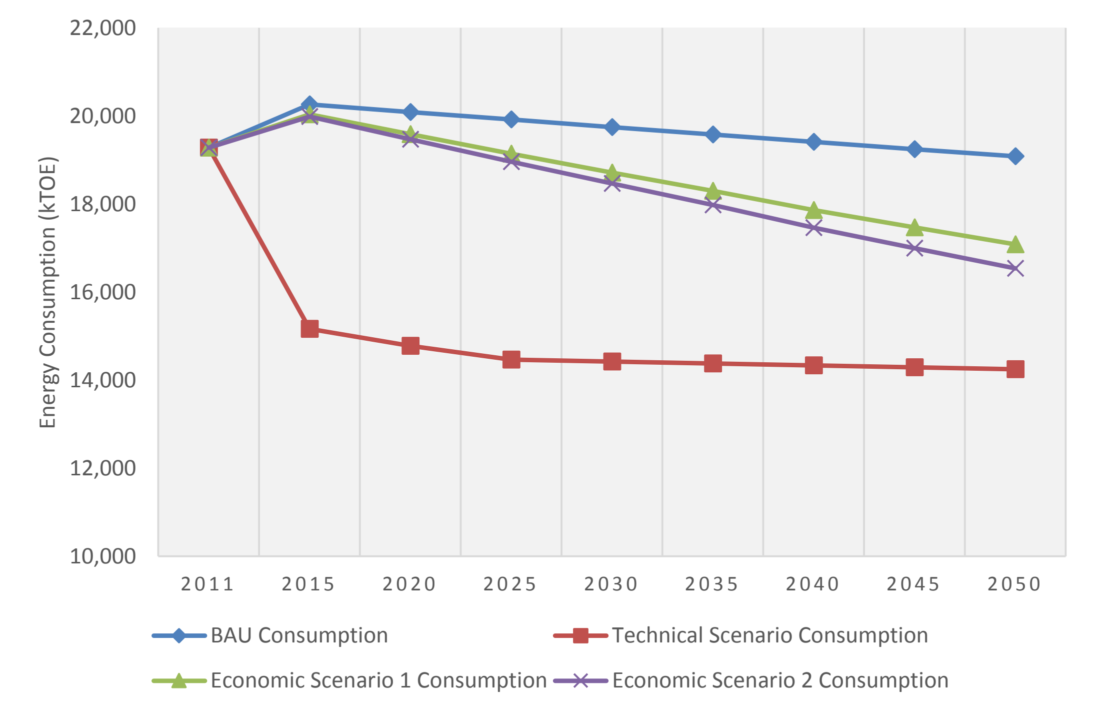
[140] The economic scenario 1 assumes an uptake of ESOs which fulfils the less than 2 year simple payback criteria, whereas the economic scenario 2 assumes an uptake of ESOs of less than 5 year simple payback.

[141] Under the technical potential scenario, it is assumed that all technically feasible ESOs relevant to the sector is implemented regardless of economic viability.

- Impeller trimming (pump)
- High efficiency non-packaged HVAC
- Optimized process re-design

The full list of Energy Saving Opportunities is presented in Annex 3. The list of ECOs under economic scenario 1 and 2 is presented in Annex 4.

Figure 3.83 Projected economic and technical potential scenario energy use



The following energy saving opportunities listed in Table 3.73 represents approximately 71% of the overall sector's projected technical saving potential.

Table 3.73 Projected sector energy saving opportunities with highest technical potential

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Sub-metering and interval metering	Sub-meters are used to measure the amount of energy consumed by equipment, or portions of the plant. They communicate with a central system where the information is trended, stored or transferred to a data historian system for archiving.	701	671	13.2% / 13.9%
Integrated control system	A neural network system is an example of an integrated control system. The information of the sensors is used in control systems to adapt the process conditions, based on artificial intelligence, mathematical ("rule"-based) or neural networks and "fuzzy logic" models of the industrial process.	766	706	14.4% / 14.6%

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Implement Lean Manufacturing System	Lean emphasizes maximizing customer value while minimizing waste. Simply put, if a particular action or activity does not add value to a product that the customer is willing to pay for, then that action or activity is wasteful and therefore should be eliminated, resulting in energy reduction as a consequence.	383	359	7.2% / 7.4%
Premium efficiency control with ASDs (motors, pumps)	Adjustable Speed Drives (ASDs) match the motor speed to load requirements for motor operations resulting in significant energy savings, especially in applications that require variable load. Energy savings vary between 7% and 60% depending on the application.	382	394	7.2% / 8.2%
Optimized Process Re-design	While this opportunity might capture some similar improvements to Lean Manufacturing, which looks to eliminate waste in an on-going basis, the end of equipment/process life, or new plant construction, offers an even large opportunity for the most efficient processes and layouts to be selected.	320	291	6.0% / 6.0%
Exhaust gas heat recovery (furnace)	Exhaust gas heat recovery increases efficiency because it extracts waste energy from the exhaust gases and recycles it back to the process, which reduces fuel/steam requirements.	234	161	4.4% / 3.3%
Increased uptake of Energy Management System (EnMS)	A series of systemised interacting processes that enables an organization to obtain relevant energy information and act upon it to maintain and improve energy performance, while reducing environmental emissions as a consequence.	204	183	3.8% / 3.8%
High efficiency process equipment	This is a very broad measure, as the sector contains a wide array of Process Specific Equipment. For much of this equipment, modern High Efficiency versions are available for selection when replacing old equipment. Some of the improvements might include: - More insulated equipment - More efficient heating methods - More efficient rinsing techniques - Better In-built (electronic) controls - Improved Process Variations	173	139	3.2% / 2.9%
Advanced Heating and Process Control (furnace)	Advanced heating and process controls reduces energy losses by governing aspects such as material handling, heat storage and turndown.	151	114	2.8% / 2.4%
High Efficiency Burner (furnace)	These burners are more efficient at higher-temperature applications. Advancements over the recent years include the commercialization of self-recuperative and self-regenerative burners that use staged combustion to achieve flameless combustion. This results in more uniform heating, lower peak flame temperatures, improved efficiency and lower NOx emissions.	140	97	2.6% / 2.0%

Energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
Flue-gas monitoring (furnace)	Stack thermometers, fuel meters, make-up feed water meters, oxygen analysers, run-time recorders, energy output meters, and return condensate thermometers are required to maintain a proper air-to-fuel ratio to optimize fuel combustion efficiency.	116	77	2.2% / 1.6%
Impeller trimming (pump)	Since pumps are often conservatively designed, the impellers are larger than they need to be, and requiring unnecessary excess energy. Although replacing the impeller is always an option, impeller trimming offers the opportunity to customize the size without having to buy expensive parts.	113	116	2.1% / 2.4%
Optimization of pumping system	Optimization includes minimizing initial cost and life-time maintenance costs through better matching pump size and operation with and system demands (pump replacement, replacing valves), operational changes (e.g. reduction of pressure), reduce friction in pumping system by piping redesign and retrofit.	100	104	1.9% / 2.1%

Besides 3 of the sector specific Energy Saving Opportunities listed above, the other sector specific energy saving opportunity involves replacement of existing electrical equipment with higher efficiency classes, as detailed in Table 3.74.

Table 3.74 Projected sector specific energy saving opportunities assessed as technical potential

Sector specific energy saving opportunities	Description	2030 Technical potential (kTOE/a)	2050 Technical potential (kTOE/a)	% of total sector technical potential (2030 / 2050)
High Efficiency Process Equipment (Electrical)	This is a very broad opportunity, as the sector contains a wide array of process Specific equipment. For much of this equipment, modern High Efficiency versions are available for selection when replacing old equipment. Some of the improvements might include: - Improved Drives and Transmission - Better In-built (electronic) controls - Improved Process Variations	82	83	1.5% / 1.7%

4 Tertiary Sectors

4.1 Retail and Wholesale

4.1.1 Energy consumption trends

Retail and wholesale trade buildings are the largest consumers of energy among non-residential buildings in Europe. Retail and wholesale trade accounted for 28% of total energy consumption in the non-residential building sector, which amounted to approximately 19 Mtoe in 2012.[142,143] Electricity consumption accounts for close to 70% of total energy consumption in the sector.[144]

Figure 4.1 provides an outline of energy consumption and turnover in the EU wholesale and retail sectors. Overall, energy consumption has tracked turnover. A recent report noted that by 2020, growth of ecommerce will have a significant impact on retail stores. Specifically, the growth of ecommerce will result in town and shopping centre store sales declining by 27%. This will result in 21% less retail space and 31% fewer stores in town centre venues.[145] The corollary to this is that wholesale storage will likely increase to support ecommerce distribution. As noted in Figure 4.1 there is a slight disconnect between turnover and energy consumption trends from 2010 to 2012 (energy consumption declined by 4%), which may reflect early signs of retail space declines.

Energy consumption trends through 2050 are hard to define due to limited published literature.[146] As such, an estimate has been developed based on the historic information, and inferences from market trends. As such, absolute energy consumption is assumed to decline of 21% by 2020 from 2010 levels (i.e., approximately 2.5% per year) due to both energy efficiency improvements and declining retail space[147], followed by a continuing, but a slower rate of decline through 2050 of 1% per year. Consequently, 2030 and 2050 energy consumption for the sector is assumed to be 14 Mtoe, and 11.5 Mtoe, respectively.

[142] BPIE (2011) Europe's buildings under the microscope available at http://www.europeanclimate.org/documents/LR_%20CbC_study.pdf

[143] Estimates are based on Odyssee database; which represents only 12 Member States. However, the economic strength and population of these Member States (e.g., Denmark, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden, and UK), imply that these data is the majority of energy consumption data in the EU.

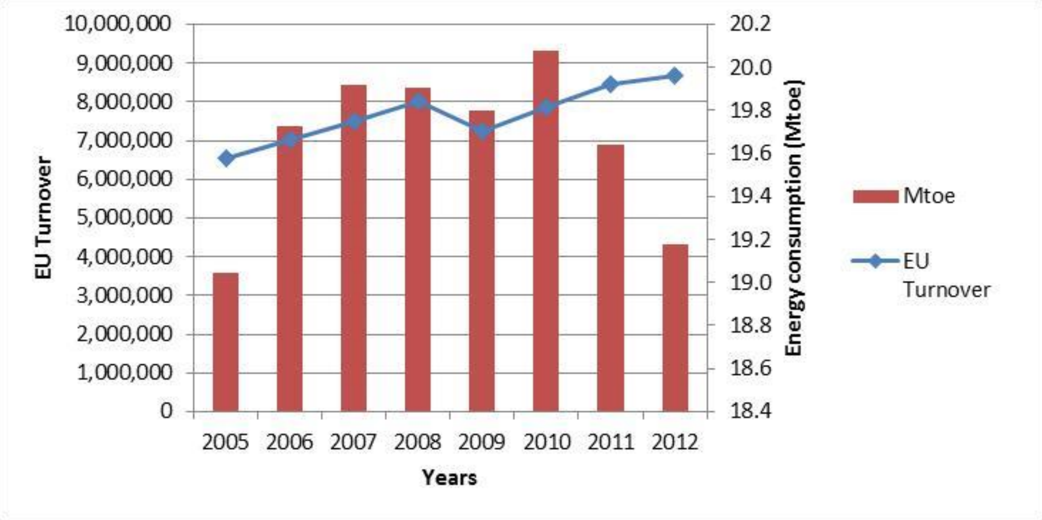
[144] Ibid

[145] Javelin Group press release, 31% fewer town centre stores by 2020, says Javelin Group report, October 2011

[146] For example, although BPIE report wholesale and retail historic energy consumption for six Member States, including Bulgaria, France and Slovakia, no data is available for the remaining Member States. Also, EU Energy, transport, and GHG emissions trends to 2050; reference scenario 2013 provides projections through 2050, but energy data is reported at the tertiary sector level only, with no disaggregation to individual sectors, such as wholesale and retail.

[147] Javelin Group press release, 31% fewer town centre stores by 2020, says Javelin Group report, October 2011

Figure 4.1 Energy consumption and turnover of wholesale and retail trade.



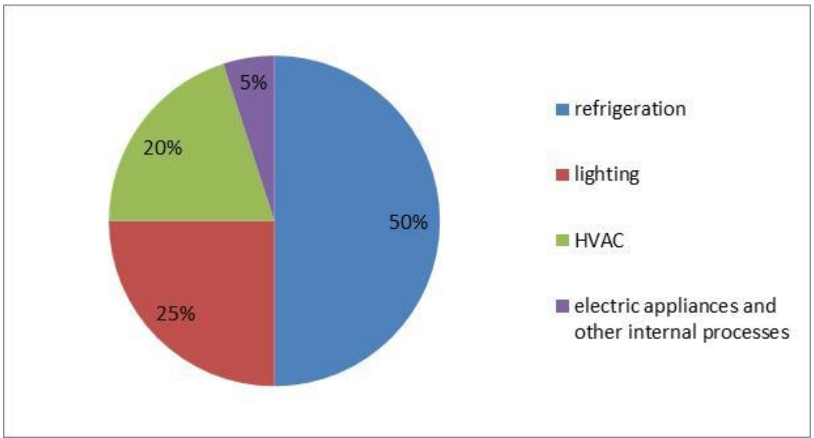
Source: ODYSSEE database on energy efficiency data: energy consumption in the wholesale and retail sector AND Eurostat: Annual detailed enterprise statistics for services: Turnover in Wholesale and Retail Trade (NACE_R2)

4.1.2 Energy usage profile

4.1.2.1 Retail trade

The distribution of energy demand varies according to the products the store offers. Figure 4.2 and Figure 4.3 illustrate an approximate breakdown of energy usage depending on food and non-food driven retail formats. Table 4.2 and Table 4.2 presents specific energy consumption in food and non-food driven retail units.

Figure 4.2 Energy consumption in food driven formats



Source: JRC (2013) Best Environmental Management Practice in the Retail Trade Sector

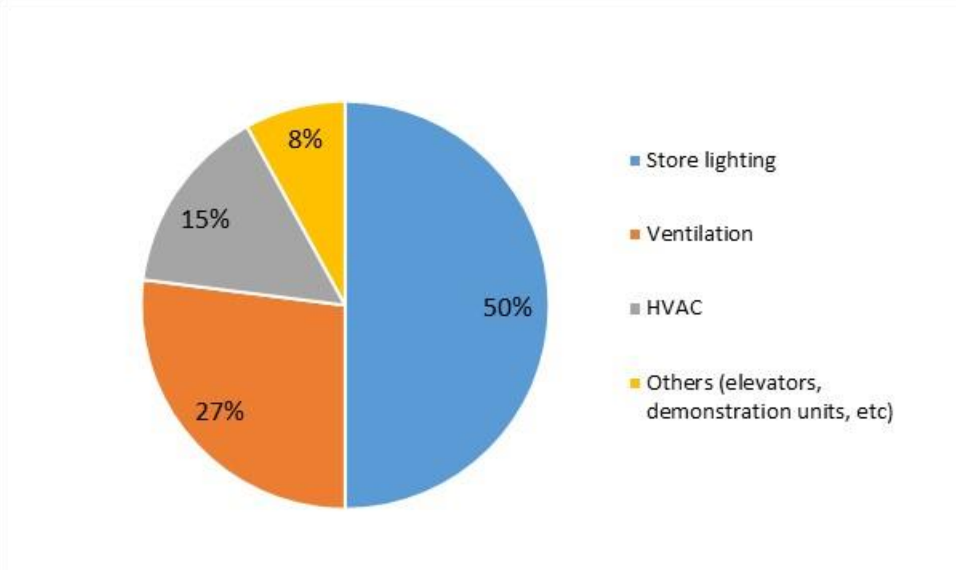
A recent JRC report outlines that the average share of energy consumption for a food retailer is largely driven by refrigeration – which accounts for 50% of the energy use. Stringent European food regulations coupled with consumers demand for convenience and fresh products are key contributing factors. Additionally, these stores require refrigeration for fresh and frozen products 365 days a year for 24 hours a day to ensure product quality.[148] Lighting

[148] European Retail Forum (2009) Issue paper on energy efficiency of stores

is the second largest energy consumer accounting for 25% in an average store followed by HVAC (20%) and electrical appliances and other internal processes (5%).

For non-food retailers, energy consumption is unclear, since energy use depends on the products being sold in the store[149]. For example, in an electronic store, electrical appliances would consume a larger proportion of energy compared to a clothes retailer, where energy consumption may be driven by lighting. A rough breakdown of energy consumption has been provided by the European retail forum in Figure 4.3.

Figure 4.3 Energy consumption in non-food driven formats



Source: European Retail Forum (2009) Issue paper on energy efficiency of stores

Figure 4.3 shows that on average, energy consumption in non-food retail formats is driven by lighting. Creating the most ambient lighting to display products is a key strategy that retailers use to best present their products and entice consumers; this is of particular importance in textile and furniture stores. Heating and air-conditioning is also a significant contributor of energy in non-food driven formats. Comfortable temperatures for consumers are maintained by retailers to ensure a 'pleasant shopping atmosphere', and this varies both regionally and seasonally across the EU.

Table 4.2 and Table 4.2 presents a summary of 'typical' and 'good practice' specific energy consumption in different types of food and non-food retail units. The 'good practice' benchmarks for existing buildings present an upper limit for new design, and so illustrate the energy saving potential from fossil fuel (heat) and electricity using equipment. In total the energy saving potential in food and non-food retail units is on the order of 20%.

Table 4.1 Specific energy consumption (kWh/m²) in existing food retail units

Building type	Typical practice		Good practice		% improvement potential
	Fossil fuels kWh/m²	Electricity kWh/m²	Fossil fuels kWh/m²	Electricity kWh/m²	
Small food shops	100	500	80	400	20%
Supermarket	261	1026	200	915	13%
Meat butchers	–	577	–	475	18%
Frozen food centres	–	1029	–	858	17%

149 JRC (2013) Best Environmental Management Practice in the Retail Trade Sector

Table 4.2 Specific energy consumption (kWh/m^2) in existing non-food retail units

Building type	Typical practice		Good practice		% improvement potential
	Fossil fuels kWh/m^2	Electricity kWh/m^2	Fossil fuels kWh/m^2	Electricity kWh/m^2	
Book stores	–	255	–	210	18%
Clothes shop	108	287	65	234	24%
Department stores	248	294	194	237	20%
Electrical goods retail	–	230	–	172	25%
Shoe shops	–	279	–	197	29%

Source: Chartered Institution of Building Services Engineers (CIBSE) Guide F (2012) Energy efficiency in buildings

4.1.2.2 Wholesale sector

Wholesale buildings are primarily warehouses, which are predominantly used for storage.[150] Nonetheless, their role has increasingly become more sophisticated. Many now provide high-tech inventory tracking and value added services such as quality control testing and repackaging. As warehouse functions have increased, their energy consumption has also grown.

Energy consumption in warehouses can vary significantly according to the types of goods stored as well as the climate of the region they are located. Table 4.3 provides a detailed breakdown of energy consumption of warehouses in the UK. The percentage breakdown may be indicative of energy consumption of warehouses in other western European countries. Heating is the largest consumer of energy; almost 60% in the UK. Across Europe energy efficiency varies in response to differences in climate. In southern Europe, warmer climates mean there is a greater risk of overheating in the summer, thus, windows are placed on either roof slants or north-facing walls.

Table 4.3 Final energy consumption in warehouses by end use; 2013 (UK)

Warehouses	Thousand tonnes of oil equivalent (ktoe)	% of total consumption
Heating	1478	58%
Lighting	428	17%
Other	262	10%
Catering	190	7%
Hot Water	106	4%
Cooling & Ventilation	54	2%
Computing	35	1%
Total	**2554**	

Source: DECC Energy consumption in the UK Service Sector, 2014 update

[150] BPIE (2011) Europe's buildings under the microscope available at http://www.europeanclimate.org/documents/LR_%20CbC_study.pdf

Table 4.4 presents the average 'typical' and 'good practice' specific energy consumption for warehouses. The data indicates that if all warehouses were to achieve 'good practice' benchmarks, the energy saving potential from fossil fuel (heat) and electricity using equipment would be significant; i.e., greater than 30%.

Table 4.4 Specific energy consumption (kWh/m²) in existing warehouses

Building type	Typical practice		Good practice		% improvement potential
	Fossil fuels kWh/m²	Electricity kWh/m²	Fossil fuels kWh/m²	Electricity kWh/m²	
Distribution warehouses	169	67	103	53	34%
Distribution warehouses (all electric)	–	101	–	55	46%

4.1.3 Opportunities

4.1.3.1 Retail Sector

According to the ENERGY STAR for Retail program[151], a 10% decrease in energy costs has an equivalent impact on operating income as a 1.26% increase in sales for the average retail stores. Retail stores are one of the more uniform space types, breaking down into only two main categories:

- **Large Retail** – Stores with high ceilings, and where store sizes can range within 5,000 – 10,000 m²
- **Small Retail** – Stores less than 500m² with lower ceiling heights.

While these types of buildings use energy in different ways, the overall methods of improving the efficiency are relatively common.

There are many economic benefits associated with a reduction in energy consumption in the retail sector. The biggest energy savings in the retail sector can be made in lighting, heating, ventilation, and air conditioning. [152] Some of the measures to achieve this are outlined in Table 4.5.

Table 4.5 Summary of retail sector opportunities

Areas	Opportunities	Typical Investment [153]	Description
HVAC	Use an Economizer	€€€	Device fitted to a boiler which saves energy by using the exhaust gases from the boiler to preheat the cold water used to fill it.
	Variable Speed Drives	€€	Applicable to situations where load being driven by a motor has a varying demand. A small speed reduction can lead to substantial reductions in energy use.
	Demand Controlled Ventilation	€€	Average airflow rate is reduced, allowing the fan to work below the maximum airflow, and thus at lower power.

[151] http://www.energystar.gov/index.cfm?c=retail.bus_retail

[152] ibid

[153] € = <€20,000; €€ = €20,000-€100,000; €€€ = €100,000-€250,000

Areas	Opportunities	Typical Investment [153]	Description
	Condensing natural gas equipment	€€€	Achieve high efficiency by using waste heat in flue gases to pre-heat cold water entering the boiler
	Temperature Setback and Scheduling	€	Setting the temperature back when the building is unoccupied. Energy savings of 2% to 4% for every 1 degree difference in thermostat setting.
	Employ Overnight Cooling	€	Cool air passes through a building overnight to remove heat that has built up through the day
	Optimise Building Management System	€	Optimise the control and monitoring of a building's mechanical and electrical equipment to ensure it operates efficiently
Lighting	Reduced-wattage compact fluorescent lamp	€	Move from T12 (old and inefficient) to T8 (higher efficiency) or T5 (highest efficiency) fluorescents.
	LED Display Lighting	€	LEDs are solid state electronic devices that allow electricity to flow through them in one direction to produce a small amount of light.
	Occupancy Controls	€	Sensor that detects occupancy of a space by people and turns the lights on or off automatically
Plug Loads	Energy Efficient Appliances	€€€	Replace old equipment with those having better minimum energy performance standards

4.1.3.2 *Wholesale sector*

The scale of distribution centres varies considerably; some are owned and run by a retailer, while others are run by a logistics company which may serve several companies. The smallest are less than 5,000 square meters; the largest may be up to 300,000 square meters. Very large operations might receive and ship over 10,000 truckloads per year and serve 50 to 125 stores. Nonetheless, all sizes of distribution centre can deploy low and no-cost methods to reduce their energy footprint. There are many opportunities to implement energy efficiency into warehouses. Some of these are outlined here in Table 4.6.

Table 4.6 Summary of wholesale sector opportunities

Areas	Opportunities	Typical Investment[154]	Typical Cost Savings
HVAC	Install De-stratification Fans	€€€	Thermal stratification results in differences in temperature from floor to ceiling and wall to wall. Leads to HVAC systems having to constantly cycle on in order to maintain building interiors. De-stratification fans balance internal temperatures and thus reduce the operation time and workload of HVAC systems.
	Use Air Curtains	€€	Ensures protection against cold drafts entering and warm air leaving the building.

[154] € = <€20,000; €€ = €20,000-€100,000; €€€ = €100,000-€250,000;

Areas	Opportunities	Typical Investment[154]	Typical Cost Savings
	Variable speed drives	€€	Applicable to situations where load being driven by a motor has a varying demand. A small speed reduction can lead to substantial reductions in energy use.
	Employ Demand-Controlled Ventilation	€€	Average airflow rate is reduced, allowing the fan to work below the maximum airflow, and thus at lower power.
	Temperature Setback and Scheduling	€	Setting the temperature back when the building is unoccupied. Energy savings of 2% to 4% for every 1 degree difference in thermostat setting.
	Employ Overnight Cooling	€	Cool air passes through a building overnight to remove heat that has built up through the day
	Optimise Building Automation System	€	Optimise the control and monitoring of a building's mechanical and electrical equipment to ensure it operates efficiently
Lighting	Use Reduced-Wattage T8 Fixtures In Low Bay Spaces	€	25% energy savings over standard T12 fixtures
	Use T5 High Output Fixtures in High Bay Spaces	€	20% energy savings compared to metal-halide high-bay systems
	Occupancy Controls	€€	Sensor that detects occupancy of a space by people and turns the lights on or off automatically
	Use New LED Technologies	€	LEDs are solid state electronic devices that allow electricity to flow through them in one direction to produce a small amount of light.

4.2 Accommodation and Food Service Activities

4.2.1 Energy consumption trends

Hotels and restaurants in Europe accounted for 11% of total energy consumption in the non-residential building sector in 2012, amounting to approximately 10.5 Mtoe.[155,156] In 2000, energy consumption in European hotels was estimated to be 39 TWh (terawatt hours) or 3.4 Mtoe.[157] Furthermore, the hotels sector accounts for 30% of the sector's turnover. As such, it is assumed that the split in energy consumption between hotels and food services is about 30% and 70%, respectively. Figure 4.4 shows that energy consumption in the sector has declined steadily between 2005 and 2012[158], which is opposite to the sector's economic activity, and may imply greater energy efficiency.

[155] BPIE (2011) Europe's buildings under the microscope available at http://www.europeanclimate.org/documents/LR_%20CbC_study.pdf

[156] Estimates are based on Odyssee database; which represents only 9 Member States (e.g., Denmark, France, Germany, Netherlands, Spain, Sweden, and UK).

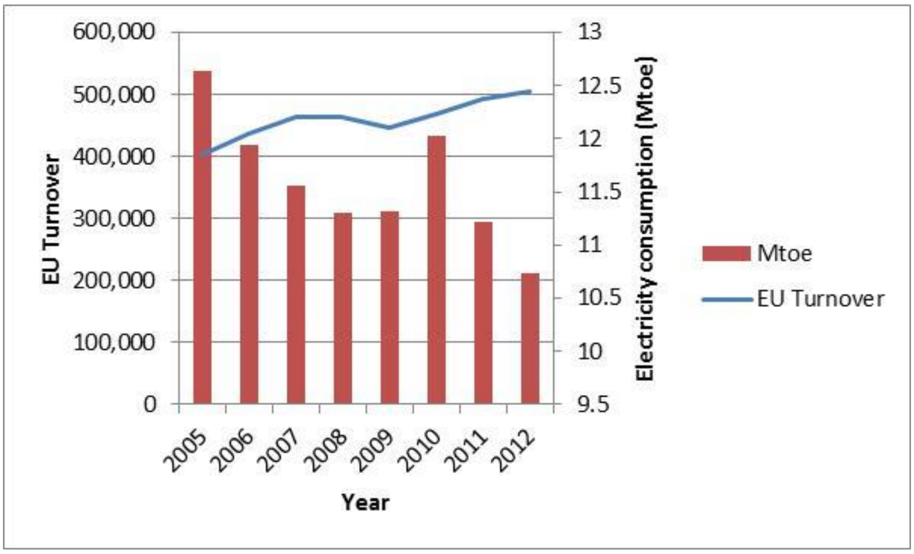
[157] Hotel Energy Solutions (2011), Analysis on Energy Use by European Hotels: Online Survey and Desk Research

[158] Odysee database – energy data for the service sector

Accommodation (hotels) contributes to 1% of global energy consumption and associated CO_2 emissions, making it an important but not major consumer of energy. There are 5.24 million hotels rooms in Europe, representing half of all global hotels.[159] For most hotels, energy use falls in the range 200 - 400 kWh/m²/yr; however, the European hotel sector is dominated by small businesses, which provide around 90 per cent of the total number of rooms, and are less proactive about the environment than large hotel chains.

In Europe, the UN predicts a 4% decline in population from 740 billion in 2010 to 709 billion in 2050. Assuming current declines in sector energy consumption (2% per year reduction between 2005 and 2012) continue through 2020, after which it decreases at a slower rate of 1% per year through 2050, along with the predicted decline in population, projected energy consumption for the sector could be in the order of 8 Mtoe and 7 Mtoe in 2030 and 2050, respectively.

Figure 4.4 Energy consumption and turnover trend for accommodation and food sector



Source: ODYSSEE database on energy efficiency data: Energy consumption of hotels, restaurants AND Eurostat: Annual detailed enterprise statistics for services: Turnover in Accommodation and Food and beverage service activities (NACE_R2)

4.2.2 Energy usage profile

4.2.2.1 Accommodation

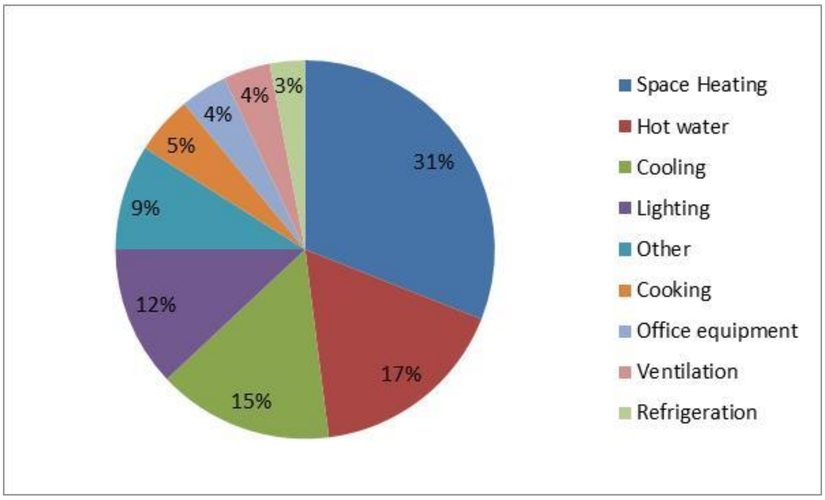
The main energy consuming activities in hotels are: heating, cooling, lighting, hot water use and other energy consuming activities by guests, preparing meals, swimming pools and other activities. [160] Figure 4.5 provides a breakdown of average energy use in European hotels. Electricity accounts for approximately 40% of energy consumed in a hotel (HES, 2011)[161].

[159] HES (2011) Key energy efficiency solutions for SME hotels: Hotel Energy Solutions project publication, HES, 2011. Available at: http://hes.unwto.org/sites/all/files/docpdf/keyenergyefficiencysolutionsaugustfinalversion.pdf

[160] Hotel Energy Solutions (2011), Analysis on Energy Use by European Hotels: Online Survey and Desk Research, Hotel Energy Solutions project publications

[161] JRC (2011) Best Environmental Management Practice in the Tourism sector.

Figure 4.5 Figure 2: energy consumption by end use in European Hotels



Source: HES (2011) Key energy efficiency solutions for SME hotels: Hotel Energy Solutions project publication in JRC (2013) Best Environmental Management Practice in the Tourism sector.

Analysis on energy use by European hotels[162] found that physical and operational parameters influence the energy consumption in a hotel. Physical parameters include:

- Size, structure and design of the building;
- Geographical and climatic location;
- Type of energy and water systems installed;
- The way the systems are operated and maintained;
- Types of energy available; and
- Energy use regulations and costs.

Operational parameters influencing energy consumption in hotels include:

- The number of facilities (e.g., swimming pools, restaurants, kitchens, in-house laundry etc.);
- Services offered;
- Occupancy levels;
- On-site energy practices; and
- Culture and awareness of resource consumption amongst guests.

This is reflected in the energy intensity range found in European hotels, which is between 200-400 kWh/m2/yr. At the upper end are luxury hotels with laundry and full HVAC, while the lower end includes budget hotels with no laundry and no/partial HVAC.

A high amount of wastage is associated with energy consumption in hotels. Guests can be given full control of thermostat settings and individual air conditioning units. These can be used simultaneously with open windows resulting in energy wastage. Additionally HVAC units are left running or on standby mode when the room is not occupied which is approximately 60-65% of the day. [163]

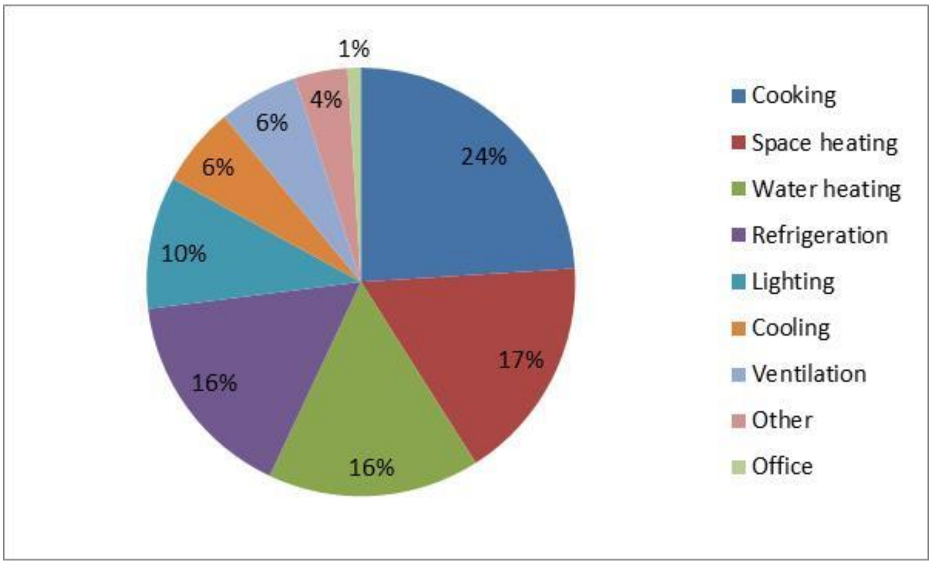
[162] Hotel Energy Solutions (2011), Analysis on Energy Use by European Hotels: Online Survey and Desk Research, Hotel Energy Solutions project publications

[163] Ibid

4.2.2.2 *Food services*

Figure 4.6 illustrates US EIA data for energy consumed in food service buildings. The Carbon Trust have stated that this is representative of energy consumed in this sector in the UK, and thus, may also be indicative of energy consumption in the European catering sector.

Figure 4.6 Catering energy consumption by energy use



Source: Carbon Trust (2012) Food preparation and catering sector overview

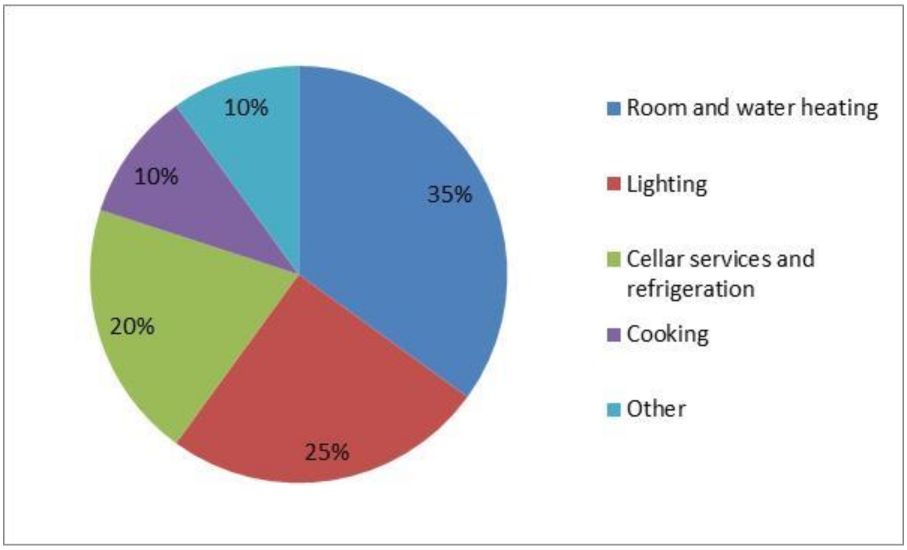
Kitchens consume a large proportion of energy in hospitality businesses. In the UK, the catering industry is estimated to consume 20,600 million kWh (1,770 ktoe) of energy per year.[164] Over 30% of this is used in commercial catering businesses, hotels, and restaurants; whereas, over 40% is used in non-commercial catering such as schools and hospitals. [165]

Figure 4.7 provides a breakdown of energy consumption in pubs, clubs and restaurants. It illustrates that heating and lighting together account for approximately 60% of energy consumption. Cellar services are the second largest energy consumers, followed by cooking. It is important to note that these values vary significantly from one business to another, depending on opening hours, and quality of customer experience.

[164] http://www.carbontrust.com/resources/guides/sector-based-advice/food-and-drink

[165] Hotel Energy Solutions (2011), Analysis on Energy Use by European Hotels: Online Survey and Desk Research, Hotel Energy Solutions project publications

Figure 4.7 Breakdown of energy use in pubs, restaurants and clubs



Source: Carbon Trust (2012) Hospitality sector overview in E.ON Pubs, Clubs and Restaurants

4.2.3 Opportunities

4.2.3.1 Accommodation sector

Based on industry benchmarks[166], a reduction in energy consumption by 10-15% should be achievable using available technology. This equates to reductions on the order of 1 Mtoe in 2030 and 2050.

Therefore those organizations that have not had a strategic approach are more likely to yield significant savings more readily when a strategic and systematic approach is put in place. With major renovations occurring every 7 to 10 years, some of the measures that hotel owners can implement include:

- Energy conservation from heating (e.g. by installing double glazed windows to reduce heat transfer coefficient, reducing internal loads by using of high efficiency lighting systems etc)
- Use natural cooling techniques (e.g. use of alternative cooling technologies such as ground cooling with ground-air heat exchangers, night ventilation techniques, fans etc).
- Energy conservation from artificial lighting (e.g. by installing occupancy sensors, improved fluorescent lamps, luminaries etc)

4.2.4 Food service sector

- Demand control ventilation[167]: Innovation opportunities include use of sensors in extraction linked to variable speed drives that can automatically vary the fan speed with the cooking load.
- Exhaust air heat recovery[168:] Among the best practices especially for new-build facilities is the use of exhaust air heat recovery to preheat incoming water. This could take some load off the water heating system and enable smaller water heaters to be installed and used.
- Commercial kitchens not equipped with energy-efficient equipment[169]: Evidence has showed that equipment used in commercial kitchens is only 50% efficient. Thus more

---

[166] CIBSE Guide F; Energy efficiency in buildings

[167] http://www.carbontrust.com/resources/reports/technology/contract-catering-sector-industrial-energy-efficiency

[168] http://www.foodserviceconsultant.org/region/worldwide/investing-in-efficiency

[169] http://www.greenhotelier.org/our-themes/energy-efficiency-in-the-kitchen/

energy-efficient equipment could result in significant energy savings. This includes electric induction hobs which are up to 50% more efficient than a traditional electric hob, open-top gas ranges with individual burners as they are more efficient than a large single burner, combination ovens that offer convection, steam and combination cooking, as they can reduce energy costs by around 50% because they offer faster cooking times,

- Innovative insulation and intelligent control systems: Most equipment is under-insulated to keep costs down or to minimise the space it takes up, but new materials mean more efficient and thinner insulation. Together, insulation and advanced controls can dramatically reduce energy costs.

4.3 Information and Communications

Most of the energy used by information and communication technology (ICT) is consumed in the ICT cloud infrastructure, including commercial data centres with their servers, storage and communication systems.

4.3.1 Energy consumption trends

Electricity consumed in data centres (including enterprise servers and storage, telecommunication equipment) is expected to account for a large proportion of electricity consumed in the EU commercial sector in the future. The approximate energy consumption of the total stock of rack servers (421 PJ/year; 10,055 ktoe), blade systems (97 PJ/year; 2,320 ktoe) and storage units (98 PJ/year; 2,340 ktoe) in the EU in 2012 is 616 PJ/year (14.7 Mtoe).[170]

Studies have estimated that European data centre services market will see a growth of 16% up to 2018 from 2012 levels (i.e., 2.5% per year), due to the growth in enterprise cloud computing, content-heavy applications, and machine-to-machine (M2M) connectivity. It is also estimated that the UK, Germany and France will be the largest data centre markets in Europe.[171]

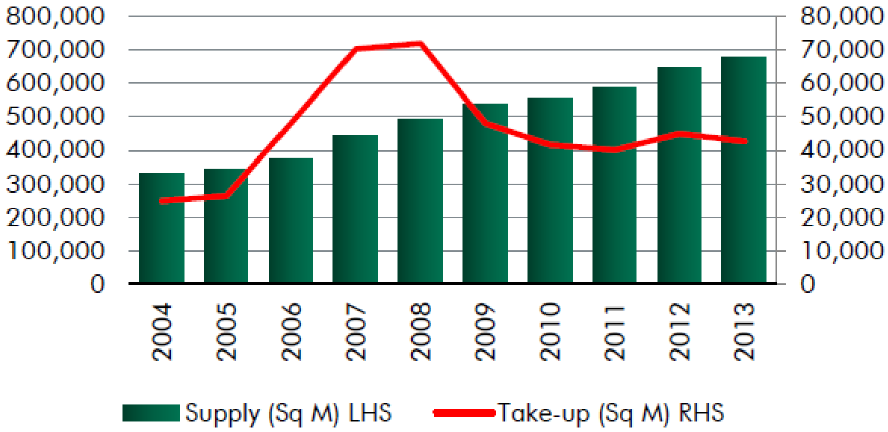
An example of this growth is illustrated by the supply and take-up of co-location facilities[172]. Since 2004, supply has increased by over 100% by 2013 (Figure 4.8). Take-up and demand has been most notable in London and Germany.

[170] Bio (2014) Draft Report Preparatory study for implementing measures of the Ecodesign Directive 2009/125/EC: DG ENTR Lot 9 - Enterprise servers and data equipment Task 5: Environment & Economics

[171] Computer Weekly (Thursday 17 July 2014) Growth in cloud and IoT lend momentum to European managed datacentres available at http://www.computerweekly.com/news/2240224750/Growth-in-cloud-and-IoT-lend-momentum-to-European-managed-datacentres

[172] A co-location facility is a type of data centre where equipment, space, and bandwidth are available for rental to retail customers.

Figure 4.8 Figure 3 European Co-location Market 2013



Source: CBRE (2013) European Data Centres MarketView

In 2013, total co-location in Frankfurt was the highest recorded for 4 years with an annual increase of 20% compared to 2012. Additionally, in 2013, London data centre uptake increased by 26% due to the award of several large contracts and an upturn in retail leasing activity.[173] This is further illustrated by the power requirement of the UK data centre industry growing by 8.8% to 3.10 GW in 2013, compared to 2012 levels. The manufacturing sectors; banking and financial services; healthcare; telecoms and media are most responsible for driving growth.[174]

If no energy efficiency improvements occur, energy consumption is assumed to grow inline with market growth; i.e., 2.5% per year through 2050. This reflects the increase in data volumes due to the growth of mobile computing, social networks, and the spread ICT in all aspects of private and work life. This has resulted in the continuous increase in both energy densities within the typical data centre and increased cooling requirements. Table 4.7 presents anticipated growth in energy consumption from 616PJ (14.7 Mtoe) at 2012 to 1,577 PJ (37.7Mtoe) in 2050, assuming no energy efficiency improvements are implemented. However, there is a growing trend towards green data centres globally. It is estimated that the green data centre[175] market will grow from US$17.1 billion in 2012 to US$45.4 billion by 2016 – at a compound annual growth rate of nearly 28%.[176]. This trend is reflected in the improvement in Power Usage Effectiveness (PUE)[177] over time. The average PUE has improved from 2.50 in 2007 to 1.89 in 2011.[178] In 2014, the PUE has improved to 1.7, reflecting the fact that the biggest infrastructure efficiency gains have already happened, and further improvements will require significant investment and effort, with increasingly diminishing returns.[179] Table 4.7 presents estimated improvements in PUE through 2050. Between 2012 and 2014, PUE improved at a rate of 2.8% per year. It is assumed that this rate will halve through 2020 (1.4%

[173] Ibid

[174] Datacentre Dynamics (20 November 2013) The DCDi 2013 Census – UK figures Available at http://www.datacenterdynamics.com/focus/archive/2013/11/dcdi-2013-census-%E2%80%93-uk-figures

[175] A Green Data Centre has mechanical, lighting, electrical and computer systems designed for maximum energy efficiency and minimum environmental impact

[176] Pike Research (2012) Green Data Centres in Navigant Research (2012) The Green Data Center Market Will Surpass $45 Billion by 2016 available at http://www.navigantresearch.com/newsroom/the-green-data-center-market-will-surpass-45-billion-by-2016

[177] PUE is a ratio of the amount of power entering a data centre by the power used to run the computer infrastructure within it. An ideal PUE is 1.0.

[178] 2014 Data Centre Industry Survey; Uptime Institute; http://journal.uptimeinstitute.com/2014-data-center-industry-survey/

[179] Ibid

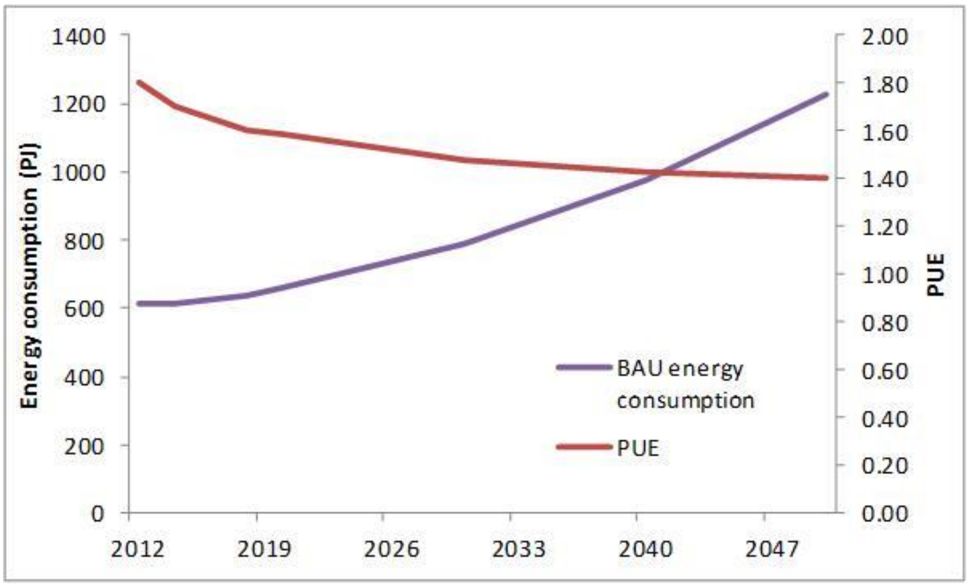
per year), and will halve with each following decade. By 2040-2050, the improvement in PUE is assumed to be 0.2% per year.

These assumptions have been overlain to develop an estimate for business-as-usual (BAU) energy consumption for the information and communications sector through 2050 (Table 4.7 ; Figure 4.9).

Table 4.7 BAU energy consumption trend for the information and communications sector based on projected market energy consumption assuming no energy efficiency (EE) improvements and PUE improvement through 2050.

	2012	2020	2030	2040	2050
Energy consumption assuming no EE improvements (PJ)	616	751	962	1231	1577
PUE	1.8	1.58	1.48	1.42	1.40
BAU energy consumption (PJ)	616	661	788	974	1226

Figure 4.9 Projected BAU energy consumption trend for Information and communications sector



Considering that the ideal PUE is 1.0; if it assumed that BAU PUE in 2030 and 2050 is 1.48 and 1.40, respectively, the technical potential for the sector is assumed to be 255 PJ (6.1 Mtoe) in 2030, and 350 PJ (8.4 Mtoe) in 2050.

4.3.2 Energy usage profile

There are four key processes that consume the most electricity in the data centre environment, these are: the ICT load; cooling and ventilation; Uninterruptable Power Supplies (UPS) and power distribution overheads; lighting and other building overheads. A typical distribution of the energy consumption of these in a data centre is outlined in Table 4.8.

Table 4.8 Distribution of energy consumption in data centres

Data Centers	Approximate % of total consumption
The IT load	40%
The cooling system	35%

Data Centers	Approximate % of total consumption
UPS and power distribution	20%
Lighting and other overheads	5%

Source: Falcon Electronics PTY (n.d) Measurement of data centre power consumption

4.3.3 Opportunities

Table 4.9 highlights some of the equipment and infrastructure approaches to improving energy efficiency in data centres.

Table 4.9 Energy efficiency improvement in data centres

Best Practices	Opportunities	Typical Investment [180]	Typical Cost Savings
Efficient Equipment	Adopt Minimum Energy Performance Requirements (EU Energy Star or SPECPower)	€€€	For IT legacy equipment, savings could be between 30% to 50%
Consolidate and Optimize	Use Virtualization to Consolidate and Optimize the exploitation of Physical Devices	€€€	63% reduction in total cost of ownership (i.e., financial impact over the product life cycle)[181]
	Implement Cloud Computing to shave peaks, by balancing data center workloads	€€	29% compared to an internal IT system[182]
Power Generation & Distribution	High Voltage DC (HVDC) to reduce to step down loss/conversion	€€€	Between 5% to 10% of facility power
	Install PV panels where cost-effective and maximize auto consumption of DC power, avoiding DC-AC-DC losses	€€	DC-AC-DC can involve 30-40% of losses (PV produce DC, converted to AC for the grid, then reconverted to DC for computing use
	Use efficient Uninterruptable Power Supplies (UPS) to match load to demand	€€€	Capital and operational savings of 20%
Heating & Cooling	Increase temperature ranges to decrease the workload on the HVAC systems	€	Up to 4% of legacy costs per degree change
	Increase humidity set points to decrease workload on humidification and cooling systems	€	Up to 50% of legacy costs[183]
	Hot/cool aisle thermal containment	€€	30% of legacy costs

[180] Very rough estimate only (for 10,000ᶠᵗ data centre): € = <€50,000, €€ = €50,000 - €500,000, €€€ = €500,000+

[181] Storage Networking Industry Association (2008), *Building the Green Data Centre; Towards Best Practices and Technical Consideration*

[182] http://broadcast.rackspace.com/hosting_knowledge/whitepapers/Cloudonomics-The_Economics_of_Cloud_Computing.pdf

[183] http://advice.cio.com/michael_bullock/cool_ways_to_save_money_in_the_data_center?page=0%2C

Best Practices	Opportunities	Typical Investment [180]	Typical Cost Savings
	Replace air conditioners with air handlers and economizers	€€	Up to 50% of legacy costs
	Variable speed fan drives	€€€	4 to 10 months return on investment (ROI)[184]
Lighting	Advanced Lighting Technology	€€	Up to 70% of legacy lighting consumption depending on lighting technology
	Occupancy Control	€	Up to 80% of lighting load depending on occupancy

4.4 Financial and Insurance Activities

4.4.1 Energy consumption trends

Office buildings are the second largest consumers of energy among non-residential buildings in Europe. Office buildings accounted for 23% of total energy consumption in the non-residential building sector, which amounted to approximately 19 Mtoe in 2013.[185]

Due to tightly packed areas, such as trading floors, the financial and insurance sector occupies office space at high densities. In the UK, an average employee working in this industry occupies 9.7m^2 of workspace.[186] In 2012, this sector employed approximately 3.15 million people in Europe.[187] Assuming that each person worked in an office, the office space used by the sector was approximately 30.6 million m^2 of space. Assuming that financial and insurance offices are located in “air-conditioned, prestige” buildings,[188] the ‘typical’ energy consumption intensity is approximately 568 kWh/m^2. As such, assuming all buildings used by the financial and insurance sector are achieving ‘typical’ energy consumption, the sector consumed 1.4 Mtoe in 2012.[189]

CIBSE (2012)[190] notes that “air-conditioned, prestige” buildings have a ‘good practice’ energy consumption benchmark of 348 kWh/m^2, which implies an energy reduction potential of approximately 39% from ‘typical’ offices.

4.4.2 Energy Usage profile

Since the financial and insurance industries occupy commercial offices, the energy usage profile in the commercial office sector is indicative of energy consumption in this sector. Table

---

184 SNIA (2008),), *Building the Green Data Centre; Towards Best Practices and Technical Consideration*

185 Survey on the energy needs and architectural features of the EU building stock, iNSPiRe, May 2014. http://www.inspirefp7.eu/wp-content/uploads/2014/08/WP2_D2.1a_20140523_P18_Survey-on-the-energy-needs-and-architectural-features.pdf

186 Occupier density study 2013; http://www.architectsjournal.co.uk/Journals/2013/09/10/c/y/n/BCO-Occupier-Density-Study---Final-report-2013.pdf

187 Eurostat Financial services statistics available at: http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tin00015&plugin=1 and http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tin00023&plugin=1

188 As defined by Energy Consumption Guide 19: Energy use in offices, these offices are purpose-built or refurbished to high standards. They are assumed to have long plant running hours to suit the diverse occupancy. These buildings include catering kitchens (serving hot lunches for about half the staff); air-conditioned rooms for mainframe computers and communications equipment.

189 [3,152,417 (employees)*9.7 (m^2 of office space)]*568 (kWh consumption per m^2)= 17,380 million kWh ~ 1.4 Mtoe (conversion using the IEA unit converter)

190 Chartered Institution of Building Services Engineers (CIBSE) Guide F (2012) Energy efficiency in buildings

4.10 outlines sector energy usage in the UK, this may be indicative of Western Europe in general.

Table 4.10 Final energy consumption in the commercial offices service sector by end use; 2013

Commercial Offices	Thousand tonnes of oil equivalent (ktoe)	Approximate % of total consumption
Heating	1,071	59%
Lighting	254	14%
Cooling & Ventilation	169	9%
Computing	117	6%
Hot Water	118	6%
Catering	50	3%
Other	48	3%
Total	1,828	

Source: DECC Energy consumption in the UK Service Sector, 2014 update

4.4.3 Opportunities

Many of the opportunities listed in the retail space apply to office based sectors, such as variable speed drives, occupancy controls, LED technology, demand controlled ventilation, temperature set-back, energy efficiency appliances, overnight cooling, and building management system optimisation. For details of these opportunities see Table 4.5.

5 Barriers for Potential Energy Saving Opportunities

The type of organisations that distinguish a sector also plays a role in how energy is perceived and addressed. For example, the pulp, paper and print sector comprises of large, SME and microenterprises across the value chain. While pulp producers are mainly large companies (>250 employees), the paper and print sectors are dominated by SMEs. For the large producers, where their products are commodities that are vulnerable to global competition, the economic recession has seen an increasing spate of consolidation in the EU as companies aim to address distressed situations, secure supply, geographically diversify into new growth markets, and reposition their product and operational portfolios. Consolidation, while it brings many benefits, including healthier balance sheets, can also introduce challenges; for example, as operations are consolidated with unprofitable operations closed, the preservation of knowledge, employees and documentation can become difficult. As such, there is a lack of standardisation of practices across sites. Furthermore, larger organisations tend to have longer and complex decision chains, which can deter or delay ESO uptake. For SMEs, the lack of access to internal or external capital is seen as a major barrier; as such, the priorities for capital investments will typically focus on increasing output rather than energy efficiency.

Vast sources of recent and past literature have focussed on a wide variety of techno- economic and behavioural aspects of barriers attributing to market failures in uptake of ESOs. Sorrell et al (2011) established a taxonomy of barriers to energy efficiency, which was categorized into four main theoretical frameworks: economic non-market failure, economic market failure, behavioural and organizational.[191] Cagno et al (2012)[192] made further refinements to the Sorrell et al. (2011) taxonomy along with a crucial structural addition of perspective, categorised into external and internal to the enterprise holding the ESO as detailed in Table 5.1

Table 5.1 New taxonomy of barriers to EE and ESOs

Origin	Area	Barriers
External	Market	Energy price distortion
		Low diffusion of technologies
		Low diffusion of information
		Market risks
		Difficulty in gathering external skills
	Government / Politics	Lack of proper regulation
		Distortion in fiscal policies
	Technology / Services suppliers	Lack of interest in energy efficiency
		Technology suppliers not updated
		Scarce communication skills
	Designers and manufacturers	Technical characteristics not adequate
		High initial costs
	Energy suppliers	Scarce communication skills
		Distortion in energy policies
		Lack of interest in energy efficiency
	Capital suppliers	Cost for investing capital availability
		Difficulty in identifying the quality of the investments

[191] Sorrell S, Mallett A., Nye, S; "Barriers to industrial energy efficiency: A literature review"; UNIDO, 2011

[192] Cagno, E, Worrell E., Trianni A., Pugliese G.; "Dealing with barriers to indsutrial energy efficiency: an innovative taxonomy"; ECEEE 2012 Summer Study on Energy Efficiency in Industry

Origin	Area	Barriers
Internal	Economic	Low capital availability
		Hidden costs
		Intervention related risks
	Organisational behaviour	Lack of interest in energy efficiency
		Other priorities
		Inertia
		Imperfect evaluation criteria
		Lack of sharing the objectives
		Low status of energy efficiency
		Divergent interests
		Complex decision chain
		Lack of time
		Lack of internal control
	Barriers relating to competences	Identifying the inefficiencies
		Implementing the interventions
	Awareness	Lack of awareness or ignorance

Source: Cagno et al, 2012

Policymakers have been addressing barriers from an external perspective, which has resulted in policies which lack sufficient buy-in from the enterprise. This creates a situation where internal and external perspectives diverge. Although the Energy Efficiency Directive aims to address some internal issues, such as Article 8 (energy audits); there still has not been sufficient attention paid to the internal perspective, which consists of many under evaluated behavioural elements, which can lead to irrational choices from an external perspective. The barriers discussed in this chapter aims to provide an internal perspective of the key factors influencing ESO decision making.

Section 5.1 and 5.2 of this chapter elaborates further on the internal barriers: economic, organisational behaviour and barriers related to competencies and awareness. These are some of the key internal factors deterring the uptake of ESOs, even in situations where they are economically viable. Section 5.3 elaborates on the specific technical barriers of selected ESOs with the highest energy saving potential.

5.1 Economic barriers

The technical scenarios discussed in Chapter 3 illustrates the energy savings potential that would occur if all industrial processes, and equipment were upgraded with ESOs that are technically feasible, regardless of any other constraints, such as economic. Generally, many organisations only invest in ESOs if they meet an internal return on investment (ROI) (or hurdle rate). The 2 year and 5 year payback criteria have been utilised to highlight the potential savings associated with what organisations might consider an acceptable and long term payback, respectively.[193] For example, economic scenario 1, reflects the uptake of projects with a 2 year payback, and might be considered as obvious cost effective opportunities that organisations should implement. However, the results illustrate that significant potential still exists across all sectors. While there are various technical, organisational, behavioural, market

[193] Organisations typically only invest in projects with a less than two-year payback, unless it has a productivity or growth outcome as well. This is particularly true of shareholder-based organisations where costs and profits are assessed over short periods (e.g., quarterly).

and competency challenges limiting uptake, uncertainty about future energy prices and the savings after implementation combined with the irreversible nature of the investment decision can make the actual ROI higher than estimated.

The analysis presented in Chapter 3 only takes direct costs (i.e., cost of equipment, service, installation, operation and maintenance) into account. However, as discussed above, there are other factors which could affect investment criteria at the enterprise or site level. These factors are excluded from the study's analyses, since they are qualitative in nature and can vary significantly across and within enterprises. The following sections discuss the factors that act to increase economic barriers, although on some occasions could also act as a driver for uptake.

5.1.1 Hidden cost

When ESOs are identified and presented (either internally or externally), often only direct costs are accounted. Indirect or associated costs are often not factored. These are referred to as hidden costs. While quantifying direct costs is relatively straightforward, hidden cost components are usually more complex to define and quantify. Hidden cost components include additional resource, training and/or equipment which may be unaccounted for when the opportunity is presented. Evaluating and implementing ESOs requires significant resource commitment. In many cases, resources would need to be diverted from the enterprise's main business activity. Unless the ESO has a significant economic potential, diverted resources are viewed as an opportunity cost to the main business activity. For opportunities with a higher degree of complexity, new hires or additional training may be required for operation and maintenance. In some cases, additional equipment may also be required (tools, additional utility capacity, modification of existing facility) but unaccounted for when the ESO is identified.

Hidden costs may also appear as an over projection of benefits. The cost benefit of ESOs are highly dependent on key operating factors such as equipment load, operational hours, pressure, temperature and production processes. In many cost-benefit analyses, ideal parameters are used, which do not reflect actual load fluctuations, maintenance practices, and potential outage duration.

On the other hand, indirect benefits are also often unaccounted for. Indirect benefits include non-energy business gains, such as increased operational hours, production capacity, and improved environmental benefits. These are important decision making drivers, which are often overlooked or poorly presented during the evaluation stages, resulting in the undervaluation of the respective ESO.

5.1.2 Risk

The implementation of any ESO introduces additional risk to the enterprise. The risk considerations vary according to the scale and complexity of the ESO. Each stage of the ESO implementation process adds further risk for consideration and depending on how they are addressed or mitigated, will impact the expected financial returns. Risks can be categorised into three main areas: technical, commercial and financial risk. Technical risk is directly associated with the ability of the ESO to deliver the benefits of its intended technical design and application. Commercial risk relates to the risk involved in dealing with counterparties involved in the ESO implementation and financial risk relates to how the ESO impacts the enterprise's financial position. Table 5.2 provides a general perspective of the minimum risk considerations to be taken into account when evaluating an ESO under these three categories.

Table 5.2 Technical, commercial and financial risk considerations

Risk categories	Risk considerations
Technical risks	
Engineering design	■ Is the engineering design appropriate for the application? ■ What modifications are required? ■ Can the operating conditions be met on site? ■ How reliable is the design? Is the design prone to failure? ■ What impact would an ESO failure have on the main business activity?
Implementation	■ Does the implementation time frame fit into the main business activity schedule? ■ How physically obstructive is the implementation or construction work? ■ Could the construction be subject to delay? ■ How would construction affect the main business activity? ■ Are the appropriate occupational health and safety measures in place? ■ Are the appropriate permits in place? ■ Will the ESO be constructed to the design specification and quality?
Operation and maintenance	■ Will the ESO operate according to the design specification? ■ Are there appropriate resources to operate and maintain the ESO? ■ Is additional training needed to operate the ESO? ■ Are the operating parameters appropriately adjusted and monitored? ■ How can the benefits be monitored and verified? ■ How do we get support in case of failure? ■ What are the impacts to the main business in case of failure? ■ What is the expected time for corrective actions?
Commercial risks	
Procurement	■ Will the cost subject to change? ■ Will all parties deliver according to its respective contractual obligation? ■ Can the ESO be procured locally? ■ Is the cost exposed to currency exchange fluctuations? ■ Do we have adequate support after procurement?
Counterparty	■ Is the manufacturer, supplier or service provider financially stable? ■ How many different counterparties are there to deal with on procurement? ■ What is the risk of the counterparty defaulting on its obligations?
Financial risks	
Expected returns	■ Are the hurdle rates appropriate to the ESO? ■ Does the ESO present the best returns on financial resources? ■ Is the ESO relevant to the current and long term financial plan?
Financing structure	■ How will the ESO be financed? ■ How would the financing cost fluctuate? ■ How will the financing structure impact the enterprise's financial standing? ■ Is the investment scale and plan within the financial budget schedule?

5.1.2.2 Technical risks

Engineering design: ESO benefits are strongly dependent on whether its design operating conditions are met (e.g. pressure, temperature, load, production capacity, operation and maintenance). In some cases, this can be difficult to evaluate or verify once the ESO has been installed. As such, careful consideration of the design reliability, equipment technology and the service provider is required. If retrofitting is involved, modification works may create further complications to the existing facility, especially for emerging ESOs with very little historical performance record. For ESOs which may have a direct impact on the main business process, implementation and operational disruption could lead to losses on a scale that minimises ESO benefits. For ESOs with a lower energy saving potential, the internal energy consumption of the ESO itself will need to be managed carefully to avoid eroding of energy saving benefits (e.g. speed drives).

Implementation: Depending on the scale and the complexity of the ESO, there are many factors which will affect the implementation. Construction works are often subject to delays due to unforeseen circumstances on site (e.g. site difficulties, weather, safety, quality), which may affect the enterprise's overall business performance. If permits from authorities are required, the application process will also have a significant impact on the implementation schedule. Implementation of ESOs may require strong technical know-how as it dictates the delivered quality and expected performance of the ESO.

Operation and maintenance (O&M): While design aspects are crucial, appropriate O&M ultimately dictates if the actual designed benefits of the ESO can be achieved throughout its expected operational lifecycle. If overlooked, the expected benefits may digress or in some cases lead to an operational cost. Therefore, dedicated resources with the appropriate technical expertise is required. This often requires new hires or further technical training of existing resources, adding to overhead costs. For more complex ESOs, frequent support from the manufacturer or service provider may be needed, therefore capability and trustworthiness plays an important factor in the decision making process.

5.1.2.3 Commercial risk

Procurement: The most common risk in procurement processes is the variation in cost after an investment decision is made. Some ESOs are provided through multiple parties and contracts, adding risk to the non-delivery of its respective contractual obligation. This process may also require much administrative or legal support, increasing the cost burden of the ESO. If the ESO is sourced outside the EU, the cost is subject to foreign exchange fluctuations, occasionally causing price increases especially for ESOs with long delivery time and payment intervals.

Counterparty risk: Implementation, operation and maintenance of the ESOS relies very much on the supplier or service provider delivering according to its contractual obligation. While strong capabilities are crucial, financial stability is equally important, especially in the case of ESOs with higher complexity and a long lifespan. In the event that a supplier dissolves, this may have significant impact on the delivery or the continued operation and maintenance of the committed ESO.

5.1.2.4 Financial risk

Expected return: In the context of an ESO investment, the expected return is established in consideration of all the risk associated with the investment class. This is a measure of the investor's opportunity cost of investing in the ESO instead of other alternative investment classes with similar risk. In general, the higher risk associated with the ESO, the higher the expected rate of return will be. In consideration of all the associated risk, investments in ESOs are usually perceived to carry a much higher risk than other investment types or classes. For example, an enterprise would rather invest on expansion or marketing of its main business activity which has the potential to generate far greater benefits in comparison with the benefits associated with the ESO, assuming that both options are perceived to carry an equivalent amount of risk. Longer investment tenures also require higher expected returns, which makes many ESOs with higher payback periods financially unattractive. Financial providers for energy efficiency investments typically prefer low risk investments, so an emphasis is placed on proven rather than new technologies.

Financing structure: Access to finance is one of the key barriers to uptake of ESOs. For larger enterprises with access to finance, capital intensive ESOs are usually financed through secured[194] loans. Additional loan or debt on an enterprise's balance sheet increases the overall risk profile of the enterprise which may be against the shareholder's interest. Project

[194] Loans which are secured using an asset as collateral.

financing[195] involves much higher costs and are applicable only for larger scale and well established ESOs. For SMEs, financing capital intensive ESOs is much more challenging as they do not have the financial capacity, as compared to larger enterprises, or access to finance. Furthermore, high transaction costs to evaluate the debt carrying capabilities to service a number of SME sized ESO projects can be high, thus discouraging the financing of EE investments. There are limited EE financial products available to support the needs of industrial customers in the current market. Although the ESCO model aims to the lower risk associated with EE finance, the majority of its success has been in the public sector. In the private sector, mortgage challenges[196], and longer project development cycles have limited ESCO performance contracting uptake.

5.1.2.5 Risk perception and mitigation

The discussion of risk is highly subjective as it is a matter of perception. As perception differs, risk evaluation is exposed to different interpretation. Classic economic theory discusses the concept of loss aversion[197], which refers to an individual's tendency to strongly prefer avoiding losses to acquiring gains. In decision-making, this leads to risk aversion.

Risk aversion is compounded if the perception of key decision makers, such senior management or finance providers are not aligned, For example, a decision maker with a weak technical background may have a different perception of technical risk compared to a decision maker who has a stronger technical background.

Liquidity is another issue which deters ESO uptake. Investment in ESOs is generally non-transferable and the investment committed cannot be diversified, hence it is illiquid. Beyond the scope of the ESO, decision makers also need to consider if the ESO is aligned with the enterprise's strategic plans. For instance, an enterprise downsizing or producing commodities that are exposed to price fluctuations will be less inclined to commit to long term ESOs.

Risk is usually mitigated through preventive actions. These preventive actions (e.g., stringent project controls, dedicated resources, trading only with reliable partners, application of established technologies) usually incur additional cost. Some risk (e.g., equipment failure, accidents), also known as residual risk, cannot be completely mitigated, and is often covered by some form of insurance. Insurance for industrial energy efficiency is still in its infancy; it is not a common product most established insurers provide.

Investment in ESOs has multiple positive benefits on the main business in addition to energy savings. Bottom line profitability is increased with lower energy cost (especially for energy intensive industries where energy costs represent a significant portion of value added or turnover). Energy security is also improved when enterprises start producing more with less. In addition, implementation of ESOs may result in positive environmental benefits. In view of this, investment in ESOs should fundamentally reduce the risk profile rather than the contrary. However, over-cautious financial providers typically fail to recognise this when it comes to financing ESOs[198].

5.2 Organisational behaviour

Investment related to EE demands much higher financial criteria in comparison with other asset classes, with an average payback of 1-2 years and hurdle rates of over 50% required to

---

[195] Project financing is a form of unsecured loan for industrial projects, whereby the project asset is the only collateral and loan is paid for by the cash-flow generated by the project.

[196] Mortgage lenders tend to prohibit industrial organisations from taking on additional debt or accepting liens on equipment since they are considered part of the assets securing the original mortgage note. Thus, legally no other claimants are allowed to take a security interest in the assets that fall under the mortgage.

[197] Kahneman, D. and Tversky, A. (1984). "Choices, Values, and Frames". American Psychologist 39 (4): 341–350.

[198] Blyth, W. Savage, M. (2011) "Financing Energy Efficiency: A Strategy for Reducing Lending Risk"

convince decision makers.[199] In fact, commercial experience with industrial enterprises suggests that average payback requirements for ESO projects are usually ≤1 year. Projects with up to 2 years payback will be given due consideration but the likelihood of it being implemented are fairly low. Such high returns lead to the question whether enterprises are making rational decisions when it comes to ESO investments.

Organisational behaviour is a known discipline of study. However, its application to ESO decision making has been under investigated. The subject is gaining interest and recognition, and recent studies suggest that it is far more random than classical economic understanding [Kahneman, 2012].

Section 5.2.1 to 5.2.4 highlights some of the key organisational behaviour issues impacting ESO uptake.

5.2.1 Low status of energy efficiency

The priority of energy performance and energy management issues is proportionate to the energy intensity of the industry or enterprise, i.e. the more energy intensive it is, the more attention and priority it gives to EE and ESOs. For non-energy intensive industries, the priority of energy issues slips down the rank as it is not considered to be a significant part of the enterprise's business strategy.

Energy performance of an organisation is often not visible to senior managers. In larger enterprises, the hierarchal distance between energy managers and decision makers are wider resulting in poor communication of energy management issues at decision making level. The evidence suggest that enterprises with energy managers having a closer working relationship with the decision making level tend to be more active in energy management issues.

5.2.2 Inertia and bounded rationalities

Inertia (or bounded rationalities) relates to the individual tendency to rely on established or familiar assumptions therefore exhibiting reluctance to revise those assumptions, even though the existing assumptions are irrelevant or obsolete. These assumptions are often deeply rooted within decision-makers steering the enterprise's strategic goals. This resistance to change carries on towards evaluation of ESOs whereby the more radical it is, the higher the resistance to accept the ESO or change the set of prior assumptions. This results in favouring quick and low investment opportunities with lower expected returns, through familiar ESOs which may be less intrusive on existing operations.

On the other hand, inertia or bounded rationalities could work on the reverse whereby an investment will proceed as long as the decision originates from the decision makers, irrespective of its financial attractiveness. When an idea is generated from the top (attributable to strategic priorities, biases, appeal to shareholder/customers, or other bounded rationalities), inertia is established and more often than not, the decision is made prior to completing the decision making process.

There are four key stages (prior to implementation) in an investment decision making process: Initial idea → Diagnosis → Build up solutions → Evaluation and Choice, bounded by internal organizational and individual factors. It has been observed from prior empirical studies that financial evaluation techniques are often not as important, often playing a secondary role and carried out at very late stages of the decision making process. In smaller organizations, decisions are often made by a single or very few individuals, which further aggravates the rationality issue as decisions are potentially influenced by bounded rationalities (or biases) of

[199] Centre for Sustainable Energy (CSE) and the Environmental Change Institute, University of Oxford (ECI); "What are the factors influencing energy behaviours and decision - making in the non-domestic sector?"; 2012

very few individuals.[200]. The strategic value of implementing ESOs in some cases may be more important than the energy saving benefits itself.

ESOs are generally presented as potential gains, however enterprises naturally commit resources towards main business activities. This leads to more focus on avoiding losses on main business activity rather than committing resources for potential gains. As such, enterprises tend not to interfere with any operations if it is perceived to be in working order.

5.2.3 Imperfect evaluation criteria

The decision to implement ESOs is often based on imperfect evaluation criteria, i.e. the potential benefit and risk of the ESO is assessed through differing facts, perceptions or biases. This is mainly attributed to asymmetric information, whereby the presenter of the ESO has more or superior information compared to the decision maker, or vice-versa. Enterprises tend not to reveal operational issues (often viewed as trade secrets) to external parties due to competitive reasons. As a result, the wider non-energy saving benefits or true potential of ESOs may potentially be unaccounted for if the supplier or service provider is unaware of an application for it, leading to poor decision making.

One of the key issues limiting evaluation is the lack of sub-metering. The lack of sub-metering may in turn lead to a split incentive as business units and staff are not responsible for the cost of energy. Furthermore, unlike energy supply, energy efficiency consists of a wide range of complex technologies and services, which are purchased infrequently and for which it is difficult to determine their quality either before or after purchase. As a consequence, the transaction costs for obtaining and processing information on energy efficiency are higher than for energy supply. Without appropriate metering and sub-metering, it is difficult to assess and verify the ESO benefits, making it much more challenging for decision makers to commit.

Evaluation of ESOs are also influenced by accounting classification and reporting standards. International accounting standards have strict criteria on how intangible assets[201] are classified. As such, investment into non-physical ESOs, which could be knowledge or service based (e.g. EnMS), are classified under expense rather than assets.

5.2.4 Competencies and awareness

Organisations often lack the internal skills and competencies to interpret technical information or evaluate the ESO. ESOs are often highly complex and involve multiple system components across multiple technical disciplinaries (electrical, thermal, mechanical, civil, etc.). ESOs with benefits that rely on multiple system and plant processes requires a strong integrated understanding of the plant's multiple operations in order to realize the benefits. This requires a strong understanding of inter-departmental needs and priorities, which is difficult to achieve in practice due to resource and time constraints. SMEs are typically unaware of potential ESOs as they lack labour resources to identify and address ESOs, such as a dedicated energy manager.

ESOs sometimes span beyond the enterprise's own facility. Since many heat intensive industrial facilities have historically been co-located in clusters due to a need to share infrastructure or resources, there are opportunities for the sharing of heat infrastructure. However, it is difficult for enterprises to be aware of energy needs of neighbouring facilities. Commercial and technical challenges are high, especially on managing different heat requirements between different organisations; and a lack of understanding of the potential process integration available have limited the sharing of heat within these clusters. This requires a strong commitment from clustered facilities on time and resource, which is difficult to achieve in practice.

[200] Cooremans, C. (2012); "Investment in energy efficiency: do the characteristics of investments matter?" Energy Efficiency, 5: 497-518

[201] Intangible asset is defined as an identifiable non-monetary asset without physical presence.

5.3 Technical barriers

There are numerous site-specific constraints that may limit the technical applicability of ESOs. Table 5.3 presents a summary of implementation challenges faced by some of the top ESOs available. As the results illustrate, many of the ESOs apply to key processes; consequently, with many industries having continuous operations, significant costs could be incurred if production is disrupted to implement or upgrade the equipment. Furthermore, even though energy represents a significant portion of production costs for many sectors, plants are usually optimised to maximise production, not energy consumption. Consequently, upgrades are typically structured around equipment investment cycles, rather than short-term energy efficiency opportunities.

Table 5.3 Technical implementation challenges associated with EE measures

Sector	EE measure	Challenges
P&P	Exhaust Gas Heat Recovery (Dryer)	Technical constraints include, the potential precipitation and accumulation of deposits on the surfaces of a heat exchanger (i.e., fouling) which increases the overall resistance to heat flow; corrosion risk, due to the moisture content of exhaust gas; excessive power requirements for effective heat recovery; inefficient heat transportation network, which is dependent on a wide variety of factors, including the length of piping, the thermal connectivity of insulation, the pipe diameter, etc. Furthermore, the heat recovery technology must be unobtrusive in relation to normal mill operations. The availability of space and the need to shut down and restart a mill (or an individual process line) are significant complications. Similarly it is important that whatever mechanism recovers gas heat demonstrates “maintainability,” whereby individual components within the system can be replaced without necessitating a process wide shutdown.
P&P; C&P; I&S; M; NFM; FBT R; NMM	Integrated control system	A major technological challenge in the development of integrated control systems is the need for the underlying software and hardware infrastructure, which must accommodate the new applications, to be reliable and predictable. Installing a new control system may require the shutdown of the legacy system, which will disrupt production. Every mill is unique with different control systems and settings, and equipment; furthermore, legacy systems are not always properly documented, since they may integrate work from different technicians and suppliers, who may not provide sufficient forethought to the total system architecture; consequently, an integrated control system will need to be customized to site-specific requirements. Customization requires time, and leads to extended implementation schedules.
P&P; C&P; FBT	Flue gas monitoring (boiler, dryer)	Flue gas challenges include, mixed composition gases; wet and/or dirty gas; large and difficult to access pipes; wide flow range and distorted, swirling flow profiles, high humidity, temperature and pressure changes, corrosive and acidic gases, and cross-sensitivity from emissions gases. Inappropriate flow meters and sensors can cause field failures, compromise sensor integrity and create considerable servicing needs.
C&P	Distillation column improved controls	Distillation columns provide operators with a margin of safety for flooding and different incipient-flood-point definitions. Consequently, when columns require trouble shooting, inconsistent definitions of the flood initiation point may lead to different revamp designs due to a lack of understanding about the cause and location of the flooding condition. Typical monitoring procedures utilise only one incipient flood point for a given set of column conditions; that is, it occurs at a specific delta pressure, and it represents the “hydraulic limit” of the column. However, since the delta pressure is only an inference of flood, avoidance of operating beyond this point leads to conservative column operation. Distillation columns comprise the majority of the separation

Sector	EE measure	Challenges
		processes used in the chemical industries; consequently, they have high economic importance. Adjustments to process control are dictated by order of economic importance with the product quality first, followed by process throughput and finally utility reductions.
C&P	Inter-plant process integration	This requires facilities to be adjacent, and have synergies (such as utilities) which are in close enough proximity to be shared. As such, this is more of an opportunity for new plant construction. In addition to technical and infrastructure requirements, there is a need for the establishment of frameworks that will facilitate the engagement of facilities from different companies, and overcome some key hurdles to utilities sharing, such as how facilities manage the dependency on a separate company with which they are integrated (i.e., what happens if the company supplying their steam requirements shuts down), how credit for the savings (cost savings) is split between facilities, and how opportunities between facilities are identified.
I&S; C&P; NFM	High Efficiency Burner (Furnace)	High[202] efficiency, regenerative burners can achieve fuel savings in excess of 50%, when compared with cold air burners. Potential high NOx-emissions may however limit preheat temperatures and hence energy savings. Also, the full benefit of the burners depends on the integration in the furnace. For low to medium-temperature applications, burner designs that achieve low-NOx (<20 ppm) usually allow for energy efficiency improvements. For high-temperature applications, NOx-emission reductions are limited by the necessary high flame temperatures needed. Modern burners that are well-designed to mix combustion air and fuel, however, reduce NOx emissions.
I&S; NFM	Flue gas monitoring (Furnace)	Flue[203] gases and combustion air take turns flowing through each regenerator, alternately heating the storage medium and then withdrawing heat from it. For uninterrupted operation, at least two regenerators and their associated burners are required: one regenerator is needed to fire the furnace while the other is recharging. Additional flue gas challenges include, mixed composition gases; wet and/or dirty gas; large and difficult to access pipes; wide flow range and distorted, swirling flow profiles, high humidity, temperature and pressure changes, corrosive and acidic gases, and cross-sensitivity from emissions gases. Inappropriate flow meters and sensors can cause field failures, compromise sensor integrity and create considerable servicing needs.
M; C&P; P&P; NFM; FBT; NMM; I&S	Sub-Metering and Interval Metering	Determining[204] the locations, type and exact model of equipment requires an inspection of sensitive areas such as switch gear and motor control centres. This may require scheduling a shutdown unless weekend or planned shutdown time is available. The actual installation may require another shutdown. For electrical sub-metering, a plant may also have problems getting its local utility to schedule a time to temporarily shut off power. Gas utilities may be sensitive to the addition of metering equipment near their own meters. Once facilities address these equipment installation issues, they may still need to install the appropriate cabling and means of communications established.

[202] Martin, N., Worrell, E., Ruth, M., Price, L., Elliott, R.N., Shipley, A.M., Thorne, J. 2000. Emerging Energy-Efficient Technology (Report No. LBNL 46990). Ernest Orlando Lawrence Berkeley National Laboratory

[203] US Department of Energy, 2004. Improving Process Heating System Performance: A Sourcebook for Industry

[204] Tutterow V., Schultz S., Yigdall J. 2011. Making the Case for Energy Metering and Monitoring at Industrial Facilities. https://www.aceee.org/files/proceedings/2011/data/papers/0085-000064.pdf

Sector	EE measure	Challenges
I&S; M; C&P; NFM	Exhaust Gas Heat Recovery (Furnace)	One[205] of the key barriers is the inability to economically capture/recover low-temperature heat with existing heat exchanger or heat-storage technology. Similar to dryers, technical constraints include, the potential precipitation and accumulation of deposits on the surfaces of a heat exchanger (i.e., fouling) which increases the overall resistance to heat flow; corrosion risk, due to the moisture content of exhaust gas; excessive power requirements for effective heat recovery; inefficient heat transportation network, which is dependent on a wide variety of factors, including the length of piping, the thermal connectivity of insulation, the pipe diameter, etc. Heat[206] losses must be minimized before waste heat recovery is investigated. As with other measures, the heat recovery technology must be unobtrusive in relation to normal plant operations. The availability of space and the need to shut down and restart operations presents significant complications. Similarly it is important that whatever mechanism recovers gas heat demonstrates “maintainability,” whereby individual components within the system can be replaced without necessitating a process wide shut down. If using regenerators, at least two regenerators and their associated burners are required for an uninterrupted process: one provides energy to the combustion air while the other recharges. Other[207] technical barriers to heat waste recovery include limited space, since many facilities have limited physical space in which to access waste heat streams (i.e., limited floor or overhead space), and inaccessibility, where it is difficult to access and recover heat from unconventional sources such as hot solid product streams (e.g., ingots) and hot equipment surfaces (e.g., sidewalls of primary aluminium cells). Safety and operational demands that require egress/access around/above most melting furnaces, boilers, heaters, and other high temperature equipment.
NFM; R	Advanced Heating and Process Control (Furnace)	Controls[208] for thermal processing require reliable and affordable sensors and control systems that can withstand harsh environments without recalibration for a certain minimum time (on the order of one year). Better, low-cost sensors are needed to monitor important process parameters such as material property uniformity, temperature, heat flux, air/fuel ratio, process atmospheres (oxidizing and reducing), emissions, and shop-floor infiltration, as well as to control burning and detect flames and flame stability. Key barriers include: few direct process measurement sensors; few low-cost sensors that are rugged, accurate, non-intrusive, and easy-to-use and maintain; excessive failures and inaccuracies of thermocouples and other sensors; inability to reliably monitor and control critical product parameters (temperature, chemistry, pressure); inability to reliably control processes; lack of smart controls; lack of cost-effective flow control devices (e.g., air/fuel ratio control).

[205] US Department of Energy, 2001. Roadmap for Process Heating Technology: Priority Research & Development Goals and Near-Term Non-Research Goals to Improve Industrial Process Heating. http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/process_heating_0401.pdf

[206] US Department of Energy, 2007. Improving Process Heating System Performance: A Sourcebook for Industry. http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/process_heating_sourcebook2.pdf

[207] US Department of Energy, 2008. Waste Heat Recovery: Technology and Opportunities in U.S. Industry. http://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/waste_heat_recovery.pdf

[208] US Department of Energy, 2001. Roadmap for Process Heating Technology: Priority Research & Development Goals and Near-Term Non-Research Goals to Improve Industrial Process Heating. http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/process_heating_0401.pdf

5.4 Barriers related to tertiary sector

Commercial buildings, as a sector, were identified by the 2006 Energy Efficiency Action Plan[209] as having significant cost effective savings potential by 2020. The main legislative instrument in Europe to improve the energy performance of commercial buildings[210] has been the 2002 Energy Performance in Buildings Directive (EPBD) and its 2010 recast. Implementation of the EPBD started in 2006, and as of July 2013 all articles should have been transposed to Member State regulations. While the EPBD has seen many benefits, including the tightening of building standards across Member States, the certification of commercial buildings, and inspections of boilers and air conditioning systems, there are still issues that are limiting its potential to improve energy performance in commercial buildings, such as split incentives and low awareness.

Energy performance certificates (EPCs) have been a key tool of the EPBD to promote better energy performance in buildings. EPCs aim to inform building owners, occupiers, and the public about a building's energy performance, and cost optimal opportunities for improvement. However, despite this potential, and its implementation across all 28 EU Member States, Issues include, mandatory training for certifiers, penalty requirements, and public access to data in only a half of EU Member States.[211] Furthermore, visibility remains poor and data quality questionable as some states do not require on-site inspections.[212] As such, while there are cases of EPCs enhancing the value of buildings for sale or rent, these are limited to Member States where there is a long history of implementation.[213] However, this may be changing. Recently, the UK Government introduced regulations to prohibit the letting of commercial properties in England and Wales rated F or G on their EPCs until their energy efficiency is improved and attains at least an E rating. This will be enforced on new leases from April 2018, and all leases from April 2023.

The rationale for an EPC, i.e., informing building owners and/or occupiers, about the energy performance level of a building, is to stimulate demand for improved energy efficiency. This approach has had an impact in the adjacent area of Energy-related Product regulations under the Ecodesign and Energy Labelling Directives. Consumers do respond positively to better information to advise their purchases and behaviours, whilst supply chains do respond positively to minimum energy requirements (MEPS) and consumer needs to produce more efficient buildings and products. The growing interest of expanding the mandatory Ecodesign MEPS approach from specific energy-using products (like boilers) into both: a) building materials that affect energy consumption (windows, insulation); and b) building heating, lighting and ventilation control systems, demonstrates the interest of Member States to improve building energy performance substantially using both national and European level instruments.

With the EED, articles 4 and 8 aim to mobilise investment in the renovation of the national stock of commercial buildings, and mandate energy audits in large commercial organisations, respectively. However, it is too early to judge the impact of these measures in addressing some of the barriers that still exist in the commercial space.

The following presents key barriers experienced by the commercial sectors, some of which overlap with barriers identified in the industrial sector.

Split incentives and interests in decisions between building owners, who would be required to pay for efficiency investments, and building occupants, who would reap the rewards of lower

[209] COM(2006) 545. Communication from the Commission - Action Plan for Energy Efficiency: Realising the Potential

[210] Includes new build or existing commercial units, such as retail, industrial, hotels

[211] BPIE (2014), Energy Performance Certificates across the EU: A mapping of national practices.

[212] Ibid

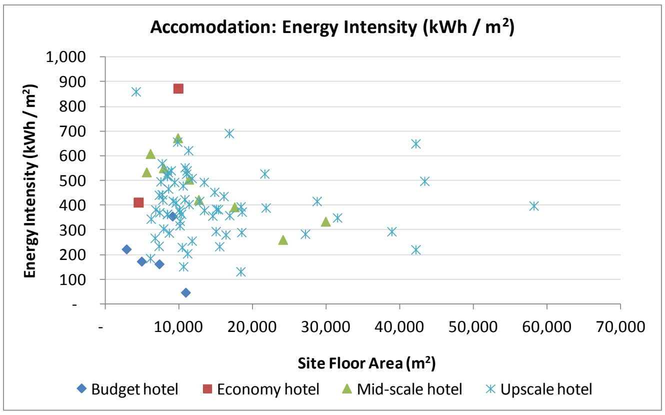
[213] EC (2013) Energy performance certificates in buildings and their impact on transaction prices and rents in selected EU countries, DG TREN.

running costs for energy. In the UK, in 2013, over half (56%) of the organisations in commercial property rented their spaces to conduct business.[214] This value has increase from 50% in 2003, and is anticipated to further increase.[215] Considering that the value of UK commercial real estate stock in 2013 was over 20% of total European commercial real estate,[216, 217] then it can be assumed that the impact of this barrier is significant, especially it similar rental to owned trends exist in other Member States. This issue can be seen in the accommodation sector, where hotels owned and managed have undertaken energy efficiency activities compared to hotels in franchised chains. Furthermore, contractual relationships between multi-tenant providers and their customers result in the data centre owner paying the power bill, the tenants buying power blocks, and their IT purchasers separately specify equipment. Therefore fragmentation results in little motivation to invest in efficiency in data centres.

Low awareness: The majority of the hotels in Europe are family centred enterprises that have limited/no awareness on energy issues. Furthermore, even within large organisations, budgets (profit and loss) and operations are localized to specific retail units, restaurants, warehouses, etc. Consequently, awareness is impacted by limited human and capital resources required to investigate and implement energy efficiency opportunities.

To illustrate this issue, Figure 5.1 and Figure 5.2 present the spread in 2011-12 energy intensity (kWh/m2) for a subset of EU-based hotels and restaurants belonging to the same organisations, respectively. These organisations have established energy efficiency programmes; consequently, one might expect a similar range in energy performance. However, the performance spreads illustrate a wide variation in how sites are operated and maintained, which is a reflection in the lack of standardisation of practices (e.g., building management systems, operator training).

Figure 5.1 Energy performance spread of EU-based hotels belonging to the same organisation (source: ICF)



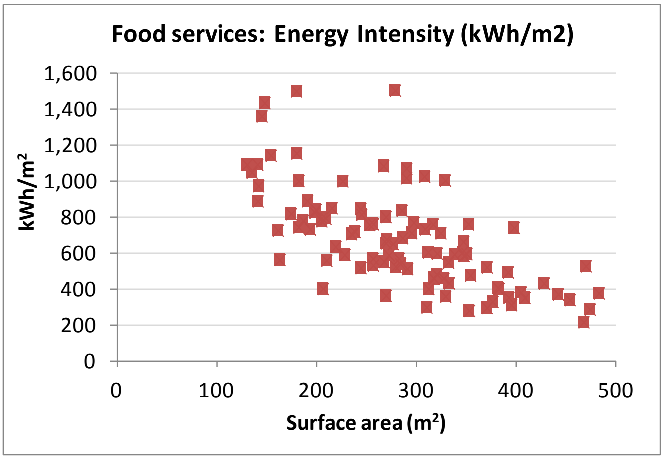
[214] Property Industry Alliance (2015), 'Property Data Report 2014'

[215] Reducing energy demand in the commercial sector, Westminster Sustainable Business Forum and Carbon Connect, 2013.

[216] Property Industry Alliance (2015), 'Property Data Report 2014'

[217] http://www.costar.co.uk/en/assets/news/2015/June/DTZ-European-CRE-stock-hits-34trn/

Figure 5.2 Energy performance spread of EU-based restaurants belonging to the same organisation (source: ICF)



Unwillingness to install energy efficiency measures that go beyond the minimum standards set in building codes, although the efficiency standards in building codes rarely represent the optimum for efficiency, and because builders and designers rarely find an incentive to exceed these efficiency standards which might increase initial costs.

Replacement cycles: Large, expensive equipment (e.g., food service, data centres) is typically installed when existing equipment fails or maintenance costs become prohibitive.

Standard procurement practices usually entail obtaining bids and then selecting the one with lowest purchase price. In the case of energy-using equipment this usually means not only low first-costs but also lower efficiency, making the equipment more expensive to own and operate over the life of the product.

Financial disincentives: Although there are substantial savings over the long run, decisions are typically dictated by up-front capital costs since expenditure on measures within a shorter financial horizon might not be justifiable compared to company turnover or available funds.

Server utilisation remains low: underutilisation is a significant contributor to energy consumption and also constrains data centre capacity. Several factors contribute towards low server utilisation, these include: over-provisioning of IT resources; unused servers that use electricity while delivering no information services; and under-deployment of server power-management solutions.

6 Proposed Policy Measures

6.1 EU policy context

6.1.1 Regulatory background

Energy efficiency is a key priority for Europe. **Europe's 2020 strategy**[218] for smart sustainable and inclusive growth set a target to increase its energy efficiency by 20% in 2020. The focus on energy efficiency has been attributed to the EU's aim to improve economic competitiveness and sustainability, lower emissions and reduce energy dependency while also raising levels of employment and social cohesion. The recent 2030 Climate and Energy Policy Framework and the Council's Conclusion of October 2014 builds on the 2020 goals by identifying an indicative EE target of 27% for 2030, which would be reviewed by the Commission having a 30% target in mind. Furthermore, the Commission aims to identify priority sectors and ways in which EE gains can be addressed.[219]

The **Energy Efficiency Directive (EED)** which entered into force in 2012 establishes a common framework of measures for the promotion of energy efficiency within the Union, to ensure the achievement of the Union's 20% target on energy efficiency which means that EU energy consumption in 2020 should be no more than 1483 Mtoe of primary energy or no more than 1078 Mtoe of final energy.

Since industry is one of the largest consumers of energy in the EU, energy efficiency is viewed as important for helping the Commission to achieve its energy efficiency target. Industrial efficiency was one of the seven flagship initiatives under the 2020 strategy. Here, the Commission established its commitment to support "the transition of manufacturing sectors to greater energy and resource efficiency".[220] Energy efficiency policy for industry has thus aimed at reducing the amount of energy required, for the same product or process.

A key regulation for energy intensive industries has been the **Industrial Emissions Directive (IED)[221]**, which introduces emission limit values for combustion plants with a total rated thermal input which is equal to or greater than 50MW. Operators of specified industrial installations operating activities covered by Annex I of the IED[222] are required to obtain an integrated permit from authorities for their activities. Additionally, there have been proposals for limiting emissions from medium combustion plants (MCP) which will apply minimum emission limit values all combustion plants with a rated thermal input (RTI) of between 1 and 50 MW[223].

Similarly, the **EU Emissions Trading Scheme**[224] sets limits on the total amount of certain greenhouse gases that can be emitted by the factories, power plants and other installations. The scheme covers more than 11,000 heavy energy-using installations in power generation

[218] COM(2010) 2020 Final EUROPE 2020 A strategy for smart, sustainable and inclusive growth

[219] EUCO 169/14 2030 Climate and Energy Policy Framework; 24 October 2014

[220] COM(2010) 2020 Final EUROPE 2020 A strategy for smart, sustainable and inclusive growth

[221] Directive 2010/75/EU

[222] Industries covered under the IED Directive are defined in Annex I to the Directive (e.g. energy industries, production and processing of metals, mineral industry, chemical industry, waste management, rearing of animals, etc.)

[223] Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the limitation of emissions of certain pollutants into the air from medium combustion plants http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0919:FIN:EN:PDF

[224] Directive 2003/87/EC, OJ L 275, 25.10.2003 (consolidated version 25.06.2009) and its implementing legislation

and manufacturing industry. Regulatory frameworks such as these support the drive towards energy efficiency in industry and provide regulatory predictability.[225]

Industrial energy efficiency has also been promoted by other legislative instruments and policy initiatives. The Energy Performance of Buildings Directive, Energy Labelling Directive, Ecodesign Directive, Renewable Energy Directive, and proposed revision of the Energy Taxation Directive, are all directed to help the Member States (MSs) achieve their energy reduction objectives. This is complemented by policy initiatives, such as Resource Efficient Europe (COM/2011/21), Industrial Policy for the Globalisation Era (COM/2012/582), the Innovation Union (COM/2010/546) and the Agenda for new skills and jobs (COM/010/682), which leads to a complex matrix of multiple, potentially non-cohesive policies.

6.1.2 Recent EC communication on Industrial Energy Efficiency

The need for improving energy efficiency to improve competitiveness for EU industry and reduce costs was further emphasized under a recent communication on the 'European Industrial Renaissance'[226]. The communication outlined that EU retail electricity prices for industry grew on average by 3.5% a year and gas prices 1% between 2008 and 2012. Consequently, it is estimated that EU industrial electricity prices are twice that of the USA and Russia and 20% higher than in China. The price gap for gas is more significant, with gas being four times more expensive for EU industry compared with the USA, Russian and Indian competitors; and 12% more expensive than in China (but cheaper than in Japan). However, prices paid by industrial users vary by Member State. The communication also highlights that energy cost disparities represent the largest concern for the competitiveness of energy intensive industries in Europe (e.g. those involved in the production of paper and printing products, chemical goods, glass and ceramics, iron and steel and non-ferrous metals), although there are variations across plants, technologies and countries.

Under this backdrop of higher energy prices, EU industry improved its energy intensity by almost 19% between 2001 and 2011, compared with 9% in the US.[227]

The EU has developed industrial leadership initiatives that help to promote the uptake of breakthrough technologies that promote energy efficiency in industry. Two recent initiatives include the SPIRE and SILC II initiatives (Box 6.1)

Box 6.1 Outline of two key Industrial leadership initiatives in the EU

- Sustainable Process Industry through Resource and Energy Efficiency (SPIRE)

  SPIRE is a contractual Public-Private Partnership (PPP) dedicated to innovation in resource and energy efficiency and enabled by the process industries. SPIRE brings together eight industry sectors operating in Europe who have a high dependence on resources in their production process; thus, they all have interest in improved efficiency and competitiveness. Its objective is to develop the enabling technologies and solutions along the value chain, required to reach long term sustainability for Europe in terms of global competitiveness, ecology and employment.

- Sustainable Industry Low Carbon II (SILC II)

  The SILC II initiative (2014-2020) was launched under the Horizon 2020 programme with a budget of €20m. The initiative will fund projects which develop low carbon technology solutions, with a special focus on energy intensive industries, in order to achieve significant greenhouse gas (GHG) emission reductions in EU industry. In practice, the initiative will support the development of new technologies, and their implementation in

[225] COM(2014) 520 final Energy Efficiency and its contribution to energy security and the 2030 Framework for climate energy policy

[226] COM(2014) 14 final For a European Industrial Renaissance

[227] Energy efficiency trends in the EU, Odyssee-Mure, 2013

some "pilot" industrial plants under real working conditions, that will allow goods to be produced with much lower GHG emissions. Targeted industries include inter alia iron and steel, non-ferrous metals such as aluminium and copper, cement, glass, pulp and paper, chemicals and ceramics.

6.2 Potential Measures

By overlaying the potential ESOs (Chapter 3), and the associated economic, organisational and technical barriers (Chapter 5), against the current EU energy efficiency policy framework (e.g., EED), potential gaps can be identified. This section presents potential policy measures that could address these gaps, and further encourage ESO uptake. A description of each measure is provided, along with background details, and context covering the reduction potential, and some of the barriers that it could address.

6.2.1 Mandatory implementation of EnMS for large enterprises

6.2.1.1 Proposed measure

This measure proposes that Member States shall ensure that energy intensive large enterprises shall implement a recognised national or international Energy Management System (EnMS) standard. The scope covers all large enterprises within the industrial sector. Energy intensive is to be defined as enterprises with a final energy consumption equivalent or over a prescribed threshold (to be determined) expressed in monetary terms or tonne of oil equivalent (TOE).

6.2.1.2 Background

EnMS enables enterprises to establish systems and processes necessary for the purpose of improving energy performance, including energy efficiency, and consumption. It is defined as a set of interrelated or interacting elements to establish an energy policy, energy objectives, processes and procedures to achieve those objectives.

Although EnMS has been practiced for decades internationally, it has regained wider attention through ISO 50001, the international standard for EnMS published in 2011 (and replacing the previous BS EN 16001). It is a refined version of previous quality (ISO 9001) and environmental (ISO 14001) management system standard and adapts the same Plan-Do-Check-Act (PDCA) framework, also known as the Shewhart cycle and refined by William Edward Deming, in achieving continual improvement. It is a relatively simple and effective framework, widely adopted internationally mainly in quality improvement. ISO 50001 adds further technical requirements such as energy review (essentially an energy audit framework), energy baseline and energy performance indicators. By design, ISO 50001 is written based on this simplified structure which is easily integrated with existing legal or business requirements and other management systems, even non-ISO standards. The lack of prescription within the standard itself is its strength, however the complexity is in the details of individual system elements and parameters, especially for organizations with complicated energy intensive processes, and this strongly depends on the 'architect' of the system rather than the standard framework. In summary, ISO 50001 provides a framework for enterprises to take a systematic approach in continually improving their energy performance, consequently maximizing profit and improved environmental benefits. There are also numerous national EnMS standards, established since 2000, which provides a very similar framework to ISO 50001.

ISO 50001 has become the standardised method for EnMS, and it is now replacing national energy management standards, as well as the European standard EN 16001. Through April 2014, over 7,100 sites worldwide have received ISO 50001 certification for their EnMS.[228]

[228] Unofficial statistics from R. Peglau

While this number is increasing (i.e., only 1,420 sites were certified in January 2013), the total still represents a very small percentage of sites in the EU, since the standards on their own are driving widespread adoption of EnMS.

6.2.1.3 Context of the proposed measure

The key objective of the proposed measure is to ensure that obligated enterprises are committed to continually improve energy performance by implementing an appropriate approach in achieving this objective. Table 6.1 summarises the estimated technical potential of energy savings for this measure.

Table 6.1 Technical potential of energy savings attributable to increased uptake of EnMS

Sector	Technical energy saving potential (kTOE)	
	2030	2050
Pulp, paper and print	360	298
Iron and Steel	611	597
Non-Metallic Mineral	219	192
Chemical and Pharmaceutical	481	539
Non-ferrous Metal	87	74
Petroleum refineries	329	260
Food and beverage	188	151
Machinery	204	183

Section 5.2 discusses numerous barriers deterring uptake of ESOs due to organisational behavioural issues. EnMS is an effective tool for enterprises to systematically address some of these issues.

Low status of EE: One of the key strengths of the ISO 50001 standard is that it requires top management commitment on an energy policy which has to be constantly assessed and reviewed. This is an effective way of bringing the discussion of energy performance into the decision making level. Another crucial strength of the standard is the mandatory appointment of a management representative, who is responsible for establishing, implementing, maintaining and continually improving the EnMS. Irrespective of where the priorities are for the organisation, EnMS ensures that energy performance is visible at decision making level.

Awareness: EnMS ensures that the enterprise communicates its energy policy, energy objectives and energy performance to within the organisation, especially to significant energy users. It also enables any individual within the enterprise to suggest improvements to the EnMS. These are crucial steps in communicating the importance of energy objectives and creating awareness among employees on identifying opportunities.

Risks: Implementation of EnMS itself is extremely low risk. The main cost elements of implementing and maintaining an EnMS is largely a commitment of resources to establish, implement and maintain the EnMS. This may require additional hiring or training depending on the availability and skill sets of the existing resources. An effective EnMS is designed and implemented to the enterprise's needs. Therefore it can be designed appropriately, so it does not intrude on the main business activity.

Policy: Article 8 of the EED mandates large enterprises to conduct energy audits once every 4 years; however, enterprises that are implementing an EnMS might be exempted from this requirement. Although an energy audit aims to measure energy use and identify ESOs, if it is conducted as a regulatory requirement rather than part of an integrated management process, there is potential risk that this is carried out only for compliance purposes and the audit findings may be ignored or de-prioritised. This measure is intended to complement the existing requirement for mandatory energy audits by requiring organisations to implement an EnMS, thus providing a systematic approach to continually identify, measure, benchmark and improve energy performance.

6.2.1.4 International references

An EnMS requires an energy review to be conducted, which an audit can underpin; thus, ensuring that it is performed within a robust system, supporting corrective actions, management review and energy planning. The benefits of this approach are reflected in the results observed from Australia's Energy Efficiency Opportunities programme, which mandated large energy using organisations to undertake energy audits as part of an EnMS framework. Results indicated that over 50% of identified opportunities were adopted by the organisations.

Alternately, evidence from schemes that have only focused on energy audits offers insight into potential issues. For example, in 2009, Russia published the Federal Law No. 261-FZ "On Saving Energy and Increasing Energy Efficiency"; the first direct legislative energy efficiency initiative in Russia with mandatory energy audits as one of the core requirements. In Russia, the industrial sector has traditionally been slow to take up new technologies as they are seen as untested and expensive. Due to a lack of financial incentives, and behavioural issues, many organizations have rushed their audits and viewed them simply as a "tick-box" exercise.

Due to these barriers, some countries, such as Denmark, Sweden and Ireland, developed their own EnMS standard, which was underpinned by a voluntary energy savings agreement between organisations and the government, and linked to incentives and support. Examples of incentives that have been used to encourage participation include, exemptions from policies, tax rebates, and subsidies for energy audits. In recent years, there are also a growing number of countries mandating EnMS for industries, including Kazakhstan, Singapore, India and Thailand. In Germany, a voluntary agreement is established that companies with certified EnMS are exempted from energy taxes, which has resulted in a drastic increase of ISO 50001 certification over the past 2 years. Japan's energy conservation policies have mandated EnMS since it was enacted in 1979.

The primary lesson learned from these programmes is that an EnMS can help organisations move beyond isolated energy management activities, such as audits, to integrate and facilitate systems and processes necessary to achieve operational control and continual improvement of energy performance, which in turn helps address some of the barriers to implementing energy efficiency; i.e., an EnMS can reduce the perceived risk to management of energy efficiency projects, which, in turn, reduces the hurdle rate that a company requires for an energy efficiency investment.

6.2.1.5 Options and issues to be considered

The scope of the proposed measure could be extended to all large enterprises, but this is not encouraged as EnMS is mainly aimed at the industrial sector and may not be as effective for the commercial sector. However, energy intensive medium industrial enterprises could be included, as EnMS benefits are largely dependent on energy consumption rather than financial turnover or number of employees.

Certification of EnMS is a relatively costly process which does not necessarily add value to continual improvement of energy performance or the EnMS of the obligated enterprise. A criteria should be established to provide obligated enterprises an option whether to have their EnMS certified or not.

6.2.1.6 Cost benefit aspects of the proposed measure

The main cost elements of implementing and maintaining an EnMS includes development of the EnMS, internal and third party audits and certification cost. In actual cost terms, this involves expert resources, both internal and external to the enterprise. From an internal perspective, the most significant internal resource is the appointment of an energy manager (and internal resources for the energy management team) to develop and maintain the EnMS. The major external cost factors could include training, professional consulting fees, third party audits and certification cost. As a general indication, EnMS implementation may cost anything from EUR 100,000 to EUR 250,000[229]. It is worth noting that this estimate is for large enterprise with a higher complexity in its energy needs (e.g. chemical sector with multiple industrial processes). The required effort reduces significantly for enterprises with a simpler energy needs, e.g. enterprises with few significant energy users, whereby medium enterprises often fall under this category. Implementation cost could also be significantly reduced/optimised when multiple sites are involves as resources and expertise could be shared out among the sites.

The operational cost of an EnMS involves appointed resources (i.e. energy managers and the associated energy management team) in maintaining and continually improving the EnMS. Maintenance of the EnMS involves scheduled internal energy assessment (energy audits) and internal audits of the EnMS performed by internal resources. Enterprises are completely free to establish their internal audit schedules to suit their business needs as long as it complies with legal or other applicable business requirements. Energy managers and the energy management team are very often existing internal resources, without the need for additional hires. Essentially, EnMS maintenance cost should only a small fraction of the implementation cost when the EnMS is fully embedded into the enterprise's business operation. The cost of any applicable recertification audits are significantly lesser than the initial certification cost. Accounting treatment of internal resource could also significantly reduce EnMS implementation cost if resource diverted for EnMS does not have any significant impact on the core business.

The primary benefit of implementing and operating an EnMS is to generate energy cost savings. It ensures that ESOs are continually identified and assessed in supporting the enterprise's effort in improving energy performance. As reported under the Clean Energy Ministerial (CEM) forum[230], initial analysis of US companies adopting ISO 50001 EnMS standard found average savings of 10% within 18 months, with annual savings ranging from US$87,000 – 984,000, with results often achieved by low-cost (or no-cost) operational measures. Nevertheless, some ESOs with higher saving potential will often require additional investment.

Further to the primary benefit, another major value of implementing EnMS is to ensure energy performance is formally assessed at board level, i.e. energy performance and ESOs will potentially have equal visibility as other business objectives at decision making level. When energy is assessed at board level, benefits of ESOs could be aligned, optimised and further exploited along core business objectives, yielding further strategic non-energy benefits (if available) which could potentially outweigh the energy benefits, such as increased revenue/market share due to improved competitiveness, increased output capacity due to excess energy available, reduction of carbon intensity, improved working environment, corporate social responsibility and etc.

Although the ESOs and its associated energy saving potential will gradually reduce as the enterprise improves its energy efficiency and energy performance, the cost of operating the EnMS will also reduce as the EnMS becomes an embedded system within the enterprise.

ICF observed that many energy intensive enterprises in the UK already have a robust EnMS established and maintained in line with the requirements of international standards. These enterprises have made a decision not to be certified as they recognise the value through energy (and non-energy) benefits rather than the certification itself.

[229] Estimated based on an energy manager with 0.5 – 1.0 Full Time Equivalent effort for a single or up to a few sites, including training, minor consultation fees, pre-certification audit and certification.

[230] http://www.cleanenergyministerial.org/Blog/the-value-of-energy-management-systems-and-iso-50001-42890

Table 6.2 provides a simplified summary of the cost benefit ratio of implementing EnMS taking a case of a large enterprise with an energy bill of EUR 2,500,000 and a potential energy saving potential of 10% for the within 12 months of implementing the EnMS, purely based on a no-cost/low-cost ESOs. The energy saving potential then halves every year, as the enterprise improves its energy performance. The EnMS implementation cost is accounted as EUR 250,000, with reference to the high end of the above estimate. The EnMS maintenance cost is assumed to be EUR 50,000 for the following year, and gradually reducing thereafter. This yields a cost benefit ratio of 1.27 over the 4 years, whereas the ratios are much higher on a year-to-year basis.

Table 6.2 Simple cost benefit analysis of EnMS implementation for a large enterprise

	Year 1	Year 2	Year 3	Year 4	Total
EnMS cost	250,000	50,000	30,000	15,000	345,000
EnMS benefit	0	250,000	125,000	62,500	437,500
Cost benefit ratio	-	5.00	4.17	4.17	1.27

6.2.1.7 *Administrative aspects of the proposed measure*

The study proposes to establish a threshold for obligated compliance based on the value of an enterprise's annual energy bill. In consideration of the above case of a simplified cost benefit ratio, the study proposes that companies with energy bills equivalent to EUR 2,500,000 per annum should be obligated to comply with the measure. As the benefits of EnMS is proportionate to energy consumption, the study proposes that the measure be applicable to large and medium sized enterprises. Energy intensive medium enterprises may benefit significantly from the measure as they may have enough internal capacity to implement and maintain the EnMS.

Eurostat estimates approximately 15,900 and 72,000 large and medium enterprises within EU28 for the manufacturing sector (NACE C code). This implies that the measure may be applicable to a subset of this enterprises with energy bills meeting the threshold requirement.

Considering that it could take 12 – 18 months for enterprises to setup an EnMS, a proposed timeline of 2 years should be allowed for the preparation time to comply with the measure. The administration of the measure could benefit from the existing administrative efforts among MS in support of the existing Article 8 of EED on mandatory energy audits of large enterprises.

6.2.2 Mandatory sub-metering requirements

6.2.2.1 *Proposed measure*

This proposed measure mandates that significant energy consuming equipment or sections of the plant must be fitted with an energy meter to account for its specific energy consumption. The measure will apply to new and refurbished equipment, where technically feasible.

6.2.2.2 *Background*

Sub-meters are installed after the utility meter in specified locations throughout the facility and are used to measure the amount of energy consumed by portions of the plant where major energy loads are known. Some of these metering systems communicate to a central system where the information is trended, stored or transferred to a data historian system for archiving. Properly maintained systems allow an organization to establish metrics for these facilities and to gauge their overall energy performance, as well as facilitate the establishment of energy documentation and management systems, capable of handling data from multiple and distinct facilities.

6.2.2.3 Context of the measure

The key objective of the measure is to enable the enterprise to monitor their significant energy users with reliable metered data. At a minimum, this will raise awareness among enterprises on the actual energy consumption of significant energy users. This could also facilitate enterprises on further actions, should they decide to act upon it.

To develop an energy picture of a facility, plant operators need accurate, real-time energy data to evaluate the performance of individual processes, pieces of equipment, departments and benchmark energy levels at multiple facilities. Sub-meters can measure electric, gas, steam, British thermal unit (BTU)[231] and other parameters to analyse various issues, including the profiling of individual or aggregated loads on equipment to pinpoint peak usage, so operational staff can employ load controlling devices to set high/low thresholds, control loads and reduce energy costs; allowing facilities to identify exact energy costs by production line, production run, individual piece of equipment or the entire facility, which enables the accurate allocation of energy costs to individual products or customers; monitoring usage and identifying potential failures, thus allowing facility managers to take proactive steps to schedule repairs before the equipment fails, thus avoiding costly and unexpected downtimes; and enabling organisations to separate production costs from other departments to support accurate budgeting. Sub-metering is often viewed as a cost component instead of an ESO. However, it plays a vital role in supporting implementation of ESOs. Table 6.3 summaries the estimated technical potential of energy savings.

Table 6.3 Technical potential of energy savings attributable to appropriate sub-metering

Sector	Technical energy saving potential (kTOE)	
	2030	2050
Pulp, paper and print	361	231
Iron and Steel	763	801
Non-Metallic Mineral	457	405
Chemical and Pharmaceutical	1,045	1,075
Non-ferrous Metal	199	170
Petroleum refineries	424	448
Food and beverage	680	603
Machinery	701	671

Section 5.2 highlights numerous barriers deterring uptake of ESOs due to organisational behavioural issues. Sub-metering is an effective tool for enterprises to systematically address some of these issues.

Imperfect evaluation: It is difficult to evaluate the effectiveness of an ESO without metered data to back up the evaluation. Sub-meters play a crucial role in ESO evaluation by providing metered data, serving as an accurate picture rather than relying on theoretical assumptions.

Bounded rationalities: The availability of sub-meters provides accurate evidence in challenging poor or unreliable assumptions associated with ESOs. This could eliminate many bounded rationalities which may have been established. Metered data also provides much more credibility to ESO proposals as there is a tangible method of estimating and verifying savings of potential ESOs.

[231] Traditional unit of energy equal to about 1055 joules.

Although there are numerous benefits to sub-metering, identifying and implementing an appropriate hardware and installation configuration are the key implementation challenges. Sub-metering at an industrial plant is complex because the current and the voltage feeding the equipment both need to be measured. While current can be measured with clamps and does not require power interruption, voltage measurement typically requires wire installation, which requires a temporary power outage. Meters can also fail or report incorrect data, so a preventive maintenance plan that manually checks all meters, including software and real-time data, so abnormalities are reported would be required to ensure the proper functioning and interacting of the system.

Risks: Sub-metering provides reliable measured data which facilitates the development of robust ESO engineering designs. In the absence of metered data, alternative methods and calculations are deployed which increases the design risk. After an ESO is implemented, metered data could be utilised to verify the actual energy savings achieved, making the investment more tangible than relying on estimated savings. If sub-meters are installed on new or refurbished equipment or facility, this minimizes the risk of disruption to the main business activity.

Policy: Article 9 of the EED stipulates that Member States shall provide smart meters to final customers when an existing meter is replaced or a new connection is made in a building or a building undergoes major renovations. However, these requirements aim to both measure individual consumption and consumption at the building-level in multi-apartment/multi-purpose buildings. Limited attention is paid to the need and opportunity within the industrial sector. The use of sub-metering in industrial sectors addresses the need to improve internal competences for effective monitoring and measurement of energy consumption of energy intensive equipment. With metered data, enterprises will be able to disseminate energy consumption data to all parties having influence on operations; develop appropriate benchmarks for internal and external comparison; use regression analyses (including multivariable regression analyses) and Cumulative Sum Control Chart (CUSUM) to better monitor energy use, consumption and performance; and develop scatter plots to inform on leaders and laggards and on worst and best practices within a portfolio.

6.2.2.4 EU References of the proposed measure

In the UK, new non-domestic buildings are required to have sub-metering in place for at least 90% of each incoming energy source to account for the different types of energy use. It also states that any output from renewable systems should be separately monitored.

6.2.2.5 Options and issues to be considered

The measure may be applied not only to significant energy using equipment, but it should also be applied to significant energy intensive processes and sections of the industrial plant with high energy consumption. Measurement could take form of direct metering or indirect metering, whereby energy consumption could be obtained from other proxy measurements applicable to the quantification of energy consumption.

6.2.2.6 Cost benefit aspects of the proposed measure

The cost of metering differs significantly with respect to the energy type and application features of the meter. Individual electrical and heat meters could cost between

6.2.3 Mandatory requirement of energy managers for large energy intensive enterprise

6.2.3.1 Proposed measure

This measure proposes that Member States shall ensure that energy intensive large enterprises shall appoint a dedicated energy manger within obligated sites. The scope shall only be applicable to energy intensive sites within the industrial sector. Energy intensive is to be defined as sites with a final energy consumption equivalent or over a prescribed threshold (to be determined) expressed in monetary terms or tonne of oil equivalent (TOE).

Note that this measure overlaps with the measure proposed in section 6.2.1. However, this measure is proposed as an alternative should the commission decide not to implement the measure mentioned in section 6.2.1.

6.2.3.2 Background

Energy managers play a crucial role in managing an enterprise's energy needs and performance. An energy manager's primary role includes:

- Establish, implement and maintain the enterprise's EnMS
- Report EnMS and energy performance to top management
- Ensuring that EnMS activities fall in line with enterprise's business activities
- Define, communicate with and facilitate resources within the EnMS to maintain effectiveness
- Establish O&M criteria and procedures required to improve the enterprise's energy performance
- Promote awareness of enterprise energy policy and energy objective

Energy managers require multi-disciplinary skills, both engineering (electrical, electronics, thermal, mechanical, civil, IT, etc.) and management (EnMS, economics, energy contracts, project management, energy purchase, etc.). Industrial facilities do not often have dedicated energy managers within their operations.

6.2.3.3 Context of the proposed measure

The key objective of this measure is to ensure that energy intensive sites have committed resources to fulfil the enterprise's energy objectives. This measure also has the potential to address some of the key barriers identified in Section 5.2.

Competencies and awareness: One of the key barriers deterring ESOs being taken up is the lack of competent resources in handling complex technical information and issues. A qualified energy manager has the necessary skill set to manage such complexities and ultimately work towards achieving the enterprises energy objectives. Energy managers constantly interact with multiple departments, thus raising the awareness level of energy issues within the enterprise.

Imperfect evaluation information: A qualified energy manager needs to be strong in handling technical issues as well as communicating complex information concisely to decision makers, thus avoiding any asymmetric information among decision makers within the enterprise which are often made up of diverse backgrounds (e.g. accountants, lawyers, economist, engineers, etc.).

Risks: With the availability of a qualified energy manager, resource and competency issues can be resolved. Therefore, the enterprise is able to take up ESOs with higher complexity while reducing technical risks associated with design, implementation and O&M. In consequence, the perception of risk may reduce, thus lowering the financial risk as well.

Policy: Article 16 of the EED stipulates that Member States shall ensure that the relevant certification, accreditation and/or equivalent qualification schemes are available for providers of energy services, energy audits, energy managers and installers of energy-related building element, including provision of suitable training programmes where necessary.

6.2.3.4 Options and issues to be considered

Although this measure may introduce additional upfront cost burden to the enterprise, qualified energy managers are professionally trained to optimize the enterprise's energy performance, reducing operational cost, thus increasing bottom line profitability. Assuming the energy manager achieves its goal, they are effectively a zero-cost resource. At least case studies should be presented of how much an energy manager costs and how much cost savings and bottom line profitability he/she can achieve.

For less energy intensive enterprises, energy managers could also be a part time role, or shared among multiple facilities. Box 6.2 provides 2 case studies in the UK demonstrating the savings and monetary benefits their energy manager continually generates which significantly outweighs the cost of hiring.

Box 6.2 UK case studies on benefits of energy managers

Major auto manufacturer

This major auto manufacturer hires multiple university interns to act as part-time energy managers. The interns are each given the responsibility to identify ESOs within the plant, make a business case for it and upon approval, implement the ESO. It was an extremely rewarding process for the interns to be given this level of responsibility and providing key contributions to the company's reduction of operational cost. The key achievements are as follows:

- Switching off of exterior lighting during weekends saved £7,000 per year;
- Change in heating control system saved another £50,000 per year;
- Measurement of leak rates and gas flow in compressed air systems together with the reduction of pressure lead to considerable annual savings.
- Quantification of wasteful habits in the context of cost for internal company dissemination.
- Successfully demonstrated that anyone can identify energy saving potential with minimal effort.

Major non-ferrous metal producer

This major non-ferrous metal producer implemented highly advanced EnMS within the plant with the energy cost quantified and tracked before and after each batch of product is produced to ensure dynamic, competitive and accurate pricing to its customers. An energy manager is hired on a part time basis and the company insist that the savings continually outweighs the cost of the energy manager. The top management of the company firmly believes that energy managers do not cost them anything. Achievements of the energy manager include:

- Managing peak time hours: savings of £75,000 per year.
- Smarter loading disciplines: savings of £186,000 per year.
- New furnace management practice: saving of £197,000 in first year, £92,000 on the subsequent year.

6.2.3.5 *Cost benefit aspects of the proposed measure*

Similar to the measure proposed in section 6.2.1, the benefits of an energy manager benefits enterprises with higher energy consumption and associated energy saving potential. However, the case study in Box 6.2 suggest that appointment of part time energy managers could contribute significantly to energy savings, generating savings which significantly outweighs the cost of hiring them. We also observed that dedicated attention and effort on energy savings is more important than experience or full-time positions of energy manager(s). This seems to suggest that the issue doesn't lie in the cost of hiring an energy manager, but the lack of appointment of an energy managers. Even on a part time basis, energy managers are capable of generating significant benefits. As such, enterprises with enough man-power could appoint existing internal resources to execute the role of a part time energy manager to ensure that ESOs (especially the low-hanging fruits) are addressed and not missed. The study proposes that all large and medium enterprises complies with this proposed alternative measure. Large and medium enterprises have a significant pool of internal resources which could be utilized to address energy issues. A fraction of savings achieved from the proposed energy bill threshold will generate enough monetary benefit which significantly outweighs the internal effort or cost allocation of appointing energy managers. To further anchor the benefits of this measure, a proposed threshold on the energy bill could be added to define the obligated parties. An energy bill of >EUR 500,000 per annum could be established to ensure that the associated savings are worth the additional effort in appointing energy manager(s).

6.2.4 Development of insurance for energy performance

6.2.4.1 Proposed measure

Member States shall take appropriate measures to understand, promote and facilitate the development of appropriate insurance products to complement efforts in uptake and financing of ESOs within the industrial sector.

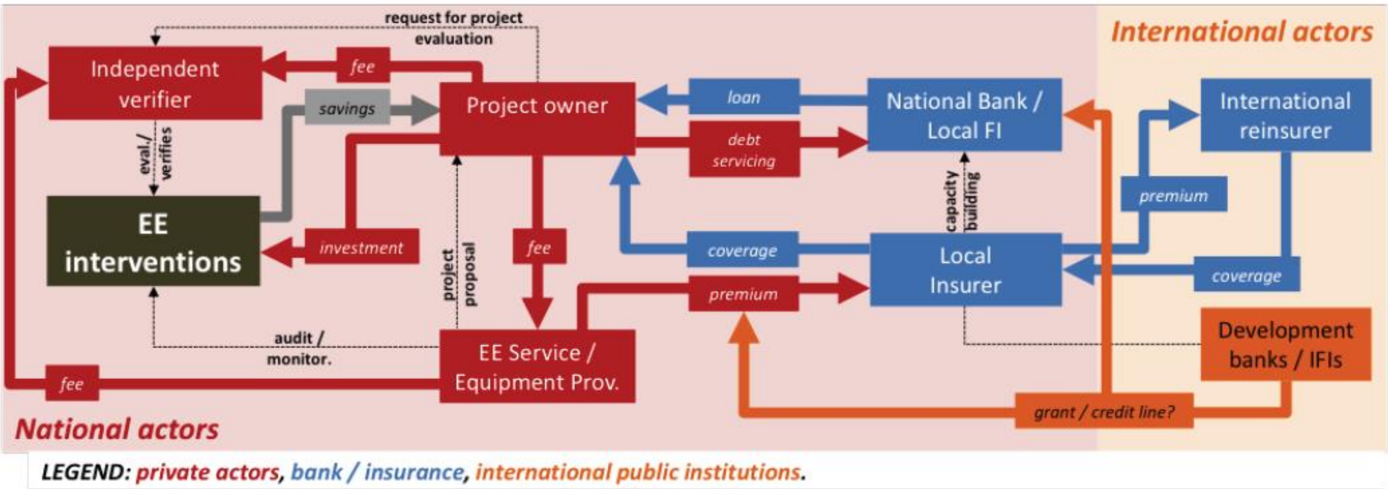
6.2.4.2 Background

As discussed in section 5.1.2.5, implementation of ESOs will introduce additional technical and financial risk to the enterprise. While some of the anticipated risk could be mitigated, some other risk are difficult to predict, e.g. reliability of technology, design or service provider, resulting in underperforming ESOs not delivering the perceived full benefits. Insurance instruments could be utilized to cover such risks.

Currently, insurance guarantees for EE or ESO projects are still in its infancy. There are very few insurance providers identified[232] who offers guarantees for under-performing EE projects. The insurance is provided in the form of an energy savings guarantee, whereby the insurers will pay for the shortfall in projected energy savings guaranteed by the energy service provider. They are mainly aimed for EE projects for buildings (lighting, HVAC, building control systems) in the US and Canada market, however it was mentioned that they apply for industrial sector as well [Fiorello H. Laguardia Foundation, 2014].

The development of insurance for energy performance guarantee is complex mainly because of the technical complexity of EE interventions and the possible involvement of multiple actors in the commercial structuring, including financing institutions for credit line and independent third party verifiers to validate the energy savings achieved. Figure 6.1 illustrates the structure of an energy savings insurance based on advancing pilot scheme in Mexico [The Lab, 2014].

Figure 6.1 Structure of energy savings insurance mechanism



Source: The LAB, 2014

[232] Munich Re, Hannover Re (together with KlimaProtect) are currently providing EE insurance products for the building sector. Multilateral development banks such as ADB and IDB are developing pilot programs to support insurance products for the energy efficiency market.

6.2.4.3 Context of the measure

The key objective of this measure is for the Commission to facilitate the development of new insurance mechanisms to complement the uptake of ESOs within the buildings and industrial sector. This could potentially act as a key driver for uptake of ESOs, boosting investor confidence by overcoming some of the key barriers identified in Section 5.2.

Technical risk. With the availability of an appropriate insurance to guarantee the energy performance of ESOs, decision maker's perception of technical risk associated with the ESO could significantly reduce given that there is an insurance instrument to complement the projected energy saving benefits.

Financial risk. With the availability of an appropriate insurance to guarantee the energy savings of ESOs will address the risk and concerns on underperforming ESOs failing to generate the expected savings. In consequence financial cost may be reduced as the risk is further undertaken by an insurance provider.

Imperfect evaluation criteria. Capacity building among financial and insurance institutions will improve services provided to the market as better understanding is generated through further implementation of EE and ESO projects. This may have the potential to significantly reduce transaction cost associated with EE financing and insurance.

Currently there are a few international donor initiatives in developing the energy savings insurance market. Further support from the Commission will accelerate the pace of these development complementing the uptake of ESOs within the industry.

6.2.4.4 Options and issues to be considered

In addition to the Energy Efficiency Financial Institutions Group (EEFIG), which consist mainly of financing institutions, a parallel working group or activity to develop appropriate insurance mechanisms to support uptake of EE or ESOs within the buildings and industrial sector will complement efforts in developing long term EE financing mechanisms.

Although the benefits of insurance mechanisms may come at a high cost of premiums, this may reduce in time when the market framework starts to improve.

6.2.5 Increased promotion and facilitation of energy use within industrial clusters

6.2.5.1 Proposed measure

Member States shall take appropriate measures to understand, promote and facilitate the sharing of energy within industrial clusters. These measures can include, fiscal incentives, access to finance, grants, prioritized permitting schedule, information provision to encourage organisations to conduct total area studies (i.e., pinch analyses) to identify inter-plant process integration opportunities, and develop new business models (i.e., commercial agreements). Member States should also look into specific zoning requirements of new industrial areas.

6.2.5.2 Background

Historically, energy intensive chemical facilities have been co-located in clusters due to a need to share infrastructure or resources. As such, inter-process material flows have been established; however, utility flows (e.g., heat) have generally been ignored, with each facility having responsibility for their own energy supplies and consumption. The majority of energy demand within a chemical plant is ultimately emitted again to the environment in the form of heat. In addition to using energy more efficiently (e.g., higher efficiency equipment, improving insulation), re-designing manufacturing to use any surplus energy in parallel or adjacent processes can improve energy efficiency. While most approaches (e.g., energy audits) are focused on the former, limited work has been done to improve the understanding and opportunity associated with inter-plant process integration for industrial clusters.

Looking at the utilization of heat by the utilities at a chemical facility, there are steam heaters and re-boilers using hot utilities for heating, as well as coolers and steam-driven generators which use cold utilities for cooling. It is therefore possible to find a large temperature difference between the heat supply side and the heat demand side. For example, low-grade heat (around 150–200 °C) of process streams is cooled by coolers and disposed of as waste heat; however, low-pressure steam (around 130 °C) could be produced from such heat. Middle-pressure steam (200–250°C) is sometimes used for re-boilers, but it can be replaced with the lower pressure steam, if the process stream requires the low level heat (about 110°C). Area-wide pinch technology provides an appropriate methodology to assess the energy saving potential of a whole industrial area (cluster), by identifying the heat sources and sinks present to find the optimum balance. As such, the first step would be to use Area Wide Pinch Technology, consisting of total site profile (TSP) analyses of the facilities in question. Acting on the findings of such a study, to achieve the savings, infrastructure (i.e., piping, heat exchangers) may need to be installed to allow for further utility sharing between facilities.

6.2.5.3 *Context of the proposed measure*

The main objective of the measure is for Member States to play an active role in supporting industrial clusters to maximise its chances of success in reducing the cluster's energy performance (energy use, consumption and efficiency) by integrating or sharing energy resources.

Many industrial facilities are co-located in clusters in regions facing socio-economic challenges and/or are significant local employers [Some concrete examples in text boxes please].[233] (DECC, 2014). Therefore reduced costs can improve the competitive position of the clusters. Some studies have been conducted, which highlight the potential, but also the numerous barriers preventing further uptake.[234,235] The biggest concern stems from a lack of information on the cluster-specific integration potential, and how energy sharing can be commercially managed between competing organisations. These concerns reflect the lack of an adequate business model to support this new approach (e.g., risk of dependency on a separate company with which the organisation is integrated, the framework for the sharing of cost savings [and investment] between facilities, and how opportunities between facilities are identified and paid for). While many facilities are interested in further integration of utilities, hurdles such as these can prevent them from adopting such strategies naturally. Policy measures to promote and facilitate the use of energy between plants in industrial clusters are required to address existing barriers, including a lack of technology awareness, lack of data on waste heat streams, access to capital, and real or perceived increased operational risks.

Table 6.4 summaries the estimated technical potential of energy savings for selected sectors where inter-plant process integration is feasible.

Table 6.4 Technical potential of energy savings through inter-plant process integration

Sector	Technical potential (KTOE)	
	2030	2050
Pulp, paper and print	374	236
Iron and steel	1,941	2,010
Chemical and pharmaceutical	1,441	1,312
Petroleum refineries	737	475
Food and beverage	528	449

[233] DECC (2013) The Future of Heating: Meeting the challenge

[234] Hills T., Gambhir A., Fennell P.S., "The suitability of different types of industry for inter-site heat integration"; ECEEE Industrial Summer Study; 2014

[235] Paramonova S., Backlund S., Thollander P., "Swedish energy networks among industrial SMEs"; ECEEE Industrial Summer Study; 2014

Since all sectors are characterized by complex production processes, which are tailored to specific inputs (e.g., fuels), equipment, and products; specific knowledge of the process is required in order for information to be useful and accepted. These challenges speak to the need for reputable sector-specific process and/or technology experts that can conduct robust assessments that provide organisations with information that can be used to make sound investment decisions.

6.2.5.4 Options and issues to be considered

Integration of energy resources among industrial clusters is highly complicated, mainly due to individual operation needs and commercial complexities. It may not be technically or commercially feasible for some industrial clusters to pursue integration of resources or processes. However, strong facilitation from EU and Member State authorities is required for selected clusters which are most feasible.

Annex 1 Sector Profiles

A1.1 Pulp, Paper and Print Sector

A1.1.1 Overview of key sect oral policy measures/incentives

Table A1.1 presents the main EU policies applicable across sectors ("generic" EU policies) and Table A1.2 provides information on EU policies specific to a given sector/subsector.

Table A1.1 "Generic" EU policies and their applicability to Pulp, Paper and Printing sector

EED	EU-ETS[a]	IED[b,c]	Ecodesign Directive	Energy Labelling Directive	Energy Performance Building Directive
Yes	Yes	Yes	Yes	N/A	N/A

Notes:

[a] *Pulp & paperboard is on the list of sectors liable to "carbon leakage" (relocation outside the EU due to high carbon price).*

[b] *BREF for Pulp and paper was developed in 2001. A revised draft has been published (07/2013).*

[c] *The EU Forest-Based Industries (F-BI), including pulp and paper manufacture and printing, are deemed to help achieve the goals of the EU's Industrial Policy, including the aspirational goal of raising manufacturing industries' contribution to EU GDP from 15.3% (2012) to 20%, i.e. the "reindustrialisation" of Europe (EC; 2013)*

The European Commission (EC) is developing scope and methodologies for product environmental footprints (PEF) in policymaking. Resource efficiency is the objective, and the resolution of the disparity of different methods for measuring environmental performance. The Commission has launched a three-year pilot on product rules, based on PEF. The Confederation of European Paper Industries (CEPI) sees the benefits of having product rules applicable to the whole sector and believes there is a business case for using PEF; e.g., comparing different materials.(CEPI; 2013b)

Table A1.2 EU policies specific to Pulp, Paper and Printing sector

Policy name	Policy description	Measure
General		
EU Timber Regulation[236]	■ Aim: to fight illegal logging and associated trade; to prohibit placing of illegal timber and timber products on the internal market ■ In force: 3 Mar 2013 ■ Type: Regulation; Mandatory	■ It requires anyone who supplies or sells timber or processed timber products for the first time on the EU market to carry out a due diligence check to assess the potential risks related to the products (origin, species, etc.) and, if needed, mitigate the risks. Any subsequent user of the wood or wood products, once it has been placed on the market, must provide basic information on his supplier and his buyer (CEPI; 2013b).
European Declaration of Paper Recycling	■ Aim: to encourage paper recycling ■ In force: 2000 ■ Type: Initiative; Voluntary	■ It sets out measures to optimise the management of paper throughout the value chain from paper and board manufacturing, converting and printing through to the collection, sorting, transportation and recycling of used paper and board products back into the paper loop. The new target of a 70% recycling rate by 2015.

[236] http://ec.europa.eu/environment/eutr2013/index_en.htm

Policy name	Policy description	Measure
Paper and Paperboard		
Packaging and Packaging Waste Directive 94/ 62/EC	■ Aim: to limit the production of packaging waste and promote recycling, re-use and other forms of waste recovery ■ In force: 31 Dec 1994 ■ Type: Regulation; Mandatory	■ Only for packaging material – minimum recycling target of 60% by weight for paper and board
Waste Framework Directive 2008/98/EC	■ Aim: to set the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. ■ In force: 12 Dec 2008 ■ Type: Regulation; Mandatory	■ Prevention, being at the top of the waste management hierarchy, means a reduction in the quantity and harmfulness to the environment of: ■ Paper and substances contained in paper products ■ Paper products and its waste at production process level and at marketing, distribution, utilisation and elimination stages ■ The WFD sets targets to be achieved by 2020 – preparation for re-use, recycling of municipal waste, at least paper, metal, plastic, glass from households, to an overall minimum of 50%. The WDF also foresees separate collection as of 2015 and empowers the Commission to consider developing end-of-waste (EoW) criteria for paper.
Printing sector		
Solvent Emission Directive 1999/13/EC	■ Aim: to prevent or reduce the direct and indirect effects of emissions of volatile organic compounds (VOCs) from organic solvent users ■ In force: 29 Mar 1999 ■ Type: Regulation; Mandatory	■ It sets emission limit values for waste gases and fugitive emissions. ■
REACH Regulation 1907/2006	■ Aim: to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances ■ In force: 1 Jun 2007 ■ Type: Regulation; Mandatory	■ It affects activities using chemical substances.

A1.1.2 Overview of the EU28 market

A1.1.2.1 Contribution to GDP, employment:

The Pulp and Paper Industry

- Sweden and Finland were the leading pulp producers in Europe in 2012, followed by Germany, with a share in total production of 31.4%, 26.9% and 7.4%, respectively (SETIS).
- The manufacture of paper and paper products in Germany employs the highest number of people in the EU; followed by Italy (almost half of the German workforce), and France (Table K). The same order applies when considering country share of EU-28 value added.
  - The relative importance of paper and paper products manufacturing was highest in Finland and Sweden (3.9% and 2% of non-financial business economy value added in 2010, accordingly). Both countries recorded over 8% share of EU-27 value added and were the highest share in any of the countries' non-financial business economy NACE divisions in 2010 (Eurostat; 2013b).
- Italy and Germany have the highest number of paper mills – around 170 mills each – followed by France (around 95 mills). Their production share in 2012 was 9.3%, 24.6% and 8.8%, respectively. Sweden and Finland, although they have a lower number of paper mills (around 40 each), their share of production is higher; 12.4% and 11.6%, respectively. This is because their mills are newer and have larger capacity (e.g., the most efficient 10% of (wood-free) paper machines account for roughly 40% of total production (SETIS)
- Number of persons employed in the manufacture of paper and paper products sector decreased by 23% over 2000-2011 (EC; 2013).

The printing industry

- Germany is the leader considering the number of persons employed in the printing and reproduction of recorded media; followed by the UK, Italy and France (Eurostat; 2013c).
  - The relative importance of the printing and reproduction of recorded media sector was highest in Estonia (0.9% of non-financial business economy value added), and in Slovenia, Croatia and Switzerland (0.8%).
- Number of persons employed in the printing and reproduction of recorded media sector was estimated to decrease by 29% over 2000-2011 (EC; 2013).

A1.1.2.2 Market developments and sector growth rates

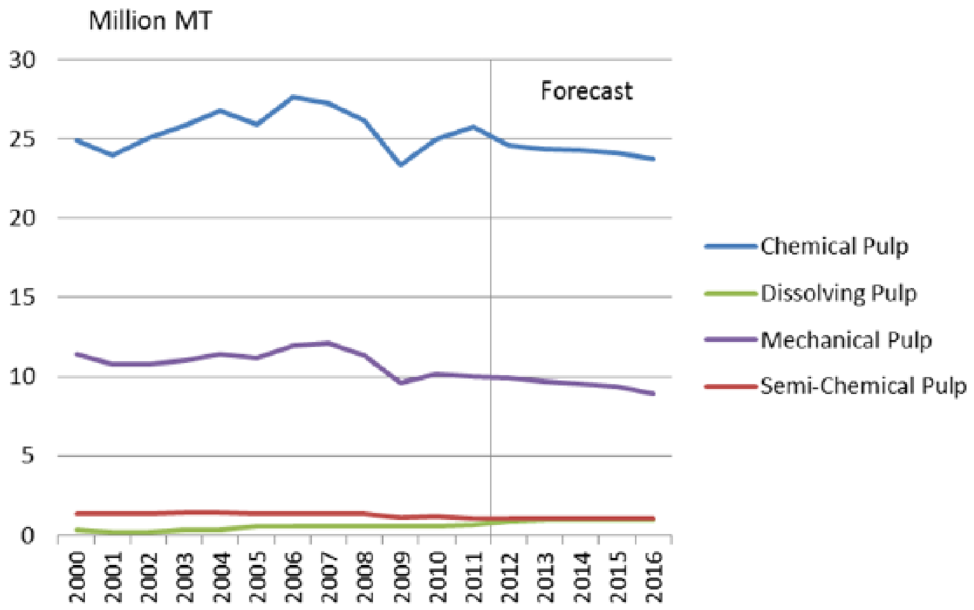
The Wood Pulp Industry:

Market developments

- Total pulp production in the EU-27 fell a few percentage points during the 2000s as a consequence of the economic crisis. The decrease from 2006 to 2009 was 16%. Out of wood pulp produced in EU-27: about 70% is chemical pulp; 25% - mechanical pulp, 3.5% - dissolving pulp, and 1.5% - semi-chemical. See Figure A1.1.
  - The production of chemical pulp in 2011 was on the same level as in 2000, ca. 10% below the peak in 2006. The decrease has been due to mills being permanently dismantled. The production of mechanical pulp in 2011 was below the 2000 level by 10%.
  - The production of semi-chemical pulp in 2011 was below the 2000 level by 13%. Dissolving pulp is only 1.5% of all pulp produced, but it noted a 79% rise in the 2000s, tracking the rapid increase in cotton price during this period. As a

consequence some mills (Mörrum in Sweden, Enocell in Finland) have now equipped their mills for production of dissolving pulp.

Figure A1.1 Wood pulp production by grades over the 2000-2011 and forecast 2012-2016, EU-27



Source: Indufor; 2013

Drivers:

- Generally linked to the production of paper and paperboards: the pulp mills tailor pulp grades according to the paper machine demands. The percentage of virgin pulp in paper is declining, since more recycled fibre is being used in paper production and characteristics of pulp have been improved (less pulp needed). Indufor (2013) forecasts the following by 2016:
  - Chemical pulp: production to slowly decline (switch to imported eucalyptus)
  - Mechanical pulp: production to decline (change from paper to electronic media)
  - Dissolving pulp: production to rise (following high cotton price and rising consumption as a raw material in the textile industry; current global share of dissolving fibre in the textile industry below 1%. NB: dissolving pulp mills will be able to return to paper grades if the price difference between the dissolving and paper grades were reversed as a result of too much capacity.
  - Semi-chemical pulp: production to decline (change from paper to electronic media)
- However, a surplus in wood supply projected in the EU through to 2030 (EFSOS) could counteract long-term import threats.

The Paper and Paperboards Industry

Market development

- The EU total production of paper and paperboards was gradually growing between 2001 and 2007. Yet, following the recession, and paper stockpiles built up in 2008, production dropped significantly in 2009 across countries. Paper production decreased in 2009 to 85-88% of the 2007 production rate. In 2010, recovery of production started, partly through re-stocking (93% of 2007 level). The 2010 paper and paperboard production was 94.6 million tonnes and slightly decreased to 93 million tonnes in 2011. See Figure A1.2.

– Production of newsprint: 15% decrease from 2000 to 2011. 17% drop in 2009 compared to 2007.

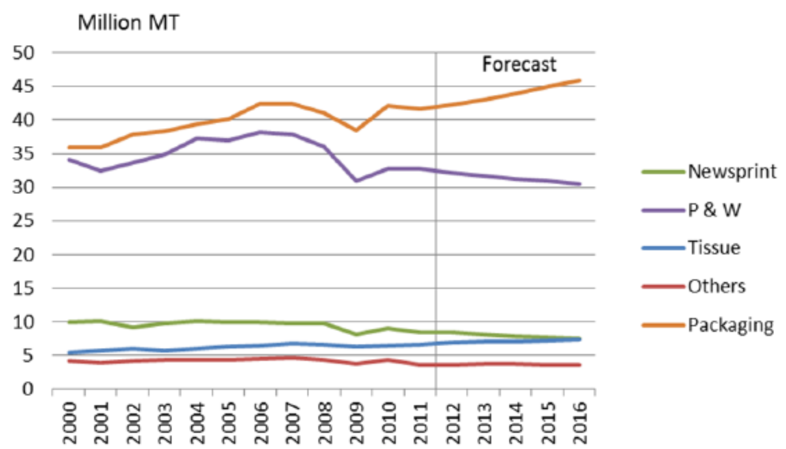
– Printing and writing paper production: 4% decrease from 2000 to 2011. 18% drop in 2009 compared to 2007. No recovery recorded in 2011, 13% below the 2007 level.

– Hygienic paper production: 23% increase from 2000 to 2011. 5% drop in 2009 compared to 2007. In 2011, only 1% below the 2007 production.

– Packaging grade production: 16% increase from 2000 to 2011. 9% drop in 2009 compared to 2007. In 2011 noted the best recovery, only 2% below the 2007 level.

– Production of other grades: relatively no change between 2000 and 2011. In 2009 - 20% below the production in 2007.

Figure A1.2 Paper and paperboard production by grades over the 2000-2011 and forecast 2012-2016, EU-27



Source: Indufor; 2013

Drivers

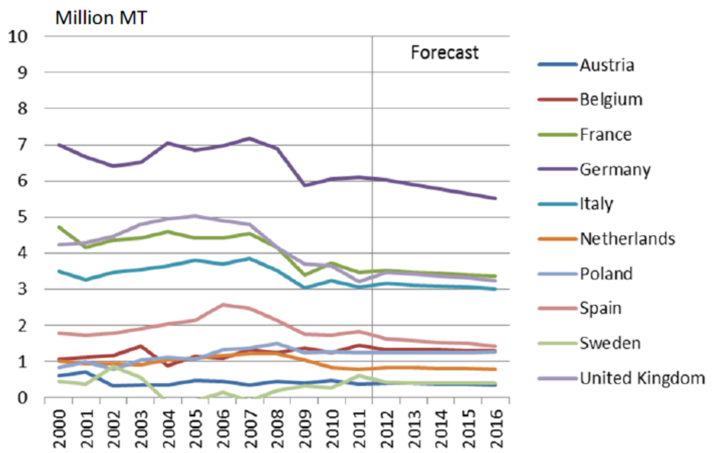
- Paper use in printing and writing papers together with newsprint and other grades is expected to decline, following the change to electronic media.
- Paper use for packaging will be increasing: more and better packaging is needed to decrease the loss of food in transport. Paper and board packaging is safe and hygienic. Also, paper still plays a significant role in branding.
- An ageing population means a long-term increase in household and sanitary products, but a slowing down for certain stationery goods.
- Decline in paper use in graphical applications might be compensated by the use of paper in emerging markets, such as bio-refineries (bio-substitutes for petroleum derivates, green chemistry, biofuels, bioplastics), paper as bio-substitutes for non-renewable materials; nanotechnology applications.(FBS; 2012)

The Printing Industry

Market development

- The total consumption in printing and writing papers in 2011 was 86% of the consumption in 2000. Consumption has decreased more than average in Austria, France, the Netherlands and Sweden, with the largest occurring in Germany. (Indufor; 2013). See Figure A1.3.

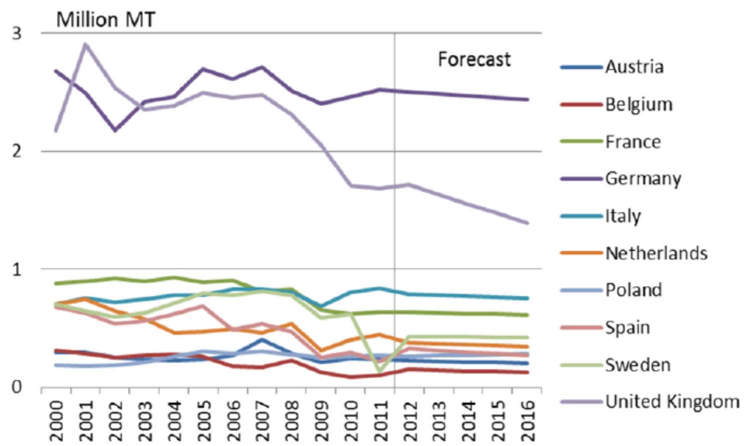
Figure A1.3 Consumption of printing and writing papers by the main consumers in EU-27, over the 2000-2011 and forecast 2012-2016



Source: Indufor, 2013

- Steady decline in newspapers in print sales. The top-line for Europe sees the print market falling. After the sharp downturn in 2008 some recovery took place in 2010–2011, but after that the market is assumed to continue falling. The whole European print market is foreseen dropping by some 9.5% between 2005 and 2015. (Veihmas K & al; 2011)
- The most dramatic change in newsprint consumption by volume is in the UK, where consumption in 2010 was only 78% of that in 2000. In contrast, in the Netherlands consumption has increased annually by 1.4%, in Italy by 1.3% and in Poland by 3.2%. Austria showed as decrease of -2.8%, France -3.5%, Germany -0.9%, Spain -8.0% and Sweden -1.2%. The changes indicate two things: the decrease of printing of newspapers resulting from the switching to digital media, and in some cases the moving of printing jobs from one country to another, which may be the case, for example, in Poland.(Indufor; 2013). See Figure A1.4.

Figure A1.4 Newsprint consumption by the main consumers in EU-27, over the 2000-2011 and forecast 2012-2016



Source: Indufor, 2013

- Free newspapers in Europe were a new concept in the newsprint market. They showed a permanent growth until 2007. From 2008 on, circulation declined from 26 million to 15 million (10% per year on average). Competition between free dailies increased from two per country in 2000 to five in 2007 and 2008. Yet, in 2012, that number dropped to three. (Bakker P.; 2013).

- Migration of readers to free news on-line has been observed. The global percentage of total information printed is decreasing, 30% of printed versus 70% of digital. as reported by Pira International (2009)
- Technology changes have been occurring: e.g. digital printing, which allows for on-demand printing, short turnaround time, and even a modification of the image (variable data) used for each impression. Potential for distributed digital printing of newspapers – leading to customised newspapers – is small at present but growing.

Drivers

- A growth in printing output is mainly restricted to printed packaging and digital print. (EC; 2013)
- The graphic industry is dependent on advertising
- Relocation of printing activities to third countries are driven by volume to be produced; time for delivery; importance of labour cost and manual operations in products. So far, the most affected categories of products have included: other books, children books, calendars/greeting cards and other printing.
- Positive factors influencing demand for printing papers: population growth; increasing literacy; increasing life expectancy; increasing number of households; improved print quality; growth of inserts and flyers; increasing copier and PC populations, especially in emerging markets (Pira International; 2009)
- Negative factors influencing demand for printing papers: growth of electronic media and communications channels; diversion of advertising spend to other media; volatility of advertising spend; declining basis weights; sustainability concerns (reducing paper usage); stagnating population growth in developed countries, e.g. Europe and Japan. (Pira International; 2009)
- Emotional need for hard copies: individual printing of text and photos; on the other rising environmental awareness leading to reduced consumption of paper.
- The Indufor (2013) expects the trend of decreasing newsprint consumption to continue especially in the UK. Germany will probably start to decline in the next few years. There will likely be some decline in most of the Member States. Similar forecasts are for printing and writing papers, as there are no other issues in the market, which would indicate a change in direction (Figure A1.3 and Figure A1.4)

A1.1.2.3 Energy Growth Rates for Pulp Paper and Printing Industry

- The pulp and paper industry (PPI) is the sixth largest industrial energy user in Europe and the single largest industrial user of biomass, using approximately 102 TWh of electricity and 330 TWh of thermal energy annually, out of which 55% originates from biomass, during 2009 (Jönsson; 2011).
- In EU-28, final energy consumption has remained relatively steady over the years (4% decrease in 2011 compared to 2001) (Eurostat; 2013a)
- Pulp, paper & print industry contributes to 11% of total energy consumption by the EU-28 industry (Eurostat; 2013a)
- Table A1.3 presents energy consumption by pulp, paper and print industry over 2000-2011. In 2000 the industry in eleven Member States consumed more than 1,000 Mtoe, with Finland, Sweden and Germany being the largest energy consumers. By 2011, the majority of these countries recorded a decline in energy consumption, except Germany (the highest increase over the years, 32%), Poland (11%) and Portugal (5%).

Table A1.3 Energy consumption (Million tonnes oil equivalent; Mtoe) by the pulp, paper & print industry per Member State over 2000-2011

GEO/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Change 2011 over 2000
Romania	319	295	356	477	286	266	251	251	121	90	165	68	-79%
Ireland	63	64	60	56	58	45	43	26	26	26	25	26	-59%
Greece	169	159	162	175	139	128	146	146	139	123	121	92	-46%
Luxembourg	20	27	31	31	27	26	20	16	18	17	13	11	-45%
France	3,570	3,403	3,489	3,493	3,264	2,912	3,182	2,673	2,468	2,182	2,360	1,995	-44%
Netherlands	1,003	945	970	952	983	976	973	934	907	725	752	704	-30%
Spain	2,093	1,913	2,180	2,667	2,292	2,488	2,184	2,403	2,176	1,927	1,429	1,477	-29%
Slovenia	213	197	217	229	259	278	234	205	194	191	179	170	-20%
Italy	2,640	2,681	2,719	2,798	2,867	2,736	2,771	2,837	2,567	2,433	2,412	2,246	-15%
Sweden	5,991	5,665	5,560	5,543	5,513	5,606	6,076	6,187	5,957	5,911	6,718	5,277	-12%
Finland	6,572	6,195	6,250	6,184	6,420	5,753	6,632	7,429	6,841	5,553	6,259	6,142	-7%
United Kingdom	2,340	2,440	2,371	2,439	2,373	2,708	2,551	2,447	2,544	2,199	2,227	2,229	-5%
Hungary	164	167	174	179	169	170	175	161	167	137	159	157	-4%
Austria	1,443	1,551	1,464	1,549	1,513	1,598	1,600	1,619	1,605	1,483	1,656	1,435	-1%
Lithuania	42	49	34	31	22	24	24	26	24	33	54	43	2%
Portugal	1,245	1,199	1,173	1,212	1,098	1,177	1,178	1,191	1,232	1,212	1,280	1,304	5%
Denmark	136	150	141	164	159	149	150	138	143	145	145	146	7%
Croatia	79	85	81	83	92	101	101	90	84	85	93	87	10%
Poland	1,121	1,111	1,125	1,200	1,219	1,202	1,210	1,196	1,177	1,211	1,261	1,244	11%
Latvia	7	8	9	10	10	11	12	10	10	11	9	8	14%
Czech Republic	485	535	626	404	428	630	630	661	612	593	607	599	24%
Germany (until 1990 for	4,574	4,591	4,481	4,528	4,901	5,133	4,997	5,671	6,160	5,616	6,244	6,017	32%
Estonia	43	41	44	43	34	32	46	56	54	52	67	64	49%
Belgium	534	513	554	601	641	617	710	838	735	757	827	799	50%
Cyprus	1	1	1	1	2	2	2	2	2	2	2	2	100%
Bulgaria	103	75	143	162	193	196	165	172	171	68	190	219	113%
Slovakia	227	436	425	480	488	486	514	565	553	632	530	501	121%

(Eurostat, available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home)

Note: *Malta does not have the pulp, paper & print industry, thus it is not included in the table above.*

Range of subsectors:

- Table A1.4 presents the key economic indicators per sector and subsector within the Pulp, Paper and Printing industry.
- Key economic indicators for the paper industry per Member State are given in Table K and for the printing industry in Table A1.4.

Table A1.4 Key economic indicators per sector and subsector

Description	NACE	Number of enterprises	Number of persons employed	Turnover	Value added	Personnel costs	Investment in tangible goods	Production value
				EUR million				
Manufacture of paper and paper products	**C17**	**19,394**	**588,500**	**176,977**	**41,564**	**25,079**	**6,721**	**168,216**
Manufacture of pulp, paper and paperboard	C17.1	2,137	169,818	82,042	16,899	9,211	2,955	78,783
Manufacture of articles of paper and paperboard	C17.2	17,257	418,682	94,935	24,664	15,868	3,766	89,433
Printing and reproduction of recorded media	**C18**	**109,101**	**628,786**	**74,347**	**27,678**	**18,469**	**3,484**	**72,974**
Printing and service activities related to printing	C18.1	104,117	610,612	71,101	26,689	17,841	3,373	69,946
Reproduction of recorded media	C18.2	4,984	18,174	3,246	989	628	111	3,028

Source: Eurostat data, 2011

***Note:** Eurostat provides data per Member State for indicators (e.g., annual turnover, number of persons employed) based on NACE codes of the format AXX.XX (e.g., NACE C17.12). In addition to this level of granularity, Eurostat provides aggregated values of the overarching NACE codes. This would be codes C17 and C17.1 in the case of C17.12. However, due to limitations inherent in the current Eurostat database, these aggregated values do not always match the sum of their parts. For example, the sum of C17.1 and C17.2 does not equal the Eurostat aggregated value for C17. In most cases, such discrepancies have been found to be minor. Therefore, the selected approach for analysis has been to use sums of the parts (i.e., sum of C17.1 and C17.2 to represent the overall code C17).*

Table A1.5 Key indicators; manufacture of paper and paper products (NACE Division 17)

Countries	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE – Belgium	267	4,971	4,782	1,084	721	144	12,977
BG – Bulgaria	507	427	408	94	36	28	9,090
CZ - Czech Republic	958	2,562	2,375	536	290	160	19,155
DK - Denmark	155	1,239	1,179	0	0	40	4,836
DE – Germany	1,754	42,090	39,145	9,395	6,608	1,383	142,513
EE – Estonia	46	213	201	56	20	15	1,349
IE – Ireland	113	520	498	182	134	6	3,206
EL – Greece	0	0	0	0	0	0	0
ES – Spain	1,820	13,435	12,985	3,390	1,892	575	47,016
FR - France	1,419	18,955	17,145	4,026	3,258	920	67,465
HR - Croatia	347	383	366	94	57	24	5,000
IT – Italy	4,155	22,198	22,198	4,711	2,898	682	74,441
CY - Cyprus	38	54	53	19	14	2	614
LV – Latvia	97	0	0	0	0	0	1,419
LT - Lithuania	89	285	279	71	35	24	3,284
LU - Luxembourg	3	0	0	0	0	0	0
HU - Hungary	556	1,509	1,332	309	152	96	10,999
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	354	6,221	6,016	1,528	950	167	18,268
AT - Austria	142	6,266	5,914	1,710	960	221	16,679
PL - Poland	2,590	7,090	6,918	1,809	640	457	54,785
PT - Portugal	495	3,632	3,620	832	295	110	11,267
RO - Romania	674	754	723	162	71	62	11,826
SI - Slovenia	172	737	709	144	97	55	4,368
SK - Slovakia	292	1,296	1,210	292	110	50	7,219
FI - Finland	195	14,437	13,866	2,939	1,534	307	25,580
SE - Sweden	476	14,396	14,426	3,719	2,116	790	35,144
UK - United Kingdom	1,680	13,308	11,871	4,465	2,192	403	0

Source: Eurostat data, 2011

Table A1.6 Key indicators; printing and reproduction of recorded media (NACE Division 18)

Countries	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	0	0	0	0	0	0	0
BG - Bulgaria	1,117	306	296	91	39	0	9,626
CZ - Czech Republic	0	0	0	0	0	0	0
DK - Denmark	925	0	0	0	0	0	0
DE - Germany	12,547	21,967	21,823	7,734	5,889	928	170,573
EE - Estonia	318	207	197	66	37	9	2,819
IE - Ireland	359	1,067	919	341	238	9	5,768
EL - Greece	0	0	0	0	0	0	0
ES - Spain	14,821	7,022	7,023	2,873	1,984	263	71,001
FR - France	16,563	0	0	0	0	370	77,967
HR - Croatia	1,698	548	473	166	100	19	8,861
IT - Italy	16,577	12,014	12,162	3,928	2,566	468	94,596
CY - Cyprus	0	0	0	0	0	0	0
LV - Latvia	418	156	158	42	22	17	2,776
LT - Lithuania	425	168	170	56	29	8	3,732
LU - Luxembourg	97	0	0	0	0	0	0
HU - Hungary	3,658	911	715	229	139	45	16,253
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	4,036	4,660	4,531	1,700	1,257	167	29,608
AT - Austria	914	2,507	2,438	1,031	665	115	13,917
PL - Poland	8,621	2,669	2,583	852	429	165	46,545
PT - Portugal	3,096	1,095	1,074	458	303	71	17,778
RO - Romania	1,872	705	701	239	99	69	17,672
SI - Slovenia	1,218	431	412	137	87	24	4,923
SK - Slovakia	1,455	396	363	119	68	35	6,697
FI - Finland	1,163	1,425	1,446	537	411	50	10,448
SE - Sweden	3,278	2,729	2,732	955	788	128	17,226
UK - United Kingdom	13,925	13,365	12,759	6,125	3,321	523	0

Source: Eurostat data, 2011

Main players:

The Pulp and Paper Industry

- Pulp and paper is relatively concentrated around medium (50-240 employees) and large enterprises (>250 employees). Larger companies are concentrated in pulp and paper sector, whereas amongst the paper and board converting side, SMEs are more common (EC; 2013)
  - In Finland and Sweden more than four fifths of the value added from paper and paper products manufacturing stemmed from large enterprises. The lowest contributions from large enterprises, across the EU Member States, were recorded for Italy, Romania and Greece (2009 data), while there were no large enterprises in this sector in Cyprus or Latvia. The value added share of medium-sized enterprises exceeded 50 % of the total in Latvia, Greece (2009 data) and Ireland, as well as Croatia, and was also above two fifths of the total in the Netherlands, Lithuania and the UK. Although small enterprises provided only 10.8% of the EU-27's value added in the paper and paper products manufacturing sector in 2010, their share reached 55.1 % in Cyprus and was also more than twice the EU-27 average in Latvia, Italy and Romania (Eurostat; 2013b).
- Number of companies increased by 8% over 2003-2010, the only increase noted in the Forest-based Industries (F-BI) (EC; 2013)

The Printing Industry

- Printing sector is dominated by SMEs (<250 employees) and microenterprises (<10 employees) with relatively few large firms and only a handful of very large and multinational companies. Printing companies operate mainly in domestic markets (EC; 2013)
  - SMEs contributed at least three fifths of value added within the printing and reproduction of recorded media sector in 2010, ranging from 62.6% in Slovakia to 99.8% in Cyprus and 100% in both Denmark and Latvia. The value added share of micro enterprises in the printing and reproduction of recorded media sector reached over 40.0% in Cyprus and Greece (2009 data), around twice the EU-27 average, while medium-sized enterprises (employing 50 to 249 persons) generated more than half of the sectoral value added in Latvia, Ireland and Bulgaria (Eurostat; 2013c).
- Number of companies decreased by 9% over 2003-2010 (EC; 2013)

Trade flows:

- Across the EU Member States there are variations related to the absolute and the relative importance of the F-BI sub-sectors nationally, their consumption of F-BI products, and their export performance. This is because some MSs are net exporters of wood-based goods, some net importers, and others both producers and traders (EC; 2013).
- Over 90% of wood raw material comes from the EU forest; with the remainder being imported from Russia and other neighbouring countries, as well as North America and very small amounts of tropical woods (EC; 2013)
- The paper and board industries in Austria, Germany, Spain, Hungary, Sweden, Slovenia and Lithuania are dependent on imported recovered paper, which is sourced mainly from other Member States (Indufor; 2013).

Wood Pulp

- Europe is a net importer of pulp (Figure A1.5) and Brazil is a major supplier (Figure A1.6). About 75% of the pulp is produced in Group A countries (net exporters), 17% in

Group B (traders) and the rest 7-8% in Group C countries (net importers)[237]. A majority of European pulp (>60%) is produced in Scandinavia, mainly in Sweden and Finland (Jönsson; 2011).

- The biggest European pulp importer is Austria, followed Germany, Sweden and Finland (Figure A1.7). Pulp exports from the EU are almost three times lower than imports to the EU. The main destination is China (Figure A1.5).

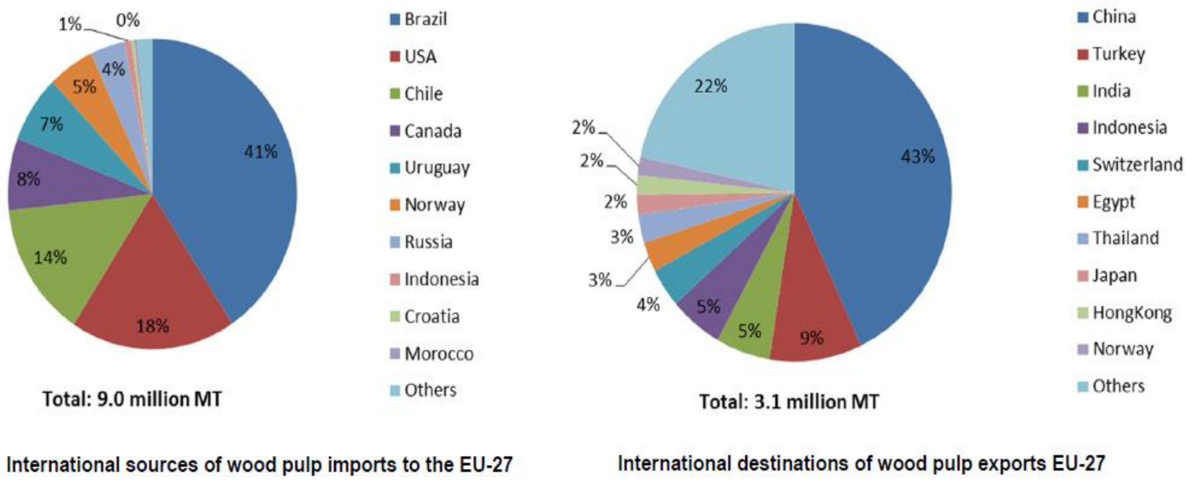
Figure A1.5 Pulp Trade Flows in CEPI countries in 2011

Source: Indufor, 2013

***Note:** CEPI = EU-27 [minus (Bulgaria + Cyprus + Denmark + Estonia + Greece + Ireland + Latvia + Lithuania + Luxembourg + Malta)] + Norway + Switzerland*

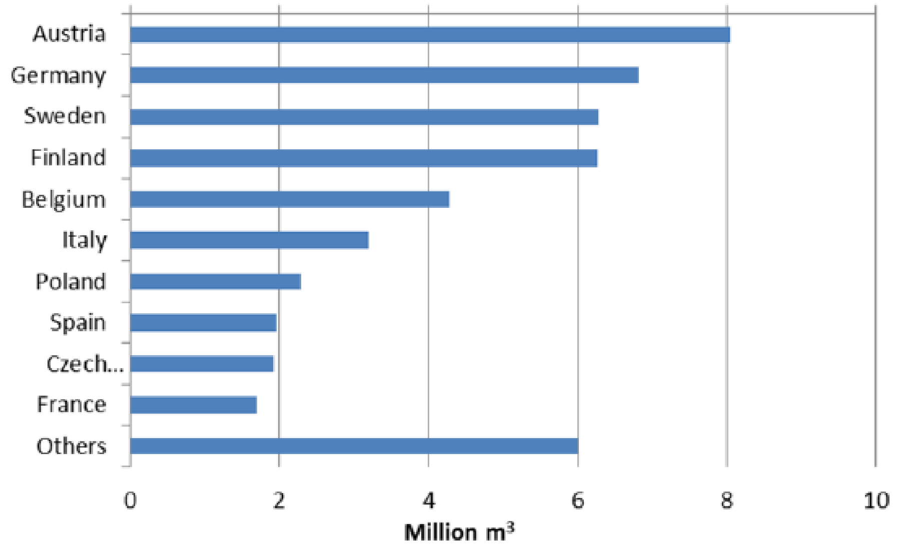
[237] The Indufor study (2013) divides countries into three groups: Group A (net exporters) includes Austria, the Czech Republic, Estonia, Finland, Latvia, Lithuania, Portugal, Slovakia, Slovenia, Sweden; Group B (importer and exporter) includes Bulgaria, Cyprus, France, Germany, Hungary, Italy, Luxembourg, Poland, Romania, and Group C (net importers) includes Belgium, Denmark, Greece, Ireland, Malta, the Netherlands, Spain, the United Kingdom

Figure A1.6 International sources of wood pulp imports and exports, E-27, 2011



Source: Indufor, 2013

Figure A1.7 Major importers of wood pulp EU-27

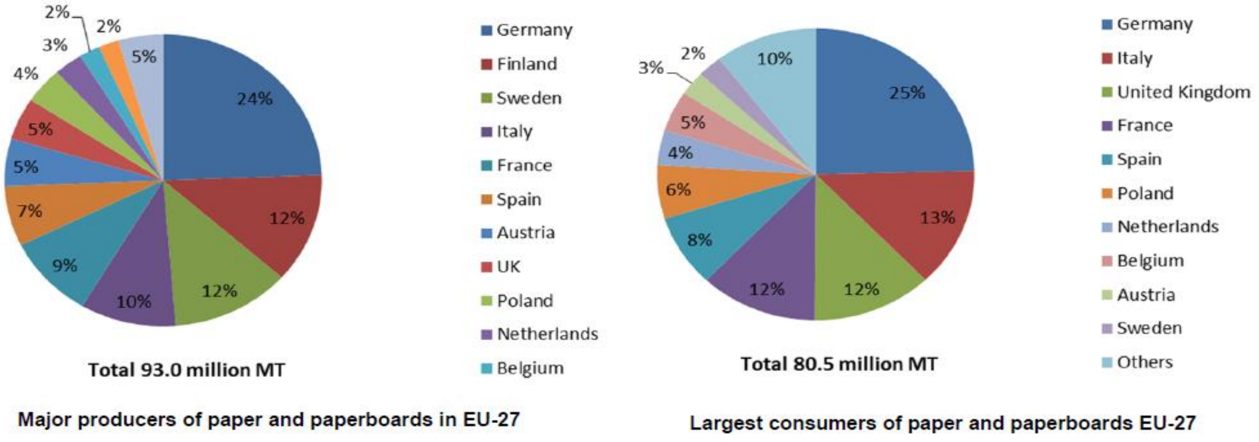


Source: Indufor, 2013

Paper and Paperboard

- The EU-27 produces more paper than it consumes (6% more in 2000, 16% in 2011). The major producer and consumer is Germany (Figure A1.8).

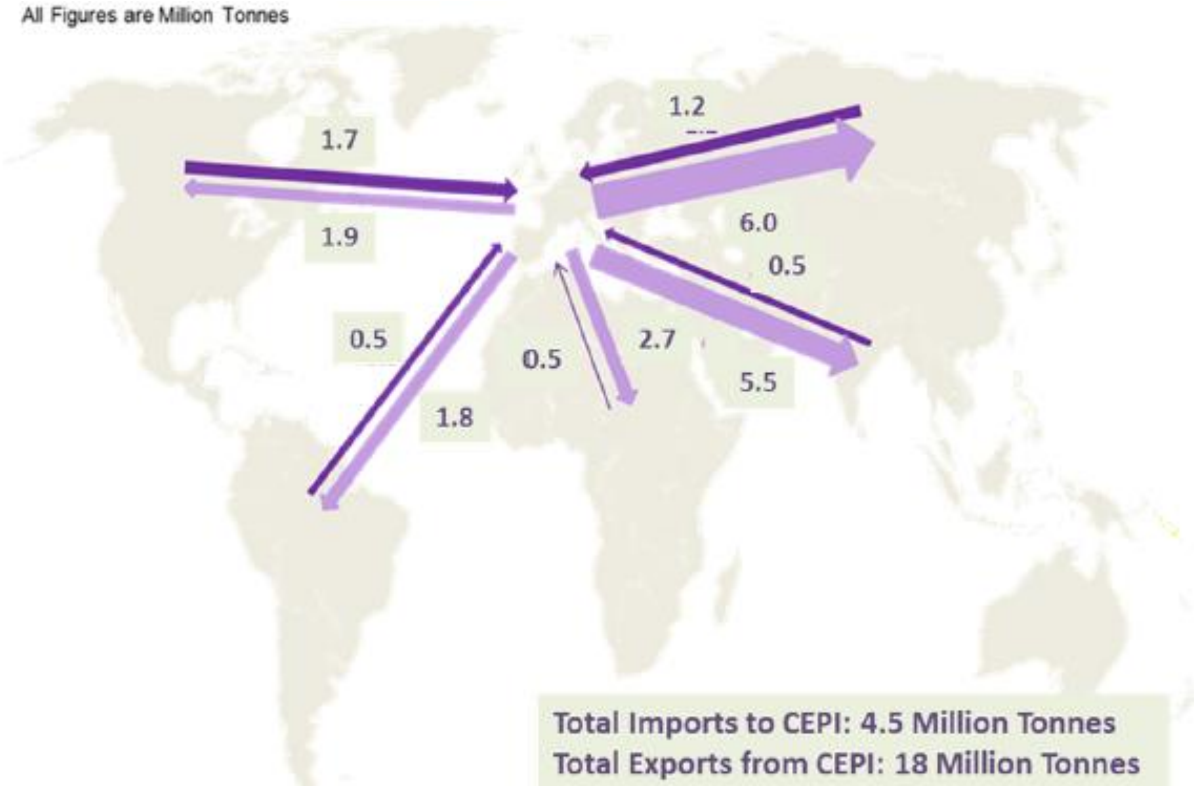
Figure A1.8 Major producers and consumers of paper and paperboard in the EU-27, 2011



Source: Indufor, 2013

- Europe is a net exporter of paper and paperboard, four times more is being exported than imported (Figure A1.9). Major outlet markets for European paper and paperboard are Russia, China, Japan, Turkey North America, and Brazil (Induforl 2013).

Figure A1.9 Imports and exports of paper and paperboard in CEPI countries, 2011 (Indufor; 2013)



Product type and consumer groups:

Pulp

- There are four grades of pulp: chemical (70% of pulp consumed), mechanical (25%), dissolving, and semi-chemical.

Paper and Paperboard

- In paper and paperboard production both virgin fibres and recovered paper are utilised as raw material. Packaging has the highest raw material use; with ca.75% being recovered paper. Fresh wood fibre is highly used in the printing and writing industry (over 85% of its raw material use) (Indufor; 2013).
- Paper and paperboards are consumed by: graphic papers (including newsprint); printing & writing; hygienic products (including sanitary and household); packaging (including corrugated boxes, folding boxes, beverage cartons, solid board boxes, paper sacks and flexible packaging) and others (e.g. wallpaper, bookbinding).

Printing

- Printed products include: newspapers, magazine production, catalogue production, general commercial printing, stationary/business forms, books and publications, advertising materials, direct mail, greeting cards, transactional print (e.g. bills and transactions), and non-media products (e.g. pharmaceutical test strips or parts for solar cells). New products have been emerging, such as print to web communication (QR Codes link the printed product to electronic media (website, video etc.)) and printed electronics (batteries, circuits, RFID, OLEDs, solar cells etc.).

A1.1.3 Business environment

A1.1.3.1 What are the key competitive strengths?

The Pulp and Paper Industry

- Significant industry in Europe: €81bn of turnover; €18bn of added value; 60% of direct and indirect jobs in rural areas; European paper value chain generates €100bn of added value and provides to 1,600 thousand jobs. (Presas T.; 2013)
- Around 90% of the initial wood raw material input to the EU F-BI comes from sustainably managed EU forest (EC; 2013). Very significant European base. Surplus in wood supply predicted by EFSOS through 2030.
- In paper production, increasing use of recovered raw material, which reduces the pressure on primary raw material. Paper recovery and recycling, linked to increased processing efficiency, have allowed a substantial production increase without the need to use more new wood.
- The high level of expertise and continuous research and innovation enables the exploitation of new business models, development of novel products and applications, and technologies, progressing toward a low-carbon bio-economy (EC; 2013). Excellent sectoral knowledge centres.
- The industry has become more self-sufficient: 95.2% of electricity is produced using the combined heat and power method compared to total on-site electricity generation in paper mills. Bioenergy accounts for 56% of the sector's energy use. Also, the sector is the largest industrial producer of bioenergy, generating 20% of the biomass-based energy in Europe. (CEPI; 2013b). Some pulp mills even export electricity to the grid.
- Proximity of large, sophisticated domestic market and nearby export markets.

The Printing Industry

- High fragmentation facilitates reacting to niche markets and local needs, and gives flexibility to respond to consumers' variable orders in ever-shortening lead times and small print runs (EC; 2013)
- The emergence of new media and technologies supports the building of closer relationships with customers and creating more added value through diversified services The examples are: the introduction of customisation features in print; the management of databases; the production of short runs and electronic storage for later runs; the production of electronic versions; cross-media publications; comprehensive communication solutions; web-based communication solutions; e-business solutions; routing and dispatch, storage facilities, etc. (DG Enterprise and Industry)
- Excellent track record of environmental and social performance, and using it as differentiating factor from non-EU, low-cost competitors (EC; 2013)
- Modern and efficient production tools (Intergraf; 2008)
- The postal industry remains the only effective communication network that is guaranteed to reach 100% of Europe's citizens. This fact is enshrined in European law. The postal industry provides a strategically essential service that simply cannot be replaced.

A1.1.3.2 How are these advantages envisaged as changing over the next 10-15 years?

The Pulp and Paper industry

- Paper consumption is still growing in those countries that have joined the EU more recently. However, the consumption levels of printing and writing papers and newsprint per capita will not grow to the same level as the consumption in the old Member States, as it is more practical to move directly to the digital media. (Indufor; 2013)
- The industry is approaching a transitional situation – where it is no longer only producing pulp and/or paper but also producing additional products which can increase both the mill profitability and the overall mill energy efficiency – thereby transforming mills into so-called biorefineries. These additional products can be electricity, district heating, wood pellets, dried bark chemicals, materials, biofuels etc. (Jönsson; 2011).
- The industry has been producing original bio-based products (e.g. water-repellent fabrics, smart packaging, second generation biofuels and concept cars) made fully of cellulose- based material. It has the experience, technology and supply chain to play a big part in the bioeconomy. (CEPI; 2013b)
- EU industry will further embark on higher innovation

The Printing Industry

- There is a need for enhanced research and innovation to provide new paper-based products with added functionalities such as paper-printed electronics. These new products could exploit the sustainability of the support (i.e., paper) but provide the user with added functionality beyond simple printed paper, resulting in new markets and higher added value for the printing industry (EC; 2013)
- The paper-based version of a service will, in many cases, be transformed into a digital format and then re-materialise as a print-out. Print effectively complements information and communications technology (ICT) in distributing and communicating information. New technologies enable print products to link with online applications (via smartphone or webcam) and thus turn print into an interactive medium. (PMG; 2012)
- New product developments, such as temperature-sensitive paper, paper batteries, digital printing equipment, touch-surface print applications, and intelligent paper, pave the way

for entry into new markets. Today's printing house can offer database management, storage, fulfilment, online services, integrated graphic design and web hosting. Also, digital technology has allowed publishers to reach audiences in new ways. Regional newspapers, for example, can now be accessed from around the world. Finally, web-to-print offers a range of commercial opportunities for personalised products, from greeting cards and posters to short-run books and individualized photo albums. (PMG; 2012)

A1.1.3.3 What are the main threats which currently impact on the sector?

The Pulp, Paper and Printing Industry

- Competition for raw materials with bio-energy and in the future emerging bio-based industries (EC; 2013).
  - The greater the need and growth of biofuels, with associated subsidies, the more the pulp and paper producers will have to compete with fuel producers for the wood instead of only for wood residues (Indufor; 2013). As a consequence of this competition, wood prices may go up.
  - The supply of suitable paper for recycling is threatened by its energy generation potential. Incineration should be the final destination for fibre, only after all possibilities for creating value through new paper products have been exhausted.(CEPI; 2013b)
- Impact of electronic media: consumption of some paper grades and printed paper goods is declining and is only partially compensated by increases for other formats such as printing on plastics and textiles (EC; 2013). In some media, like newspapers, the trend towards e-media has persisted already for a decade (Indufor; 2013)
- Profit margins for has been approximately halved (10% gross margin) over the period of 2000 to 2012. (Poyry; 2013).
- Increases in wood prices further squeeze thin margins which cannot be compensated either through by-products or sales prices. This is especially the case for pulp & paper sector (EC; 2013);
- High labour costs, which up to now have been compensated through high labour productivity (EC; 2013)
- Energy is a significant cost item (oil, gas and electricity): paper and printing sector has 2-3 times higher electricity and gas intensities than the EU average of ca. 600MWh/Million EUR; sectoral energy purchase costs accounted for 5-6% of total production costs in 2010 (whereas, industrial EU average was around 2.5%)[238]
- – EU energy fuels are expensive to other global F-BI producers (i.e. US, China, Russia), e.g. electricity prices for industrial consumers are more than double those in the US, and 20% higher than in China; European gas import prices are around three times higher than in the US (EC; see footnote[239])
- The EU environmental, climate change, energy and transport policies also have major influences on the future of the sector (EC; 2013)
- Ageing workforce (EC; 2013)

[238] Source: European Commission (EC); 2014; *Energy prices and costs report*; SWD(2014) 20 final/2

[239] Source: European Commission (EC); 2014; *Energy prices and costs in Europe*; COM(2014) 21 /2

The Pulp and Paper Industry

- Export tariff barriers restricting market potential: the sector is increasing its share of exports outside the EU. Yet, tariff barriers, applied to nearly half of the exports and protectionist subsidies for rival goods, create an uneven playing field. On the raw materials supply side, taxes and exports duties imposed by EU trade partners on wood exports, notably by Russia, also raise concerns, especially when combined with heavy bureaucracy. Fibre raw material, from primary and secondary sources, represents the highest share of production costs, thus its availability at affordable prices is crucial for the sector (EC; 2013)
- Weak enforcement of import rules: the lack of rigour in the surveillance of the European paper market penalises the local industry for complying with European standards and legal requirements. (CEPI; 2013b)
- Growing supply of low-cost and high-quality imports of commodity-grade papers, especially from China (DG Enterprise and Industry)
- Phytosanitary issues (e.g. pinewood nematode outbreak risks reducing raw wood supply from EU forests) (DG Enterprise and Industry)
- Impact of climate change on forest health and productivity (DG Enterprise and Industry)

The Printing Industry:

- Low level of consolidation and limited R&D activities: there are a lot of printing companies employing less than 10 people and without any technical expert. The current market conditions force them to give the customers a quick service, so they don't have enough time for studying the legislation and developing variations on their processes (BATsGRAPH; 2009).
- Weak negotiation position: many printers face a small group of large suppliers for paper and machinery (Intergraf; 2008)
- The increasing costs of production in Europe, specifically energy, raw materials and labour costs, have further decreased margins. The relative concentration of printing sector suppliers places it, also, in a disadvantaged position (EC; 2013)
- Structural over-capacity: estimated at up to 30%, as result of a declining demand for many printed products, increasing global competition and improved machinery productivity (EC: 2013)
- Intense price war and growing presence of third countries: competitors from low-cost countries, notably Asia, are capable to fulfil the European consumers' standards in terms of quality and are putting strong pressure on prices. Consequently, imports from China of printed products to the EU have increased more than four-fold over a decade (EC; 2013). Imports are particularly touching categories of books, children books, calendars and greeting cards. Thus, products involving a large amount of manual labour.
  - Limited legal enforcement of intellectual property rights (e.g. copies of European printing machines have been seen at Chinese trade fairs) (Intergraf; 2008)
- Increased financial institutions' reluctance to provide loans to SMEs often lacking financial capacity (EC; 2013)
- Risk of unemployment intensified by the workforce's low mobility, partly due to specialised skills, unique to this sector but which are non-transferable (EC; 2013)
- Investment focus on equipment acquisition. R&D and other immaterial investments are more marginal (Intergraf; 2008; EC: 2013)

A1.1.3.4 How are these envisaged as changing over the next 10-15 years?

The Pulp and Paper industry:

- The competing demands for wood from the EU woodworking products (WP), pulp & paper (P&P) and bio-energy sectors will continue being an issue. By 2016 the EU is forecasted to face a shortfall from EU sources of 63 million m³ of RWE240 per annum in trying to meet the EU renewable energy targets. Thus, imports will need to fill the gap (Latin America and Southeast Asia), if internal EU resources cannot be mobilised. However, EFSOS predicts a surplus of wood supply in the EU through 2030, which could offset these threats.
- Continuing decrease in graphic paper consumption is expected as a result of the growing pace of digitalisation and changing lifestyles. However, this is counterbalanced by growth in packaging and hygiene papers, mainly due to demographic trends in Europe (EC: 2013)

The Printing Industry:

- Relocation of activities to rise: imports of printed products that are not time-sensitive are likely to continue increasing. Even though magazines have been still low in total imports, as they are a time sensitive product and thus less likely to be produced in far east countries, the increase that can be noted at least for Germany seemed to suggest that this market is currently being explored and will further increase in the near future as obviously efficient means and times of transport have been identified.[241]
- The impact of external factors can differ according to organisational size. SMEs, although at great risk, have the ability to accommodate to changes in market needs more swiftly than large companies. Large companies are primarily struggling with overcapacity, which has resulted in a huge price war across the industry. Intergraf (2011) states that 5% of interviewed companies viewed closure as an option in the short term; 47% saw ceasing to operate as a longer term scenario; while 45% considered they may have no option but to sell. Other defensive strategies included: reducing the size of plant, equipment and numbers of staff (36% in the longer term). More consolidation can be expected (PMG; 2012)
- Direct mail is expected to survive (more targeted and personalised campaigns); newsprint is expected to decline further as a result of falling advertising revenues (in Western Europe; the decline was about 30% between 2000-2010)[242], but might be minimised in the short term by free newspapers; office paper use will decline as a result of substitution effects. (Pira International; 2009)
- Print media has proved to be more resilient than widely predicted. Many consumers have a strong attachment to printed newspapers, even while they also access journalism online. In the UK, for example, 32.9 million read a regional or local newspaper every week in 2011, making this the most widely read print medium in Britain. Co-existence of print and digital newspapers therefore looks like the reality for many years to come. The trend towards Internet news readership shows no signs of slowing; with the number of unique visits to popular news websites showing exponential growth. (ENPA; 2012)
- Although print advertising is projected to rise, two thirds of the increases in total advertising revenue will be due to online advertisements. Similarly, digital newspapers

[240] RWE = roundwood equivalent, i.e. how much wood raw material is needed for a given quantity of product.

[241] Intergraf, *The printing industry China and the EU*, 2006. Available at: http://www.egin.nl/downloads/Annual_2008/Report-China%20Study%20Intergraf.pdf

[242] Intergraf; 2011

are expected to contribute to more than 75% of total sector growth and ca. 97% of growth in sales between 2010 and 2015. (ENPA; 2010)

- According to Veihmas Kaisa & al (2011), the European printing industry must increase production efficiency and flexibility, increase the value of printed products or launch new applications and services exploiting printing competence.

A1.1.3.5 Business strategy and decision making

The Pulp and Paper industry:

Both energy and resource efficiencies represent technological challenges for the EU forest-based industries:

- Progress is needed to increase forest management efficiency as part of an overall policy framework supporting the sustainable supply and cascading use of wood resources, in addition to energy efficiency (EC; 2013)
- Considering that the paper recycling rate in Europe is very close to its maximum limit, as determined by deteriorating quality and the non-collectable and non-recyclable fractions, efforts need to be directed to improvements in collection and sorting systems and technology. This would increase the quality and availability of the secondary raw material. Yet, the European industry may need to compete for this secondary raw material with the increasing recovered paper exports to third countries, notably to China. To ease such competition, the EC (2013) suggests the follow up of the feasibility study of applying a global certification scheme for recycling treatment facilities to the export of waste streams, which would build on environmentally-sound management criteria.
- Innovations to current industrial processes aiming at energy efficiency and adding more value to the raw materials - such innovations could provide, in parallel to the traditional outputs of the industry, new products that could be utilised by other industrial sectors, with creations of new “bio” value chains and higher value creation by the forest-based industries.
- Knowledge sharing should be enhanced, e.g.: (i) of good practice, especially amongst small and micro firms, on successful resource- and energy-efficient measures for wood-processing; (ii) of the pioneering work done by the printing sector on socially responsible restructuring which could be transferable to other sub-sectors; (iii) experience in the EU printing sector with group energy purchase and also long-term, fixed-price contracts, including for the purchase and sale of energy, which could be explored by other forest-based industries sub-sectors (EC; 2013)
- Areas for further research and investment:
  - Nano-materials; intelligent packaging products, end-products with less raw materials (e.g. light-weight paper grades for packaging), resource efficiency using the "cascade principle"243. (EC; 2013)
  - Following the Confederation of European Paper Industry’s (CEPI) launch of the Forest Fibre Industry 2050 Roadmap in 2011, CEPI issued a report describing breakthrough technologies that would be needed by 2030 to achieve sector’s reduction of its fossil-based CO_2 emissions by 80% while at the same time creating 50% more added value. Eight concepts are described in detail, and CO_2 and energy savings are estimated for each. These are: Deep Eutectic Solvents; Flash

[243] Note: CEPF, the Confederation of European Forest Owners, does not support the legally binding application of cascade principle. See for more detail: http://www.cepf-eu.org/vedl/Joint%20statement%20on%20cascade%20use.pdf

Condensing with Steam; Supercritical CO2; 100% electricity; Steam; DryPulp for cure-formed paper; Functional Surface; the Toolbox to replicate (CEPI; 2013).

- New processes, products and markets require high levels of academic qualifications, laboratory and workshop techniques and industrial awareness. As such, retraining as well as appropriate course development, to be applied through life-long learning will be increasingly important (EC; 2013)

The Printing Industry

- Printed Products are standardized products which can be produced with the machines available to anyone everywhere – printers have to be innovative in order to sell more than just a commodity.
- Hardly any cooperation of printers in order to face customers' demands, however, alliances between printers could change the disadvantage of fragmented industry structure into an advantage.
- New growth basis: Move from a commodity business to a high value added industry; integrate some new competences such as marketing, design, sales management, strategic planning etc. Give value to additional services in order to generate new income and better position the company on the market.
- General up skilling will be essential: 57% of companies surveyed by Integraf (2011) were considering retraining existing staff; while 38% were looking at recruitment of staff with different skill sets.

A1.1.3.6 Mitigation activities

The Pulp and Paper Industry

- Although pulp and paper manufacturing sector is energy- and raw materials–intensive, with high capital costs and long investment cycles, EU industry has an excellent track record in resource-efficiency and innovation (EC; 2013)
- EU pulp and paper industry is demonstrating continuous improvement in reducing production cost. There is also further strategic consolidation and procurement of low-cost production assets in Eastern Europe and Russia. Additionally, the sector is also demonstrating significant divestments into non-core businesses. The EU industry requires further re-examination and improvement of its existing operating models in order to sustain growth and profitability. (Poyry; 2013)
- Over the last two decades, it has substantially reduced all environmental emissions and also water and energy consumption, effectively de-coupling all of these from production growth, thanks to improved process efficiency. It has become more energy self-sufficient and less CO2-intensive by generating more than half of its primary energy from biomass. Thanks to the voluntary, industry-led initiatives in addition to legislative measures, the paper recycling rate in Europe exceeds a high level of 70% and raw materials used in paper and board production and converting come from sustainable sources (EC; 2013)
- Despite the high penetration of cogeneration in the pulp and paper industry, it is estimated that only 40% of Combined Heat and Power (CHP) potential capacity has been installed in this industry. One of the main barriers to expansion is the 'spread price' – the difference between the price of the fuel used by the CHP and the price of the electricity generated. Priority grid access and dispatch for CHP electricity sold back to the national grid would lead to a quicker and wider implementation.(SETIS)
- Future improvements:
  – Jönsson (2011) in her study argues that the energy use and thus on-site emissions of CO_2, in the pulp and paper industry (PPI) are associated with only a few

geographical sites, i.e. mills. Due to this fact, making changes in the energy system at only a limited amount of mills can have significant impact on the European energy system as a whole and consequently also on the emissions of CO2. She focused on thermal energy efficiency and implementation of selected new concepts based on the thermal characteristics of different mills. Her research shows that kraft pulp mills, proven pathways, such as increased electricity production and district heat production, are economically robust, i.e., they are profitable for varying energy market conditions. The new and emerging technology pathways studied, Carbon Capture and Storage (CCS), Black Liquor Gasification (BLG) and lignin extraction, hold a larger potential for reduction of global CO_2 emissions, but their economic performance is more dependent on the development of the energy market. Annex 1 presents a list of characteristics for potential technology pathways. The study conclusions are as follows:

a. Using high-temperature excess heat internally gives, in general, a better economic performance and a larger potential for reduction of global CO2 emissions than using the excess heat externally.
b. The new, emerging technology pathways that can be combined with carbon capture show the largest potential for reduction of global CO2 emissions; however, the proven technology pathways show a more robust economic performance
c. The technology pathways giving the largest reductions of global CO2 emissions never have the best economic performance; however, for a future with high CO2 charge, the marginal cost for further reductions is low
d. If lignin can be valued as oil rather than biomass, extraction of lignin shows both a good economic performance and fairly large potential for reduction of CO2 emissions.
e. If electricity is produced from the product gas (BLGCC) and/or if BLG is combined with CCS, BLG holds a potential for large reductions of global CO2 emissions, compared to the other pathways studied.
f. For the European PPI, CCS has an up-hill road in order to be a viable, large-scale alternative for reduction of CO_2 emissions.

- SETIS reports that the prime candidates for further improvement are the boilers, followed by the most energy-intensive part of paper production, the drying of the paper. Out of potential breakthrough technologies, the bio-route aims to develop integrated bio-refinery complexes producing bio-pulp, bio-paper, bio-chemicals, biofuels, bioenergy and possibly bio- Carbon Capture and Storage (CCS). This route includes further development of the gasification of black liquor, which is an energy rich by-product from kraft pulp production. It is currently burned in a recovery boiler to produce electricity and steam for the pulp mill. However, it may be that the use of black liquor for the production of transportation fuels is a better option in economic terms.
- Carbon Trust (2011) states that innovation opportunities having the greatest carbon impact include: low carbon energy supplies; online moisture measurement; optimised dryer operation; and hot press.
- According to Fleiter (2010) to substantially reduce energy demand, radical process innovations will be necessary because the dominant paper making process has been constantly improved over a long period of time. For the future development of energy demand in industry, the production of paper will be the most influential driver, much more influential than the use of energy-efficient technologies. A number of analysed technologies with their energy saving potential is presented in Annex 2.

The Printing Industry:

- Printing companies are at the forefront of improvements in environmental performance in manufacturing, with high adoption rates of environmental management standards, such as ISO 14001, as well as of FSC and PEFC chain of custody accreditations, or further national schemes. The performance of printing processes is constantly being improved by technological developments, allowing the reduction of specific environmental impacts, such as air emissions resulting from the use of solvents. They include substitution of materials, or digital control devices enabling an overall reduction in the use of materials and consumables. The graphic industry is increasingly actively involved in investigating and reducing its carbon footprint and energy consumption. (Intergraf; 2012)
- Further production efficiency could mean that printing presses support a wider range of formats and products more flexibly than before. Hybrid printed products, combining digital and traditional printing, are a case in point. Efficiency can also be improved by moving production methods closer to the end user and using a printing press for processing the printing substrate. (Veihmas K. &al; 2011)

A1.1.4 Sector projections

- Pulp production has experienced a slight decline in production between 2000 and 2011 (Indufor; 2013). Its manufacture is primarily linked to paper and paperboard production, and since the percentage of virgin pulp in paper is declining, so has associated production. However, these declines will be offset by anticipated increases in paper and paperboard production, so pulp production will remain relatively flat.
- While imports of wood material, as well as competition for wood material from emerging bio-based industries is a potential future threat (Indofur; 2013), it is anticipated that the potential supply from forests and other sources of wood in EU will exceed demand until 2025 [Mantau U et al, 2010] and EU wood supply is anticipated to increase up to 2030 [EFSOS II, 2010]. However, it is unclear if the supply is economically sufficient to fulfil both the forest and non-forest based industries beyond 2025.
- Paper and paperboard production has remained relatively constant between 2000 and 2011. In recent years there have been strong declines in newsprint, and some losses in printing and writing paper production due to increasing moves to digital media and communications. This trend is expected to continue through 2020 (Indufor; 2013) and beyond. However, these declines have been offset by increasing production of packaging grade materials and hygenic paper production, which have seen 16% and 23% increases in production between 2000 and 2011 (Indufor; 2013). Moving forward, both types of products are anticipated to increase further to address greater E-commerce sales[244], and demand for household and sanitary products due to an aging EU population. Additionally, paper use in emerging markets, such as bio-based products ((e.g. water-repellent fabrics, smart packaging) is anticipated to increase (CEPI; 2013b).
- In the printing industry, there has been an overall decline in consumption of 14% between 2000 and 2011 (Indufor; 2013) due to significant declines in newspapers, books, from a move towards digital media. Continuing declines are anticipated moving forward due to higher low cost imports which are putting pressure on EU manufactures whose margins are being squeezed by increasing energy, labour and material costs (EC; 2013). While there are some positive drivers for growth, such as printed packaging, digital print (EC; 2013), and emerging products, such as paper batteries, temperature sensitive paper (PMG; 2012), these are offset by growth of electronic media and

[244] http://blogs.forrester.com/martin_gill/13-03-13-european_online_retail_forecast_2012_to_2017_online_growth_will_begin_to_polarize_across_europe

communications channels; sustainability concerns (reducing paper usage); stagnating population growth in Europe (Pira International; 2009). Furthermore, it is estimated that the EU printing industry has structural over-capacity of up to 30%, as result of a declining demand for many printed products, increasing global competition and improved machinery productivity (EC: 2013).

- The printing industry accounts for approximately 30% of EU revenues from the pulp, paper and print sector (Eurostat; 2013a). Consequently, declines in printing are assumed to be offset by increasing demand for paper and paperboard products.
- Overall, production in the pulp, paper and print sector is assumed to increase slowly through 2050 (approximately 0.2% per year)[245], with gains in paper and paperboard production, offsetting print declines. Table A1.7 presents the anticipated Business-as-Usual (BAU) production profile for the sector.

Table A1.7 Projected BAU production of market pulp, paper and paperboard in EU (million tonnes)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Production (MT)	105*	104*	105	106	107	108	109	110	112	113

Based on CEPI statistics

- The pulp and paper manufacturing sector is energy- and raw materials–intensive, with high capital costs and long investment cycles. However, the sector has a good track record in reducing environmental emissions and water and energy consumption, effectively de-coupling all of these from production growth (EC; 2013). Process efficiency improvements are anticipated to continue, as the sector meets exisiting legislative requirements (e.g., EED, IED), and further innovates to develop new products and improve margins. Incremental energy intensity improvements will continue through 2050 reflecting the uptake of recently developed or commercialised technologies (Table A1.8).

Table A1.8 Projected BAU energy intensity trends for production of pulp, paper and paperboard (Thousand tonnes oil equivalent per dried metric tonne)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Energy intensity (TOE/dried tonne)	0.409*	0.405*	0.389	0.373	0.359	0.344	0.331	0.317	0.305	0.292

Based on CEPI statistics

245 Historic growth rate rates reported by CEPI (2013) and FAO statistics for the period 2000-2012 are between 0.1% and 0.3% per year. Future projections are assumed to continue this trend.

A1.2 Iron and steel

A1.2.1 Overview of key sectoral policy measures/incentives

Table A1.9 presents the main EU policies applicable across sectors ("generic" EU policies) and Table A1.10 provides information on other EU policies pertaining to the steel and iron sector.

Table A1.9 "Generic" EU policies and their applicability to Steel & Iron sector

EED	EU-ETS[1]	IED[2,3]	Ecodesign Directive[4]	Energy Labelling Directive	Energy Performance Building Directive5
Yes	Yes	Relevant	Relevant	N/A	Limited

Notes:

[1]The steel industry is one of the largest sources of CO_2 emissions. It is also a sector deemed to be at risk of carbon leakage. Due to this risk, the steel industry will in principle be allocated emissions allowances at 100% of the benchmark based value for free. Under the ETS state aid guidelines it may receive financial compensation as from 1 January 2013 until 31 December 2020, under the ETS third phase. Free allowances though will be reviewed in 2014 (EC, 2013).

[2]The IED applies to all the installations of the steel industry, irrespective of the technology adopted, from the production/preparation of key inputs through the production of finished products, as well as to the power plants included in integrated steel mills.

[3]The main reference documents for the emission levels applicable to the steel industry are:

the Iron and Steel Production BREF which covers the preparation of raw materials and the steel making process "proper, and

the Ferrous Metals Processing Industry BREF which covers downstream processes.

Other BREFs partly applicable to the industry include the BREF for LCP (currently under revision - it is expected to devote a special section on LCP in the steel industry) and the BREF for some cross-industry activities, such as the storage and handling of materials and the cooling systems.

[4]Iron and steel furnaces are part of the product group "Industrial and laboratory furnaces and ovens", which is covered by the Eco-design Working Plan for 2012 – 2014 and for which an implementing measure is expected to be adopted by end 2014.

Table A1.10 Other EU policies specific to Iron and Steel sector

Policy name	Policy description
Waste Framework Directive 2008/98/EC	▪ It lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use.
Scrap Metal Regulation No 333/2011	▪ Closely connected to the WFD, the Scrap Metal Regulation builds upon provisions in the WFD (article 6) and determines the *criteria under which scrap metal ceases to be regarded as a waste*. ▪ By effectively removing iron and steel scrap from the list of materials regarded as waste, the Regulation frees operators from the substantive and administrative obligations applicable under the WFD.
Reach Regulation No 1907/2006	▪ Based on he REACH Regulation steel makers are subject to registration requirements for certain products and to the obligation of providing information to downstream users while the utilization of several substances used in the steel making process may be subject to authorization or restrictions.

Policy name	Policy description
Construction products regulation No 305/2011	■ It lays down a set of harmonised rules on how to express the performance of construction products in relation to their essential characteristics (art. 1) ■ The regulation applies to operators and extends to steel products used in the construction industry. In particular, the Regulation introduces the mandatory CE-marking for all construction products starting from 1 July 2013 and from 1 July 2014 for fabricated structural steel works.
End of Life Vehicles Directive 2000/53/EC	■ It aims at reducing the waste arising from end-of-life vehicles and covers various aspects along the life cycle of vehicles as well as aspects related to treatment operations (e.g. relevant to mills using scrap metal as input).
Packaging and Packaging Waste Directive 94/62/EC	■ This Directive aims to harmonise national measures in order to prevent or reduce the impact of packaging and packaging waste on the environment and to ensure the functioning of the Internal Market. It contains provisions on the prevention of packaging waste, on the re-use of packaging and on the recovery and recycling of packaging waste. ■ Amended by Directive 2006/340/EC of 19 February 2006 on heavy metals concentration in packaging.
Waste electrical and electronic equipment Directive 2002/96 together with the daughter RoHS Directive 2002/95/EC	■ The former sets collection, recycling and recovery targets for all types of electrical goods and the later sets restrictions upon European manufacturers as to the material content of new electronic equipment placed on the market.

A1.2.2 Overview of the EU28 market

A1.2.2.1 Contribution to GDP, employment:

Europe is the world's second largest steel producer after China accounting for 11% of the world's total steel output. The iron and steel industry comprised over 8,600 enterprises and employed **615,300** people in 2011. Total production amounted to €233bn with more than 170Mt produced in 2011 across EU28 based on Eurostat statistics. According to the European Commission, Europe is the world's second-largest steel producer, accounting for 11% of the world's total steel output and employing 360,000 people.

- Germany is leading the way with a value added in excess of €13m in 2011 accounting for 29% of total EU28 production in terms of value. Second comes Italy with a 16% share in total value added, followed by Spain (9%). These top 3 countries collectively account for approximately 60% of total production in EU28 and employ more than 315,000 people.
- Italy has the highest number of enterprises generating a turnover of 45m in 2011 followed by Germany, the UK and Poland.
- Amongst the countries with the smallest contribution in value added were Slovakia, Bulgaria, Croatia, Lithuania, Latvia, Estonia, Ireland, Denmark and the Netherlands.
- The process of concentration in Europe due to various mergers and acquisitions undergone over the past years has dropped the number of companies in the steel industry since the beginning of 2000 by about 1% a year and the size of the workforce by roughly 1.5% p.a. (Deutsche Bank Research, 2009).

A1.2.2.2 Range of subsectors:

Table A1.11 presents the key economic indicators per sector and subsector within the Iron and Steel industry.

Table A1.11 Key economic indicators per sector and subsector (2011 Eurostat data)

Description	NACE	Number of enterprises	Number of persons employed	Turnover	Value added	Personnel costs	Investment in tangible goods	Production value
				EUR million				
Manufacture of iron and steel		**8,637**	**615,297**	**235,552**	**39,380**	**27,444**	**8,892**	**233,173**
Manufacture of basic iron and steel and of ferro-alloys	C241	2,207	305,695	156,747	22,008	15,189	6,501	156,700
Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	C242	1,901	119,307	33,523	6,851	4,672	1,090	32,467
Manufacture of other products of first processing of steel	C243	2,660	75,841	25,765	4,713	3,115	569	24,959
Casting of iron	C2451	1,377	87,472	15,067	4,341	3,320	577	14,769
Casting of steel	C2452	492	26,982	4,450	1,467	1,148	154	4,278

Table A1.12 Key indicators, steel and iron products (NACE Division 24.1-24.3 & 24.51-24.52)

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	242	11,732	11,737	1,775	1,627	1,854	22,638
BG - Bulgaria	108	907	838	73	21	11	6,481
CZ - Czech Republic	176	6,614	6,682	878	533	155	27,747
DK - Denmark	106	286	251	0	0	6	1,093
DE - Germany	1,654	69,458	68,023	13,427	9,164	2,011	171,785
EE - Estonia	12	1	1	1	0	0	14
IE - Ireland	102	286	248	76	52	9	1,310
EL - Greece	0	0	0	0	0	0	0
ES - Spain	690	19,689	19,780	2,833	2,216	436	44,274
FR - France	455	23,036	21,770	3,505	2,936	777	55,956
HR - Croatia	106	199	206	11	51	8	3,639
IT - Italy	2,182	45,348	46,068	6,278	3,872	1,200	87,422
CY - Cyprus	0	0	0	0	0	0	0
LV - Latvia	17	24	20	6	3	2	2,663
LT - Lithuania	27	77	77	11	9	1	776
LU - Luxembourg	4	0	0	0	0	0	0
HU - Hungary	145	1,308	1,306	183	155	42	8,486
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	180	585	506	86	54	30	3,114
AT - Austria	64	9,927	10,088	2,513	1,400	319	22,610

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
PL - Poland	704	8,907	8,905	1,451	690	260	47,166
PT - Portugal	115	1,980	1,994	251	122	45	4,928
RO - Romania	243	3,805	3,732	356	287	419	29,178
SI - Slovenia	52	954	954	197	115	63	4,849
SK - Slovakia	45	385	382	89	74	18	4,848
FI - Finland	103	5,894	6,005	873	630	310	12,666
SE - Sweden	323	10,817	10,749	1,979	1,669	477	38,513
UK - United Kingdom	782	13,333	12,852	2,531	1,764	441	13,141

Source: 2011 Eurostat data

6.2.5.5 Main players:

- Given that steel manufacturing is an elaborate and cost-intensive process, and also in order to exploit economies of scale, the sector consists mainly of large companies with several thousand workers. The major players in Europe are ArcelorMittal, ThyssenKrupp, Tata Corus and Riva, internationally operative groups that have arisen from numerous mergers in the past (Deutsche Bank Research, 2009).
- The sector is characterised by a significant degree of concentration which will probably persist as companies look to improve their cost structure and increase their market power through acquisitions.
- There are three different categories of players in the steel industry (Boston Consulting Group, 2007):
  - **Global players**, which own a global network of facilities, provide a full range of steel products, are vertical integrated (even in the mining sector), and produce more than 50 million tonnes per year (the only example being ArcelorMittal – the world's leading steel producer);
  - **Regional champions**, which produce between 5 to 50 million tonnes per year, have a strong regional presence, and can be divided into two sub-categories:
    - Companies which have access to low-cost countries and provide high added value products (technology leaders, such as ThyssenKrupp and Riva);
    - Companies which are based in low-cost countries and provide steel commodities (for instance steel makers located in new member states);
  - **Niche specialists**, which provide only a narrow range of products, usually very specialized, are present in few locations, and produce less than 5 million tonnes.

Industries associations:

- Below presents the EU-wide and national industry associations related to Iron and Steel.

Table A1.13 Industry associations for the Iron and Steel sector

Geographic area	Iron & Steel related associations[246]	Websites
EU-wide[247]	European Steel Association – Eurofer European Association of metals – Eurometaux The European Stainless steel Development Association **APEAL** - *the Association of European Producers of Steel for Packaging*	www.eurofer.be/ www.eurometaux.org/ www.euro-inox.org/ www.apeal.org/
Austria	Fachverband der Bergwerke und Eisen erzeugenden Industrie	www.wk.or.at/bergbau-stahl
Belgium	Groupement de la Siderurgie – GSV	www.steelbel.be
Bulgaria	Bulgarian Association of the Metallurgical Industries – BAMI	www.bcm-bg.com/
Croatia	Association of production of metal and metal products	www.hgk.hr
Czech Republic	The Steel Federation - Hutnictvi Železa	www.hz.cz
Denmark	Dansk Metal	www.danskmetal.dk
Finland	Association of Finnish Steel and Metal Producers - Metallinjalostajat	www.teknologiateollisuus.fi/
France	French Steel Federation - Federation Francaise de l'Acier Chambre Syndicale des Producteurs d'Aciers Fins et Speciaux	www.ffa.fr www.spas.fr
Germany	German Steel federation - Wirtschaftsvereinigung Stahl Edelstahl-Vereinigung	www.wvstahl.de www.stahl-online.de/stahl_zentrum/edelstahl_vereinigung_e_v.htm
Greece	ENXE - Hellenic Steelmakers Union	No site available
Hungary	MVAE - Association of the Hungarian Steel Industry	www.mvae.hu
Italy	Federacciai Assofermet - Italian National Association of iron and Steel Trader	www.federacciai.it www.assofermet.it
Latvia	Association of Mechanical Engineering and Metalworking Industries	www.masoc.lv/masoc/index.php?lang=2
Lithuania	Metalo pramonės profesinių sąjungų susivienijimas, MPPSS	No site available
Luxembourg	Onofhängege Gewerkschafts-Bond Lëtzebuerg	www.ogbl.lu/
Netherlands	Dutch Association for the Metal Industry	www.metaalunie.nl/

[246] In lieu of relevant information on the internet, no trade associations have been identified for Ireland and Estonia.

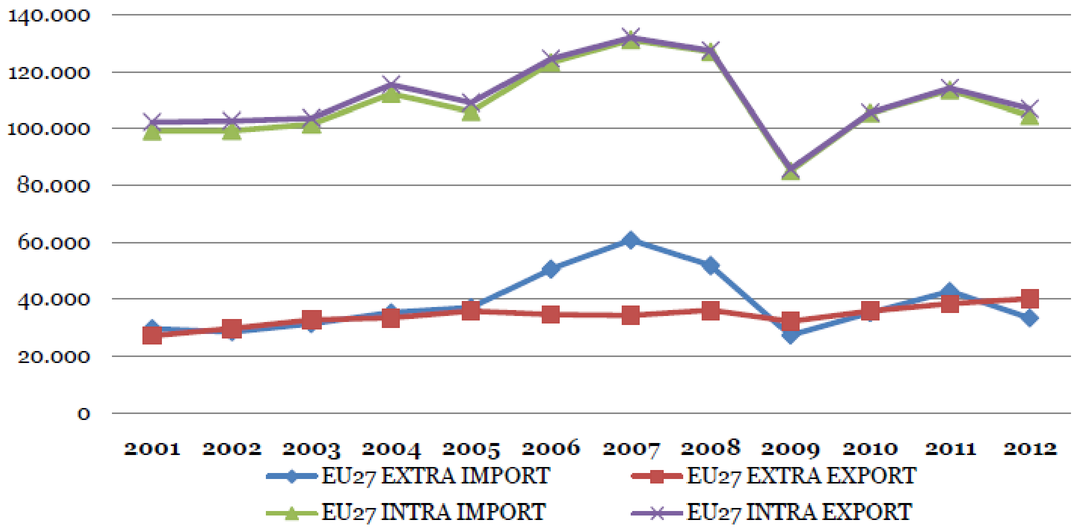
[247] Cyprus and Malta have not been examined as based on Eurostat data they are not steel producers.

Geographic area	Iron & Steel related associations[246]	Websites
Poland	Polish Steel Association	www.hiph.com.pl
Portugal	ACOMEFER	www.acomefer.pt
Romania	Uniunea Producatorilor de Otel din Romania – UniRomSider Asociatia Romana a Distribuitotolor de Metal (ARDIMET)	www.web2all.ro/us_romana.htm www.ardimet.ro
Slovakia	Metal Trade Union Association - Odborový zväz KOVO	www.ozkovo.sk/
Slovenia	Metal and Electro Industries Trade Union of Slovenia - Sindikat kovinske in elektro industrije Slovenije Sindikat kovinske, elektro in metalurške industrije, SKEM	www.skei.si/ No site available
Spain	UNESID Spanish Steel Association	www.unesid.org
Sweden	Swedish SteelProducers' Association – Jernkontoret	www.jernkontoret.se
United Kingdom	UK Steel	www.uksteel.org.uk

6.2.5.6 *Information obtain primarily from Trade flows:*

- EU-27, that used to be a net exporter, has turned into a net importer from 2006 to 2009 due to a marked increase of the imports volume; finally, the EU-27 turned back into a net exporter in 2010 and 2011 (CEPS, 2013a).
- The European market for iron and steel is mainly represented by intra-EU flows as shown below:

Figure A1.10 Intra and Extra-EU Trade of Iron and Steel (thousand tonnes)



- In 2012, intra-EU trade accounted for 72% of the total, while only 28% of trade was directed towards extra-EU economies. The same can be noticed for imports, where 74% has come from EU member states and 26% from outside EU borders.
- Based on COMEXT data, which disentangle between intra and extra-EU trade, the EU was a net importer of iron and steel from 2004 to 2008 and again in 2011. Finally, in 2012, EU recorded a positive net balance of 66.8 million tonnes (CEPS, 2013a).
- Intra-EU trade flows and extra-EU imports dramatically dropped in 2009 (the former by about one third, and the latter by almost half on a year-to-year basis), while extra-EU exports showed a slow but steady increase throughout the decade.
- As for EU exports, the most remarkable spike is in trade flows towards Algeria, which increased eight-fold from 2001 to 2012, making it the second-largest importer of European steel.
- Exports towards India, Russia and Turkey almost trebled, while exports towards China 'only' increased by 50%.
- The destinations of extra-EU flows are diversified geographically, showing that the EU is fairly integrated in the global trade dynamics.
  - In 2012 almost 45% of EU exports were directed to Turkey, US, Algeria and Switzerland.
  - The same year, 53% of total imports came from Russia (8,322 thousand tonnes), Ukraine (6,048), and China (3,502).

Figure A1.11 EU27 exports, imports and net positions in iron and steel by selected destination countries - 2001 and 2012 (thousand tonnes)

Destination Countries	2001			2012		
	Export	Import	Net	Export	Import	Net
Total Extra-EU	**27,048**	**29,573**	**-2,525**	**40,150**	**33,341**	**6,809**
Turkey	1,741	3,326	-1,584	5,284	1,830	3,454
USA	6,312	334	5,978	5,237	509	4,728
Algeria	562	133	429	4,603	34	4,569
Switzerland	2,179	1,051	1,128	2,478	1,251	1,228
India	449	326	123	1,432	1,585	-154
Russia	438	6,644	-6,207	1,299	8,322	-7,023
China	758	449	309	1,160	3,502	-2,342
Mexico	668	307	362	1,142	31	1,111
Morocco	689	15	674	1,035	38	997
Norway	1,120	1,656	-536	891	1,118	-227
Canada	939	168	771	812	130	682
Brazil	435	1,302	-867	791	1,388	-597
South Korea	300	737	-437	462	1,331	-869
South Africa	178	2,181	-2,003	423	1,332	-910
Ukraine	115	4,190	-4,075	350	6,084	-5,734
Japan	123	433	-310	152	316	-164

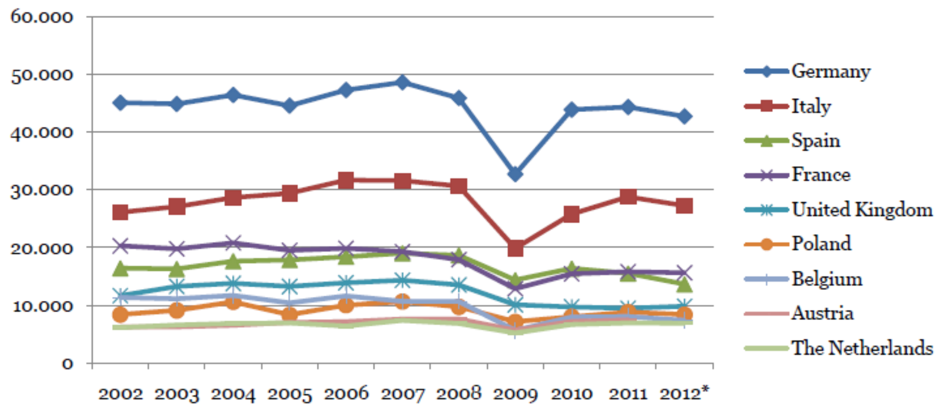
6.2.5.7 Product type and consumer groups:

Based on the phase of manufacture, industry products are grouped into 3 main categories (Chatham House, 2008):

Crude steel

- Crude steel is used to make semi-finished and finished products destined for the consumer market or as inputs for further processing (Chatham House, 2008).
- Approx. 40% of the total crude steel production in Europe is produced by EAF technologies and the share has been rising for years. Approx. 60% is produced by BOF technologies (Ecorys, 2008).
- Crude steel production is concentrated in a relatively limited number of EU countries. In 2013, 9 countries (Germany, Italy, France, Spain, United Kingdom, Poland, Belgium, Austria, and the Netherlands) accounted for 83% of the total EU production (EUROFER, 2014).

Figure A1.12 Production of crude steel in selected member states (thousand tonnes)



Semi-finished products

- Semi-finished products include steel shapes (blooms, billets or slabs) that are later rolled into finished products such as beams, bars or sheet. Continuous casting is the process whereby molten metal is solidified into a semi-finished billet, bloom, slab or beam blank.

Finished products

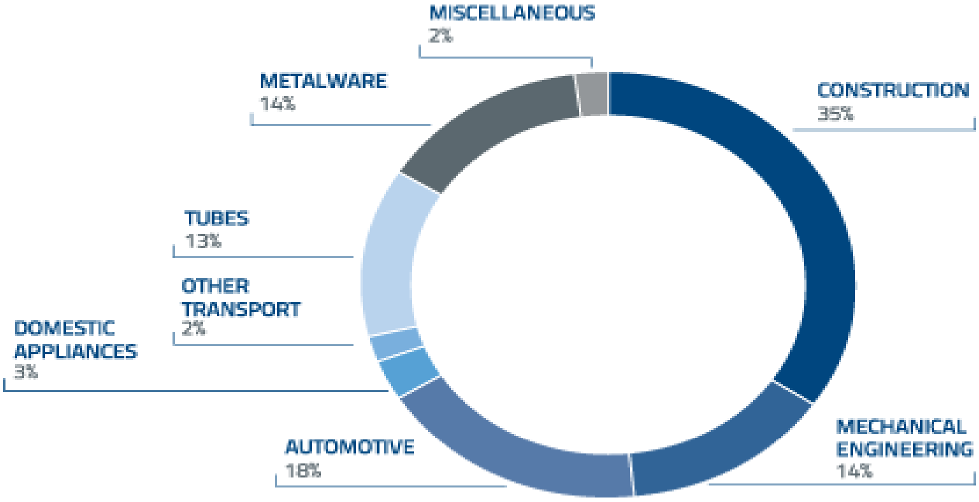
Finished products are subdivided into two basic types, flat and long products:

- Flat products include slabs, hot-rolled coil, cold-rolled coil, coated steel products, tinplate and heavy plate. They are used in automotive, heavy machinery, pipes and tubes, construction, packaging and appliances (Arcelormittal).
  - Flat products represent approximately 60% of the EU hot rolled steel output; this proportion was constant over the period 2002-2011, meaning that EU countries maintained their solid position in the high added-value portion of the steel market (Ecorys, 2008).
- Long products: include billets, blooms, rebars, wire rod, sections, rails, sheet piles and drawn wire. The main markets for these products are construction, mechanical engineering, energy and automotive (Arcelormittal).
- Alloyed steels which are sometimes also called special steels and may be considered specialty products account for a relatively small portion of all finished steel products. The most important of these is stainless steel.

End users

- Steel is a major component in buildings, tools, appliances, automobiles and various other products. The steel industry primarily supplies the construction sector, the automotive sector, the packaging industry, the consumer goods industry (domestic appliances etc.), and the electrical and mechanical engineering sector (Eurofer, 2010).
- Automotive and construction sectors have usually been the two largest steel end users (accounting for over 50% of total EU consumption in 2010). Therefore, fluctuations in turnover in these industries significantly affect steel demand.
- Other important buyers from steel companies are steel pipe and tube producers, manufacturers of metal products such as radiators, tools, locks and fittings, and steel and ship builders, which together account for over 30% (Deutsche Bank Research, 2009).

Figure A1.13 Sector shares in total EU steel consumption (Eurofer)



6.2.5.8 Market developments and sector growth rates

Market developments

- As the international financial crisis deepened in September 2008 and spilled over into important customer markets, the international steel industry, which had enjoyed good business in the previous years, spiralled into an abrupt decline.
- Europe's steel industry has witnessed large scale changes over the past decade. It has seen its share of the world market decline and its companies have increasingly become the target of new emerging competitors from Asia (The European Union Centre of Excellence, 2008).
- The downward trend in real steel consumption over the last 5 years largely stemmed from weakening activity in the steel using industries in the EU. More specifically, automotive and construction sectors (the two largest steel end users) experienced a remarkable decline in 2007-2009 with no sign of recovery in 2010 (CEPS, 2013b):
  - Construction output in particular was severely affected by the impact of austerity measures on public sector investment.
  - Automotive sector activity felt the brunt of low levels of consumer and business confidence and difficult financing conditions.
  - Weak levels of consumer confidence and reduced activity in the residential property sector (both in terms of new housing construction and sales of existing houses) were main factors negatively affecting demand for domestic appliances in the EU.

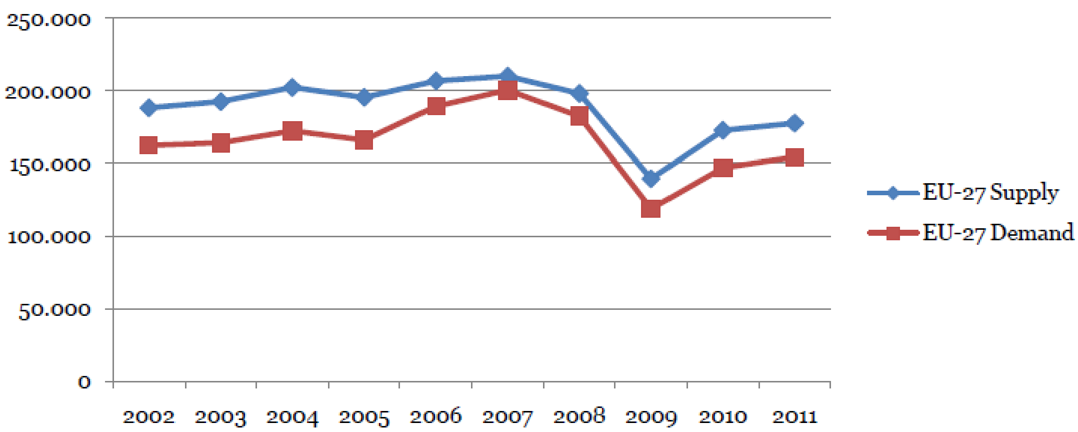
Supply of Crude steel

- After a steady growth between 2002 and 2007 (+12%), the production of crude steel in the EU fell by 34% over the period 2007-2009 (Figure 1). The partial recovery shown in 2010 (+24%) and in 2011 (+3%) is threatened by a new reduction recorded in 2012 (-5%).
- The Compound Annual Growth Rate (CAGR) over a 10-year period (2002-2012) was -1%. Trends are similar in both EU-15 countries and new EU member states, with a 10-year CAGR respectively of -1.1% and -0.8% (CEP, 2013b).

Demand for steel finished products

- Demand for finished steel products in the EU fell between 2007 and 2009 by 41% after a remarkable growth experienced over the period 2005-2007 (+21%), which in turn followed a period of relative stability in 2002-2005 (+2%).
- Signs of recovery were registered in 2010 (+24% on yearly basis) and 2011 (+5%), but total demand is still below the 2007 level (about 50 million tonnes lower).
- In 2011, demand for finished steel products in the EU was geographically concentrated. Germany, Italy, France, Spain, Poland, United Kingdom, Czech Republic, Belgium (including data for Luxembourg), and Austria accounted for more than 84% of the total demand (CEP, 2013b).

Figure A1.14 Production of crude steel in selected member states (thousand tonnes)



Note: Demand measures apparent steel use of finished steel products, expressed in volume terms as deliveries of finished steel minus net exports of steel industry goods; Supply measures total production of crude steel.

Future outlook and trends

- The outlook for the year 2013 is expected to be rather bleak. Total activity in the steel using sectors is expected to have contracted by 1.8% in 2013 due to the continuation of difficult operating conditions across most sectors (Eurofer, 2014).
- Despite the negative trends which remained in force in 2013, activity in the steel using sectors is gradually gaining traction in 2014 and 2015.
- The SWIP (Steel Weighted Industrial Production) index is forecast to increase by 2.5% in 2014, followed by almost 3.5% growth in 2015. Showstoppers could be continued Euro strength and difficult access to finance.
- The outlook for 2014 and 2015 is for a gradual and rather cautious recovery of real steel consumption in the EU (1.9% expected growth in 2014 and 2.4% in 2015).

Figure A1.15 Development of the main steel using sectors (% change year-on-year in the SWIP (Steel Weighted Industrial Production) index)

	% share in total Consumption	Q113	Q213	Q313	Q413	Year 2013	Q114	Q214	Q314	Q414	Year 2014	Year 2015
Construction	35	-7.5	-3.3	-1.1	-0.5	-2.9	2.4	0.0	1.5	1.7	1.3	2.4
Mechanical engineering	14	-7.6	-3.3	-2.6	-0.8	-3.6	3.1	2.1	3.0	3.5	2.9	4.4
Automotive	18	-8.5	2.5	4.0	6.0	0.7	5.4	3.0	1.2	2.4	3.0	2.5
Domestic appliances	3	-1.9	1.3	3.1	1.9	1.1	2.5	2.9	3.0	3.1	2.9	3.7
Other Transport	2	0.3	-0.4	4.3	4.4	2.1	4.3	3.7	4.4	5.2	4.4	3.8
Tubes	12	-7.6	-3.6	-6.8	0.7	-4.4	0.2	2.8	4.2	5.8	3.1	5.2
Metal goods	14	-4.7	-0.2	2.1	3.3	0.0	2.6	2.4	2.9	2.9	2.7	3.4
Miscellaneous	2	-4.7	-0.9	0.4	2.8	-0.6	2.9	3.1	3.2	3.4	3.1	3.3
TOTAL	100	-6.9	-1.6	-0.3	1.6	-1.8	3.0	1.8	2.3	2.9	2.5	3.3

.Source: Eurofer, 2014

Drivers:

- Fierce international competition and the stronger Euro will limit any further growth potential on the key export markets (Eurofer, 2012).
- The production trend of the steel industry has been subject to structural change over the last twelve years, mainly due to the increase in the Asian production. As a result, exports market shares of semi-finished and finished steel products shift mainly from EU27 to Asia.
- Steel protectionism in third countries continued to grow in 2012, notably in India, Brazil and Middle East/ North Africa. Measures comprise market access, industry support and metallurgic raw materials (Eurofer, 2014).
- Increasing energy prices and raw materials have become a substantial handicap for the EU economy. The gap in average energy prices between the EU and other major economies is further increasing.
- As EU and global economic momentum builds, the investment cycle will turn positive again, to a significant extent supported by pent-up demand.
- The outlook for capital goods investment in the EU is rather bright for the coming two years, whereas also private consumption is seen gaining some strength again (Eurofer, 2014).
- Growth expected in the top 4 industries correlated to steel (Eurofer, 2014):
  - EU **construction** activity is forecast to rise almost 1.5% in 2014 and by close to 2.5% in 2015. The pick-up will largely be driven by the residential sector and renovation and modernisation work.
  - EU **automotive** production activity – including the manufacture of parts and components - is forecast to increase by 3% in 2014, whereas 2.5% growth is currently pencilled in for 2015. Export demand from the US and Asia will continue to boost activity at the German and UK premium segment manufacturers. The overall

mature car market in Europe is expected to improve only cautiously, and will basically remain driven by replacement demand.

- The **mechanical engineering** sector output is expected to increase by 3% in 2014 with a further acceleration of 4% in 2015. Recovery in demand is underpinned by the expected pick-up in capital goods investment, improved business confidence and moderate easing of financing constraints.
- EU production of **steel tubes** is expected to rise by around 3% in 2014 and 5% in 2015.

Energy growth rates for Iron and Steel industry

Table A1.14 presents total energy consumption in the steel and iron industry in EU-28 over the period 2001-2011. A significant 22% decline has been reported in EU-28 over that period mainly driven by:

- Reduced energy consumption in 21 out of 25 countries with relevant production.
- A fall in energy consumption amongst the top 5 most energy intensive countries accounting for 59% of overall consumption in EU28. Specifically, Germany, the only country consuming over 10,000Mtoe annually, achieved an 8% reduction followed by Italy, France, Spain and the UK with 12%, 23%, 23%, and 50% respectively.
- A moderate increase in 3 countries with annual consumption above 1,000Mtoe with Slovakia reporting the highest increase (25% over 2001-211) followed by the Netherlands (8%) and Austria (7%).

Table A1.14 Energy consumption in MToe by the iron and steel industry per Member State over 2000-2011

GEO/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Change 2011 over 2000
Ireland	46	24	7	5	1	1	1	2	1	1	1	1	-98%
Bulgaria	845	893	842	1,023	907	892	908	880	581	201	137	148	-82%
Denmark	126	129	97	75	72	77	70	66	60	32	34	32	-75%
Latvia	138	140	134	131	134	131	136	135	127	114	130	47	-66%
Belgium	4,906	4,805	3,849	3,962	3,840	3,384	3,284	3,023	3,202	1,687	2,138	1,986	-60%
Lithuania	6	5	4	3	4	5	5	6	4	3	2	3	-50%
United Kingdom	6,222	4,972	4,368	4,775	4,759	4,575	4,933	4,849	4,720	3,387	3,305	3,130	-50%
Poland	4,912	4,237	3,830	4,071	4,563	3,436	3,626	4,061	3,223	2,156	2,440	2,677	-46%
Portugal	290	151	131	156	154	190	199	210	191	144	144	162	-44%
Croatia	50	40	28	32	32	37	46	42	48	29	38	33	-34%
Romania	2,883	2,836	2,893	3,039	3,482	3,632	3,629	3,373	2,862	1,791	2,023	2,003	-31%
Spain	3,985	4,573	4,444	4,556	4,950	4,475	3,676	3,760	3,688	2,579	2,996	3,063	-23%
France	6,720	6,278	6,690	6,395	6,385	6,601	6,930	6,789	6,042	4,557	5,456	5,201	-23%
Czech Republic	3,085	3,182	3,084	3,025	3,168	2,995	2,971	2,980	2,747	2,345	2,378	2,495	-19%
Hungary	703	618	631	622	628	638	649	651	628	478	573	579	-18%
Slovenia	167	149	137	133	134	157	163	137	156	118	148	138	-17%
Sweden	1,755	1,785	1,964	2,023	2,090	2,046	1,868	1,939	1,850	1,138	1,576	1,508	-14%
Italy	7,090	7,074	6,581	7,090	7,329	7,458	7,409	6,842	6,456	4,537	5,934	6,248	-12%
Germany	14,807	14,243	14,135	14,197	14,312	13,682	14,337	14,991	14,797	10,768	13,406	13,639	-8%
Greece	192	212	242	248	221	219	227	255	225	188	177	183	-5%
Finland	1,506	1,474	1,513	1,558	1,600	1,593	1,628	1,540	1,503	1,106	1,536	1,488	-1%
Estonia	0	1	1	1	0	1	1	1	0	0	0	0	0%
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0%
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0%
Luxembourg	344	337	343	293	395	329	445	432	418	354	425	347	1%
Austria	2,148	2,088	2,089	2,088	2,156	2,450	2,410	2,460	2,498	2,057	2,207	2,309	7%
Netherlands	2,167	2,279	2,292	2,413	2,470	2,452	2,267	2,471	2,316	1,939	2,177	2,334	8%
Slovakia	1,614	1,408	1,561	1,786	1,760	1,694	1,803	1,555	1,503	1,363	2,151	2,015	25%

Source: Eurostat (available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home)

Note: 0% change has been reported for Estonia, Cyprus and Malta due to non-production

A1.2.3 Business environment

A1.2.3.1 Competitive strengths

- **Product development leadership and high quality output with focus on value creation.** The EU steel industry is a modern and technologically advanced industry, leading in product development, focusing on value creation and capable of delivering complex, high-quality products, and solutions. Value creation drives the competition in EU markets and export markets and in this area the EU takes a strong position (Ecorys, 2008).
- **The location of steel making facilities** - in terms of both proximity to the customers plants and worldwide production to supply global customers in several markets becomes a competitive advantage factor (CEPS, 2013b). Important offtakers of steel are based in Europe, facilitating cooperation and development partnerships with customers from the automotive industry, mechanical engineering and industrial plant construction, for example. D This is an obvious strength, which also creates the foundation for seeking new opportunities in high-end export markets.
- **High R&D capabilities** characterise the EU industry and the sub-sectors. This is an important prerequisite for the industry's current and future competitive strengths. Moreover, it makes European R&D facilities attractive from an investment and cooperation perspective. R&D facilities are kept and established in the EU due to the high level of expertise. This applies to all subsectors (Ecorys, 2008).
- Focus on **high-tech steel products**. European steelmakers are pursuing a customer-oriented strategy designed chiefly to set them apart from emerging market products. (Deutsche Bank Research, 2009)
- **High degree of specialisation.** Notably the foundry sector, is highly specialised, with a high capacity to meet the special requirements of customers.
- **High degree of recycling.** EU steel production is characterised by a high degree of recycling, leading to a relative lower use of iron ore which leads to lower costs. However, the degree of recycling might have reached its limits.
- **New member States attractive to investors**. NMS have emerged as attractive locations for investments due to high growth rates resulting from domestic demand, relatively low costs, highly skilled workers and improved knowledge of the technology, together with an increasingly strong presence of manufacturing industries (Ecorys, 2008).
- **Alternative methods of generating electricity** work enormously to steelmakers' advantage. RES is assuming greater prominence in Europe.
- Data related to labour productivity show positive tendencies. In this regard, the EU steel industry is **becoming less and less labour intensive**, which is also reflected in the fact that labour costs is a minor aspect of the total cost structure.

A1.2.3.2 How are these advantages envisaged as changing over the next 10-15 years?

- Although Europe is a considered to be a strong regional industry with competitive position in high-end domestic markets, strong competition from other parts of the world and especially new competitors from China, India, Brazil and the CIS countries, means that this position must be defended through continuous improvement of products and services while keeping costs low (Deutsche Bank Research, 2009)
- Even if the European steel industry's share of the world market does shrink appreciably, Europe will remain an important steel-producing region as manufacturing networks with important local customers continue to deliver essential advantages (Deutsche Bank Research, 2009).

- The steel industry in Europe should continuously maintain and improve its ability to compete with products produced in third countries, facilitate process and product innovation to meet advanced customer demand and continually reduce production costs. However, competitors are also improving their technological capacities and competencies reducing the gap.
- Attractiveness of New European Member States will decline in the future as wage levels are expected to rise, and recruitment of skilled labour might become increasingly difficult in most new Member States. This might change the attractiveness of the NMS as investment locations.
- A window of opportunity for the European steel industry is that industrial demand for special steels in the highly-developed countries is increasing.

A1.2.3.3 Threats

- **Competition from China.** Increasing international engagement and exports into the EU from China is a threat. This is supported by increasing capacity in China together with state aid to Chinese enterprises. Direct and indirect state aid implies uneven conditions for competition to the disadvantage for European producers. The pipe industry faces significant Chinese price competition.
  - The production of crude steel in the EU in 2012 represented about 11% of total world production (1 510Mt of crude steel), compared to a 24.6% share in 1998. The contraction of the EU's share in overall world production is largely due to the fact that Chinese production has grown more than fourfold over this period (SETIS, 2014).
- **The Competition from other countries** such as the C.I.S, Brazil and India is increasing. Easy access to raw material supplies makes these countries competitive.
- **Decision power moves out of Europe.** Strong, global players are emerging outside the EU. This poses a threat to the EU in terms of losing control and decision-making power over investments with a European perspective. Moreover, strong global players may gain increased access to European markets through cooperation with European partners (Ecorys, 2008).
- **Imbalances in demand and supply for raw materials**. Iron ore reserves are immense. However, supply-demand imbalances have occurred and will most likely continue in the foreseeable future due to the high demand for steel led by China and remaining bottlenecks in supply infrastructure (Ecorys, 2008).
- **Increasing freight rates, malfunctioning transport markets and logistics infrastructures.** Malfunctioning transport markets create barriers for EU steel producers. Moreover, increasing freight rates and malfunctioning logistics infrastructures increase the relative costs for EU steel producers, and makes it more difficult for them to compete on the export markets.
- **Access to energy and malfunctioning energy markets.** Global competition for the main resources used as inputs for the steel industry, i.e. energy and raw materials, has intensified. Securing access to energy has become a major issue.
- **Environmental legislation.** Environmental legislation and specifically the new ETS (for the period post 2012) might lead to loss of competitiveness vis-à-vis competitors who are not faced by as restrictive emissions schemes. In addition, it might drive down the interest of investors.
- **Uneven global playing field.** Although tariff barriers are becoming less important for steel exporters, a number of non-tariff barriers still remain impeding a fair and even playing field for EU steel producers globally. Some non-EU countries benefit from domestic subsidies that protect their home markets and improving their cost-competitiveness (Ecorys, 2008).

- **Demographic changes in the long run**. The declining European workforce and difficulties in attracting young people to technical educations may lead to a limited supply of qualified labour – more that 20% will retire by 2015 and close to 30% during the following 10 year (SETIS, 2014). Competition for qualified labour will increase internally between industries and externally between companies in different countries/regions.
- **Protectionist policies and subsidies** can exacerbate crises in steel (ie. non-tariff barriers on steel imports, exports restrictions of raw materials, measures that favour over-capacity). (OECD, 2012)

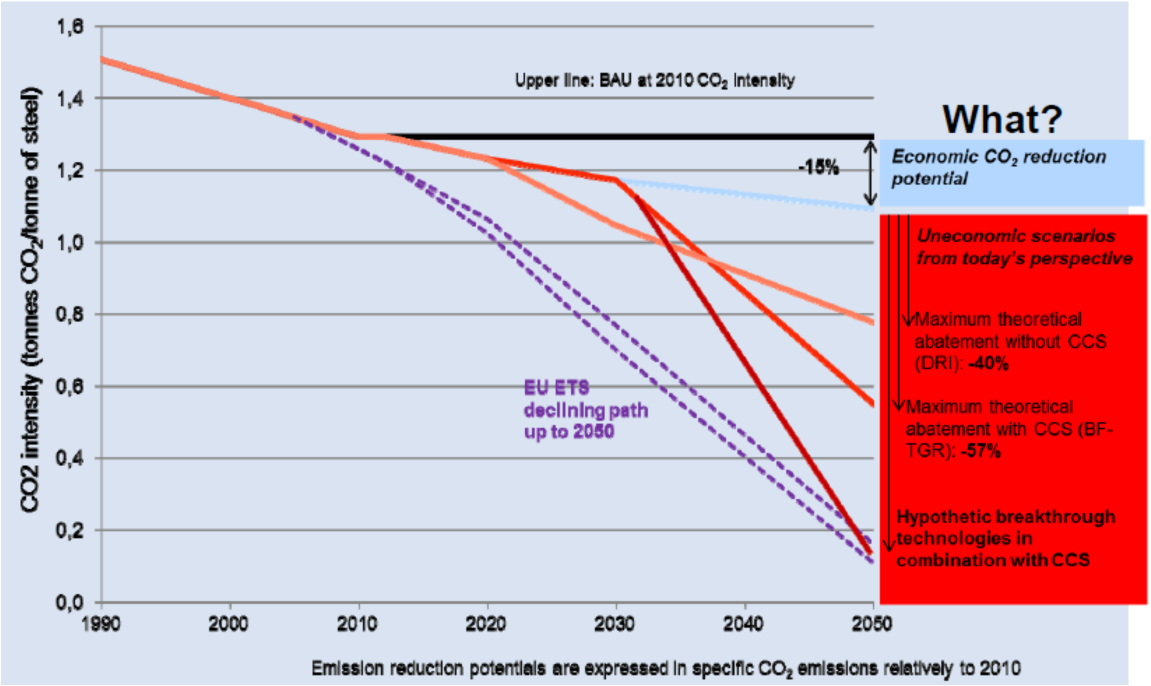
A1.2.3.4 How are these envisaged as changing over the next 10-15 years?

- **Decreasing EU share in world production.** The EU steel industry as whole has not fully benefited from the worldwide growth in the demand for steel and this has resulted in a gradually decreasing share of the world production. This trend is likely to continue (Ecorys, 2008).
- **Demand and supply of raw materials**: The increasing demand for steel, led by notably China, has resulted in current imbalances in supply and demand for raw materials which most likely will continue in the short to medium term (iron ore reserves are immense and the supply shall increase with exploitation of new capacities and elimination of bottlenecks in supply infrastructure).
- While this affects all countries, the EU28 is particularly sensitive to such imbalances due its dependency on imported raw materials. This contributes to a shift in steel production towards third countries offering more attractive production conditions in terms of better raw material supply and cheaper energy, and this constitutes a threat to the EU28 as a location for steel production and employment.

A1.2.3.5 Business strategy and decision making

- Steel has undergone significant changes over the past 50 years, including the virtual elimination of traditional blast furnace open-hearth furnace (BF-OHF) production, a doubling in the proportion of production through the scrap-based electric arc furnace (scrap EAF) route, and almost a complete switch from traditional casting methods to continuous casting (Boston Consulting Group, 2013).
- Given those developments, the specific CO2 intensity fell by 15% between 1990 and 2010 whereas the absolute CO2 emissions dropped by 25% (Eurofer, 2013a).
- Eurofer's steel roadmap integrates the results of several studies which conclude that meeting the commission's objectives for the low carbon roadmap is technically and economically unfeasible for Europe's steel industry (Eurofer, 2013b).
  - Available cost-effective mitigation technologies could decrease the sector's CO2 emissions at best by a further 15% tonne of steel by 2050 compared to 2010.
  - In order to achieve radical CO2 reductions this would require yet unproven technologies and a functioning infrastructure for carbon capture and storage (CCS). Such a scenario could lead to a reduction of CO2 emissions of up to 60 % in 2050, still falling short of the commission's 88-92% aspirational objective for industry (see figure below).

Figure A1.16 CO2 intensity pathways up to 2050



Source: Eurofer, 2013

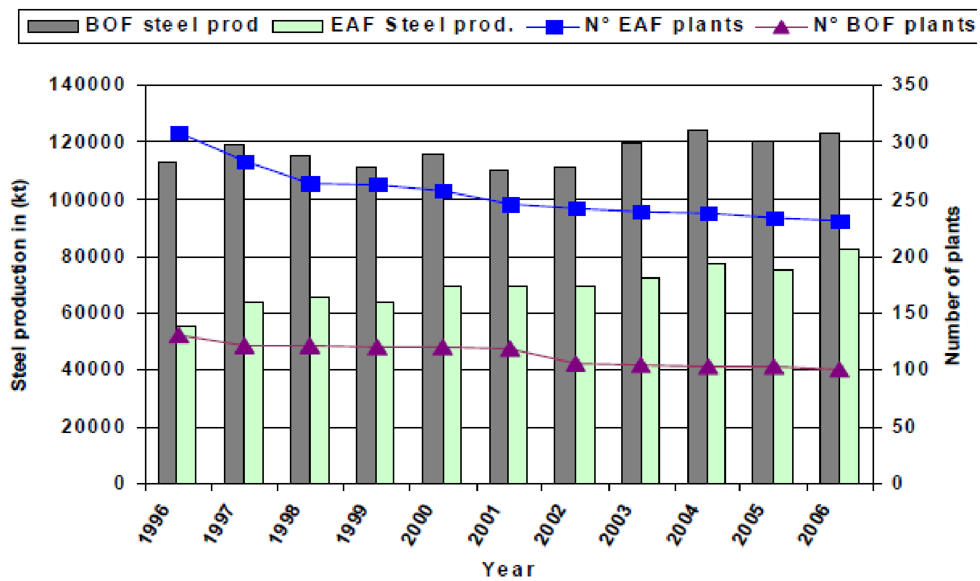
- However, steel can make a significant contribution to climate protection in Europe as a CO2 mitigation enabler. More specifically, the steel's contribution to climate protection in applications far outweighs the CO footprint of steel production (Boston Consulting Group, 2013).
  - Base on eight CO2 savings applications for which steel cannot be replaced by any other material, the yearly savings for the EU of these applications alone would be at least 443 Mt CO2 in 2030. This is more than six times as much as the 70 Mt CO2 released by producing the steel grades under consideration.
- The transition towards a competitive low carbon Europe requires the spread of new technologies and large investments in new infrastructure. In this context, the EU steel industry is committing to (Eurofer, 2013a):
  - deliver further measureable cost-efficient improvements in carbon and energy efficiency,
  - implement incremental technologies (mainly process optimisation and retrofits),
  - continue investing in R&D for mitigation of direct and indirect emissions from the sector,
  - reinforce horizontal cooperation in best-practice sharing, energy efficiency, R&D, demonstration and pilot plant projects in relevant existing or new platforms,
  - apply innovative technologies if economic viability is met,
  - continue to work on the development of innovative steel grades for CO2 mitigation and carbon-lean steel applications, together with our customers,
  - actively participate in finding global solutions to mitigate CO2 emissions in the steel sector.
- In order to overcome the associated challenging technical, economic and political barriers, a number of conditions must be met (Eurofer, 2013a):

- Ambitious climate objectives must be based on a commensurate industrial policy. This requires sheltering the steel industry from distortive CO2 costs and providing access to energy and raw materials at competitive prices so that steelmaking remains a profitable activity in Europe. Future EU climate and energy policies must be such that they foster growth and attract inward investments.
- Supporting policies have to be put in place to facilitate the development and deployment of innovative technologies. The EU ETS on its own and as it is designed now is not able to bring breakthrough technologies into being in all sectors.
- The extent to which CO2 pricing and CO2 targets are applied must be determined in accordance with a sector's ability to respond positively to such drivers. At the very least, this necessitates more differentiated treatment between the power sector and manufacturing sectors.

A1.2.3.6 Mitigation activities

- In the past 40 years there has been a 50% reduction in energy consumption in the industry in Europe. This has mainly been due to the increased use of recycled scrap iron from a 20% share in the 1970s to around 40% today, while the manufacture of iron from iron ore has declined. However, a complete shift to recycling is limited by the availability and quality of scrap (SETIS, 2014).
- EAF is powered by electricity in contrast with BF and BOF/OHF. Thus shifting towards the EAF process would enable fuel switching towards renewable energy or other low carbon electricity production, implying lower GHG emissions. The secondary route, using EAF with scrap as feedstock, is the most favourable. However, it cannot completely replace the primary route due to the requirement of virgin materials for certain products and due to the limited availability of scrap.
- The low use of scrap in several countries does indicate a potential for increasing production using scrap as feedstock (Bureau of International Recycling, 2011).
- Electric arc furnace steel production has been gradually increasing in the EU. Nevertheless, according to the European IPPC Bureau (2010) the BF/BOF is expected to remain the dominant production route, at least in the medium term (ESA[2], 2012).

Figure A1.17 Steel production by electric arc furnace and oxygen steel in the EU from 1996 – 2006



Source: JRC, 2013

A1.2.3.7 Technology road map

- Alternatives to the two main production routes include **direct-reduced iron technology** and **smelting reduction**. The advantage of these technologies compared with the integrated route is that the raw materials do not need to be treated ('beneficiated'), e.g. by sintering and making coke, and that they can adjust well to low-grade raw materials. On the other hand, more primary fuels are needed, especially natural gas for direct reduced iron technology and coal for smelting reduction (SETIS, 2014).
- 20-25% savings in CO2 emissions in the smelting reduction process can be achieved if the additional coal is transformed into process gases, which are then captured and used to produce heat and electricity. At present in EU-28, only one plant uses direct-reduced iron technology (in Germany) while none of the eight operational facilities for smelting reduction in the world are in Europe.
- There is potential for reducing direct CO2 emissions by about 27 Mt per year by applying best practice, including the retro-fitting of existing equipment. This potential however relies strongly on a substitution of local raw materials with increased imports of best performance raw materials from outside the EU - especially ores and coal (SETIS, 2014).
- Although progress in the past has been great, simply extrapolating current technologies leaves little leeway for drastic new reductions in emissions. As such, breakthrough technologies, which have received little attention in the past, should be examined in order to significantly reduce CO2 emissions (JRC, 2013).
- In the EU, ULCOS is a flagship programme which aims to reduce the CO2 emissions of today's best routes by at least 50%. Four main processes have been earmarked for further development as a result of the 1st phase (JRC, 2012):
  - The **top gas recycling blast furnace** is based on the separation of the off-gases so that the useful components can be recycled back into the furnace and used as a reducing agent. Meanwhile, oxygen is injected into the furnace instead of preheated air to facilitate CO2 capture and storage (CCS).
  - The **HIsarna technology** combines preheating of coal and partial pyrolysis in a reactor, a melting cyclone for ore melting and a smelter vessel for final ore reduction and iron production.
  - The **ULCORED** (advanced Direct Reduction with CCS) involves the direct reduction of iron ore by a reducing gas produced from natural gas. The reduced iron is in a solid state and will need an electric arc furnace to melt the iron.
  - The experimental processes, known as **ULCOWIN** and **ULCOSYS**, are **electrolysis processes** to be tested on a laboratory scale.
  - Potentials for steel production using biomass and hydrogen have been shown, but these development paths have not been chosen as focus for inclusion in the ULCOS programme. (ESA[2], 2012).

Figure A1.18 Abatement potentials of the ULCOS technologies (Eurofer, 2013b)

Technology	Expected potentials for direct CO_2 mitigation effects	Soonest expectations (from a purely technical perspective)
Top Gas Recycling Blast Furnace (ULCOS-BF)	15% without CCS 60% with CCS	Laboratory: done Pilot: done Demonstrator: tbc Deployment: > 2020 onwards
Bath smelting (HIsarna)	20% without CCS 80 % with CCS	Laboratory: done Pilot: 2011-2013 Demonstrator: 2020 Deployment: > 2030
Direct reduction (ULCORED)	5% without CCS 80% with CCS	Laboratory: done Pilot: 2013 Demonstrator: 2020 Deployment: > 2030
Electrolysis (ULCOWIN)	30% with today's electricity generation mix 98% with CO_2 free electricity generation	Laboratory: ongoing Pilot: 2020 Demonstrator: 2030 Deployment: > 2040

- In thermal power plants, the development of new steel grades will increase temperature and pressure and will contribute to the improvement of energy efficiency. In advanced supercritical plants with steam conditions up to 600°C and 30 MPa, net efficiencies between 46 and 49% could be reached whereas older pulverised coal plants, with subcritical steam parameters, operate with efficiencies between 32 - 40%.
  - Each percentage point efficiency increase is equivalent to a 2.5% reduction in tonnes of CO2 emitted.
  - The development of new grades (lightweight alloys) for the automotive industry can decrease steel consumption (energy consumption) and at the same time improve the efficiency of the final products – lighter cars will be more efficient.

Other emerging techniques include (JRC, 2012;2013):

- BF
  - Reduction of CO emissions from hot stoves with an internal combustion chamber (this process has already been introduced at one integrated steelworks in the EU-28).
  - Slag heat recovery (no commercial application as of now).
  - Injection of waste in blast furnaces: Investigations have been carried out for the use of oil-contaminated mill scale together with fly ash. Injection rates up to 100 kg/t hot metal have been tested.
- BOF and casting
  - Improvement of BOF slag stability for extended use (in 2010 it was used in 2 European basic oxygen steelmaking plants).
  - Improving clean gas dust content in wet scrubber-based BOF plants by upgrading to Hydro Hybrid (under development).
  - Whirl hood for secondary dedusting (the engineering was developed a few years ago but further development is needed and a new system will be built in the near future).
  - Recycling of BOF and EAF ladle slags as a flux agent in electric steelmaking (already implemented in Italy and Germany).

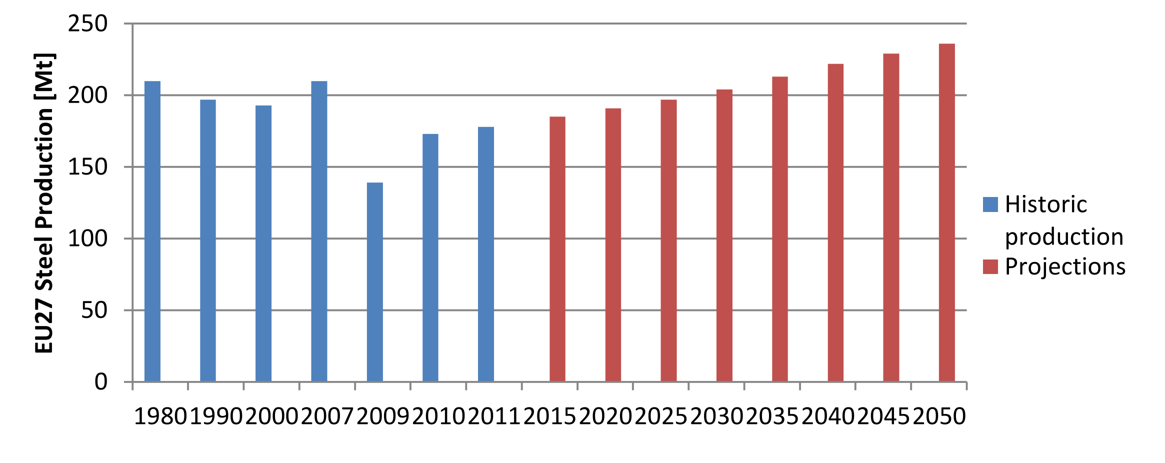
- EAF
  - Contiarc furnace (none implementation in EU).
  - Intermetallic bag filter to minimise emissions of dust, PCDD/F and heavy metals.
  - Recovery of old tyres in EAF (trials carried out in France and Luxembourg).
  - Recycling of (BOF and EAF) slags as a flux agent in electric steelmaking

A1.2.4 Sector projections

A1.2.4.1 Projections of EU Steel Production

- EUROFER/BCG provided a baseline projections forward of expected growth in EU crude steel production with an average annual increase of 0.8% p/a from 2010 – 2050, as summarized in Figure A1.19
- EU demand for steel use over the short range period (2013 – 2015) is forecasted to grow annually at a rate of approximately 3%.
- EU steel makers have remained competitive in terms of overall costs and in terms of quality, through a continuous process of investments and restructuring, and this despite energy prices and raw materials, labour and regulatory costs among the highest worldwide. (EUROFER, 2013)
- Global crude steel production reached 1.52 billion tonnes in 2012 and 11% of which was produced in EU27.
- Looking at the longer statistic trend, EU27's production of crude steel has remained relatively flat throughout the period of 1980 – 2008 whereby the production output was 208 and 199 million tonnes respectively. There was a drastic drop in production to 139 million tonnes in 2009, which coincides with EU's financial crisis, and gradually increasing to 166 million tonnes in 2013 (World Steel Association statistics, accessed on 2014).
- Even if the European steel industry's share of the world market does shrink appreciably, Europe will remain an important steel-producing region as manufacturing networks with important local customers continue to deliver essential advantages (Deutsche Bank Research, 2009).
- The steel industry in Europe should continuously maintain and improve its ability to compete with products produced in third countries, facilitate process and product innovation to meet advanced customer demand and continually reduce production costs. However, competitors are also improving their technological capacities and competencies reducing the gap.

Figure A1.19 EU Steel Production Projections



Source: EUROFER/BCG, 2013

A1.3 Non-Metallic Minerals Sector Profile

A1.3.1 Overview of key sectoral policy measures/incentives

Table A1.15 presents the main EU policies applicable across sectors ("generic" EU policies) and Table A1.16 provides information on EU policies specific to a given sector/subsector.

Table A1.15 "Generic" EU policies and their applicability to Non-Metallic Minerals sector

EED	EU-ETS[1,2]	IED[3,4]	Ecodesign Directive	Energy Labelling Directive	Energy Performance Building Directive
Yes	Yes	Yes	N/A	N/A	Relevant

[1]In 2009, the cement and glass industries were put on the list of sectors exposed to carbon leakage. The European Commission is set to review the list by the end of 2014. CEMBUREAU (the European Cement Association) argues that the cement industry is still prone to carbon leakage (CEMBUREAU; 2013). Glass Alliance Europe calls for the glass industry to remain on that list (Glass Alliance Europe; 2013)

[2]More than 75% of ETS ceramic installations in Cerame-Unie's membership are classed as 'small emitters' (with production of more than 75t/day and emissions of less than 25ktCO2/year).

[3]The Commission's Decision (2013/163/EU) establishes the best available techniques (BAT) under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the production of cement, lime and magnesium oxide.

[4]The Commission's Decision (2012/134/EU) establishes the best available techniques (BAT) under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the manufacture of glass.

Table A1.16 Table 1: EU policies specific to Non-Metallic Minerals sector

Policy name	Policy description	Measure
General		
▪ REACH Regulation 1907/2006	▪ Aim: to improve the protection of human health and the environment through the better and earlier identification of the	▪ It affects the activities related to chemical substances used.

Policy name	Policy description	Measure
	intrinsic properties of chemical substances ■ In force: 1 Jun 2007 ■ Type: Regulation; Mandatory	
Cement and Lime		
■ Incineration of waste Directive 2000/76/EC	■ Aim: to prevent or to reduce as far as possible negative effects on the environment caused by the incineration and co-incineration of waste ■ In force: 28 Dec 2000 ■ Type: Regulation; Mandatory	■ It applies to incineration plants, but also to co-incineration plants, such as cement or lime kilns. It imposes strict operating conditions and technical requirements
■ Management of waste from extractive industries Directive 2006/21/EC	■ Aim: to limit risks to public health and the environment related to the operation of extractive waste processing facilities ■ In force: 1 May 2006 ■ Type: Regulation; Mandatory	■ It applies to waste resulting from the extraction, treatment and storage of mineral resources and the working of quarries. Extractive waste must be managed in specialised facilities in compliance with specific rules.
Cement		
■ WBCSD Cement Sustainability Initiative	■ Aim: to explore what sustainable development (SD) means for the cement industry and what steps/actions can the sector take to accelerate progress towards the SD ■ In force: 1999 ■ Type: Programme; Voluntary	■ One of the largest global sustainability programmes ever undertaken by a single industry sector. CSI task forces work to address key issues for the cement industry: – CO_2 and climate protection – responsible use of fuels and materials – employee health and safety – emissions monitoring and reporting – local impacts on land & communities – recycling concrete ■ There are clear commitments made in each area and regular reporting on results achieved
Ceramics		
■ Ceramic articles intended to come into contact with foodstuffs Directive 84/500/EEC	■ Aim: to set maximum limits for lead and cadmium ■ In force: 17 Oct 1984 ■ Type: Regulation; Mandatory	■ Ceramics can transfer toxins (lead and cadmium) to foodstuffs with which they are in contact. Only ceramic objects intended to come into contact with foodstuffs must be accompanied by a written declaration from the manufacturer or seller stating that they do not exceed the maximum limits for the transfer of lead and cadmium.
■ Good Manufacturing Practice (GMP) for food contact materials	■ Aim: to ensure food safety and prevent unacceptable changes in food (e.g. composition, taste or odour) caused by these materials.	■ The Regulation establishes the principles to be observed during the manufacturing of the materials. The EU's GMP for food contact materials expect to have in place: 1. A 'quality assurance system';

Policy name	Policy description	Measure
	■ In force: 1 Aug 2008 ■ Type: Regulation; Mandatory	2. A 'quality control system'; and 3. Proper documenting records.
Ceramics and glass		
■ Packaging and packaging waste Directive 94/62/EC	■ Aim: to limit the production of packaging waste and promote recycling, re-use and other forms of waste recovery ■ In force: 31 Dec 1994 ■ Type: Regulation; Mandatory	■ Among other requirements it restricts the use of certain heavy metals.
Glass		
■ End-of-life vehicles Directive 2000/53/EC	■ Aim: to prevent waste from vehicles and to encourage reuse, recycling and other forms of recovery of end-of life vehicles and their components ■ In force: 21 Oct 2000 ■ Type: Regulation; Mandatory	■ This Directive applies to vehicles and end-of-life vehicles, including their components and materials.
■ Waste electrical and electronic equipment /Directive 2012/19/EU/ Directive 2011/65/EU	■ Aim: to contribute to the protection of human health and the environment, including the environmentally sound recovery and disposal of waste EEE ■ In force: ■ 2012/19/EU: 13 Aug 2012 ■ 2011/65/EU: 21 Jul 2011 ■ Repealed versions: 13 Feb 2003 ■ Type: Regulation; Mandatory	■ The 2012/19/EU Directive sets collection, recycling and recovery targets for all types of electrical goods. ■ The 2011/65/EU Directive lays down rules on the restriction of the use of hazardous substances in electrical and electronic equipment (EEE). ■ Glass is used in a range of equipment including display screens, lighting and in the doors of large appliances such as cookers. A large proportion of this is the cathode ray tube (CRT) of television and monitor screens. The glass at the back of the CRT has a high lead content. The plate glass at the front is coated with phosphorescent luminophores as a fluorescent coating. ■ The WEEE Directive requires the pre-treatment of all CRTs to remove the fluorescent coating.
■ Plastic materials intended to come into contact with foodstuffs Regulation No 10/2011	■ Aim: to limit toxic substances in plastic materials and articles, which present a risk to human health ■ In force: 4 Feb 2011 ■ Type: Regulation; Mandatory	■ It establishes specific requirements applicable to the manufacture and marketing of plastic materials and articles intended to come into contact with food. ■ Glass fibres and microballs are used in the manufacture of plastic materials and articles subject to the restrictions specified in the Regulations.

A1.3.2 Overview of the EU28 market

A1.3.2.1 Contribution to GDP, employment:

- Germany and Italy had the largest non-metallic mineral products manufacturing sector in 2011 considering their contributions to value added (22.7% and 15.9%, respectively) and workforce (18.2% and 15.7%, respectively) in the EU-28. See Table A1.18.
- Non-metallic mineral products manufacturing sector had the highest importance in Poland, where it contributed 2.1% of the non-financial business economy total in 2010. Other Member States that are relatively specialised in this sector were Bulgaria, the Czech Republic, Romania and Portugal (1.9%). The lowest contributions were recorded in Ireland and the United Kingdom (0.6%). (Eurostat; 2013).
- The leading Member States producing cement are Germany, Spain, France and Poland (BGS; 2013)

The leading Member States producing ceramics are Italy, Germany, Spain, France, the UK, Portugal and Austria. Production in the new Member States appears to be strongest in the Czech Republic, Poland and Hungary, all of which have traditionally exported to other EU countries (Cerame-Unie).

A1.3.2.2 Range of subsectors:

Table A1.17 (below) presents the key economic indicators per sector and subsector within the Non-Metallic Minerals industry.

Key economic indicators for the non-metallic minerals industry per Member States are given in Table A1.18.

Table A1.17 Key economic indicators per sector and subsector

Description	NACE	Number of enterprises	Number of persons employed	Turnover	Value added	Personnel costs	Investment in tangible goods	Production value
				EUR million				
Manufacture of other non-metallic products	**C23**	**97,068**	**1,305,341**	**216,939**	**63,224**	**41,659**	**11,949**	**204,415**
Manufacture of glass and glass products	C23.1	15,647	316,365	46,811	15,373	10,499	3,844	44,424
Manufacture of refractory products	C23.2	795	27,730	5,618	1,640	1,093	196	5,292
Manufacture of clay building materials	C23.3	3,673	121,052	18,723	6,312	4,139	967	17,814
Manufacture of other porcelain and ceramic products	C23.4	12,942	106,910	9,135	3,454	2,525	404	7,941
Manufacture of cement, lime and plaster	C23.5	943	62,309	20,059	6,957	3,108	1,635	20,126
Manufacture of articles of concrete, cement and plaster	C23.6	23,301	401,361	75,423	18,573	13,114	2,984	70,780
Cutting, shaping and finishing of stone	C23.7	35,680	172,468	13,870	4,870	3,481	531	13,233
Manufacture of abrasive products and non-metallic mineral products n.e.c.	C23.9	4,087	97,146	27,301	6,045	3,701	1,389	24,807

Source: Eurostat data, 2011

Note: Eurostat provides data per Member State for indicators (e.g., annual turnover, number of persons employed) based on NACE codes of the format AXX.XX (e.g., NACE C17.12). In addition to this level of granularity, Eurostat provides aggregated values of the overarching NACE codes. This would be codes C17 and C17.1 in the case of C17.12. Due to limitations inherent to the current Eurostat database, however, these aggregated values do not always exactly match the sum of the parts. For example, the sum of C17.1 and C17.2 does not always exactly match the Eurostat-provided aggregated value for C17. In most cases, such discrepancies have been found to be minor. Therefore, the selected approach for analysis has been to use sums of the parts (i.e., sum of C17.1 and C17.2 to represent the overall code C17). This approach ensures consistency between data and intends to maximize accuracy.

Table A1.18 Key indicators, manufacture of other non-metallic minerals (NACE Division 23)

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	1,625	8,612	7,789	2,303	1,598	813	29,784
BG - Bulgaria	1,379	1,084	1,098	322	113	125	22,069
CZ - Czech Republic	6,865	5,322	5,116	1,682	877	308	56,428
DK - Denmark	548	2,539	2,389	0	0	104	12,370
DE - Germany	10,207	47,040	43,474	14,339	9,914	1,873	237,713
EE - Estonia	194	311	291	96	54	14	3,363
IE - Ireland	322	1,275	1,189	378	274	42	6,263
EL - Greece	0	0	0	0	0	0	0
ES - Spain	9,898	19,906	19,671	6,221	4,344	952	120,790
FR - France	8,613	31,093	27,682	8,707	6,261	2,564	128,671
HR - Croatia	1,357	1,015	928	296	161	69	12,925
IT - Italy	22,223	36,783	36,560	10,063	6,837	1,866	204,636
CY - Cyprus	330	473	470	146	84	22	3,018
LV - Latvia	375	267	262	66	34	14	4,531
LT - Lithuania	1,099	359	358	94	57	24	7,558
LU - Luxembourg	40	177	171	50	37	4	724
HU - Hungary	2,166	2,047	1,833	571	309	244	24,062
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	1,912	6,560	5,907	1,845	1,298	201	25,460
AT - Austria	1,332	6,584	6,185	2,326	1,613	343	32,720
PL - Poland	9,261	11,929	11,285	3,694	1,433	879	131,823
PT - Portugal	4,491	4,338	4,075	1,307	808	268	45,632
RO - Romania	2,359	2,580	2,550	836	295	278	42,123

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
SI - Slovenia	580	919	817	238	173	61	8,116
SK - Slovakia	3,156	1,692	1,582	502	257	101	20,365
FI - Finland	802	2,551	2,489	860	589	80	13,433
SE - Sweden	2,133	4,845	4,578	1,527	1,020	224	19,476
UK - United Kingdom	3,801	16,638	15,666	4,757	3,218	480	91,288

Source: Eurostat data, 2011

A1.3.2.3 Main players:

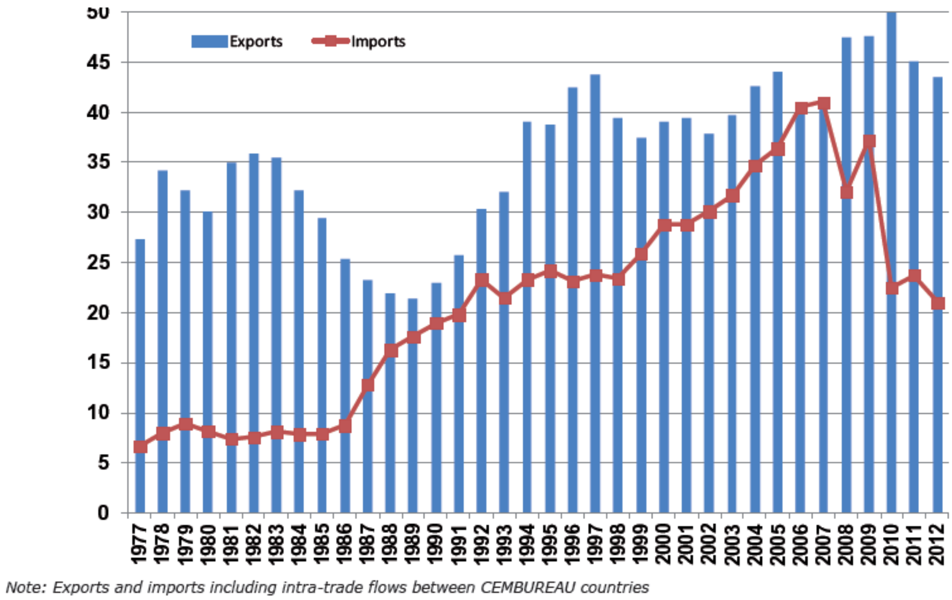
- SMEs as a group dominate the sector in terms of number of enterprises (99% of the EU-27's sectoral total) and persons employed (64% of the EU-27's sectoral total) in 2010. Within that group, micro enterprises were most numerous, but it was medium-sized enterprises that employed most people. However, large enterprises were relatively most important compared to other size classes (micro, small and medium), as they alone provided 47.1 % of the EU-27's non-metallic mineral products manufacturing value added, and employed 35.8 % of the non-metallic mineral products manufacturing. (Eurostat; 2013)
  - The German and Italian workforces were the largest contributors amongst Member States (over 200 thousand); followed by Poland, Spain and France (over 100 thousand).
  - The highest share of micro enterprises was reported in Greece (almost 40% of the total); of small enterprises – in Cyprus (62% of the total); of medium enterprises – in Slovenia, Ireland and Lithuania (around 40%); and of large enterprises – in Finland and Sweden (about 50%). (Eurostat; 2013)
- Within the glass industry more than 80% of glass is produced by less than a dozen multinationals of each more than 1000 employees. Small or medium-sized companies, mainly specialists, make up the remainder. (Glass Alliance Europe)

A1.3.2.4 Trade flows:

Cement:

- Destinations for cement and clinker exports are: USA, South America and Africa. Germany is by far the largest European exporter; followed by Spain, Belgium and Italy (BGS; 2013). Imports, three-quarters of which are clinker, come mainly from far eastern Asian countries, like China, Thailand, and the Philippines. (EC Enterprise and Industry; 2013). Yet, a lot of trading takes place within Europe. France, the Netherlands and the UK are the main importers.
- Total exports of cement and clinker from the CEMBUREAU member countries fell by -3.6% in 2012 compared to 2011 (ca. 43.5Mt), further to the -11.4% decrease recorded in 2011. Imports declined by -11.5% to approximately 21Mt. In 2012, clinker represented 24% and 15.6% of total export and import flows respectively. (CEMBUREAU; 2012b)
- Figure A1.20 presents the trade (exports and imports) in CEMBUREAU countries.

Figure A1.20 CEMBUREAU trade of cement and clinker (in million tonnes) over 1977-2012

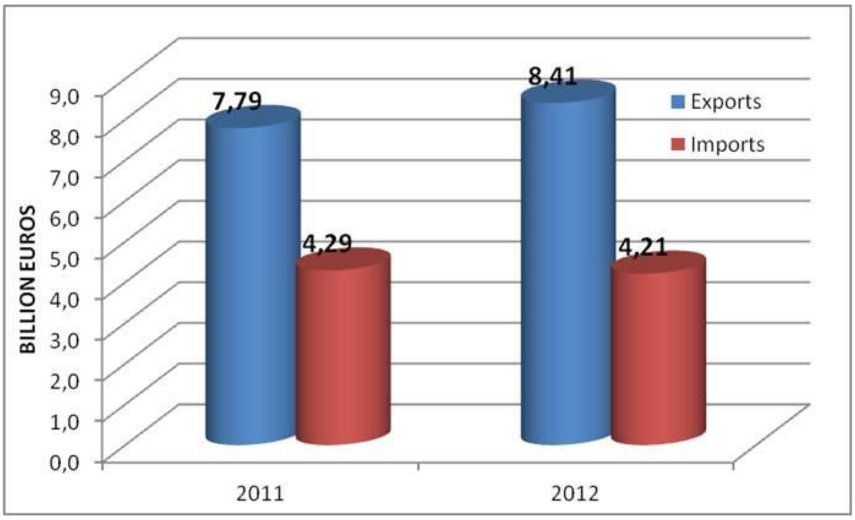


Source: CEMBUREAU

Ceramics:

- Bricks, roof tiles and vitreous clay pipes, with high weight and low price are traded on local or regional markets, whereas tableware and wall & floor tiles are exported over long distance – around 30% of the output is exported outside the EU. The USA is the biggest export market, followed by Switzerland, Russia and Japan. The most important source of imports is China, with 70% of all imports, followed by the USA and Thailand. (EC Enterprise and Industry; 2013)
- The European ceramic industry notes 25% of production being exported outside the EU and a positive trade balance of €3.7 billion (Cerame-Unie; 2013). See Figure A1.21.

Figure A1.21 Trade statistics for ceramics in Europe 2011-2012



Source: Cerame-Unie

***Glass*:**

- The EU-27 is the world's largest glass market, both in terms of production and consumption; accounting for over 25% of the non-metallic mineral sector. Foreign trade from third countries does not play a dominant role in the EU glass market. The ratio of export/import was 1.26 in 2012. (Glass Alliance Europe)
- About 80% of output is traded with other Member States. (EC Enterprise and Industry; 2013)

***Lime*:**

- Lime is a heavy product with a relatively low selling price, so transport costs dictate over what distance it can normally be transported on a regular basis under viable conditions. Therefore, delivering lime over long distances is rare except for certain speciality products, or to areas of the world with no natural source of limestone. Only a very small percentage of total production is exported, and this is mainly to neighbouring countries. Where the biggest producer has identified potential markets, it has usually taken the decision to invest in production capacity in those markets. (EC Enterprise and Industry; 2013)

A1.3.2.5 Product type and consumer groups:

Cement

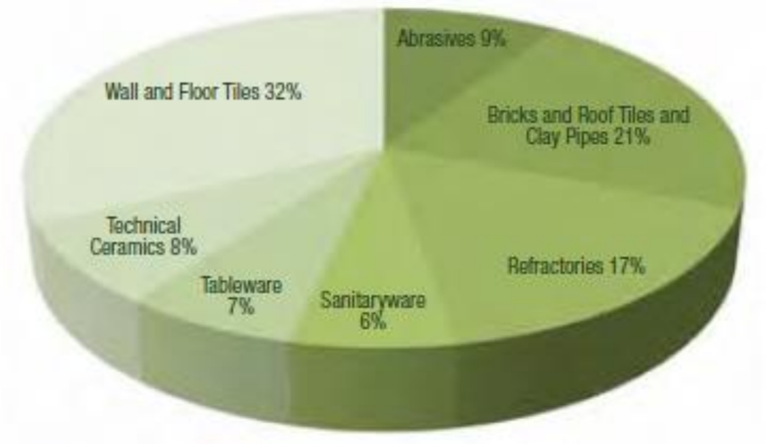
- Cement is widely used in construction and building industry (production of mortar; concrete). Other growing applications include: solidification/stabilization (S/S) for the management and disposal of a broad range of contaminated materials and wastes; and engineered soils to stabilize substandard soils as a base for buildings, roadways, airport runways, parking lots and other uses. Cement products are:
  - Specialty cements: White cements, trass cements; sulphate resisting Aquament and Portland cement for hydraulic engineering; anti-sulphate for sewage works construction; Microcem, extremely fine cement for soil injection and masonry repair; Depocrete and Procrete for waste dump sealing;
  - Masonry cement; and
  - Specific binders.

Ceramics

- The ceramics industry includes sub-sectors (Cerame-Unie):
  - Bricks and roof tiles: use in the construction industry.
  - Wall & floor tiles: indoor (buildings) and outdoor environments.
  - Table- and ornamental ware: manufacturing kitchen and household goods, e.g. plates, dishes, cups, bowls jugs and vases.
  - Refractories: a vital element in all high-temperature processes, such as metals making, the production of cement, glass and ceramics, and petrochemical processes. The main end user is steel industry (55.6%), followed by cement and lime industries (17.8%).
  - Sanitary ware: high quality products tailored to the specific requirements of end consumers; e.g. s toilets, sinks, cisterns and bidets.
  - Technical ceramics: a wide range of strategic applications. Examples include: improvements in security (e.g. crash/airbag sensors, fire protection, and military protection); improvements in health (e.g. prostheses, pacemakers, cochlear implants); improvements for the environment (filter systems, e.g. catalytic converters, high pressure fuel injection, thermostats, insulation).

- Abrasives: a wide range of applications from industry (car, machinery, energy, air & space, shipyard, wood working, glass) to construction and consumer markets (DIY). Four types of abrasives products include: Bonded abrasives (ceramic and organic), Coated (cloth, paper), Superabrasives (Diamond and CBN) and Grains.
- Clay pipes: used for sewage and drainage purposes.

Figure A1.22 Percentage of production value of the ceramic



Source: Cerame-Unie; 2013

Glass

- The glass sector comprises five subsectors covering different products, applications and markets (Glass Alliance Europe):
  - Container glass (60% of the EU glass production): a wide range of glass packaging products for food and beverages as well flacons for perfumery, cosmetics and pharmacy.
  - Building, automotive, solar-energy glass (flat glass) (30%): the building (windows and facades) and automotive industries (windscreens, side and rear-side glazing, backlights and sunroofs). Flat glass is also used in solar-energy applications (photovoltaic and solar thermal panels) as well as in urban and domestic furniture, appliances, mirrors and greenhouses.
  - Continuous-filament glass fibre: applications ranging from the automotive and transportation sector (such as aircrafts) to wind energy, agriculture, construction, communication, electrical and electronic as well as sport and leisure.
  - Domestic glass (4%): glass tableware, cookware and decorative items such as drinking glasses, bowls, plates, cookware, vases and ornaments.
  - Special glass (2%): a large range of products such as lighting glass, glass tubes, laboratory glassware, glass ceramics, heat-resistant glass, optical and ophthalmic glass, extra thin glass for the electronics industry (e.g. LCD panels, photovoltaics) and radiation protection glasses.

Lime

- Lime is an essential ingredient in the iron and steel industry, in construction (building and civil engineering), agriculture, environmental protection and in numerous chemical manufacturing processes. Lime products are (EuLA):
  - Calcium oxide (quick lime, burnt lime)
  - Calcium magnesium oxide (burnt dolomitic lime, dolomitic quick lime)
  - Calcium hydroxide (slaked lime, hydrated lime)

- Calcium magnesium hydroxide (hydrated dolime, hydrated dolomitic lime)
- milk of lime / dolime (a suspension of lime products in water)

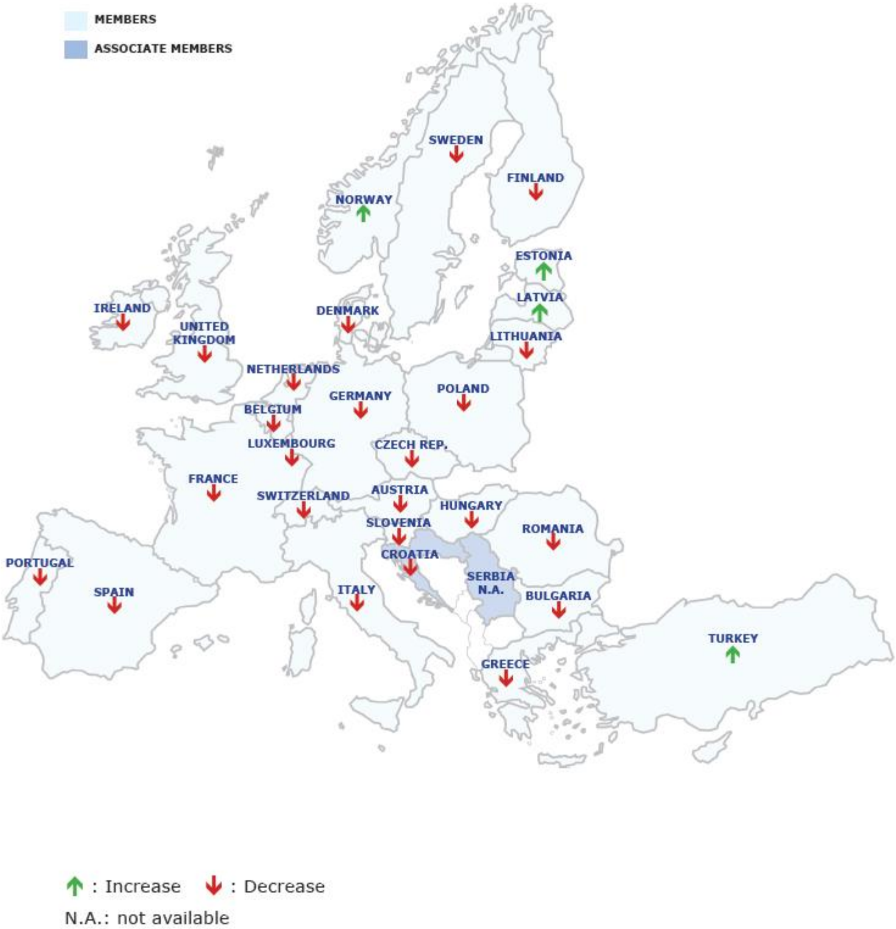
A1.3.2.6 Market developments and sector growth rates

Cement

Market development

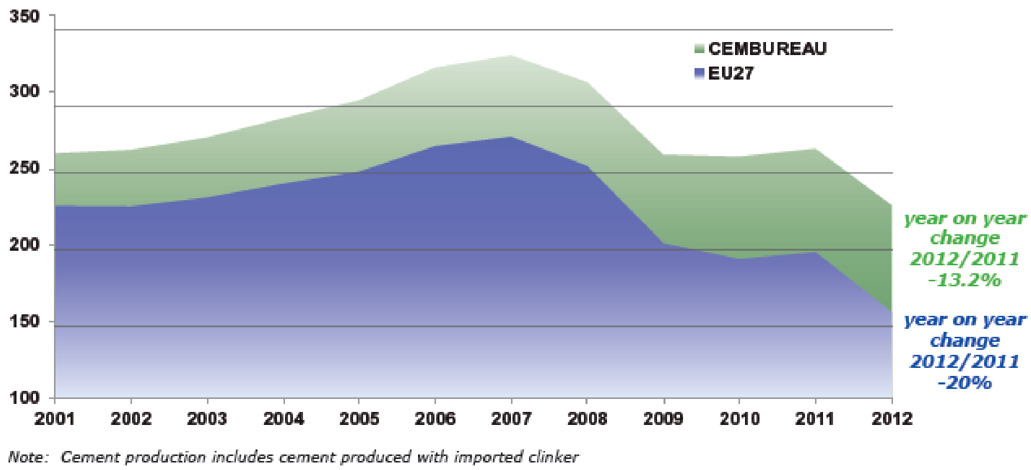
- Output in the cement industry was climbing steadily, up 23% between 1998 and 2007. Yet, since the economic crisis, the production has been declining. In 2012, cement production in the CEMBUREAU countries recorded a considerable decrease of -13% compared to 2011, reaching 228.4Mt, which was a record low. Major European markets recorded sharp drops, including Spain (-39.5%) and Italy (-20.8%), whereas more moderate fall was in Germany (-4.8%) and France (-7.3%). Contrary to 2011, declines in cement production were also observed in Eastern European countries, such as the Czech Republic and Poland with drops of -10% and -16%, respectively. (CEMBUREAU; 2012b).
- The domestic demand for cement in 2011 followed the general downturn. Cement consumption recorded a decrease compared to 2011 in most of the CEMBUREAU countries and by -13.4% in the whole region. Yet, this overall figure conceals a wide disparity between countries as the crisis resulted in moderate decreases in some national markets compared to double-digit falls in others. (CEMBUREAU; 2012b).
- See Figure A1.23 for consumption trends in 2012; and Figure A1.24 for production over the last decade.

Figure A1.23 Cement consumption in CEMBUREAU countries, variation 2012/2011



- In the EU27, cement production fell by -20%, year-on-year, in 2012 i.e. from 195.5 to 156.3Mt. (See Figure A1.24)

Figure A1.24 Cement production (in million tonnes) in CEMBUREAU countries in EU-27 over the years 2001-2012



Source: CEMBUREAU; 2012b

- Where European cement producers have identified demand for cement in non-EU countries, they have generally invested in manufacturing sites in those countries. As such, EU companies now own almost 60% of US production capacity, and have significant production facilities in the rest of the world. (EC Enterprise and Industry; 2013)
- It is expected that the overall EU cement consumption per capita will remain around 450 kg per capita with local variations per country. Assuming these average values, cement production in Europe will be about 234 Mt by 2030, less than its 2006 production. (SETIS; 2014)

Drivers

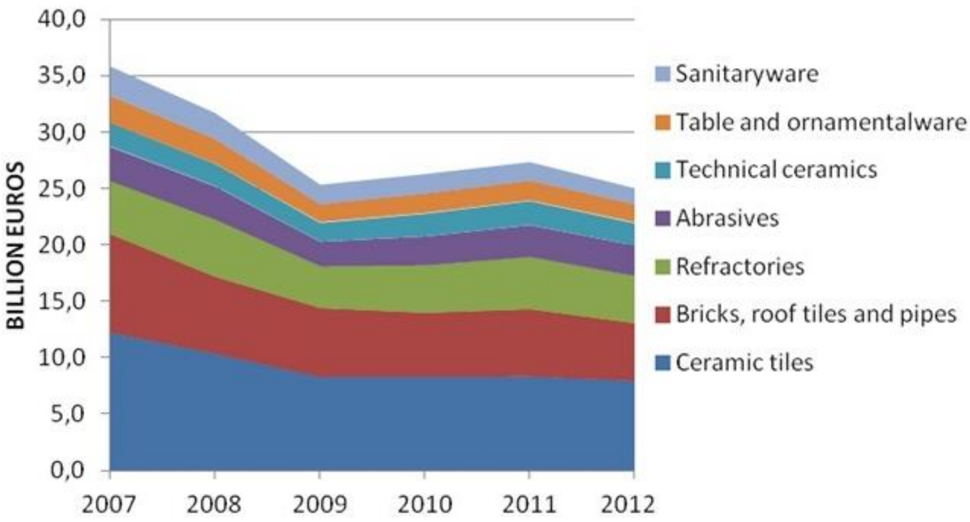
- Demand for cement is cyclical, depending entirely on building and civil engineering requirements.

Ceramics

Market development

- Ceramics sector, across its subsectors, has been recording falls in production value since 2007 (Figure A1.25).

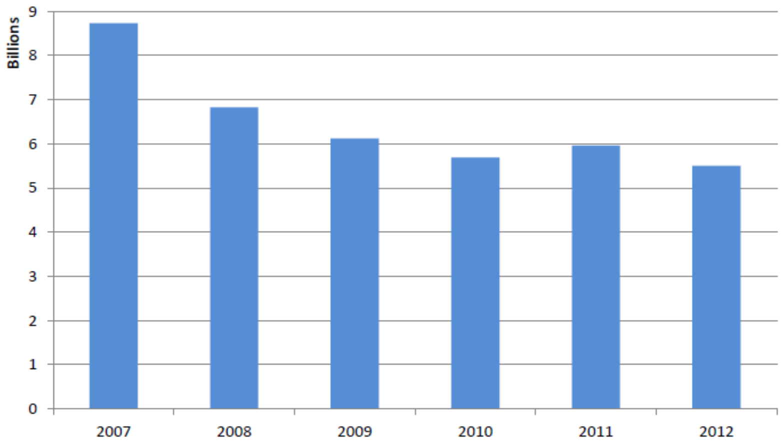
Figure A1.25 Production value trends in the ceramics industry, 2007-2012



Source: Cerame-Unie

- In 2012, the joint production of six member states in bricks and roof tiles (Germany, France, Italy, the UK, Portugal and Poland) accounted for 79% of total EU production. The production value of the EU's bricks and roof tiles industry which, between 2007 and 2012, decreased from a level of 8.7 billion euros to roughly of 5.5 billion euros (i.e. -36%). See Figure A1.26.

Figure A1.26 Production value of bricks and roof tiles in the EU (data expressed in billions of Euros)



Source: CEPS, 2014

- Regarding the ceramic tile industry, Europe saw a slight rise in production in 2012, up from 1,667 to 1,700 million sq.m (+2% compared to 2011) and equivalent to 15.3% of world production. In particular, the European Union (EU-27) remained stable at 1,168million m^2 (0.8% down on 2011), while non-EU Europe reached 532 million m^2 (+8.6%). As for consumption, the European Union was the only region in 2012 to see a fall in demand, caused by a contraction in almost all countries, with the exception of Poland. This contrasted with the strong demand in non-EU Europe (+10.7%). 32% of 2012 world exports originated from the EU (745 million m^2).[248]
- The production of refractories was steadily rising from 2004 to 2007. In 2008 and 2009 the production fell by 5 and 27% compared to the 2007 level. Some recovery has started in 2010; yet the 2011 production 15% below the 2007 output. (PRE; 2012)
- EU ceramic table- and kitchenware industry reports the following negative trends in 2007-2012: more than 10,000 jobs lost (30% job loss); more than €650 million loss of EU production (45% loss); more than 110 EU factories closed; 260% growth of Chinese exports of ceramic table- and kitchenware to the EU and loss of 56% of EU jobs in the sector since removal of quotas in 2004. While 2011 was relatively stable, the first quarter of 2012 was difficult with several further bankruptcies and loss of jobs in the EU. (FEPF; 2012)

Drivers

- The demand for wall and floor tiles is closely derived from the demand for construction which is influenced by the number of new-builds, and demand for renovations and upgrading. Demand is also closely influenced by changing consumer preferences and fashions.
- The demand for bricks, blocks and roof tiles is seasonal as well as cyclical and is also driven by the demand for new housing and housing renovation. For example, change in the new housing mix from detached and semi-detached houses (which require up to 10,000 bricks per dwelling) towards flats and apartments (which require 3,000 to 5,000 bricks per dwelling) has resulted in a decline in the demand for bricks. Also, the use of brick substitutes in construction such as in steel-framed and timber structures has reduced the demand for traditional load-bearing bricks in some EU countries.
- Again, the demand for sanitary ware products is driven by the demand for construction and renovations.

[248] CWW; *Ceramic World Review publishes survey of "World production and consumption of ceramic tiles* http://www.ceramicworldweb.it/DocumentList.aspx?documentId=18869&documentTypeId=44&language=eng

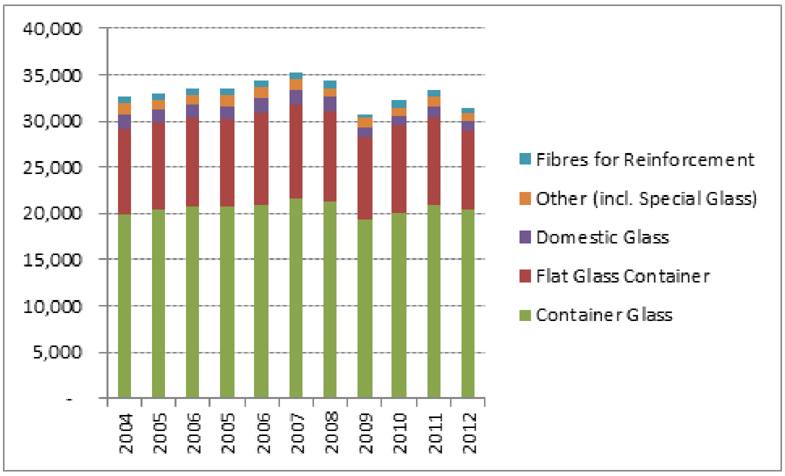
- The demand for refractories is driven by demand in major basic industries, such as iron and steel, cement, lime, glass, etc.
- The demand for clay pipes is largely driven by the policy of local authorities and utility companies
- In general, population growth and rising number of households are key to most of the ceramics subsectors.

Glass

Market development

- In 2000s the volume of total glass production in the EU has been relatively stable, with two years of recorded fall (-3% in 2008 and further -10% in 2009 of year-on-year change) due to the economic recession. Many closures have been noted, which negatively impacted production and employment.
- There are variations in the performances of sub-sectors. The domestic glass noted the biggest decrease over the years: -36% in 2012 compared to 2004, followed by other glass (-27%) and fibres for reinforcement (-9%). This reflects the increasing pressure these sub-sectors are coming under from lower cost imports. Container glass is the only subsector that recorded an increase between 2004 and 2012 (2%).
- See Figure A1.27 for the glass production trends since 2004 to 2012.

Figure A1.27 EU-27 Glass production by sub-sectors in thousand tonnes; 2004-2012



Source: Glass Alliance Europe

- The industry went through a number of restructurings and mergers, alliances, co-operations and takeovers, which allowed many companies to increase their strength and invest initially in Central and Eastern Europe; but now in Asia (e.g., China).
- In 2012, the total glass production in the European Union reached a volume of more than 31 million tonnes. The European Union is the largest glass producer in the world. The production value amounted to approximately €36 billion. Germany is the EU's biggest producer with about one fifth of the volume, closely followed by France, Italy, Spain and the UK.

Drivers

- Container glass is primarily used for packaging. As such, its demand is driven by consumer industries within the EU, which then sell their packaged products into markets in the EU and the rest of the world.
- The demand for flat glass is directly influenced by consumer demand for vehicles and commercial construction and housing (especially glazing).

- Domestic glass production depends on population growth and number of households.
- The performance of fibres for reinforcement sub-sector depends on activity in the construction and optic fibre industries.

Lime

Market development

- Germany, France, Poland, Belgium, Spain and Italy are the largest producers of lime in the EU-27. Most of the EU lime producers were small often with one single plant. However, within the last decade, a growing trend towards concentration has been observed and some large international companies having gained a considerable market share.(JRC; 2013)
- The production of lime in the EU countries dropped at the end of the 1980s, only to increase again at the beginning of 1994. This was as a consequence of changes in patterns of consumption. One of the main users of lime, the iron and steel industry, reduced its specific lime consumption per tonne of steel from 100 to 40 kg. However, around the middle of the 1990s the growing use of lime for environmental protection brought sales figures back up again. Nowadays, lime is used in environmental applications, such as water, sludge, soil, acid gas, and disinfection treatments; as well as in construction and clay soil stabilisation, chemicals, paper, food, feed, and healthcare, etc. (JRC; 2013)
- In EU 27 in 2006, production was estimated at 28 million tonnes, roughly 12% of the 227 million tonnes produced worldwide. This was worth a value of some €2.5 billions, and numbers employed are estimated at 11 000. (EC Enterprise and Industry; 2013)

Drivers

- The lime production is driven by demand mainly in sectors of steel making and non-ferrous metals processing; as well as construction. Environmental protection, agriculture and forestry, clay soil stabilisation and other sectors (chemicals, non-ferrous metal refining, PCC for paper, food, feed and healthcare) have an impact to a lesser extent.

A1.3.2.7 Energy growth rates for Non-Metallic Minerals industry

- In EU-28, final energy consumption has decreased by 15% in 2011 compared to 2001 (Eurostat; 2013a)
- Non-metallic minerals industry contributes to 13% of total energy consumption by the EU-28 industry (Eurostat; 2013a)
- Cement accounts for about 70 – 80% of the energy use in the non-metallic minerals sub-sector (IEA; 2007).
- Cement production is predicted to be between +10% or -10% of 2006 levels by 2050 (IEA & WBCSD; 2009);
- Table A1.19 presents energy consumption by non-metallic minerals industry over 2000-2011. In 2000 the industry in ten Member States consumed more than 1,000Mtoe, with Italy, Germany and Spain being the largest energy consumers. By 2011, the majority of these countries recorded a decline in energy consumption, except France (11% increase), and Poland (15%). Greece reduced its energy consumption by 44% and fell below the 1,000Mtoe threshold in 2011. However, Austria has been gradually increasing its consumption, surpassing the 1,000Mtoe in 2011 (by 47% in 2011 compared to 2000).
  - Amongst the countries with energy consumption lower than 1,000Mtoe, five out of seventeen noted an increase (Austria, Bulgaria, Lithuania, Estonia, and Latvia. The latter recorded the relatively highest increase in the EU-28 of 126%). The remaining countries reduced their energy consumption within the industry (from -12% in Sweden and Slovenia to -46% in Cyprus).

Table A1.19 Energy consumption in MToe by the non-metallic minerals industry per Member State over 2000-2011

GEO/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Change 2011/2001
Italy	8,089	7,623	7,685	8,463	8,814	8,893	8,153	8,145	8,242	5,947	5,895	5,798	-28%
Germany	7,072	6,509	6,545	6,412	6,057	5,679	5,763	6,832	6,660	5,996	6,430	6,637	-6%
Spain	6,368	7,047	6,194	7,368	6,870	7,527	6,616	6,732	6,264	4,468	4,539	4,573	-28%
France	3,703	4,233	4,366	4,295	4,271	4,056	4,432	4,305	4,401	3,916	4,004	4,121	11%
United Kingdom	2,770	2,863	2,680	2,682	2,553	2,983	2,874	2,910	3,014	2,606	2,666	2,626	-5%
Poland	2,600	2,378	2,247	2,356	2,508	2,530	2,573	2,933	2,651	2,561	2,725	3,001	15%
Portugal	2,108	2,079	2,220	1,830	1,937	2,013	1,966	1,880	1,749	1,508	1,589	1,481	-30%
Belgium	1,418	1,322	1,208	1,465	1,472	1,193	1,318	1,162	1,385	1,038	912	1,253	-12%
Greece	1,287	1,371	1,229	1,116	1,207	1,121	1,102	1,478	1,124	856	969	727	-44%
Czech Republic	1,150	1,172	1,108	1,141	1,183	1,171	1,180	1,265	1,256	978	1,028	1,005	-13%
Romania	980	1,004	1,030	615	790	1,024	975	756	688	584	543	609	-38%
Netherlands	860	842	727	726	725	734	730	775	763	673	721	629	-27%
Austria	740	765	806	798	851	897	900	958	994	980	964	1,091	47%
Slovakia	717	556	501	481	410	499	462	498	458	376	376	400	-44%
Denmark	623	619	587	620	643	628	660	685	505	408	406	439	-30%
Hungary	575	628	650	673	644	636	614	625	647	456	444	422	-27%
Bulgaria	506	508	552	557	593	614	674	774	708	523	606	511	1%
Sweden	499	505	490	438	459	441	459	456	440	380	428	440	-12%
Croatia	439	487	479	457	491	522	510	532	529	417	391	344	-22%
Ireland	375	450	453	491	521	521	572	588	517	359	262	280	-25%
Finland	369	377	387	387	414	397	410	417	405	269	283	316	-14%
Cyprus	224	205	210	222	239	196	189	208	225	194	167	120	-46%
Slovenia	220	225	186	218	214	220	252	238	229	181	185	193	-12%
Luxembourg	166	179	148	132	148	153	145	123	122	110	110	112	-33%
Lithuania	154	155	155	155	163	185	222	223	188	121	132	155	1%
Estonia	112	152	89	84	109	129	129	207	202	126	111	149	33%
Latvia	65	69	88	104	98	117	117	127	120	80	135	147	126%

Source: Eurostat, (available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home)

Note: *Malta does not have the pulp, paper & print industry, thus it is not included in the table above.*

A1.3.3 Business environment

A1.3.3.1 What are the key competitive strengths?

- Raw materials are extracted mainly on-site, which avoids unnecessary transportation and the costs and environmental damage which that could cause. Reduced reliance on imports.
- Backbone for local economies by promoting a local industrial base, driving the development of its economy, and relying on a skilled labour force in smaller communities. (BCG; 2013)
- Committed to innovation through:
  - Increasing the use of wastes as alternative raw materials and fuels – the industry uses carefully selected wastes from other industrial processes as secondary raw materials or alternative fuels. For example, the cement industry's role in disposing of animal remains at the height of the mad cow disease. Large co-processing potential[249];
  - The development of new products, some with very positive environmental impact as in energy and CO_2 efficient buildings,
- European Cement Research Academy (ECRA) has been set up as a platform of over 40 leading cement producers worldwide to support, organise and undertake research activities within the context of cement production and its application in concrete in terms of sustainable development.

Ceramics

- Some of the waste arising from the production process can be recycled back to the kiln, and that which cannot be recycled internally is sent for external recycling (e.g. road construction) or disposal (e.g. landfill). Some producers are beginning to bring in waste for recycling, but this is by no means common, as in, for example, the glass industry, and there is no standardised collection system. (EC Enterprise and Industry; 2013)
- High quality ceramic products manufactured by flexible and innovative companies, mainly SMEs. These companies are able to react quickly to changing market demand and new opportunities.
- Committed to innovation (EC Enterprise and Industry; 2013):
  - Its closeness to the market place and the ability to offer just-in-time and just-to-market service,
  - Increasing R&D in technical ceramics, smart materials, use of lasers,
  - Increased process automation,
  - Labelling and communications advantages - certification systems, origin marking, eco-labelling.
- The global leadership is still in Europe, with many of the top worldwide ceramic companies being headquartered in the EU. (Cerame-Unie; 2013)
- Durability of its products

[249] Co-processing offers a solution to use both waste and industrial by-products in a way that maximises their potential, i.e. by extracting the energy potential and using what remains as a raw material (CEMBUREAU; 2013b)

Glass

- Made of resource-efficient material (sand and glass waste (cullets)) and is fully recyclable
- Europe has the innovative and technological leadership in glass-making.
- Committed to innovations:
  - Investing significant resources in intensive R&D programmes to develop new ways to use glass, to make available new products; E.g. glass fibre substituting metals and wood via composites
  - Process R&D that has resulted to improvements in the field of energy saving and environmental protection, efforts to enhance recyclability and effective recycling; a switch from fossil to non-fossil energy
- Contributing to energy efficiency: many of glass applications are energy-saving solutions, e.g. insulating glass for windows and facades; weight-lightening reinforcement glass fibre used in automotive, aviation and other transport modes to reduce the weight of vehicle and their fuel consumption. Glass is also used to generate renewable energy through solar-thermal and photovoltaic applications and wind turbine, which largely profit from light weight reinforcement glass fibres.

Lime:

- Raw materials are extracted mainly on-site, which avoids unnecessary transportation and the costs and environmental damage which that could cause. Reduced reliance on imports.
- Energy-efficient: since 1997, the European lime industry has been using more waste fuels as well as biomass; thus reducing its consumption of fossil fuels. Yet, use of waste fuels is limited for reasons of quality requirements.
- Support to local communities: providing employment to local people
- Fundamental ingredient for many industries. In some of its applications, lime plays a very positive role in terms of the environment, such as in water, sludge, soil, acid gas and disinfection treatments.

A1.3.3.2 How are these advantages envisaged as changing over the next 10-15 years?

Cement:

- Technology is at a mature stage. Further developments are likely to be in the field of environment (emissions abatement and substitution of fossil fuels by wastes).
- The market penetration of cement with a decreasing clinker-to-cement ratio will largely depend on: availability of raw materials; properties of the cement; price of clinker substitutes; intended application; national standards; and market acceptance.
- SETIS (2014) points out that the cement industry needs predictable, objective and stable CO_2 constraints and an energy framework on an international level. Also, research and development of capabilities, skills, expertise, innovation and international partnerships must continue to be developed.

Ceramics:

- Globalisation and increased international competition have forced the EU ceramic manufacturers to evolve to a more efficient production process, resulting in increased labour productivity. This trend of increased productivity will presumably continue in the future. In particular, the imposed energy-saving regulations are pushing the EU manufacturers to a more economic, energy-saving production process, implying an increase in productivity (Ecorys; 2008)

- There is a continuous need to invest in R&D and innovation in order to stay ahead of low-cost competition.
- The relatively limited supply of a high-skilled workforce may form an important barrier to be able to keep up this high level of innovation in the future, especially when third countries are catching up. Investments in education and an optimal recruitment policy will therefore be indispensable. (Ecorys; 2008)
- For future sector development opportunities lie in (Ecorys; 2008):
  - Access to new markets: Eastern and Central Europe, China, India and other Asian markets as well as several South American countries are expected to record relatively high growth rates. As such, European Ceramics companies should position themselves in terms of creating production capacity, sales and marketing and distribution channels aimed at these new growth markets;
  - Uniqueness and design in high value ceramics is another opportunity for the ceramics sector in brand and design conscious consumer markets.
  - Development of cleaner technologies and cleaner products: e.g. development of new techniques for recycling raw materials, reducing the need for imported raw materials; R&D in technologies or processes to help to reduce energy consumption or handling and recycling of wastewater; energy management and energy optimisation in all production processes; development of roof solutions with built-in solar panels or development of highly energy efficient clay blocks with strong insulation effects.

Glass:

- Demand in the flat glass and insulating glass sectors can be expected to grow once EU provisions on the energy performance of buildings starts to have an effect.
- For future sector development, opportunities lie in (Ecorys; 2008b):
  - Access to new markets, e.g. the Middle East and Asia
  - New specialised products: it is expected that the demand for high-quality products will increase in the future, such as in the flat glass sub-sector in respect of laminated, tempered, mirrored glass, solar control glass, double-glazed insulating glass units, etc. At the same time, new products may open new markets and export opportunities, e.g., heat resistant glass, photosensitive glass, and fibre optics;
  - Increased R&D: e.g., from cross-disciplinary research, exploitation of new converging technologies, new materials, new functionalities of materials, etc. In respect to new production technologies, introduction of still more sophisticated manufacturing systems and energy efficient techniques may alter the cost structure of the production process.

Lime:

- Technology is at a mature stage. Further developments are likely to be in the field of environment (emissions abatement and substitution of fossil fuels by wastes).
- Innovation challenges for the lime industry include using the environmentally friendly applications of lime to further improve the industry's overall image, and continuing research for more environmental applications and speciality products.
- Growth of demand is mainly expected in environment and construction sectors.
- A trend towards more technical and higher added value products has been observed. This trend is expected to continue and to support market internationalisation and substitution of other products (e.g., cement). Furthermore, additional competition on lower added value products is expected from several European periphery ovens which currently work at sub-capacity. (FPS; 2011)

A1.3.3.3 Threats

A1.3.3.4 What are the main threats which currently impact on the sector?

Cement:

- High energy costs (30% of the cement industry's total operating expenses relate to energy costs) (CEMBUREAU; 2013b)
- Vulnerable to imports (CEMBUREAU; 2013b, BCG; 2013))
- Closely linked to the construction sector, which closely follows general economic activity (CEMBUREAU; 2013b)
- High capital and operating costs due to high energy and electricity prices and external imposed liabilities, including investments which are needed in order to meet regulatory requirement. Also, regulatory uncertainty in Europe discourages companies from making the investments required in order to improve the efficiency of cement plants and the lack of an appropriate legal framework deters companies from adopting structural adjustments (BCG; 2013)
- Unable to pass on rising costs to customers. Cement prices fell by 13% between 2007 and 2011, despite a rising cost base[250] of between 6-26% during the same period. The sector is currently suffering from a structural lack of reasonable return on investment (3-5% below the industry's cost of capital). As a result the industry started to reduce investments in maintenance, 50% between 2009 and 2010 (BCG; 2013)

Ceramics:

- Serious competition in mass volumes of low-cost products from emerging economies, especially tableware,
- High energy prices,
- Reliance on virgin raw materials from third country producers; rising prices of raw materials from Asian countries, especially China, are starting to threaten markets where traditionally Europe has been a leader.
- Trade barriers either in the form of tariffs, testing and certification schemes,
- Life style changes and substitution by other products,
- Attracting and keeping a skilled workforce.
- The electro-intensity of the ceramic sector is expected to rise towards 2050 as some processes may shift from gas to electric firing. Moreover, increasing demands under the EU Industrial Emissions Directive and other legislation may require more use of electrically-powered equipment. Therefore, some ceramic sectors will have significantly more electricity usage and therefore could become vulnerable to job and carbon leakage as they are highly-exposed to international trade. (Ceramie-Unie; 2013)

Glass:

- A number of non-tariff barriers, such as the introduction of compulsory testing and certification schemes are beginning to be seen, as well as the bans of imports of certain products into countries where there is a strong domestic production. Other non-tariff barriers have been reported in several countries. (EC Enterprise and Industry; 2013)
- Challenges (EC Enterprise and Industry; 2013; Glass Alliance Europe):
  - Global competition and consolidation,

[250] Including fuel costs (rise by 26%), raw material extraction costs (rise by 10%), average manufacturing labour costs (rise by 6%) and electricity costs (rise by 12%)

- Competition from low-cost countries,
- Downstream bargaining power and increasing cost-cutting demands,
- Production over-capacity in some sub-sectors,
- Energy prices and lack of security of supply,
- Substitution by other products,
- Third country trade barriers, counterfeiting of European designs.

- Strongly rising production costs and the growing legislative burden, as well as the strong Euro, have led to investments being made outside the EU.
- Imports from Asian countries, and particularly China, are steadily increasing regarding tableware, special glass and reinforcement glass fibres. (Glass Alliance Europe)

***Lime*:**

- Competition with non-EU producers: the EU lime industry operates in competition, especially around the periphery of the EU, with other producers in other countries which do not have to conform to European quality standards, and do not necessarily meet European standards on energy use, environmental control, or working conditions.
- Guaranteed long-term access to the lime industry's raw material, calcium carbonate, is an important issue.

A1.3.3.5 How are these envisaged as changing over the next 10-15 years?

Cement

- Due to differences in national application documents of the European concrete standard, concrete can often not be used universally. Therefore, the cement industry must promote standard harmonisation at the EU level. (SETIS; 2014)
- Energy costs are predicted to rise. According to the International Energy Agency (IEA), crude oil prices, which are an indicator of petcoke prices (one of the main fuels used in the cement industry together with coal), are expected to increase by 3 percent per year until 2020.(BCG; 2013)
- If the challenges faced by the cement industry are not addressed in time, future demand will be increasingly covered by imports. Yet, import rates might be at risk, as exporting countries are either unstable or demands from internal markets for infrastructure development are expected to grow (BCG; 2013)

Glass and ceramics

- It is expected that the competition from production facilities in the Middle East will increase. The competition in high-value products will become fiercer as China and other countries are steadily improving their technical know-how day by day. As such, the competition will continue to post a severe threat.

A1.3.3.6 Business strategy and decision making

Cement

- Capital-intensive industry with long-term investment cycles (cost of cement plants usually >€150M per million tonnes of annual capacity, which is equivalent to around 3 years of turnover); energy intensive (production of one tonne of cement requires 60 to 130 kilogrammes of fuel oil or its equivalent, depending on the cement variety and the process used, and about 110 KWh of electricity); and low labour intensity (process industry). (CEMBUREAU)
- Cement production technology and efficiency have evolved to the extent that they represent the best possible in terms of environmental performance. Further major

improvements at the production stage are unlikely in the short term. (EC Enterprise and Industry). No breakthrough manufacturing technologies are foreseen that will reduce significantly thermal energy consumption (SETIS; 2014)

- The sector's roadmap to 2050 (CEMBUREAU; 2013b) presents a vision to achieve 32% emission reduction compared with 1990 levels; focusing on five routes:
  - Resource efficiency, including alternative fuels, raw material substitution, clinker substitution, novel cements, and transport efficiency
  - Energy efficiency, including electrical energy efficiency and thermal energy efficiency
  - Carbon sequestration and reuse, including carbon sequestration and reuse, and biological carbon capture
  - Product efficiency including low carbon concrete
  - Downstream including smart buildings & infrastructure development, recycling concrete, re-carbonation, and sustainable construction.
- For each route, the document presents the key success factors, challenges and policy recommendations. In addition, for the first three routes, which are deemed under the sector's control, potential savings are discussed and where possible quantitative estimates are given: 27% in fuel CO_2 emissions due to change in fuel mix; 4% of CO_2 savings due to reduced clinker-to-cement ratio; 50% potential carbon reduction associated with novel/promising technologies; and 50% reduction in transport emissions due to reduced road transport, higher share of alternative transport means and innovation in the transportation sector. The last two routes look at how cement and concrete can contribute to a low carbon society.
  - Furthermore – breakthrough technologies will be needed if deeper emission reduction is to be achieved. It has been assumed that 85% of total clinker production (equivalent to 59% of cement plants) will need to be equipped with, for example, carbon capture and storage technology.

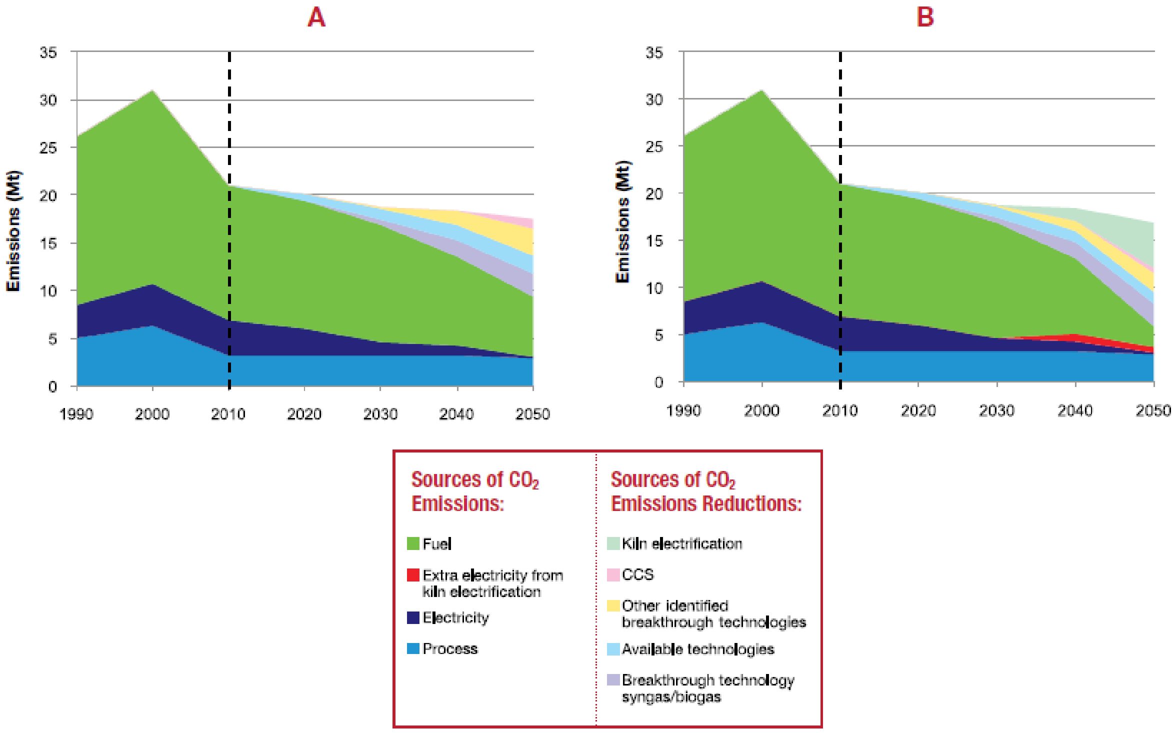
    Note: WBCSD and IEA (2009) prescribe similar levers for carbon emissions reductions: thermal and electric efficiency; alternative fuels; clinker substitution; and CCS. For each explains limits to implementation; R&D needs and goals, and Partner roles. The Roadmap also describes what policy and financial support is needed. Annex 2 provides roadmap indicators developed to track progress against the cement roadmap.
- The stakeholder consultation on the future of the cement industry listed the following for further investigation (CEMBUREAU; 2012):
  - Several externalities/policies (i.e. elements which will have an impact on the direction taken by the cement industry): Carbon leakage; Research: stimulate, support and finance; Training: skilled workforce; Access to market for breakthrough technologies; Integrated EU industrial policy; Eco-design legislation/standards/public procurement; Public acceptance; National climate change roadmaps (China, Russia, India);
  - Technologies: Limestone-free cements; Alternative fuels; Clinker substitutes; Carbon capture; Recycling; New, innovative products with a higher value; Circular economy

Ceramics

- The sector's roadmap to 2050 (Cerame-Unie; 2013) discusses how the industry achieved and could make further significant emission reduction:

- – Reducing fuel emissions: installing improved kilns251, dryers, thermostats and seals; implementing automated controls; saving heat by improving thermal insulation through the use of novel refractory linings, coatings and other ceramic materials; recovering excess heat by e.g. capturing kiln gases in order to preheat the combustion or dryer air; smart design of manufacturing facilities (i.e. the physical distance between the different processes, e.g. firing and drying, can account for energy savings); electrification of kilns using low-carbon electricity. The latter is not currently economically-viable due to the significantly higher cost of power compared to natural gas.
- – Alternative energy sources: alternative fuels (biogas, syngas from biomass or waste); renewable energy; CHP

- The following figure shows current and future technologies in the ceramics industry that will help achieve emission reductions by 2050 via two scenarios of CO_2 emissions reduction by 2050. The scenarios show that the industry could achieve 65% or 78% emissions reduction (mainly because of unavoidable process emissions); as such further research and development into breakthrough technologies which are not known today is required. (Ceramie-Unie; 2013)



Glass

- High start-up costs, production facilities are capital intensive and require long investment cycles (up to 18 years[252]), and in some sub-sectors, products ranges are very diverse making it difficult to obtain a sufficiently high production volume to secure profit margins.(EC Enterprise and Industry)

[251] Note: The lifetime of a kiln can be more than 40 years and it is a major capital investment, as such it is not financially-feasible to routinely upgrade kilns before the end of their life and replace them with more energy-efficient models.

[252] Glass Alliance Europe; 2013

- The flat glass industry's roadmap to 2050 (Glass for Europe; 2013) extensively describes how flat glass products can help Europe achieve low carbon economy by 2050, as they provide energy efficient solutions for buildings, energy generation (solar) and transport.
  - The flat glass industry believes that achieving 80% emission reduction by 2050 will not be possible. It estimates that reductions of 5-10% of its CO2 emissions per output unit by 2030 are feasible owing to continuous improvements in furnace insulation, in the most efficient use of energy and in increased recycled glass use. To go beyond would require major breakthrough in thermo-dynamic science and in raw material use, the combination of greater recourse to electricity and the development of Carbon Capture and Storage. Yet, the latter two options are deemed huge challenges for the sector in terms of industrial processes but also for authorities, particularly in the field of infrastructure development. Having said that, the decarbonisation of the flat glass manufacturing industry is expected to follow a slow path in the next 20 to 30 years as technologies and infrastructures are put in place and then rolled out to all installations.

Lime

- The industry is capital and energy intensive, with energy costs accounting for up to half of total production costs. Lime kilns are long-lasting (about 40 years), which means that it can be difficult for producers to comply in the short term with legislation affecting energy or emissions, for example, depending on the stage in the life cycle of the kiln, and in any case, the cost of compliance with environmental legislation can represent a significant proportion of production costs. The industry has reached a level of performance which in many cases cannot be improved upon with current technologies, so that further major improvements at the production stage would require access to breakthrough technologies. (EC Enterprise and Industry)
- 2050 Roadmap for the European Lime Industry is planned for publication in early 2014[253].
- Belgium has developed a roadmap for its lime sector, in which three scenarios till 2050 horizon are described. Energy and CO_2 reduction potential could be realised by (FPS; 2011):
  - Product mix: increase the proportion of products that require less CO2
  - Energy efficiency: reduce mechanical and thermal losses (e.g. kiln type, recycled dust); recover thermal losses (e.g. CHP)
  - Process improvements: modify the way products are made (e.g. switch from batch to continuous process)
  - Alternative fuels: increase the proportion of fuels which emit less CO2 (biomass, lignite to gas, waste)
  - End of pipe: capture the CO_2 emitted by the production (CCS)

A1.3.3.7 Mitigation activities

Cement

- Most CO_2 emissions from cement manufacturing result from the production of clinker (the main component of cement), which is obtained during the calcination and sinterisation of limestone in a kiln. Thus, reducing the clinker content leads to reductions in energy consumption and carbon intensity of the cement produced. Cement production generates CO_2 emissions from two sources: combustion (40%) and calcination (60%). Combustion-generated CO_2 emissions are related to fuel use while emissions due to

[253] http://www.ecofys.com/en/project/2050-roadmap-for-the-european-lime-industry/

calcination are made when the raw materials (mostly limestone and clay) are heated and CO_2 is liberated from the decomposed limestone. (SETIS; 2014)

- Other emissions include NO_X, SO_2, and dust. Dust abatement has been widely applied for many years and SO_2 is a plant-specific issue. NO_X abatement has taken off in recent years with more than 100 SNCR (selected non-catalytic reduction) installations in the cement industry. Some plants have installed primary measures to improve clinker quality, thus reducing energy consumption and emissions to air. (EC Enterprise and Industry; 2013)
- Between 1990 and 2011, the EU-28 cement industry reduced its gross CO_2 emissions per tonne of cementitious by 13%; alternative fuel usage has multiplied by almost 7, and the clinker to cement ratio has dropped by 4.5%. (GNR) (BCG; 2013)
- Over the past 20 years, the European cement industry has reduced CO_2 emissions per tonne of cement due to the implementation of a number of measures including (CEMBUREAU; 2013b):
  - Replacing older wet technology kilns with dry technology kilns. Nowadays, over 90% of the clinker produced in Europe is based on this technology.
  - Improving grinding technologies
  - Enhancing thermal energy consumption
  - Optimising and modernising existing plants by installing state-of-the-art automation, process control technology and auxiliary equipment.
  - Using greater quantities of alternative fuels (a sevenfold increase since 1990), consisting of either waste material or biomass.
  - Utilising waste material like contaminated soils, construction waste, ceramic moulds, foundry sand, gypsum from plasterboard, mill scale, cement kiln dust, refractory bricks and road sweepings or fly ashes as raw materials, thereby reducing the requirement for limestone and other virgin materials in the production process.
  - Substituting clinker with materials such as finely ground limestone filler material, ground naturally occurring pozzolans or reactive by-products from other industries, such as fly ash
- CCS may be a viable option in long term; yet, in the short term CO_2 emission reduction will be achieved through higher uses of clinker substitutes in cement and increased use of alternative fuels, such as waste and biomass. The volume of CO_2 emission savings from the latter is estimated to be 18Mt of CO_2 in 2020 and 23.5Mt of CO2 by 2030. Alternative fuels and raw materials already meet about 18% of the European cement industry's requirements. (SETIS; 2014)
- A number of energy efficiency measures are already on the table, but their deployment is usually site-specific, making it difficult to assess the overall gains that can be expected. (SETIS; 2014). Production technology is at a mature stage. Scope for further improving energy efficiency and reducing emissions is limited

Ceramics

- High-performing and durable ceramics must be fired at high temperatures. As such, the most energy-intensive process in ceramic manufacturing is kiln firing and in some cases the drying and shaping processes. (Ceramie-Unie; 2013)
- At around 30%, energy remains one of the highest production costs in the European ceramic industry, where the energy mix is around 85% natural gas to 15% electricity.(Cerame-Unie; 2013)
- The industry's energy consumption has halved over the last 25 years principally as a result of a switch in fuel usage (replacing solid fuel with natural gas). (EC Enterprise and

Industry; 2013). Reduction was also due to better kiln design, more efficient firing, scaling up and improving the efficiency of kiln technology, and moving, where appropriate for the scale of operation, from intermittent (batch) to continuous (tunnel or fast-fire roller kiln) technology.(Ceramie-Unie; 2013)

  – The energy used to produce the bricks for a 1m² brick wall decreased by 39% from 1990 to 2007. For one tonne of wall and floor tiles, the energy used decreased by 47% from 1980 to 2003. By changing from a twice-fired process at conventional firing temperatures to a single firing process at reduced firing temperatures, one UK hotel tableware producer reduced emissions by 79% compared with similar products. (Ceramie-Unie; 2013)

- Scope for further improving energy efficiency and reducing emissions is limited. (EC Enterprise and Industry; 2013). Breakthrough technologies need to be developed in near future (Ceramie-Unie; 2013) – see Annex 2.

Glass

- Energy accounts for the largest share of manufacturing costs. CO_2 in glass manufacturing have two sources: the use of fossil fuel to fire furnaces (75% of CO_2 emissions) and the carbon contained within and released by raw materials during the melting process. The latter cannot be avoided; yet the industry investigates ways to increase the use of recycled glass and therefore uses fewer raw materials (glass melting without any raw material and with recycled glass only is not feasible for physical and quality reasons).
- Over the last decades, the energy intensity of glass manufacturing was reduced by 77% (i.e. 35GJ/tonne of glass in 1960 compared to 8GJ/tonne today) and CO_2 emissions by 50% despite increases in production. This was achieved by process innovation and the systematic use of the best available techniques. (Glass Alliance Europe)
  – Economists at the French Research and Investment Institute CDC Climat, acknowledge that sectors including glass reduced CO_2 emissions since 2005 not only because of the economic crisis but mainly because of energy intensity improvements and renewable energy deployments. (Glass Alliance Europe; 2013)
  – The flat glass industry managed to reduce energy consumption per unit of production by 55% between 1970 and 2000, thereby doubling output with no overall increase in CO2 emissions. Major energy efficiency improvements can only be undertaken when production is completely stopped, which requires waiting for the end of the 16 to 18 year production cycle. (Glass for Europe; 2013)
- Glass manufacturing technology is at a mature stage, and further savings in energy consumption are likely to be limited. (EC Enterprise and Industry; 2013). Extensive research programmes are currently being financed by glass manufacturers to get to a new break-through and overcome current technological barriers to reducing energy consumption (Glass Alliance Europe)

Lime

- Process emissions are a large proportion of total emissions resulting from the lime production.
- CO_2 emission reductions can be achieved by the use of more efficient kilns and through improved management of existing kilns using similar techniques to those in the cement industry. Switching to low carbon fuels can further reduce CO_2 emissions.

A1.3.4 Sector projections

In 2011, the non-metallic minerals sector accounted for 1.5% of EU GDP. It has over 97,000 enterprises, generating €217 billion of revenues in 2011 (Eurostat; 2013). SMEs dominate the sector, accounting for 99% of enterprises and 65% of the workforce. However, in glass and cement, a few large organisations dominate production. The non metallic minerals sector accounted for 13% of total industrial energy consumption in 2011; however, energy consumption has declined by 15% since 2001 (Eurostat; 2013). This is a combination of improvements in efficiency and declining production in some sub-sectors. The non metallic minerals sector is strongly linked to economic growth; specifically, the construction and transportation sectors.

EU-27 is the world's largest glass market, in terms of production and consumption, with 80% of production traded within the EU (EC Enterprise and Industry; 2013). The market is dominated by less than a dozen multinationals that produce over 80% of the total glass produced in the EU. Between 2004 and 2012, production declined slightly, by approx. 5%. While container and flat glass production remained relatively constant, production declines were due to large decreases in demand for domestic, specialty glass and glass fibres due to low cost foreign imports. In 2012, glass production totalled 33 million tonnes (Glass Alliance Europe). Demand for flat and container glass products are driven by the consumer, construction and automotive industries; as such, it is anticipated that total glass production will follow historic trends and remain relatively stable.

Ceramics production is dominated by Germany, France, Italy, UK, Portugal and Poland, who account for nearly 80% of total EU production. In 2000, EU production was 55 million tonnes (Ecofys; 2009), which remained relatively constant through 2007. However, since 20007, all ceramic sub-sectors have experienced production declines totalling 36% through 2012 (Cerame-Unie; 2012). As such, it is estimated that EU production is on the order of 35 million tonnes in 2012. As with glass, demand for bricks, wall, roof, and floor tiles are influenced by the construction sector. However, unlike glass, the industry has suffered from low cost imported products; and an over-reliance on imported raw materials, where costs are rising. This is anticipated to continue, with a continuing slow decline in future production.

Between 1998 and 2007, cement production increased by 23%; however, since the economic crisis, the production has been declining. In 2012, cement production declined by 13% compared to 2011, reaching 228.4Mt, which was a record low. Demand is cyclical and driven by the construction sector. It is expected that the overall EU cement consumption per capita will remain around 450 kg per capita with local variations per country. Assuming these average values, cement production in Europe will remain relatively constant, with total production in 2030 estimated to be 234 Mt (SETIS; 2014).

Germany, France, Poland, Belgium, Spain and Italy are the largest producers of lime in the EU-27. Between 2006 and 2011, EU lime production declined from 28 million tonnes (Eurostat; 2013) to 22 million tonnes (EuLA; 2014), reflecting a 20% decline. Demand is driven by the environmental and construction industries; however, the industry is suffering from poor access to raw material, calcium carbonate, and competition from producers on the periphery of EU. Future production is anticipated to continue to decline, but at a lower rate.

Overall, production in the non-metallic minerals sector is assumed to remain relatively flat through 2050; slight declines in lime and ceramics will be offset by stable production in glass, and a slight increase in cement production. Table A1.20 presents the anticipated Business-as-Usual (BAU) production profile for the sector.

Table A1.20 Projected BAU production of non-metallic minerals in EU (million tonnes)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Production (MT)	318.2	318.2	317.2	316.6	316.1	315.6	315.3	315.0	314.9	314.8

The non-metallic minerals sector is energy- and raw materials–intensive, with energy costs contributing to significant part of production costs (>30%). The sector is defined by high capital costs, with long term investment cycles (e.g., kilns have 40 year lifetimes). Consequently, once an investment is made the ability to upgrade and improve energy efficiency is impacted. 2050 sector roadmaps have been developed for all sectors, and energy efficiency is listed as a key objective. However, many of the sectors are dependent on breakthrough technologies that are not available today. As such, overall energy intensity for the sector is anticipated to remain stable for the near future and then decline slowly through 2050. Table A1.21 presents the anticipated BAU energy intensity trend through 2050.

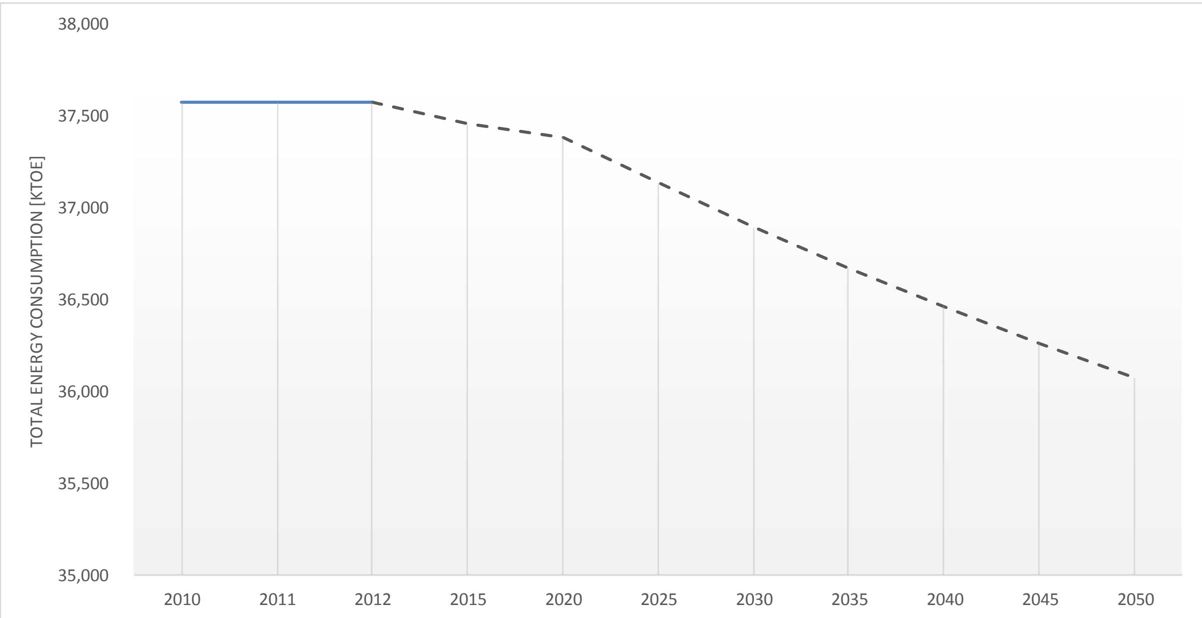
Table A1.21 Projected BAU energy intensity trends for production of non-metallic minerals (Thousand tonnes oil equivalent per dried metric tonne)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Energy intensity (kTOE/ tonne)	0.118	0.118*	0.118	0.118	0.118	0.117	0.116	0.116	0.115	0.115

**Base year energy intensity based on: Glass – Glass Alliance Europe (2014); Ceramics - Ecofys (2009), Cement – BCG (2013) and Lime – EuLA (2014)*

Figure A1.28 illustrates the projected energy consumption trend for production of non-metallic minerals for EU28 over the period 2012 to 2050, based on a Business-as-Usual (BAU) scenario.

Figure A1.28 Projected BAU energy consumption trend for production of non-metallic minerals



A1.4 Chemicals and Pharmaceuticals Sector Profile

A1.4.1 Overview of key sectoral policy measures/incentives

Table A1.22 presents the main EU policies applicable across sectors ("generic" EU policies) and 0 provides information on EU policies specific to a given sector/subsector.

Table A1.22 Table : "Generic" EU policies and their applicability to Chemical and Pharmaceutical sector

EED	EU-ETS[1,2]	IED[3]	Ecodesign Directive	Energy Labelling Directive	Energy Performance Building Directive
■ Yes	■ Yes	■ Yes	■ N/A	■ N/A	■ N/A

Notes:

[1]All Chemicals subsectors, except C20.3 and C20.4, are on the list of sectors and sub-sectors deemed to be exposed to a significant risk of carbon leakage.

[2] Pharmaceuticals subsectors are on the list of sectors and sub-sectors deemed to be exposed to a significant risk of carbon leakage.

[3]Reference Documents on Best Available Techniques for: (i) Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical Sector (2003; formal draft of 2011); (ii) Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers Industries (2007); (iii) Large Volume Inorganic Chemicals – Solids and Others Industry (2007); (iv) Large Volume Organic Chemical Industry (2003); (v) Manufacture of Organic Fine Chemicals (2006); (vi) Production of Speciality Inorganic Chemicals (2007)

Table A1.23 Table : Key EU policies specific to Chemicals and Pharmaceuticals sectors

Policy name	Policy description	Measure
Chemicals and Pharmaceuticals		
REACH Regulation 1907/2006	▪ Aim: to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances ▪ In force: 1 Jun 2007 ▪ Type: Regulation; Mandatory	▪ It affects the activities related to chemical substances used.
Chemicals		
Classification, Labelling & Packaging (CLP) Regulation 1272/2008	▪ Aim: to ensure a better protection of human health and the environment during the handling of chemicals, including their transport and use. ▪ In force: 20 Jan 2009 ▪ Type: Regulation; Mandatory	▪ Chemicals need to be classified based on their level of hazard. The system replaces the various classification and labelling standards worldwide and instigates consistent criteria for classification and labelling on a global level. ▪ On 1 December 2010, all chemical substances were due to be classified and labelled according the new system. Compliance for mixtures is due by June 2015.
Pharmaceuticals		
Directive on the Community Code relating to Medicinal Products for Human Use 2001/83/EC as amended by 2004/24/EC (human medicines) and 2004/27 EC (veterinary medicines), as amended by Directive 2009/53/EC	▪ Aim: to safeguard public health ▪ In force: 18 Dec 2001 ▪ Type: Mandatory	▪ It deals with disparities between certain national provisions, in particular between provisions relating to medicinal products (excluding substances or combinations of substances which are foods, animal feeding-stuffs or toilet preparations), and such disparities directly affect the functioning of the internal market.
Regulation (EC) No. 726/2004	▪ Aim: to harmonise internal market for medicinal products ▪ In force: 20 May 2004 ▪ Type: Regulation; Mandatory	▪ It lays down Community procedures for the authorisation, supervision and pharmacovigilance of medicinal products for human and veterinary use. It also established a European Medicines Agency.

Policy name	Policy description	Measure
Regulation (EC) No. 658/2007	▪ Aim: to safeguard public health ▪ In force: 18 Dec 2001 ▪ Type: Regulation; Mandatory	▪ It lays down rules concerning the application of financial penalties to the holders of marketing authorisations, granted under Regulation (EC) No 726/2004.
Directive on laying down the principles and guidelines of good manufacturing practice in respect of medicinal products for human use and investigational medicinal products for human use 2003/94/EC	▪ Aim: to guarantee the safety, quality and efficacy of medicinal products, both for clinical trials and for commercial purposes ▪ In force: 3 Nov 2003 ▪ Type: Mandatory	▪ All medicinal products for human use manufactured or imported into the Community, including medicinal products intended for export, are to be manufactured in accordance with the principles and guidelines of good manufacturing practice.
VOC Solvent Emissions Directive 1999/13/EC	▪ Aim: to reduce industrial emissions of volatile organic compounds (VOCs) in the European Union ▪ In force: 18 Dec 2001 ▪ Type: Mandatory	▪ It covers a wide range of solvent using activities, including manufacture of pharmaceutical products. It requires installations in which such activities are applied to comply either with the emission limit values set out in the Directive or with the requirements of the so-called reduction scheme. The Directive sets out emission limit values for VOCs in waste gases and maximum levels for fugitive emissions (expressed as percentage of solvent input) or total emission limit values.

Note: Besides the general rules of REACH and Classification & Labelling, specific products containing or being made of chemicals have to comply with several other Directives or Regulations providing harmonised requirements for their placing on the market and use. Among these regulated products are: Fertilisers, Detergents, Explosives, Pyrotechnic Articles and Drug Precursors. These rules are adapted to the specific need and characteristics of the products in question and aim at achieving a high level of protection of human health and the environment. Products complying with the rules can circulate freely in the Internal Market.

A1.4.2 Overview of the EU28 market

A1.4.2.1 The Chemicals industry

- In 2011 27.3 thousand enterprises operated within the chemicals and chemical products manufacturing sector in the EU-28. They employed 1.20 million people. The industry generated €112 billion of value added (see Table :).
- The manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms (C20.1) is the biggest subsector in terms of employment and generated value added. With regards to the workforce, the next largest subsectors were: the manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations (C20.4); the manufacture of other chemical products (C20.5); and the manufacture of paints, varnishes and similar coatings, printing ink and mastics (C20.3). The combined share of these four activities was 96% of the EU-28's sectoral employment and value added in 2011.
- The industry was the largest in Germany in value added terms in 2011. France and the United Kingdom followed with much lower contributions (less than a half of German's share). The combined valued added from those countries was 56% of the EU-28's value added in this sector. Almost the same order applied in employment; with the exception of the UK which was surpassed by Italy and Poland. These five Member States employed 67% of the EU-28's sectoral workforce.
- For the relative importance of the chemicals and chemical products manufacturing sector in Member States in 2010 see Table A1.24.

Table A1.24 Largest and most specialised Member States in manufacture of chemicals and chemical products, 2010

	Highest value added	(% share of EU-27 value added)	Most specialised	(% share of non-financial business economy value added((2)
Manufacture of chemicals and chemical products	Germany	33.0	Belgium	3.6
Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	Germany	37.0	Lithuania	2.8
Manufacture of pesticides and other agrochemical products	Germany	40.4	Germany	0.1
Manufacture of paints, varnishes and similar coatings, printing ink and mastics	Germany	30.7	Estonia	0.5
Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	Germany	22.1	Poland	0.5
Manufacture of other chemical products	Germany	29.1	Belgium	0.5
Manufacture of man-made fibres	Germany		Austria	0.2

(1) The data set is incomplete with some missing combinations of Member State, activity, indicator, the information presented is drawn from available data; for more details refer to the data set online.

(2) Estimates made for the purpose of this publication.

(Eurostat (online data code: sbs_na_ind_r2); 2013a)

- In 2010 the other most specialised countries in the manufacture of the chemicals and chemical products were Lithuania (3.1%), Germany (2.8%) and the Netherlands (2.7%). The least specialised Member States, in value added terms, were Cyprus, Slovakia, Ireland, Latvia and Portugal, where this sector contributed less than 1.0 % of non-financial business economy value added, as it also did in Croatia and Norway. (Eurostat; 2013a)

A1.4.2.2 The Pharmaceuticals industry

- The pharmaceuticals manufacturing sector in the EU-28 is characterised by its small number of very large, capital-intensive enterprises. In total, almost 3,790 enterprises in 2011 were operating in the EU-28. They employed about 430.6 thousand persons and generated €64.4 billion of value added.
- The EU-28's pharmaceuticals manufacturing sector is split between the large subsector of pharmaceutical preparations manufacturing (C21.2) and the much smaller basic pharmaceutical products manufacturing subsector (C21.1). In fact, the former contributed 80% and more across all key indicators.
- One quarter of the value added generated in the EU-28's pharmaceuticals manufacturing sector in 2011 was contributed by Germany, ahead of Ireland (23%), France (15%), and Italy (13%). In terms of employment, Germany hired 27% of the sectoral workforce; followed by France (18%) and Italy (15%).
- For the relative importance of the pharmaceuticals manufacturing sector in Member States in 2010, see Table A1.25.

Table A1.25 Largest and most specialised Member States in manufacture of basic pharmaceutical products and pharmaceutical preparations, 2010

	Highest value added	(% share of EU-27 value added)	Most specialised	(% share of non-financial business economy value added((2)
Manufacture of pharmaceutical products and pharmaceutical preparations	Germany	18.0	Ireland	15.8
Manufacture of basic pharmaceutical products	Ireland		Ireland	3.7
Manufacture of pharmaceutical preparations	Germany		Ireland	12.1

1) The data set is incomplete with some missing combinations of Member State, activity, indicator, the information presented is drawn from available data; for more details refer to the data set online.

(2) Estimates made for the purpose of this publication.

(Eurostat (online data code: sbs_na_ind_r2); 2013b)

- Ireland was the most specialised EU Member State (in value added terms) for both subsectors in 2010. In fact, its specialisation in the basic pharmaceutical products manufacturing subsector was so great that it was the largest Member State in terms of its contribution to EU-27 value added, contributing 45.5 % of the sectoral total in 2009. (Eurostat; 2013b)
- The next most specialised Member State within basic pharmaceutical products was Slovenia, where 3.6 % of non-financial business economy value added was generated. Switzerland was also highly specialised in this sector (5.3%). The least specialised Member State (among those for which data are available), was Estonia where 0.1% of non-financial business economy value added was generated through the manufacture of pharmaceuticals.

Range of subsectors:

Table A1.26 to Table A1.28 (below) presents the key economic indicators per sector and subsector within Chemicals and Pharmaceuticals industries.

Key economic indicators for the Chemicals industry per Member States are given in

Table A1.26 Table : Key economic indicators per sector and subsector

Description	NACE	Number of enterprises	Number of persons employed	Turnover	Value added	Personnel costs	Investment in tangible goods	Production value
				EUR million				
Manufacture of chemicals and chemical products	C20	27,329	1,119,670	543,388	111,959	60,766	19,398	487,424
Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	C20.1	8,612	548,961	346,765	65,431	32,843	13,565	316,911
Manufacture of pesticides and other agrochemical products	C20.2	623	22,257	12,950	2,962	1,543	258	10,278
Manufacture of paints, varnishes and similar coatings, printing ink and mastics	C20.3	3,958	133,098	39,786	10,131	6,850	986	36,271
Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	C20.4	7,682	225,205	59,004	14,402	8,903	1,977	53,239
Manufacture of other chemical products	C20.5	6,135	164,727	76,448	17,007	9,449	2,253	62,544
Manufacture of man-made fibres	C20.6	319	25,422	8,436	2,026	1,178	361	8,182
Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21	3,790	430,624	189,803	63,443	28,351	6,252	184,284
Manufacture of basic pharmaceutical products	C21.1	781	45,131	21,185	7,177	2,817	1,175	29,551
Manufacture of pharmaceutical preparations	C21.2	3,009	385,493	168,618	56,266	25,534	5,077	154,734

Source: 2011 Eurostat data. Note: Eurostat provides data per Member State for indicators (e.g., annual turnover, number of persons employed) based on NACE codes of the format AXX.XX (e.g., NACE C17.12). In addition to this level of granularity, Eurostat provides aggregated values of the overarching NACE codes. This would be codes C17 and C17.1 in the case of C17.12. Due to limitations inherent to the current Eurostat database, however, these aggregated values do not always exactly match the sum of the parts. For example, the sum of C17.1 and C17.2 does not always exactly match the Eurostat-provided aggregated value for C17. In most cases, such *discrepancies have been found to be minor. Therefore, the selected approach for analysis has been to use sums of the parts (i.e., sum of C17.1 and C17.2 to represent the overall code C17). This approach ensures consistency between data and intends to maximize accuracy.*

Table A1.27 Table : Key indicators, Manufacture of chemicals and chemical products (NACE Division 20), 2011

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	681	36,251	34,260	6,919	3,911	1,878	46,069
BG - Bulgaria	574	1,178	1,143	209	81	61	13,556
CZ - Czech Republic	1,786	6,892	6,079	1,234	511	257	29,015
DK - Denmark	238	3,491	3,361	1,397	720	163	12,986
DE - Germany	3,149	163,950	133,421	37,193	21,623	4,984	336,093
EE - Estonia	67	517	498	98	37	15	2,402
IE - Ireland	98	3,401	3,295	1,021	361	78	5,484
EL - Greece	0	0	0	0	0	0	0
ES - Spain	3,530	38,278	36,069	7,792	3,964	877	82,755
FR - France	2,786	80,082	72,067	15,253	9,883	4,692	152,038
HR - Croatia	327	907	887	151	97	24	6,631
IT - Italy	4,562	51,347	50,094	9,432	5,538	1,547	111,498
CY - Cyprus	45	75	55	21	16	2	705
LV - Latvia	152	120	113	25	18	15	2,523
LT - Lithuania	88	2,287	2,320	362	75	24	4,483
LU - Luxembourg	15	0	0	0	0	0	0
HU - Hungary	571	4,645	4,148	594	264	275	13,413
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	784	50,412	46,971	7,828	3,439	1,486	44,494
AT - Austria	335	13,615	13,173	2,406	1,161	430	17,568
PL - Poland	1,916	14,109	13,431	3,314	1,098	593	75,172
PT - Portugal	776	4,668	4,428	733	377	325	12,816
RO – Romania	827	2,631	2,457	747	256	399	31,325
SI - Slovenia	170	1,241	1,107	312	153	64	5,791
SK - Slovakia	262	2,571	2,441	337	153	100	9,717
FI - Finland	298	6,303	5,110	1,460	647	217	10,975
SE - Sweden	825	8,452	7,850	2,434	1,308	385	21,281
UK - United Kingdom	2,467	45,966	42,648	10,687	5,076	508	70,880

Source: 2011 Eurostat data

Table A1.28 Table : Key indicators, Manufacture of basic pharmaceutical products and pharmaceutical preparations (NACE Division 21), 2011

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	0	0	0	0	0	0	0
BG - Bulgaria	59	324	319	116	46	43	0
CZ - Czech Republic	87	1,421	1,320	444	196	96	9,912
DK - Denmark	90	8,499	8,545	3,810	1,710	355	24,884
DE - Germany	603	42,403	37,550	16,150	8,133	1,350	117,450
EE - Estonia	12	0	0	0	0	0	0
IE - Ireland	64	40,115	38,873	14,565	1,188	455	15,194
EL - Greece	0	0	0	0	0	0	0
ES - Spain	356	14,288	12,396	3,632	2,150	604	37,837
FR - France	379	36,838	25,672	9,286	5,379	1,167	77,451
HR - Croatia	37	0	0	0	0	0	0
IT - Italy	513	27,471	24,213	8,257	4,285	862	62,922
CY - Cyprus	7	151	148	58	31	12	1,169
LV - Latvia	26	0	0	0	0	0	1,887
LT - Lithuania	16	71	73	13	13	4	605
LU - Luxembourg	0	0	0	0	0	0	0
HU - Hungary	85	2,876	2,780	1,294	456	264	16,637
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	179	6,282	5,228	2,471	922	109	15,091
AT - Austria	88	3,981	3,429	1,511	697	157	11,514
PL - Poland	294	3,157	2,893	1,184	423	134	22,511
PT - Portugal	133	1,181	1,021	343	206	41	6,196
RO - Romania	117	692	628	274	100	51	9,058
SI - Slovenia	20	0	0	0	0	0	0
SK - Slovakia	0	0	0	0	0	0	0
FI - Finland	36	0	0	0	0	0	0
SE - Sweden	139	56	57	39	24	5	306
UK - United Kingdom	450	0	19,140	0	2,392	543	0

Source: 2011Eurostat data

Main players

The Chemicals industry

- In terms of a number of enterprises, micro companies (employing fewer than 10 people) are the most numerous (almost two thirds of all companies in 2010). However, it is the large enterprises (>250 employees) that contribute the most of value added (65% in 2010) and hire most of the sectoral workforce (56% in 2010). Micro enterprises generated 2.4% of sectoral value added and employed 4.7% of the workforce in 2010. (Eurostat; 2013)
- In 2010 over 50% of sectoral value added was generated by large enterprises in 16 Member States. Their share exceeded three quarters in Romania (76.8 %) and Germany (79.8 %); but was below one third in four of the Member States — Ireland, Greece (2009 data), Portugal and Cyprus — with the latter having no large enterprises in this activity. (Eurostat; 2013)

The Pharmaceuticals industry

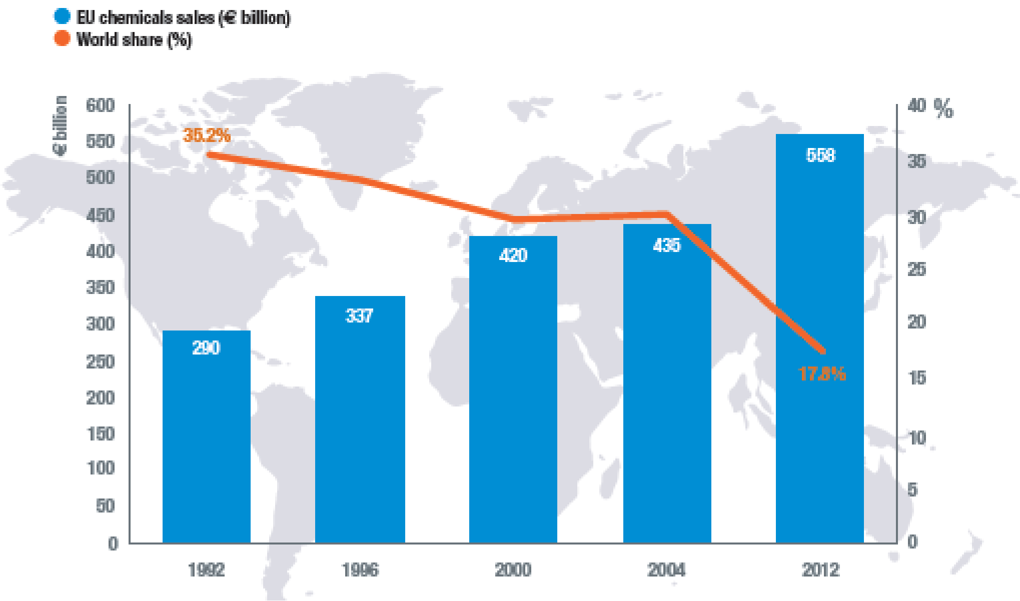
- Within the pharmaceuticals sector, micro and small enterprises were prevailing (70% of all enterprises). Nevertheless, the biggest share of sectoral value added and workforce is attributed to large enterprises: 78.1% and 87.4%, accordingly. For comparison, small companies generated about 2% of total value added and employed 4% of total workforce. (Eurostat; 2013b)
- Large enterprises provided more than half of the 2010 sectoral value added in a majority (15) of the EU Member States. 90% or higher share was reached in Germany, Hungary, Finland, the United Kingdom and Denmark. The lowest share was in Portugal, i.e. 25.5%. No large enterprises in the sector were reported in Estonia and Lithuania. In none of the Member States (with data available) did the share of micro enterprises or small enterprises surpass 8%. By comparison, the contribution of medium-sized enterprises was relatively large, exceeding 10% in 11 of the Member States and reaching as high as 64% in Portugal and 92.4% in Estonia. (Eurostat; 2013b)

Trade flows

Chemicals

- The EU share in 2012 global chemicals sales was 17.8%. It has lost its top ranking since 2002, in favour to emerging markets. The EU noted a decline of 12.7%, while China reached the EU's 2002 share in 2012. Yet, the total value of EU sales has actually been continuously growing, but the overall world chemicals sales have grown faster. (Figure A1.29).

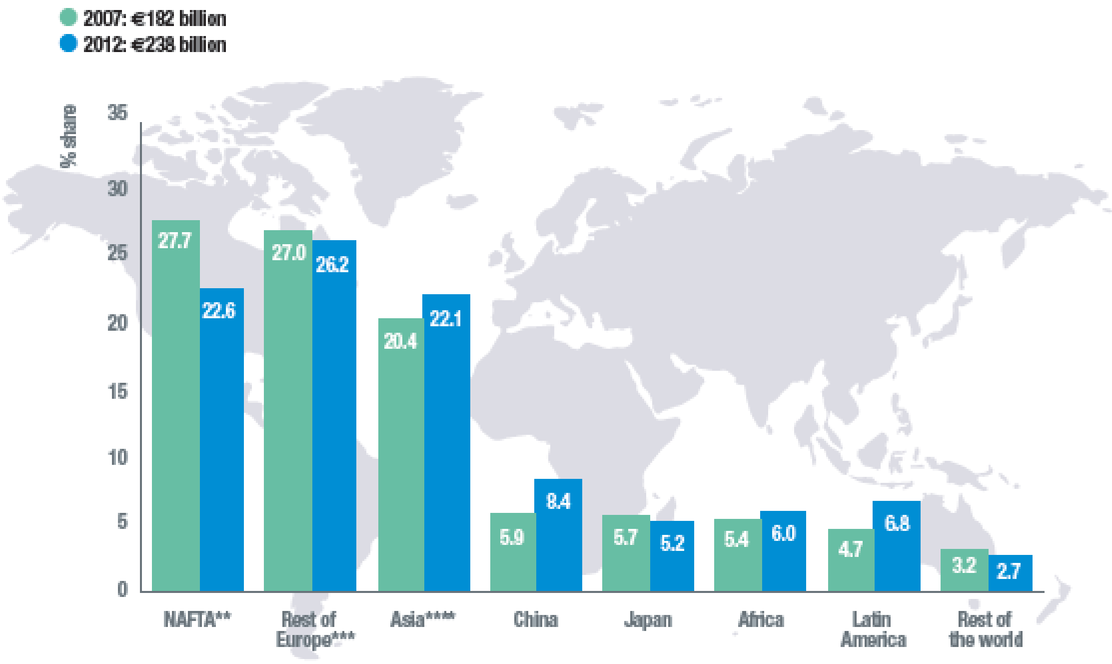
Figure A1.29 EU sales in chemicals and its global share; 2002-2012



Source: Cefic; 2013

- Seven Member States (Germany, France, the Netherlands, Italy, UK, Spain and Belgium) constituted 85% of EU chemicals sales. Their share varied from 28.9% (Germany) to 6.4% (Belgium). Amongst the other European countries, Poland, Austria, Sweden, the Czech Republic and Finland contributed 1-3%. (Cefic; 2013)
- The EU was the world's top exporter and importer of chemicals (38.1% of global trade in 2012). A third of the trade is intra-company, reflecting the industry's integration. (HLG; 2009). Most of the trade in EU chemicals is intra-EU (48% in 2012), followed by home sales (26%). (Cefic; 2013)
- The primary export markets are: EU neighbour countries (Switzerland, Norway, Turkey, Russia and Ukraine); the NAFTA trade bloc (USA, Canada and Mexico) and Asia. The trade with the former two has declined over the past decade (-18% and -3% over 2002-2012, respectively). See Figure A1.30.
- The EU has a consistent trade surplus in chemicals (€49.1 billion in 2012 vs €29.8 billion in 2002). It has a surplus with each main trading region (NAFTA, Asia excluding Japan, Latin America, Africa, rest of Europe and Oceania). Yet, according to The Trade Competitiveness Indicator (TCI) – an indicator that compares the trade balance to total trade activity of a region –competitiveness of the overall EU chemical industry is deteriorating. In other words, that total chemicals imports are growing faster than total chemicals exports.
  - Specialty chemicals and consumer chemicals have the strongest external trade performance (47.8% and 30.7% of the EU chemicals trade surplus in 2012). The only group with a trade deficit was basic inorganics. (Cefic; 2013).

Figure A1.30 Extra-EU chemicals trade (extra-EU exports + extra-EU imports) with international markets

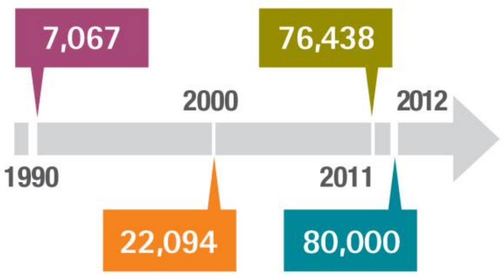


Source: Cefic; 2013

<u>Pharmaceuticals</u>

- In 2012 Europe accounted for 26.7% of world pharmaceutical sales, compared with 41% for North America. 18% of sales of new medicines launched during the period 2007-2011 were on the European market, compared with 62% on the US market. (Efpia; 2013)
- The industry has had a positive – and growing - trade balance since 1990 (Figure A1.31[254]).

Figure A1.31 European Pharmaceutical Industry Trade Balance



Source: Efpia, 2013

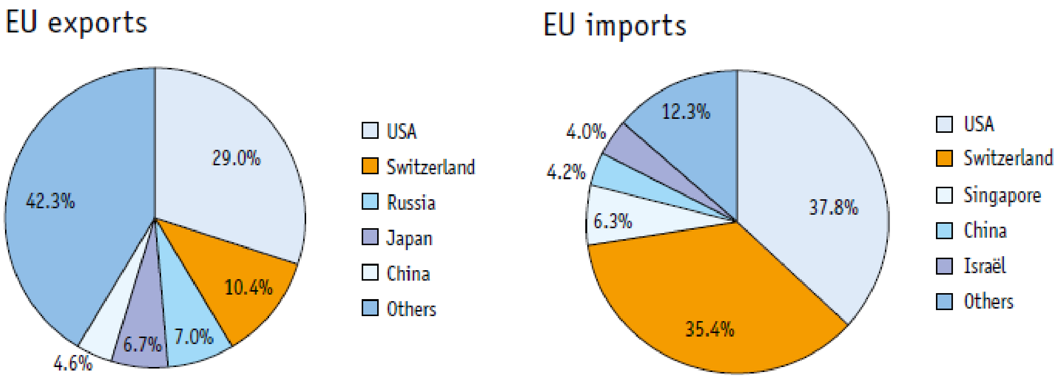
- In 2012, it was €54,401mln for the EU-27: the highest figures compared to other high-technology sectors (€33,530mln for power generating machinery and equipment; -€48,454 for office machines and computers; -€40,409 for telecommunications, sound,

[254] Data includes Norway, Switzerland, Serbia and Turkey.

TV, video; €1,281 for electrical machinery; and €16,545 for professional, scientific, controlling material)

  - In 2011, the positive trade balance was the case for 12 Member States. The highest figure was achieved by Ireland (€22,243mln), followed by Germany (€13,791mln) and Belgium (€8,767mln). These three countries accounted for 91% of the total EU-28 trade balance.
- USA and Switzerland are the top trading partners in pharmaceuticals exports and imports. These two countries accounted for almost 40% of EU exports and almost 75% of EU imports (Figure A1.32)

Figure A1.32 The European Union's top 5 pharmaceutical trading partners, 2012



Source: Efpia; 2013

- In 2011, within the EU, Germany, Belgium, the United Kingdom, Ireland and France were the largest exporters. Of the new Member States, Hungary, Poland and the Czech Republic were the largest exporters. (Efpia, 2013)
- In 2007, the EU had a share of more than 50% in total imports of 14 fastest growing markets. In 15 countries the share of the EU countries increased between 2002 and 2007.(Ecorys; 2009b)

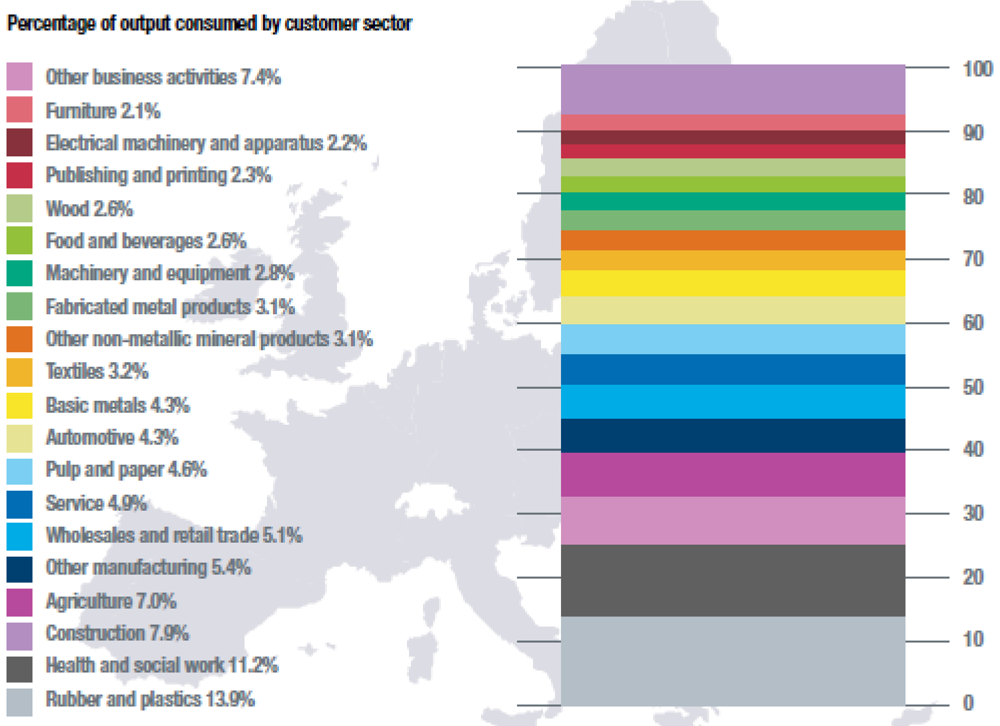
Product type and consumer groups:

- Only 30% of the combined output of the chemicals and pharmaceuticals industries is sold to private households and other end users. The rest goes to other industries, services and agriculture. (HLG; 2009)

Chemicals

- The products fall under three distinctive groups:
  - base chemicals: petrochemicals and their derivatives, polymers (plastic, synthetic rubber, man-made fibres), basic inorganics (fertilizers, industrial gases, other). Produced in large volumes and sold within the chemical industry itself or to other industries. 63.1% of the EU's 2012 sales.
  - specialty chemicals: auxiliaries for industry, paints and inks, crop protection, dyes and pigments. Produced in small volumes. 25.4% of the EU's 2012 sales.
  - consumer chemicals: sold to final consumers, such as soaps and detergents as well as perfumes and cosmetics. 11.5% of the EU's 2012 sales.
- The chemicals industry has an extremely broad range of customers, underpinning virtually all sectors of the economy (Figure A1.33). Nearly two-thirds of EU chemicals are supplied to the EU industrial sector, including construction. More than one-third of chemicals go to other branches of the EU economy such as agriculture, services, and other business activities. (Cefic; 2013)

Figure A1.33 Users of the Chemicals industry output and their percentage share



Source: Cefic; 2013

Pharmaceuticals

- Pharmaceutical products include, for example, chemical drugs, biologics/biologicals (vaccines, (anti)toxins, blood, blood components, and blood-derived products), herbal drugs, radiopharmaceuticals, recombinant products, gene therapy products, cell therapy products and tissue engineered products; veterinary medicaments.
- Pharmaceuticals preparations are drugs intended for human or veterinary use, presented in their finished dosage form. Examples include capsules, ointments and tablets.
  - Pharmaceuticals can be classified by therapeutic class, i.e. according to organ or system on which they act and their chemical, pharmacological and therapeutic properties. Drugs are classified in groups at five different levels[255] (Figure A1.34).

Figure A1.34 Overview of the various level 1 therapeutic classes

Class	Description
A	Alimentary tract and metabolism
B	Blood and blood forming organs
C	Cardiovascular system
D	Dermatologicals
G	Genito urinary system and sex hormones
H	Systemic hormonal preparations, excl. sex hormones and insulins

[255] The drugs are divided into fourteen main groups (1st level), with one pharmacological/therapeutic subgroup (2nd level). The 3rd and 4th levels are chemical/pharmacological/therapeutic subgroups and the 5th level is the chemical substance. The 2nd, 3rd and 4th levels are often used to identify pharmacological subgroups when that is considered more appropriate than therapeutic or chemical subgroups

Class	Description
J	Anti-infectives for systemic use
L	Antineoplastic and immunomodulating agents
M	Musculo-skeletal system
N	Nervous system
P	Antiparasitic products, insecticides and repellents
R	Respiratory system
S	Sensory organs
V	Various

Source: Ecorys; 2009b

A1.4.2.3 Market developments and sector growth rates

Table A1.29 Growth and volatility in EU-27 manufacturing industries 1990-2011 (%)

NACE Rev. 2 codes	Industry	Cycle			Growth			Crisis production loss
		Max.	Min.	Cyclical intensity	Max.	Min.	Average	
C20	Chemicals	7.4	-12.1	0.9	17.1	-22.2	1.7	-22.2
C21	Pharmaceuticals	2.1	-4.2	0.4	16.8	-8.7	5.1	-2.7

Source: EC; 2011b

***Notes**: The columns below the heading 'cycle' present the maximum, minimum and the cyclical intensity of the cycle components for each industry. Cyclical fluctuations are measured as deviations of actual output from trend output. The cycle fluctuation for each industry is compared to the total manufacturing industry by dividing the standard deviation for each industry's cyclical component with the standard deviation for the total manufacturing industry's cyclical component. A cyclical intensity around 1.0 indicates that an industry faces the same cyclical fluctuations as the aggregate manufacturing.*

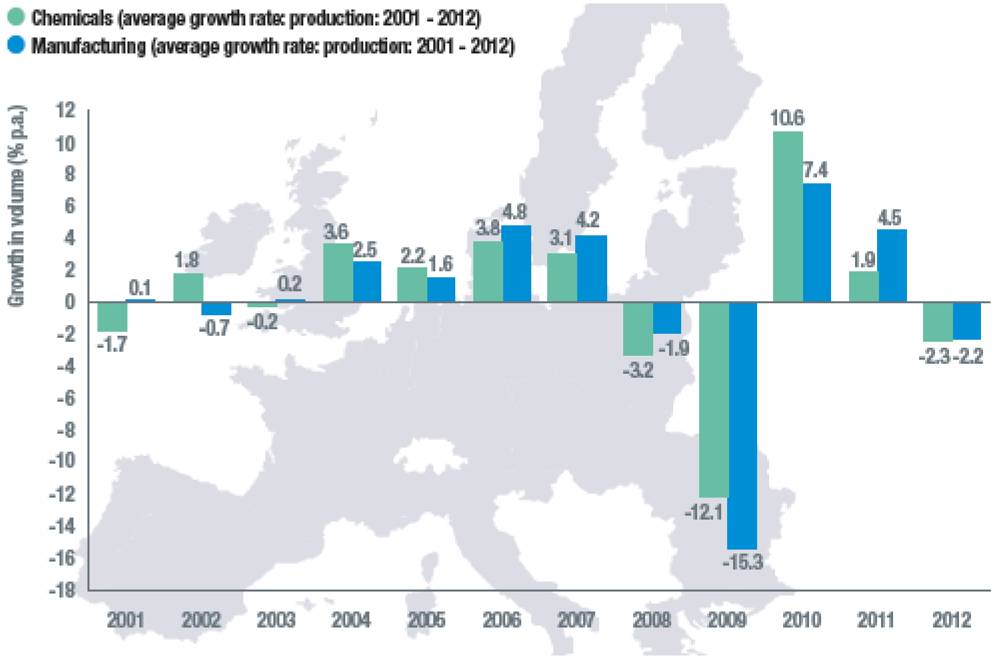
The columns below the heading 'growth' present the maximum, minimum and average twelve month growth rates. The growth rates are calculated as the monthly growth rates relative to the same month of the previous years.

The Chemicals industry:

Market developments

- The production of chemicals is largely concentrated in a few areas, notably North Western Europe.
- The production of the EU chemical industry grew by 0.6% on average in 2001-2012, a rate slightly higher than the 0.4% for all of the manufacturing industry. Such a growth rate was mainly caused by the significant declines in production levels during the 2009 economic downturn as compared with pre-crisis levels. In the aftermath of the economic crisis, the chemicals recorded a strong year 2010, with 10.6% growth rate in volume terms compared with 2009. Yet, the following years were much worse: 1.9% growth in 2011 compared to the year before; 2.3% decline in 2012 compared with 2011. (Cefic; 2013) See Figure A1.35.

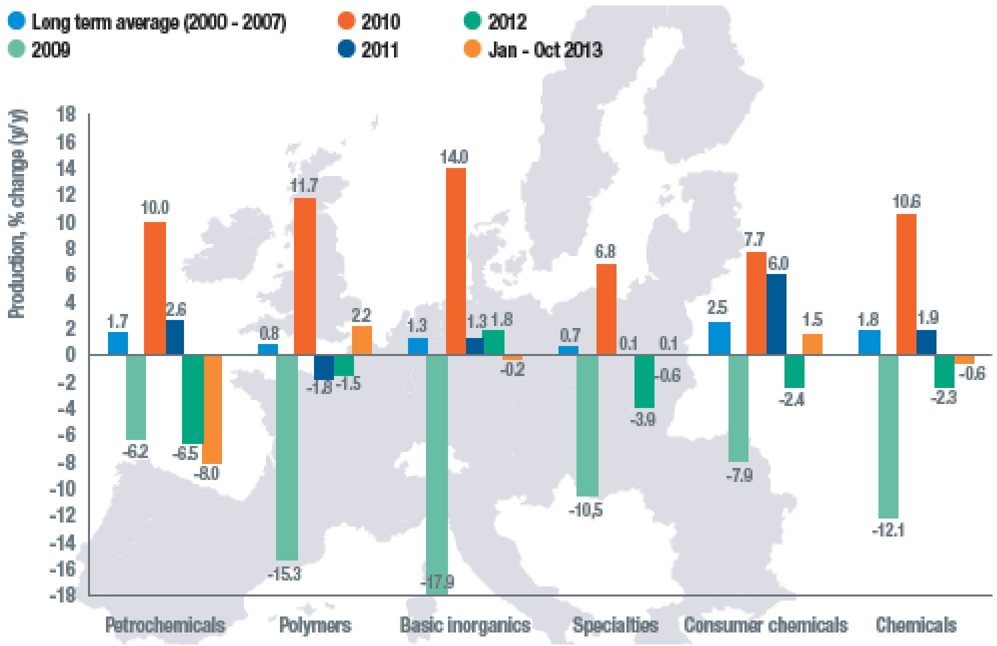
Figure A1.35 Production growth in the Chemicals industry, 2001-2012



Source: Cefic; 2013

- In 2013 the industry noted zero growth, i.e. it remained 6.4% below the pre-crisis, full-year peak level reached in 2007. (Cefic; 2014)
- As for the performance of subsectors, basic inorganics and polymers were hit the most by the economic crisis. Production of petrochemicals remained under pressure as it registered the fastest decline in 2012 and prospects for 2013 looked also depressed. Polymers and consumer chemicals were the only two sectors with positive growth during the first nine months of 2013 compared with the same period in 2012. (Cefic, 2013). See Figure A1.36.
  - Based on the latest Cefic data: petrochemicals output contracted in December 2013 by 7.1% compared with December 2012. This decline was partially offset by strong growth in basic inorganics, up 8.8% in December year-on-year. Production in polymers, consumer chemicals and specialty consumers also noted positive growth rates over the same period (4%, 0.8% and 1.6% respectively). (Cefic; 2014)

Figure A1.36 Production growth in the Chemicals subsectors, 2001-2013



Source: Cefic; 2013

- Employment in the industry has decreased by about 2% annually on average over the past ten years. This is due to the high increase (2.4%) in labour productivity, which has been far greater than the average annual increase in production (0.6%). (Cefic; 2013)

Drivers:

- Cyclical demand: production is closely related to economic output; following the cyclical trend in demand in automotive, construction, electrical, electronics and textiles industries (key customers of chemicals).
- Drivers for basic chemicals (largest product group) are (VCI; 2012):
  - World population: increase in housing (demand for plastics, coatings, lighting); in clothing (man-made fibres; dry-cleaning); mobility (demand for battery technology, plastics)
  - Energy: increase in renewable energies (demand for biotechnology, materials); energy efficiency (demand for lightweight materials, insulants); storage technology
  - Clean water: increase in water treatment (demand for ion exchanger, membrane); disinfection (demand for chlorine); transport such as pipes and gaskets (demand for plastics, rubber)
  - Nutrition: increase in agriculture (demand for fertilizers, plant protectants); animal feeds (demand for amino acids); protection of foodstuff (demand for plastics for packaging)
  - Health: increase in pharmaceuticals (demand for active ingredients), medical auxiliaries (demand for specialty plastics); sportswear/equipment (demand for fibres/plastics).

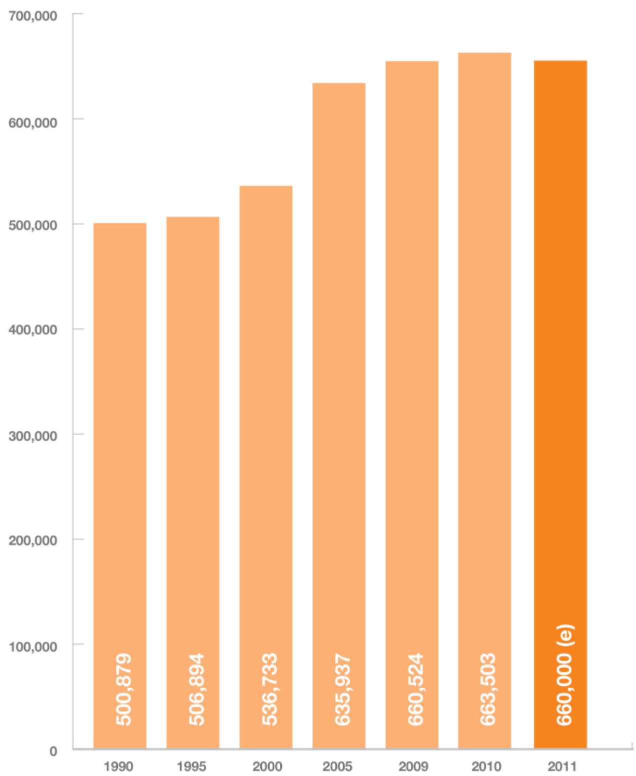
The Pharmaceuticals industry

Market development

- Production value has been increasing since 1990: from €63,010mln in 1990 to €205,622mln in 2011. (Efpia; 2013)

- Production in the pharmaceuticals industry was hardly affected by the recession. Production only fell by 2% from February to March 2008. Production of pharmaceuticals thereafter continued to increase and the pre-recession peak was surpassed in August the same year. (EC; 2011b)
- Highest production value was recorded in 2011 in Germany (€26,935mln); Italy (€25,137mln), the UK (€20,206mln), Ireland (€19,700mln) and France (€19,578). All these countries accounted for 66% of EU-28 total production (Note: data for the Czech Republic, Estonia, Lithuania, Malta, and Slovakia not available, thus not included in the total EU-28 figure). (Efpia; 2013)
- Pharmaceuticals displayed the highest EU average annual production growth rate in 1995-2010, i.e. over 5% (EC; 2011b)
- Employment in the industry increased by 32% over 1990-2011. Since 2009, it remains on a relatively the same level (Figure A1.37).

Figure A1.37 Employment in the Pharmaceutical Industry, 1990-2011



Source: Efpia; 2013

Note: Data includes Croatia and Lithuania (since 2010), Estonia and Hungary (since 2009), Czech Republic (since 2008), Cyprus (since 2007), Romania and Slovakia (since 2005), Malta, Poland and Slovenia (since 2004)

- With deteriorating growth rates, pharmaceutical companies have been increasingly focusing on mergers and acquisitions (M&A), both horizontal and vertical as a cost cutting measure, and also to diversify their portfolio in health-related business in another attempt to maintain shareholder (Ecorys; 2009b)
- The knowledge growth in the pharmaceutical industry is expansive, making it impossible for the pharmaceutical companies to have all the required know-how in house. As such, the pharmaceutical companies have been more and more cooperating with external high-technological third parties. Companies perform only those processes and products in

which they excel themselves, while outsourcing the remaining processes and products to other. The outsourcing occurs mostly vertically, towards smaller companies; horizontal cooperation is much less prevalent. (Ecorys; 2009b)

Drivers

- Use and financing of pharmaceuticals are specific to local/regional conditions, as they are affected by the following peculiarities:
  - *Role of third parties*, such as social security institutions, private insurance companies or governmental organisations and private companies; they play a predominant role in financing decisions;
  - *Prescription*: the majority of the goods and services delivered or used are prescribed by physicians or other providers of health care and do not involve a decision made by the end-user;
  - *Different ways of distributing medicine to patients*: in-patient setting versus an out-patient setting in another.
- The demand for pharmaceuticals is driven by population growth, the composition of the population, consumption behaviour of patients, prescription behaviour of physicians, the existence and set up of health insurance system, share of prescription drugs and over-the-counter drugs, level of self-care, level of generic entry, level of parallel trade, existing government regulation, level of in-country pharmaceutical production, incidence rate of diseases (e.g. cancer), share of hospital and ambulatory care in total healthcare, rate of hospital efficiency, intensity of care and use of technology. (Ecorys; 2009b)

Energy growth rates for Chemicals and Pharmaceuticals industries

- In EU-28, final energy consumption has decreased by 4% in 2011 compared to 2000. It was relatively stable in 2001-2003 (58-59Mtoe); then started dropping – with a slight break in a trend in 2007 – until 2009 when it hit the lowest level (50Mtoe). Over the following two years, it is increasing, yet still below the 2001 level. (Eurostat; 2013c)
- Energy consumption is estimated to growth by over 30% through 2050 (Cefic; 2013b).
- The Chemicals and Pharmaceuticals industries together contributed 19.4% of total energy consumption by the EU-28 industry in 2011, compared to 18% in 2001.
- Table A1.30 presents energy consumption by combined industries (C20-C21) over 2000-2011. In 2011 the industries in twelve Member States consumed more than 1,000Mtoe: Germany, Belgium, France, Netherlands, the UK, Italy, Poland, Spain, Romania, and the Czech Republic and Spain. Half of these countries recorded a decline in energy consumption (from -2% in the Czech Republic to -40% in the UK). France's consumption remained almost unchanged. Energy consumption in the rest of these countries increased (from 4% in Romania to 92% in Belgium
  - In 2000, Bulgaria and Sweden were also beyond the threshold; yet by 2011 they considerably reduced their energy consumption, -35% and 71% respectively (NB: Swedish drop was the biggest amongst the Member States)
  - Amongst the countries with energy consumption lower than 1,000Mtoe, seven noted a decrease (from -14% in Denmark to -54% in Estonia); while eight recorded an increase (from 8% in Austria to 100% in Cyprus).

Table A1.30 Energy consumption in thousand Toe by Chemicals and Pharmaceuticals industries per Member State over 2000-2011

GEO/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	change 2011/200
Cyprus	1	2	2	2	2	2	2	2	2	2	3	2	100%
Lithuania	161	146	169	187	202	221	266	277	266	285	297	318	98%
Belgium	3,193	3,032	3,113	3,194	3,177	3,382	3,405	3,575	3,454	3,118	4,083	6,118	92%
Latvia	15	18	18	17	17	17	19	16	26	25	28	23	53%
Luxembourg	53	53	52	66	68	71	63	61	53	44	48	76	43%
Slovenia	116	107	114	183	182	168	172	183	160	159	170	156	34%
Portugal	472	628	610	624	640	563	546	617	543	545	556	600	27%
Finland	754	754	756	817	829	826	747	1,067	1,075	950	980	948	26%
Germany (until 1990 forn	10,249	10,266	10,484	9,931	9,269	9,953	9,211	11,503	10,908	10,735	13,144	12,517	22%
Austria	814	801	820	887	883	987	906	872	966	842	915	878	8%
Netherlands	5,634	5,501	5,531	5,676	5,787	5,779	4,667	4,127	4,011	5,536	6,146	6,035	7%
Romania	2,146	2,620	2,907	3,122	2,605	2,627	2,502	2,512	2,703	2,191	2,056	2,234	4%
France	6,122	7,350	7,201	8,156	7,072	7,066	6,990	7,224	7,753	6,200	5,944	6,104	0%
Czech Republic	1,577	1,270	1,271	1,527	1,862	1,862	1,754	1,424	1,334	1,511	1,626	1,538	-2%
Poland	4,115	3,834	3,682	3,714	3,752	3,529	3,816	3,794	3,654	3,670	3,601	3,748	-9%
Denmark	257	273	261	255	238	242	232	199	212	216	225	220	-14%
Spain	3,748	3,656	4,010	4,024	4,425	4,678	4,474	4,339	4,190	3,041	3,180	3,155	-16%
Croatia	265	253	212	243	303	237	265	276	250	234	220	205	-23%
Ireland	346	362	356	354	381	395	375	332	288	285	288	249	-28%
Italy	6,162	5,313	5,312	5,763	5,548	5,425	5,179	5,674	4,719	4,365	4,164	4,020	-35%
Bulgaria	1,352	1,370	1,116	1,197	1,200	1,199	1,150	1,196	1,087	675	723	881	-35%
Greece	270	251	256	210	243	268	269	221	260	224	194	174	-36%
Hungary	829	809	766	651	503	590	624	665	627	497	511	507	-39%
United Kingdom	6,953	6,932	6,952	6,505	5,634	5,271	5,037	4,801	4,986	4,032	4,177	4,160	-40%
Slovakia	609	601	656	544	451	484	409	428	495	347	335	325	-47%
Estonia	89	87	62	115	103	110	110	111	113	50	50	41	-54%
Sweden	2,034	1,759	1,588	1,212	1,277	986	823	814	688	540	568	600	-71%

(Eurostat, available at: ***http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home****)*

Note: Malta is not included, as 0Mtoe was reported over the period. Note that Malta is a member of Efpia, industry associations and its contribution to production and trade is included in the statistics.

A1.4.3 Business environment

A1.4.3.1 What are the key competitive strengths?

The Chemicals industry

- Important source of direct and indirect employment in many regions of the European Union
- Highly developed business environment: part of industrial clusters; availability of efficient transportation infrastructure and services; access to a highly qualified labour force, presence of many related and supporting industries providing the chemicals industry with access to productive general inputs and services. (PwC; 2012)
- Industry with traditions and global reach: having strong linkages to other markets and often playing important role in the activities of clusters elsewhere in the world
- Innovative; providing solutions for environmental and climate-related challenges
- Strong and successful player in the world market
- Products enabling energy efficiency and greenhouse gas emission reductions in all sectors: e.g. products made in 2010 will, over their lifecycle, avoid emissions equivalent to 30% of the EU's total emissions in that year (Cefic; 2013b)

The Pharmaceuticals industry

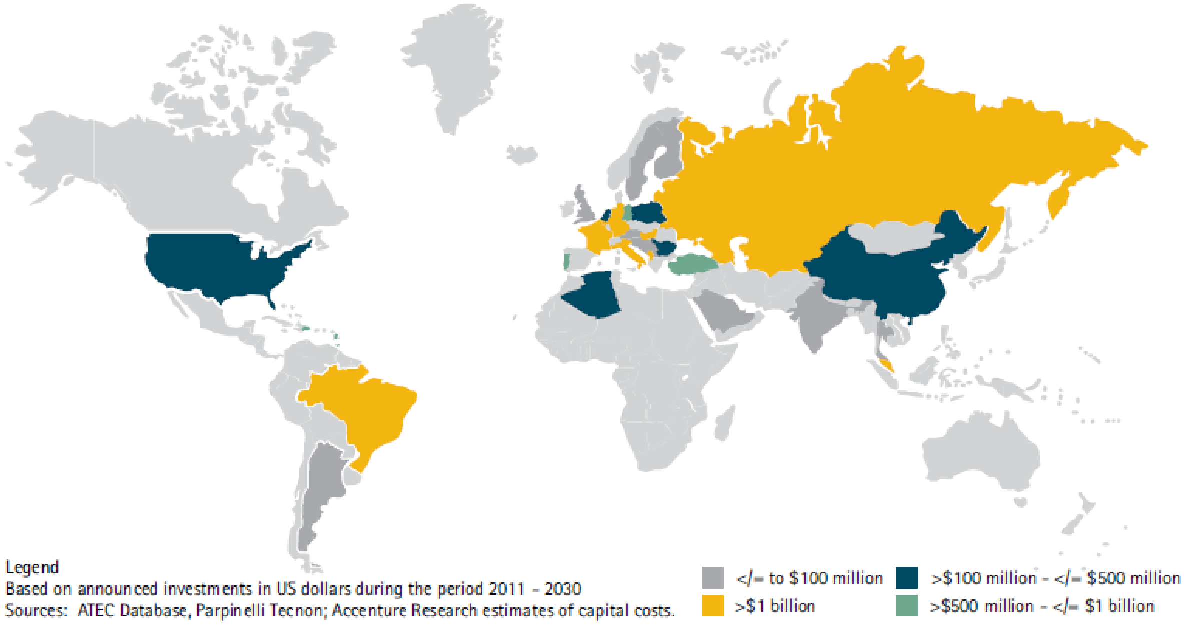
- One of Europe's top performing high-technology sectors
- Innovative: R&D expenditure has been rising since 1990. It is estimated that it equalled €30,000 million in 2012. It is the sector with the highest ratio of R&D investment to net sales amongst other manufacturing industries (Efpia; 2013)
- Industry generating three to four times more employment indirectly - upstream and downstream – than directly. Moreover, large share of these are valuable skilled jobs which can help maintain a high-level knowledge base and prevent a European "brain-drain" (Efpia; 2013)

A1.4.3.2 How are these advantages envisaged as changing over the next 10-15 years?

The Chemicals industry

- Global demand for chemicals is forecasted to grow on average by 4.5% annually until 2030. This growth will be driven by two trends: (i) increased demand from the emerging markets – particularly in Asia – where population growth and increasing affluence among the middle classes are the key factors; and (ii) rising demand for chemicals in industrialised countries (VCI; 2012b).
  - European chemical producers can take advantage of booming markets in other parts of the world, provided they can build on a strong home market in Europe and have access to these new markets in emerging economies (HLG; 2009). Figure A1.38 presents the investment plans of European chemical companies.

Figure A1.38 European chemical companies' investment, total announced between 2011 and 2030 (based on data for more than 100 petrochemicals



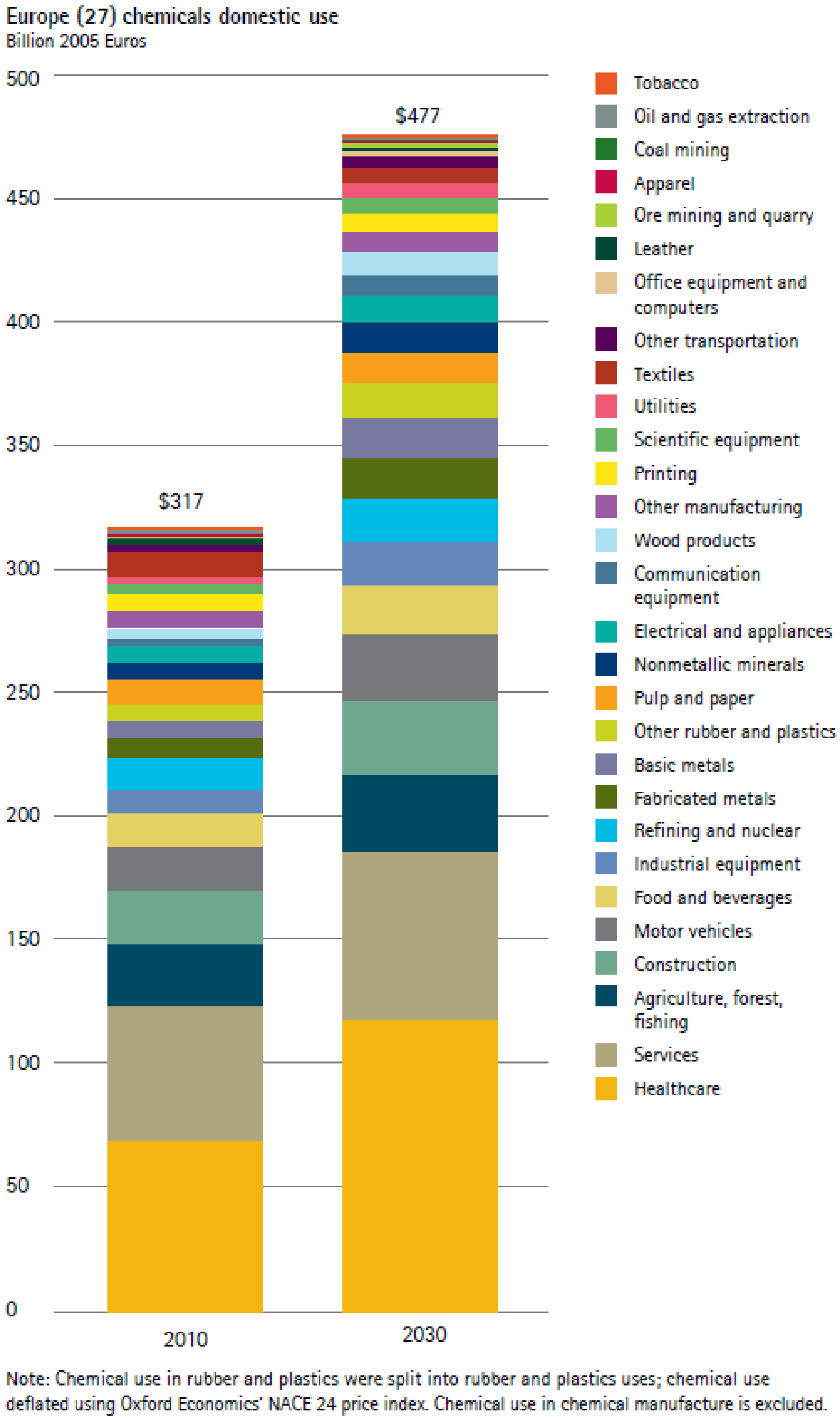
Source: Accenture; 2011

- Germany – the biggest European player in the chemical industry – predicts that its chemical exports will grow by 2.6% annually on average to 2030; increasing the sector's export dependence by 8% (in 2030, 60%of total output will be destined for export). Although today's major customers are all European countries, including France, Italy and Belgium; the forecasted growth in exports will make China the second-largest customer outside of Europe for German chemicals by 2030. (VCI; 2012b)
- Operating in China entails certain risks like price sensitivity, environmental challenges, increasing labour costs, a threatening real estate bubble, powerful authorities, and intellectual property protection issues. As such, European chemical companies are targeting other countries that have favourable demography, enabling environment, skilled resources and ease of doing business. These are Turkey, Mexico, Indonesia, Malaysia, Saudi Arabia, South Korea, United Arab Emirates, Vietnam, Chile, Colombia, and South Africa. (ATKearney; 2012).
- As for the demand for chemicals in industrialised countries, this will not be a matter of volume growth (like in the case of emerging markets) but rather a shift in demand towards high-quality and high-priced innovative chemicals. Moreover, the chemical intensity is rising in some customer industries, because more specialty chemicals are needed for innovative products. (VCI; 2012)

■ Aside of globalisation, another change affecting the future production will relate to chemicals applications. On the example of Germany: private consumption will fall due to decrease in domestic population; but this will be compensated by the growing demand from industry, such as chemical industry itself, the plastics and automotive industries. A growing use of electronic components and polymer-based parts in vehicle construction will boost the demand for chemicals in these sectors. Other areas stimulating chemicals growth include construction (insulation materials); electrical engineering (fuel cells and solar cells); emergence of new applications in the fields of climate and environmental protection (high-grade chemicals, which will be needed, for example, to manufacture wind-power plants and photovoltaic modules). (VCI; 2012b)

- Basic chemicals will play a less important role due to a decline in competitiveness, following rising costs for raw materials and energy and creation of new production facilities in emerging markets. However, progress is expected in specialty chemicals and application niches with technological leaps in customer industries, such as biotech and fuel cells.
- Accenture (2011) forecasts that that the key European chemical markets doing well today will be those that continue to thrive in the coming years (Figure A1.39). These markets will change in share to some degree by 2030, based on projected downstream industry growth, but will nevertheless remain the largest overall. The top seven European chemical markets are and will continue to be:
  - *Healthcare*: €120 billion in 2030. The sector, including pharmaceuticals, consumes many high-end chemical products. Specialty soaps and disposable plastics are used in large amounts by hospitals and other medical institutions. Also, high growth is expected in Latvia, Bulgaria, Romania, Slovakia and other former Eastern Bloc nations as they “catch up” in the development of healthcare and other services
  - *Services* such as wholesale and retail trade for recreational products, sanitation/sewage, hotel/restaurant uses, R&D chemicals, etc.: €70 billion.
  - *Agriculture*: €31 billion. Since available arable land in Europe is restricted, crop productivity is essential, combating pests and addressing limited water resources. Clearly, there are opportunities for the fertilizer, pesticide and seed businesses.
  - *Construction*: €30 billion. This sector will be driven by emerging market growth, such as in Poland and other Eastern European countries, which are catching up to Western Europe in prosperity. Green building constructions will also increase. Growth will be primarily driven by improving economic conditions, EU energy saving directives, and increasing awareness and infrastructure building requirements.
  - *Motor vehicles*: €28 billion. Higher performance cars will be in demand and consumers will continue raising their requirements, such as for more “green” and lower-cost fuels, as well as more sustainable parts. Plastics blends and composites will resume making inroads, especially to replace heavier metal components.
  - *Food and beverages*: €18 billion. Farmers and food processors will demand chemical solutions specific to their needs, and innovations in sustainability will be a likely area of focus. Also, there are regions in Europe experiencing higher-than-average agricultural development due to the availability of land and favourable business climate, such as Slovakia, Hungary, Romania and Ireland.
  - *Industrial equipment*: €18 billion Specialized machinery is needed for industrial growth all over the world, and this segment uses a variety of chemicals, such as nylon and other engineering polymers, lubricants and surface coatings. Higher-performance chemicals are required to improve on quality/durability and adhere to environmental and safety regulations.

Figure A1.39 Domestic European chemical sales by end market for 2010 and projected for 2030



Note: Chemical use in rubber and plastics were split into rubber and plastics uses; chemical use deflated using Oxford Economics' NACE 24 price index. Chemical use in chemical manufacture is excluded.

Source: Accenture; 2013

The Pharmaceuticals industry

- According to the industry's competitiveness study, there are a number of trends that the EU pharmaceuticals sector may benefit from (Ecorys; 2009b):

- High expected growth rates in GDP and pharmaceutical sales in the new Member States and emerging economies as these countries are catching up on spending across the full range of remedies.
- Rising demand for pharmaceuticals due to the increase in the chronic disease burden owing to the aging population, the higher risk of pandemics due to globalization and urbanization, and the emergence of new diseases.
- Strong R&D and innovation of the EU pharmaceuticals industry: EU firms have strong positions in the field of cancer remedies and other complex drugs for which the demand are expected to grow strongly in coming years. EU firms have also begun to make innovations in drug delivery and services and can rely on a very solid scientific base and a large pool of highly-skilled staff.

- The pharmaceutical industry is increasingly focusing on fast growing markets, notably those countries with a large market potential. The 25 fastest growing markets had the predicted annual growth in pharmaceutical market ranging from 7.8% (Tunisia) to 32.1% (Venezuela). (Ecorys; 2009)
- Focus areas for R&D seem to be oncology, vaccines and biologics, as in these areas there is still a relatively high unmet demand, and the possibility to prove improvement appears to be higher. Developments in the vaccine market are specifically increasing as a result of an increasing focus on the prevention of diseases and due to the absence of generic competition within the vaccines segment (also relevant for biologics). Within the vaccine market, most R&D for vaccines is in the field of oncology (cervical cancer), pneumococcal and influenza vaccines. (Ecorys; 2009b)

A1.4.3.3 What are the main threats which currently impact on the sector?

The Chemicals industry

- Growth linked to performance of key customers in automotive, construction, electrical, electronics and textiles industries: production is affected by the seasonality of end market customers
- Highly volatile input costs: industry uses energy products, namely oil, gas and to a minor degree coal and biomass not only as a source of energy but as principal raw materials for its final products.
- High cost of energy (up to 50% in its overall cost base for multiple essential building blocks) undermines the sector's competitiveness on the global market (Cefic; 2013b)
- Rising global competition: in the period 2008-2012 considerable commodity capacity, mainly ethylene and polyethylene, is coming on line, especially in the Middle East and in China. This new capacity is not expected to be fully absorbed by Asia, but it is expected to affect the European markets. (PwC; 2012)
- Relocation of customer industries to Asia
- Threatened protection of Intellectual Property rights
- Advanced regulatory environment leading to higher cost of production: increasing differences in policy costs in a continued, fragmented policy framework are estimated in direct CO_2 costs alone at € 1.7billion per year in 2030 and € 3.1billion in 2050 for the European chemical industry. (Cefic; 2013b)
- Aging capacity infrastructure: production facilities are unable to reach economies of scale of new investments made by international competitors (e.g. Asia)
- Increasingly tough global competition for talent

The Pharmaceuticals industry

- Prone to governmental austerity measures: pharmaceutical expenditures have become a favoured cost-containment target, as witnessed by the consolidation of pharmaceutical expenditure as a share of total health spending and GDP in recent years (Ecorys; 2009b)
- Expiration of a number of important patents: this will affect the value of pharmaceutical sales and negatively affect the finance available for R&D in the short and medium run. To illustrate, original products experienced a growth in value of sales of approximately 5%: those still with exclusivity protection grew with approximately 13%, but those that had lost exclusivity declined substantially with almost 9% (Ecorys; 2009b)
- Additional regulatory hurdles
- Increasing cost of R&D: the cost of researching and developing a new chemical or biological entity was estimated at €1,172 million in 2012 (i.e. $1,506mln compared to $625mln in 1993 and $1,031mln in 2003) (Efpia; 2013)
- Declining success rate of innovation: in 2009 the industry was investing twice as much as it was ten years ago to produce 40% of the new medicines (Ecorys; 2009b)
- Obstructed access to capital: focus on specialised medicines for relatively small groups of patients make investors less willing to invest in these types of drugs. Also the increase in the time to market new products due to regulation and approval procedures makes drug development less attractive to investors. Finally economic crisis has decreased the pool of available funding for the sector. (Ecorys; 2009b)
- Gradual migration of economic and research activities from Europe to fast-growing markets like Brazil, China and India
- Globalisation leading to the rise of counterfeiting of medicines
- Fragmentation of the EU market resulting in lucrative parallel trade[256] (estimated at €5,000mln in 2011): it deprives industry of additional resources to fund R&D (Efpia; 2013)

A1.4.3.4 How are these envisaged as changing over the next 10-15 years?

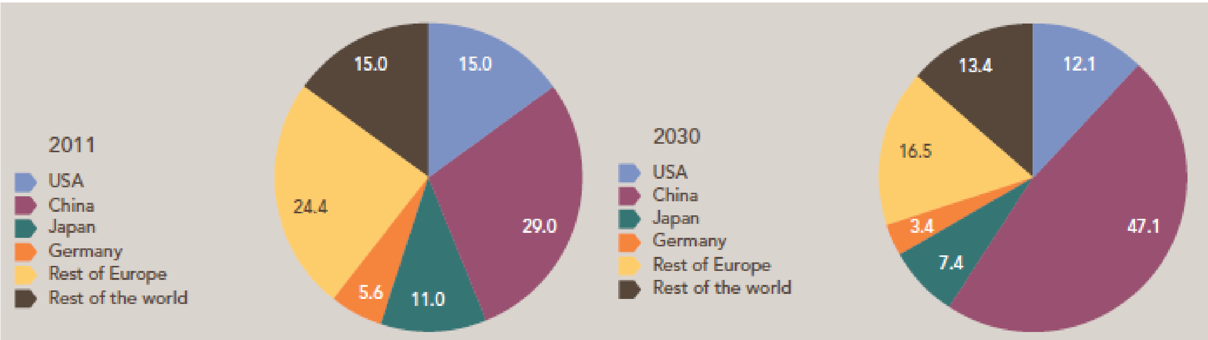
The Chemicals industry:

- Industry pricing power may not offset energy costs. In an environment of rising energy crisis chemicals companies may not have sufficient pricing power to pass along the increase in raw material costs. (PwC; 2012)
- Fundamental economic and political developments require adjustments of EU climate and energy policies. A continued unilateral climate policy would lead to leaking investments, reducing growth and importing embedded carbon through imported goods. Some studies anticipate that carbon costs of between €15 and €40 per tonne EU production of basic chemicals and petrochemicals would make the industry increasingly uncompetitive and it would be cheaper to produce substances elsewhere and import them into Europe. (Cefic, 2013b)
  - Regulations can cripple the growth but they can also stimulate innovation. Thus, if new standards follow global trends, the level playing field with foreign markets is maintained. Domestically, the implementation of Better Regulation Agenda and Lisbon Growth and Employment Strategy should simplify and improve the regulatory framework; enhancing entrepreneurship and innovation. (HLG; 2009)

[256] Parallel trade is the legal importation of a patented drug without the authorization of the patent holder. The main driver behind parallel trade is the variation in the manufacturers' drug prices across markets. Importing occurs from countries with a low drug price relative to the price of the same drug in the importing country and where the price difference is sufficient to cover the costs of transport, registration, relabeling/repackaging, creating and inserting leaflets according to national requirements (Ecorys; 2009a)

- Globalisation and rising operational costs have resulted in relocation of production to low cost manufacturing and low cost feedstock countries
  - Companies will continue to set up new chemical production facilities in regions where there is strong growth in demand, and the operational costs can be cheaper. Thus, the coming years will see a growth in production capacity in regions in Asia (mainly China), the Middle East and Brazil. The increasingly important role played by the emerging markets will equally impact all the industrialised countries, although the latter will remain an important location for production. The US chemical industry will profit increasingly from shale gas exploration and dynamic growth in its domestic market. (See Figure A1.40).
  - By 2030, it is predicted that at least half of the top 10 chemical companies in the world will be Asian or Middle Eastern (ATKearney; 2012).

Figure A1.40 Breakdown of global chemicals production by country and region; 2011 and 2030



Source: VCI; 2012b

- Offshoring of customers' activities (e.g. pulp and paper production moving to Latin America and Asia) will impact the industry's investment decisions. European chemical producers will have to leverage the competitive edge of their existing products and relationships to supply out of Asia or Europe. Growth options for the European chemical industry players include developing local products, collaborating with Easter players, transferring know-how, developing specific local sales approaches and adjusting offerings to local regions. (ATKearney; 2012)
- The trade position of certain important sub-sectors shows signs of serious deterioration. In particular, raw materials and energy-intensive parts of the chemical industry, such as petrochemicals and fertilizers, find their global competitive position at risk. (Cefic; 2013)
- Considerable reinvestments in industrial plants and infrastructure will be necessary over the coming decades. Otherwise, closures of outdated plants would lead to production shutdowns also for downstream products, triggering domino effects in further production chains based on by-products and harming the customer industries. (VCI; 2012)

The Pharmaceuticals industry:

- Brazilian and Chinese markets grew by 16% and 21% accordingly in 2012; while five major European markets contracted by 2%. The geographical balance of the pharmaceutical market – and ultimately the R&D base – is likely to shift gradually towards emerging economies.
- The effects on R&D and innovation in the sector are uncertain: whilst generic companies have a much lower R&D intensity than originators, nevertheless increased competition from generics will provide incentives for originator companies to increase the efficiency of R&D spending and focus on more innovative business models and improving cost efficiency etc. (Ecorys; 2009b)

- Next to providing additional services an important element in the diversification strategy seems to be the focus on personal healthcare. While the potential benefits are large, substantial obstacles need to be overcome for attaining clinical utility in general medical practice. These range from scientific hurdles emerging from biological and genetic complexity, to cultural, economic, legal, regulatory and ethical issues. (Ecorys; 2009b).

A1.4.3.5 Business strategy and decision making

The Chemicals industry:

- The average life time of chemical production plants is 50 years (Ecofys; 2009)
- In 2007, a High Level Group (HLG) on the Competitiveness of the European Chemicals Industry in the European Union was created. Two years later, the Group issued 39 recommendations for the Commission, Member States, regional authorities and industry. Conclusions have been grouped under the three themes
  - More innovation and research are key to securing the future of the European chemicals industry;
  - Responsible use of natural resources and level playing field for sourcing energy and feedstock are success factors for competitiveness and sustainability; and
  - Competitive chemicals industry needs open markets with fair competition.

  In 2011, the European Commission issued a report analysing the implementation progress of HLG's recommendations. It concludes that implementation is still rather uneven, both in terms of individual recommendations and actors involved. In terms of innovation, there have been new developments in policy and clusters, initiatives to better interlink energy infrastructures and to more concretely identify and address trade barriers. Yet, progress in other areas such as intellectual property rights, global or sectoral agreements on climate change, transport and logistics, or multilateral trade negotiations has been rather slow. (EC: 2011)

  In 2012; another report – *Analysis of policies in chemical regions to support the competitiveness of the chemicals industry* – was published with information that would assist public authorities in designing strategies, policies and programmes to support and strengthen the international competitiveness of the European Chemicals Industry (PwC; 2012).
- A mix of critical policy implementation is required. In the shorter term full implementation of energy market liberalisation and completion of the internal EU energy market is important. Mid-term development of policies, including structural improvements of the ETS, and assurances of industry supportive measures for carbon leakage, state aid and EU 2030 targets are essential. (Cefic; 2013b)
- The European chemical industry has had a strong track record on energy efficiency for more than 20 years, but it is the small- and medium-sized companies that still hold a substantial untapped energy management potential, estimated at 10-15%. In 2013, the Sectoral Platform in Chemicals for Energy Efficiency Excellence (SPiCE^3)[257] was launched enabling companies, particularly SMEs, to benefit from existing energy efficiency tools and exchange best practice through an on-line platform, industry workshops and tailored training. Another recent initiative targeted at SMEs is the Care+ Project[258].
- It is necessary to counteract the labour shortage brought about by a declining population. Thus, the education system needs to be improved; efforts to attract skilled professionals have to be enhanced. Government should support research, better training, and greater

[257] www.spice3.eu

[258] www.cefic.org/Policy-Centre/Energy/Energy-Efficiency/CARE-/

public acceptance of technological advancements (VCS; 2012b). Chemical companies need to entice technical students early on to consider careers in the chemical industry and develop training and knowledge retention systems. Other programs may include: conducting school partnerships or funding public laboratories; increasing and promoting the "sustainability" contribution of the chemical industry; co-funding education programs; or tapping new talent channels, such as programs to hire science and engineering talent with disabilities or in rehabilitation (Accenture; 2011).

- According to the German vision for its chemical industry, the response to intense global competition constitutes the following: <u>increase innovation efforts; focus on specialty chemicals; more efficient production; and optimization of resource base</u> (i.e. reducing reliance on fossil fuels). (VCI; 2012b)
  - Innovation should be aligned with global mega trends, i.e. alternative feedstock and energy sources, improved energy storage, environmental technology, energy efficiency, intelligent materials and nutrition. (ATKearney; 2012)
- European chemical producers will have to strengthen links with customer industries, especially those that are less likely to migrate. <u>Strongly connected value chains</u> will play a key role. In principle, if production costs remain competitive and relocation is costly, incentives to move are low. In addition, inherent advantages of regional or local production, compared to production in Asia, should be highlighted, such as: customer proximity, logistics costs and the agility to respond to often rapidly changing customer demands. (ATKearney; 2012)
- According to Accenture (2011), three developments indicative of future growth for the industry are
  - Continuation of "safe haven" markets; local markets, such as fresh food packaging and construction.
  - Ability for Europe to stay ahead of import competition; continuing emphasis on "high-end" manufacturing.
  - Harnessing of the advantages and low-cost opportunities of Europe's burgeoning regions, such Central and Eastern Europe (e.g., Poland, the Czech Republic and Hungary) and even Western Europe (e.g., Ireland and Spain).
- Annex 1 demonstrates projected EU demand for and production of chemical products by 2050. In all scenarios EU demand for chemical products increases. Under a level playing field scenario, European production could meet this demand. Under a scenario of unilateral EU climate action, production substantially shifts outside Europe. (Cefic; 2013b)
- In the German analysis, four scenarios of potential growth in the chemical industry are considered: basic scenario, weak global growth, disrupted value chains, innovation-friendly environment. The EU chemistry is estimated to grow by 1.8%-2.1% per year by 2030, depending on a scenario. (VCI; 2012b)

The Pharmaceuticals industry

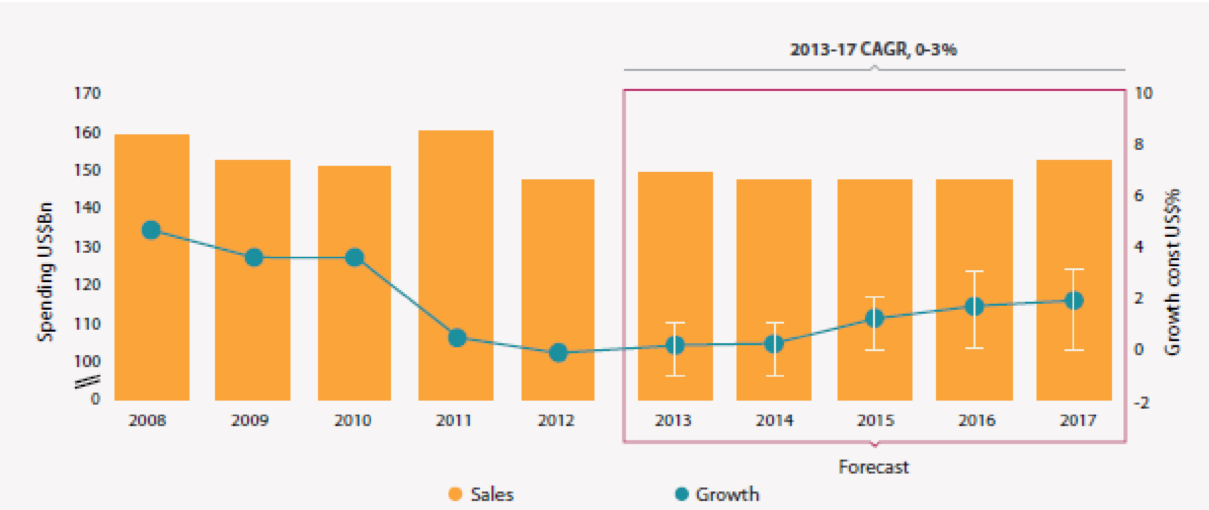
- There are two types of producers (Ecorys; 2009b):
  - *Originator companies* undertake research into new pharmaceuticals, develop them from the laboratory to marketing authorisation and sell them on the market. These companies range from very large multinationals to SMEs concentrating on certain niche products.
  - *Generic companies* use a business model aimed at the development of a medicine which is identical or equivalent to originator products. Generic companies market their products as soon as the originator product encounters loss of exclusivity, and their products are sold at a much lower price than the original product. Generic

companies active on the European market tend to be significantly smaller than originator companies.

The difference in business models between originator and generic companies is also reflected in their cost structure: whereas for generic companies manufacturing costs account for the largest share of the costs, for originator companies research and development, marketing and sales together account for a much larger share of total costs than the manufacturing process.

- It takes some 12 to 14 years on average to develop a new medicine (Ecorys; 2009b)
- The location of costs differs. R&D is an international activity, while Marketing and Sales activities are more of a national or regional nature. Manufacturing costs are also an international activity, and manufacturing is nowadays mostly located outside Europe. (Ecorys; 2009b)
- With the trend towards increased pharmaceutical sales in the developing world; increased outsourcing of both R&D and other parts of the production process, and an increased chance for pandemics, it is expected that higher drug volumes must be transported further, necessitating the use of logistics coordination on a global scale. (Ecorys; 2009b)
- This inventory of welfare effects of pharmaceutical regulations indicates that substantial scope exists for improvements of the efficiency of pharmaceutical markets by making regulatory processes smarter and less time consuming. The Ecorys study (2009a) provides recommendations on reduce side-effects of regulation.
- Growth in spending among the EU5 countries (France, Germany, Italy, Spain and the UK) will be negligible in aggregate as governments continue to apply a range of austerity measures across the region designed to shift usage to generics and restrict use of innovative launches. The growth in EU5 is forecasted to increase by 0-3% by 2017, compared to 2.4% for 2008-1012 (Figure A1.41). Alternative scenarios exist for Europe based on macroeconomic factors and the impact on use of innovative medicines – see Annex 2 for details. (IMS; 2013)

Figure A1.41 Top 5 Europe Spending and Growth, 2008-2017

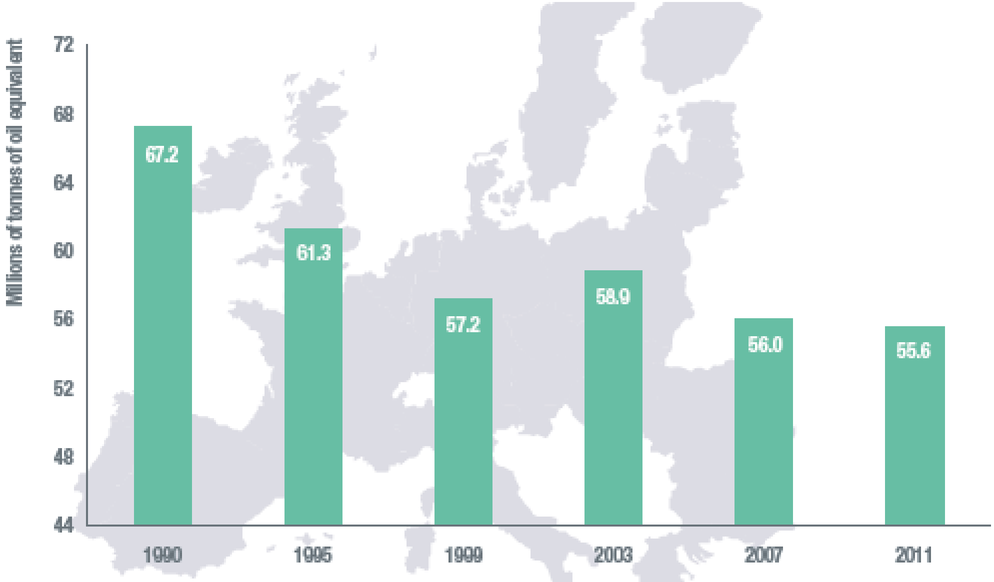


Source: IMS; 2013

A1.4.3.6 Mitigation activities

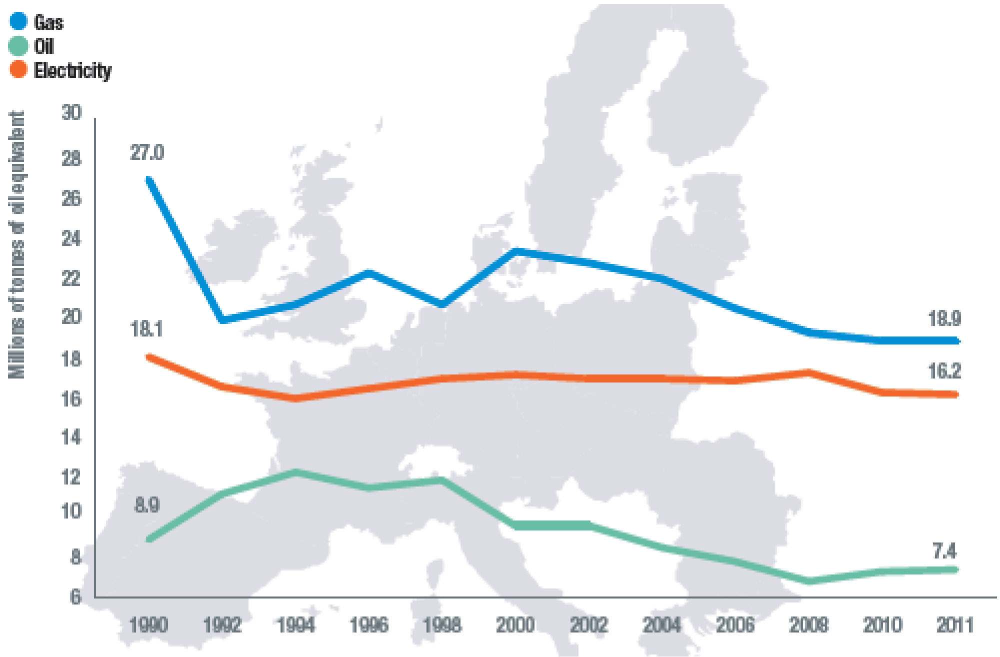
- The EU chemicals and pharmaceuticals industries together have reduced their fuel and power consumption by 17% since 1990 (Figure A1.42).
- The consumption of other raw materials also dropped over the same period of time: gas - 30%, oil – 17%, electricity – by 17% (Figure A1.43).
- By 2011, energy intensity – energy consumption per unit of production – in the two industries, was 48.7% lower than in 1990; on average by 3.1% per year (Figure A1.44).

Figure A1.42 Fuel and power consumption in the combined industries of Chemicals and Pharmaceuticals; 1990-2011



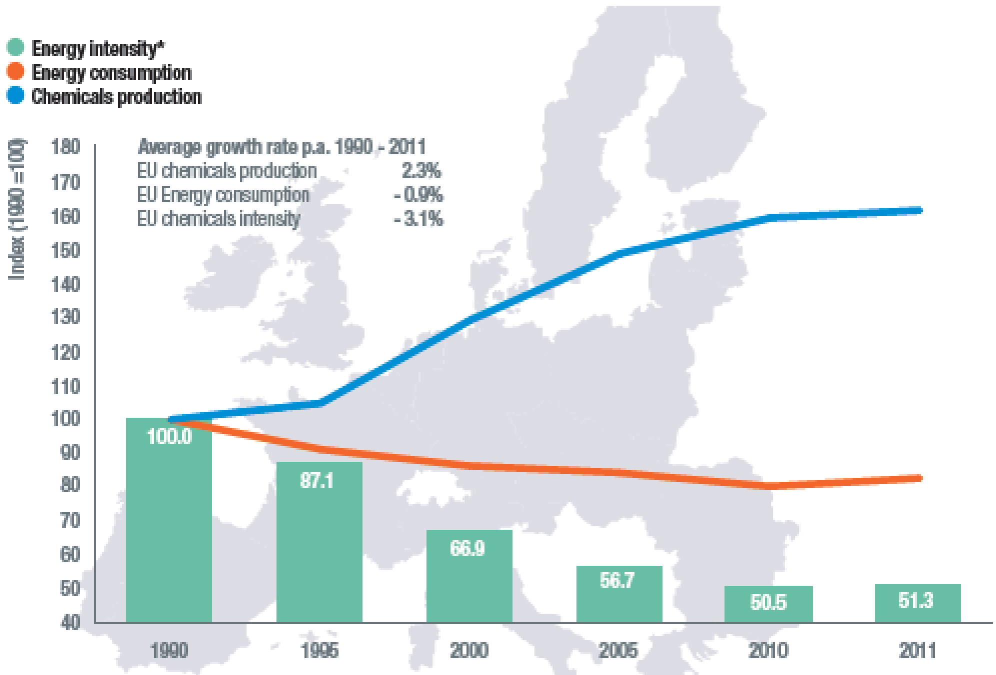
Source: Cefic; 2013

Figure A1.43 Gas, oil and electricity consumption in the combined industries of Chemicals and Pharmaceuticals; 1990-2011



Source: Cefic; 2013

Figure A1.44 Energy intensity change in the combined industries of Chemicals and Pharmaceuticals, 1990-2011



Source: Cefic; 2013

- According to the European Environmental Agency (EEA), both industries together emitted a total of 153.9million tCO_{2eq} in 2011, down from a total of 327.3million in 1990.

This reduction of 53% was achieved simultaneously with the 61% increase in production. GHG emissions per unit of energy fell by 43% between 1990 and 2011; and the GHG intensity fell even more, 71%. (Cefic; 2013)

- In 2009, the Sectoral Emission Reduction Potentials and Economic Costs for Climate Change (SERPEC-CC) estimated that chemicals production, including pharmaceutical cosmetics would grow 1.5% per year on average and that 2% annually of 2005 stock would be replaced by more efficient plants. By applying cross cutting measures, the sector would save 9.2% of 2005 electricity consumption and 2.9 in fuel consumption by 2030. Necessary investment would in the range of €25/GJ saved and €1/GJ saved, respectively. The study provides a list of cross-cutting measures (Annex 3) and specific to subsector production (e.g. improvements in the reformer section in ammonia production plants).

The Chemicals industry:

- According to the very recent industry's energy roadmap (Cefic; 2013b), a range of current and future technologies is available to continue the industry's long track record in energy efficiency and emissions intensity improvements. Four scenarios have been analysed:
  - Continued fragmentation: current fragmented policy framework worldwide continues
  - Isolated Europe: Europe intensifies its policy ambitions, striving for a reduction of 80% in GHG emissions in 2050 as compared to 1990 in isolation from the rest of the world
  - Differential Global Action: all key economic regions take action against climate change, albeit with different policy approaches and ambition levels
  - Level playing field: a 50% global GHG reduction in 2050 as compared to 1990 combined with a similar policy burden for manufacturing industry worldwide and converging energy and feedstock prices.

  Depending on a scenario GHG intensity could be reduced by 30-40% in 2030 and by from less than 50% to 55% in 2050 compared to 2010. In absolute terms, GHG emissions could fall by 15%-25% in 2030. The higher potential under the "Continued fragmentations" scenario would happen at the expense of relocation of production to outside of Europe, with no overall reduction in global greenhouse gas emissions or even a potential increase. Under the most optimistic scenario (Level playing field) about 25% decrease in the energy intensity per unit of sales could be achieved in 2010- 2030 and further afterwards. This results in constant level energy use in the period up to 2030 and a slight increase towards 2050.

  Energy efficiency (EE) improvement options include: improvements at sites; changes in fuel mix, and N20 abatement. Deeper reductions in greenhouse gas emissions, than those described in the scenarios, are possible by decarbonising the electricity production in Europe and by carbon capture and storage (CCS) applied to emissions from the chemical industry. Yet, these two options face serious barriers (e.g. high cost of CCS) to be certain of their wider deployment in the future.

  Annex 4 includes graphs showing reductions possible to achieve under each of the scenarios. The energy efficiency improvement options are also listed.

- Netherlands and Belgium have developed national roadmaps for their chemical industries. The Dutch industry aims to have its emissions reduced by 40% by 2030 compared to its 2005 level. Annex 5 presents solutions leading to such reduction. Belgium considers three potential trajectories for the future of its chemical industry. Depending on a scenario (production growth +20%, 0% and -50%) and ambition level (4 across all scenarios: from minimum to maximum effort) the sector's emissions are estimated to be in the range of +21% to -89% compared to 2010. Annex 5 presents areas of energy efficiency improvement.

A1.4.4 Sector projections

Production in the chemicals sector grew by 0.6% per year between 2000 and 2012; however, the average was strongly impacted by production declines during the economic recession in 2008 and 2009 (Cefic; 2013). In 2013, the sector reported zero growth (Cefic; 2014), with declines in petrochemicals, offset by growth in basic inorganics, polymers, consumer chemicals and specialty products. Nonetheless, the EU has remained the world's top exporter and importer of chemicals (38.1% of global trade in 2012). With, global demand for chemicals forecast to grow on average by 4.5% annually until 2030 (VCI; 2012b), driven by population growth in emerging markets, and rising demand for chemicals in industrialized countries (i.e., demand from automobiles, electronics, textiles, construction industries), the EU is anticipated to remain at the forefront of the global market. For example, Germany, which is the EU's largest producer of chemicals (Eurostat; 2013a), predicts that its chemical exports will grow by 2.6% annually on average through 2030 (VCI; 2012b).

The pharmaceuticals sector grew on average 5% per year between 1990 and 2010 (EC; 2011b). Compared to chemicals, it has low cyclical fluctuations (Eurostat; 2011b), as demand is less linked to MS economies; as reflected in limited production impact during economic recession of 2008/2009. In 2012 Europe accounted for 26.7% of world pharmaceutical sales (Efpia; 2013). Although there are various threats to growth, including leakage of research/production activities overseas, and counterfeiting of medicines, demand is anticipated to grow to address population growth (emerging markets), the composition of the population (EU), higher risk of pandemics, emergence of new diseases, etc.

Overal, EU production in the chemical and pharmaceutical sector is assumed to increase through 2050 to meet anticpated global demand for products.. Although, pharmaceutical sector growth trends have been historically greater than the chemicals sector (5%/yr (1990-2010) compared to 0.6%/yr (2000-2012)), it accounts for only 25% of total sector revenues. Consequently, total sector growth rate is assumed to range from 1.1 to 1.3% per year through 2050. **Error! Reference source not found.** presents the anticipated Business-as-sual (BAU) sales profile for the sector. In 2050, sales are assumed to be nearly 60% greater than 2010 levels.

Table A1.31 Projected BAU sales of chemicals and pharmaceuticals in EU (billion €)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Sales (€)	672*	672	707	754	800	848	896	947	1,000	1,056

**Based on Eurostat statistics*

In EU-28, final energy consumption in the chemical and pharmaceutical sector decreased by 4% in 2011 compared to 2000 (Eurostat; 2013c). This reflects continuing efforts by the sector to improve energy efficiency by reducing its fuel and power energy consumption per unit of production (Cefic; 2013). However, the rate of improvement has been decreasing as the higher the level of energy efficiency, the more difficult it becomes to make further improvements. This is illustrated by the sector reducing its energy intensity by approximately 4% per year between 1990 and 2000, but between 2000 and 2010 the rate dropping to approximately 1% per year (Cefic; 2013). Reflecting this trend, it is assumed that sector intensity will decrease by 0.5% per year through 2020, and then by 0.25% through 2050 as further incremental process efficiency improvements are made to improve margins, and meet existing legislative requirements (e.g., EED, IED).

Table A1.32 Table : Projected BAU energy intensity trends for chemicals and pharmaceuticals (thousand tonnes oil equivalent per unit sales (€million))

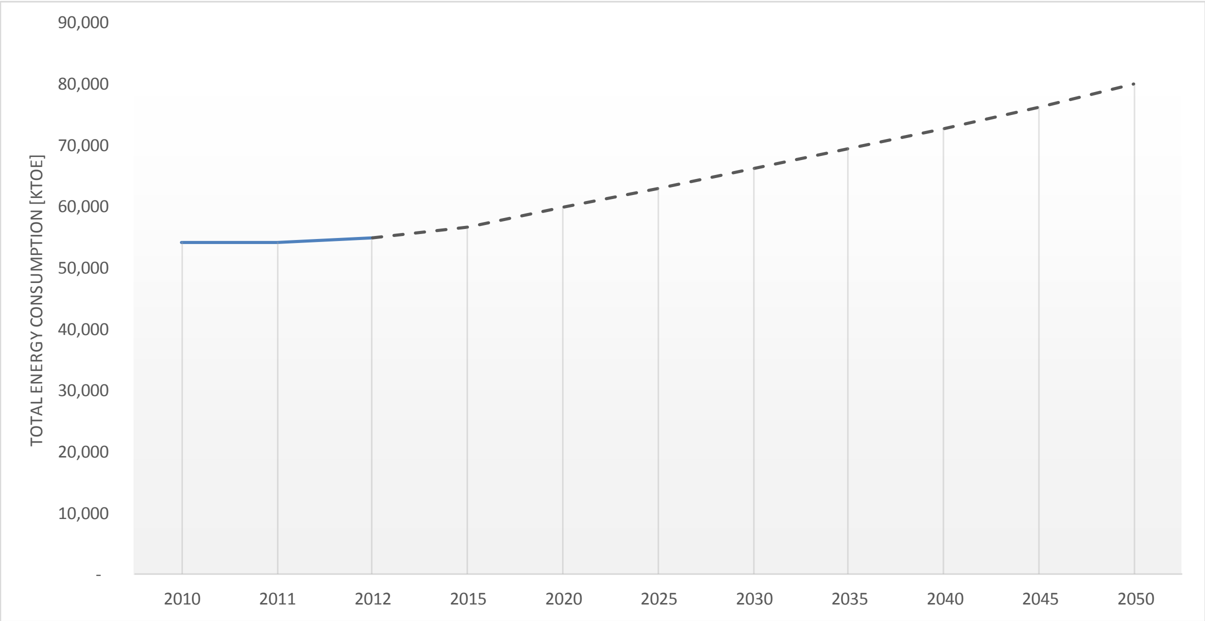
	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050

Energy intensity (Ktoe/€ million)	0.081*	0.081	0.080	0.079	0.079	0.078	0.078	0.077	0.076	0.076

**Base year energy intensity determined from Eurostat (2013)*

Figure A1.45 illustrates the projected energy consumption trend for production of chemicals and pharmaceuticals for EU28 over the period 2012 to 2050, based on a Business-as-Usual (BAU) scenario.

Figure A1.45 Projected BAU energy consumption trend for production of chemicals and pharmaceuticals



A1.5 Non Ferrous Metals

A1.5.1 Overview of key sectoral policy measures/incentives

Table A1.33 presents the main EU policies applicable across sectors ("generic" EU policies) and Table A1.34 provides information on EU policies specific to a given sector/subsector.

Table A1.33 Table "Generic" EU policies and their applicability to Non-ferrous metals sector

EED	EU-ETS[1]	IED[2]	Ecodesign Directive	Energy Labelling Directive	Energy Performance Building Directive
Yes	Yes	Yes	Yes	No	No

Notes:

[1] The Directive 2009/29/EC applies to the 'Production or processing of non-ferrous metals, including production of alloys, refining, foundry casting, etc., where combustion units with a total rated thermal input (including fuels used as reducing agents) exceeding 20 MW are operated'

[2] Section 2.5 a) and b) of Annex I to the Directive 2010/75/EU (IED) applies to:

'2.5. Processing of nonferrous metals, including:

"(a) production of non-ferrous crude metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic processes;

(b) melting, including the alloyage, of non-ferrous metals, including recovered products and operation of non-ferrous metals foundries, with a melting capacity exceeding 4 tonnes per day for lead and cadmium or 20 tonnes per day for all other metals."

Table A1.34 EU policies specific to Non-ferrous metals sector

Policy name	Policy description	Measure
Ambient Air Quality Framework Directive	Aims to minimise the harmful effects on human health by monitoring and assessing air quality and reducing pollution levels.	Policy relevant to the NFM industry as it focuses on monitoring arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in the ambient air (Ecorys, 2011).
Water Framework Directive	Sets minimum water quality standards	Policy relevant to the NFM as it identifies priority hazardous substances (PHS), especially cadmium and mercury, and priority substances (PS), notably nickel and lead (Ecorys, 2011). PHS are subject to measures aiming at the cessation of discharges, emissions and losses of these substances. PS emissions are subject to point or diffuse source control measures.
Waste Electrical and Electronic equipment (WEEE) Directive	Promote secondary production, or the recycling of scrap.	Recycling of scrap is used in 40-60% of EU NFM output. It is significantly less energy and CO_2 intensive than primary production within the industry. The WEEE stimulates the use of scrap materials and preserves strategically important scrap for the EU market (Ecorys, 2011).

Policy name	Policy description	Measure
Reach Regulation	It aimed at improving the protection of human health and the environment, while maintaining the competitiveness and enhancing innovative capacity of the EU chemicals industry.	Inorganic NFM chemicals and fall under the scope of REACH. Therefore hexachloroethane, may not be used in the manufacturing and processing of NFM. The main impact of REACH on the NFM industry is that all metals must be registered. The majority of NFM need full registration as per the Annex IX and X requirements of the REACH Regulation (Ecorys, 2011).

A1.5.2 Overview of the EU28 market

Non Ferrous Metals (NFM) are non-magnetic and generally more resistant to corrosion than ferrous metals; several NFM are also good conductors of electricity. There are three key groups that make up the NFM industry, these primarily include:

- Base metals (aluminium, copper, zinc, lead, nickel, tin).
- Precious metals (silver, gold, palladium, other platinum group metals).
- Minor metals including refractory metals (e.g. tungsten, molybdenum, tantalum, niobium, chromium) and specialty metals (e.g. cobalt, germanium, indium, tellurium, antimony, gallium).

Table A1.35 provides an overview of the different subsectors in the NFM industry and their NACE classifications.

Table A1.35 Sub-sectors of the NFM industry and their NACE classifications

NFM sub-sector	NACE Rev. 1.1 code	NACE Rev. 2 code	NACE Rev. 1.1 Category Description
Precious metals	27.41	24.41	Precious metals production
Aluminium	27.42	24.42	Aluminium production
Lead	27.43	24.43	Lead, zinc and tin production
Zinc	27.43	24.43	Lead, zinc and tin production
Tin	27.43	24.43	Lead, zinc and tin production
Copper	27.44	24.44	Copper production
Nickel	27.45	24.45	Other non-ferrous metal production
Minor Metals	27.45	24.45	Other non-ferrous metal production: • production of chrome, manganese, nickel etc. from ores or oxides; • production of chrome, manganese, nickel etc. from electrolytic and aluminothermic refining of chrome, manganese, nickel etc., waste and scrap; • production of alloys of chrome, manganese, nickel etc.; • semi-manufacturing of chrome, manganese, nickel etc.; • production of mattes of nickel.
plus related castings industries			
	27.53	24.53	Casting of light metals
	27.54	24.54	Casting of other NFM

Source: Ecorys (2011) Competitiveness of the EU Non-ferrous Metals Industries

Together, aluminium, copper and zinc represent more than 85% of annual global NFM production (Ecorys, 2011). Of this Aluminium accounts for almost half of the annual output tonnage; this is significant because aluminium is a light metal (Ecorys, 2011).

This sector profile will focus its analysis on base metals[259] which makes up the core of the NFM group and provide insights on precious and minor metals where possible.

A1.5.2.2 Contribution to GDP, employment:

The European NFM industry has an annual turnover of €275bn (Eurometaux, 2013). Aluminium is the most widely used NFM. In 2012, the European aluminium industry had an annual turnover of €391.7bn, producing 255,000 direct jobs and over a million indirect jobs across Europe's value chain (EAA, 2013). In 2012, European copper industry has around 45,000 direct employees (ECI, 2012), with an estimated turnover of €45 billion (ECI Website).

Table A1.36 provides an overview of the key economic indicators for the NFM sector and subsectors in 2011. It shows that the manufacture of basic precious and other non-ferrous metals dominated in all fields; it accounted for 86% of total turnover; had the largest number of enterprises (3447) in the sector; and employed over 65% of the total workforce in the sector (193,270 employees).

At member state level Germany and Italy are the main beneficiaries of the NFM industries the EU. Table A1.36 shows that Germany accounts for the largest share of EU NFM sector turnover at 34%, followed by Italy (14%) and Spain (almost 1%). Germany and Italy also benefit from the largest number of employees in the industry with 92,169 and 40,043 employees respectively. France follows in third place with 26,289 employees under the sector. Italy also has the largest share of enterprises (25%) followed by Germany (17%) and Spain (almost 1%).

A1.5.2.3 Range of subsectors:

Table A1.36 (below) presents the key economic indicators per sector and subsector within Non-ferrous metals industry.

Table A1.36 Table Key economic indicators per sector and subsector (2011Eurostat data)

Description	NACE	Number of enterprises	Number of persons employed	Turnover	Value added	Personnel costs	Investment in tangible goods	Production value
				EUR million				
Non-ferrous metals		**6,996**	**295,229**	**135,342**	**20,918**	**13,019**	**4,347**	**130,734**
Manufacture of basic precious and other non-ferrous metals	C244	3,447	193,270	116,252	15,635	9,099	3,574	111,845
Casting of light metals	C2453	1,944	75,389	12,522	3,855	2,868	630	12,424
Casting of other non-ferrous metals	C2454	1,605	26,570	6,567	1,428	1,053	143	6,465

Source: 2011 Eurostat data

Note: *Eurostat provides data per Member State for indicators (e.g., annual turnover, number of persons employed) based on NACE codes of the format AXX.XX (e.g., NACE C17.12). In addition to this level of granularity, Eurostat provides aggregated values of the overarching NACE codes. This would be codes C17 and C17.1 in the case of C17.12. Due to limitations inherent to the current Eurostat database, however, these aggregated values do not always exactly match the sum of the parts. For example, the sum of C17.1 and C17.2 does not always exactly match the Eurostat-provided aggregated value for C17. In most cases, such discrepancies have been found to be minor. Therefore, the selected approach for analysis has been to use sums of the parts (i.e., sum of C17.1 and C17.2 to represent the overall code C17). This approach ensures consistency between data and intends to maximize accuracy.*

Key economic indicators for the NFM industry per Member States are given in Table A1.37.

Table A1.37 Table Key indicators, manufacture NFM (NACE Division NACE C24.4/24.53/24.54)

	No. of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
Germany*	1,248	46,651	43,042	6,656	4,761	840	92,169
Italy	1,757	19,343	19,261	2,577	1,650	618	40,043
Spain	626	12,087	12,084	1,599	819	238	19,106
Belgium	143	11,579	11,729	1,143	637	159	9,304
France	513	10,107	9,917	1,754	1,351	1,363	26,289
United Kingdom	624	9,390	9,119	2,828	1,538	129	25,223
Austria	90	5,868	5,723	1,186	621	156	10,979
Sweden	164	5,337	5,325	674	461	196	8,079
Bulgaria	92	3,424	3,428	347	58	49	5,771
Poland	513	2,658	2,560	504	220	145	16,378
Netherlands	172	2,395	2,302	418	300	78	7,101
Hungary	153	1,631	1,470	304	141	65	8,225
Romania	183	1,121	1,092	243	77	188	8,477
Czech Republic	83	895	904	129	63	15	3,326
Slovakia	76	847	816	212	73	33	4,320
Portugal	253	777	742	93	73	24	3,758
Slovenia	84	584	565	102	63	30	2,664
Denmark	54	355	351	91	74	10	1,666
Croatia	79	202	215	28	18	9	1,398
Finland	55	90	89	30	24	2	592
Estonia	15	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0
Greece	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0
Latvia	10	0	0	0	0	0	361
Lithuania	5	0	0	0	0	0	0
Luxembourg	4	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0

Source: 2011 Eurostat data

** Germany (until 1990 former territory of the FRG)*

A1.5.2.4 Main players

Table A1.38 provides an overview of the main mining, smelting and refining companies with production in the EU. Key companies in the EU include: Hydro, Rio Tinto , Alcoa, Wieland werke, Boliden, Trimet Aluminum, Atlantic copper, Aurubis, Elkem, Metallo – Chimique, Finnfjord, IGMNir, Xstrata Zinc, Befesa, FerroPem, Voerdal, Nystar, KGHM and Norilsk

Nickel (Eurometaux, 2013).

Table A1.38 List of Main Companies with Production in EU

Mining	Smelting	Refining
Aluminium		
■ Silver & Baryte Ores Mining; ■ Aluminium de Grece.	■ Alcoa Italia; ■ Alcoa Inespal; ■ Rio Tinto Alcan; ■ BaseMet (Klesch); ■ Hydro; ■ Trimet Aluminium; ■ Aluminium de Grece (Mytilineos); ■ Kubikenborg Aluminium (Rusal) ; ■ Alro; ■ Talum; ■ Slovalco.	■ Aughinish Alumina Ltd (Rusal); ■ Aluminium de Grece; ■ Alumina Espanola; ■ Eurallumina (Rusal); ■ Aluminium OxidStade; ■ Rio Tinto Alcan; ■ Ajka.
Copper		
■ Boliden; ■ KGHM; ■ Somincor; ■ Mandesur Andevalo; ■ Minas de Aguas Tenidas (MATSA); ■ Rio Narcea.	■ Aurubis; ■ Atlantic Copper; ■ Boliden; ■ Metallo Chimique; ■ Montanwerke Brixlegg; ■ KGHM.	■ Aurubis; ■ Atlantic Copper; ■ Boliden; ■ Metallo Chimique; ■ Montanwerke Brixlegg; ■ KGHM.
Nickel		
■ Talvivaara Mining; ■ Larco; ■ Lundin Mining Corporation; ■ Belvedere Resources; ■ Eramet;* ■ XtrataNickel;* ■ Vale*	■ Boliden; ■ Talvivaara Mining; ■ Eramet;* ■ XtrataNickel;* ■ Vale*.	■ Norilsk (Harjavalta); ■ VALE; ■ Eramet.
Lead		
■ Lundin Mining; ■ Boliden; ■ Tara Mines; ■ Anglo Base Metals (Ireland); ■ Hellas Gold; ■ Miniere Iglesiente; ■ Minas de Aguas Tenidas (MATSA); ■ Lappland Goldminers.	■ Metaleurop; ■ Eco-Bat Technologies; ■ S.E.del Acumulador Tudor (Exide); ■ Campine; ■ Boliden; ■ Varta Batterie AG Hanover; ■ Piombolegthe; ■ EnviroWales; ■ Perdigones Azor.	■ Xstrata Plc; ■ Metaleurop; ■ Glencore; ■ Ecobat; ■ Varta Batterie AG Hanover; ■ Campine; ■ Umicore; ■ S.E. Del Acumulador Tudor (Exide); ■ Boliden Bergsoe.
Zinc		
■ Tara Mines; ■ Anglo Base Metals (Ireland); ■ Boliden; ■ Lundin Mining orporation; ■ Talvivaara Mining; ■ Minas de Aguas Tenidas (MATSA);	■ Asturiana de Zinc; ■ Xstrata Zinc Gmbh; ■ Huta Cynku 'Miasteczko Slaskie; ■ Nyrstar; ■ KMC SA; ■ Sometra.	■ • Boliden; ■ • Nyrstar; ■ • Xstrata Zinc; ■ • Glencore; ■ • Metal Europe; Weser GmbH; ■ • Portovesme;

Mining	Smelting	Refining
■ Hellas Gold.		■ Zaklady Gorniezo Hutzieze; ■ Umicore.
Precious and minor metals		
■ Boliden; ■ KGHM Polska Miedz.	■ Umicore; ■ Aurubis.	■ Umicore; ■ Johnson Matthey; ■ Heraeus; ■ Plansee; ■ H.C. Starck; ■ Campine ■ Vale; ■ Boliden; ■ Aurubis; ■ KGHM Polska Miedz; ■ Britannia Refined Metals; ■ Metalor.

Source: Adapted from Ecroys (2011)

A1.5.2.5 Trade flows

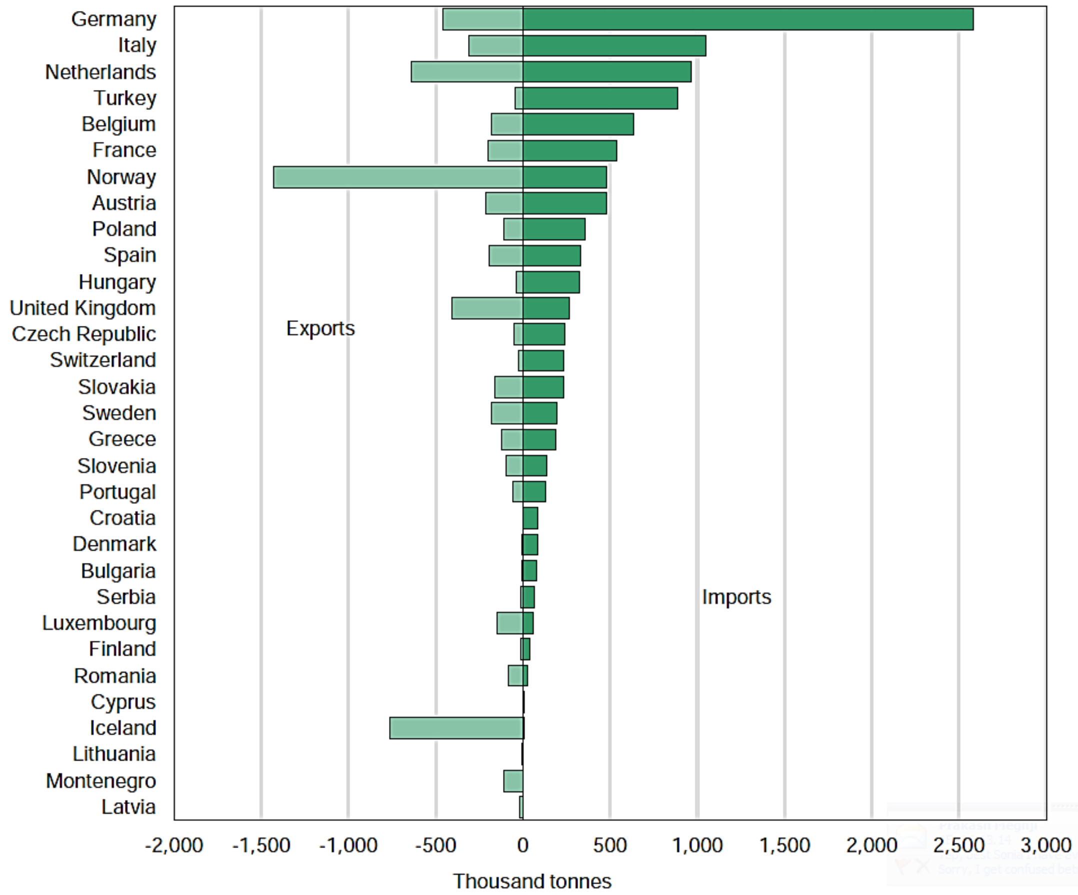
The EU is a net importer of refined NFM, and its dependence on imported metals is growing. In 2012, EU exports to the rest of the world totalled €29.7bn whereas imports into the EU totalled €38.6bn. Germany, the UK and Italy accounted for nearly half of the exports and over 40% of the imports (EC, 2013).

Trade flows for base metals are discussed further below.

Aluminium

Figure A1.46 shows that the Europe is a net importer of aluminium. It also shows that the Netherlands, Germany and UK are the highest exporters of aluminium metal in the EU27. Germany is by far the largest importer of the metal, importing over 2.5m tonnes in 2011.

Figure A1.46 Aluminium Metal - EU 35 trade in 2011

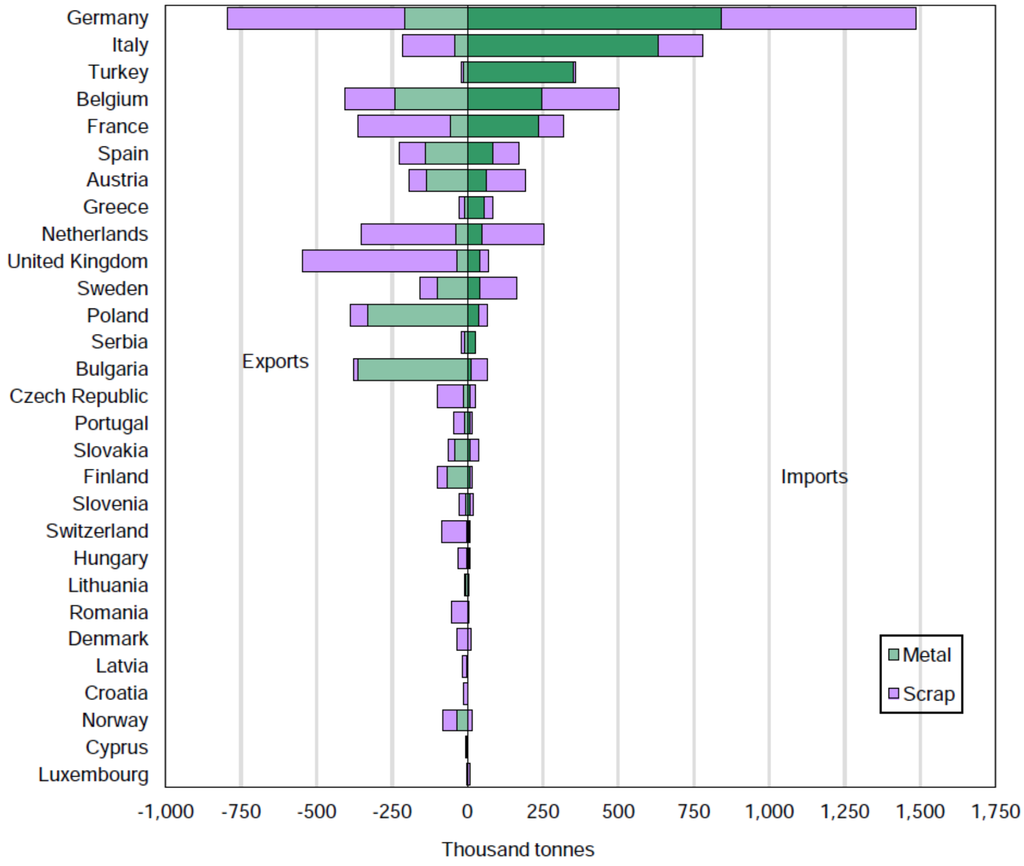


Source: British Geological Society (2013) European Mineral Statistics 2007-2011

Copper

Figure A1.47 (below) illustrates that Europe is a net importer of copper. The main EU-27 Member States importing copper in 2011 were Germany (almost 1.5m tonnes), followed by Italy, Belgium and France.

Figure A1.47 Copper - EU 35 trade in 2011



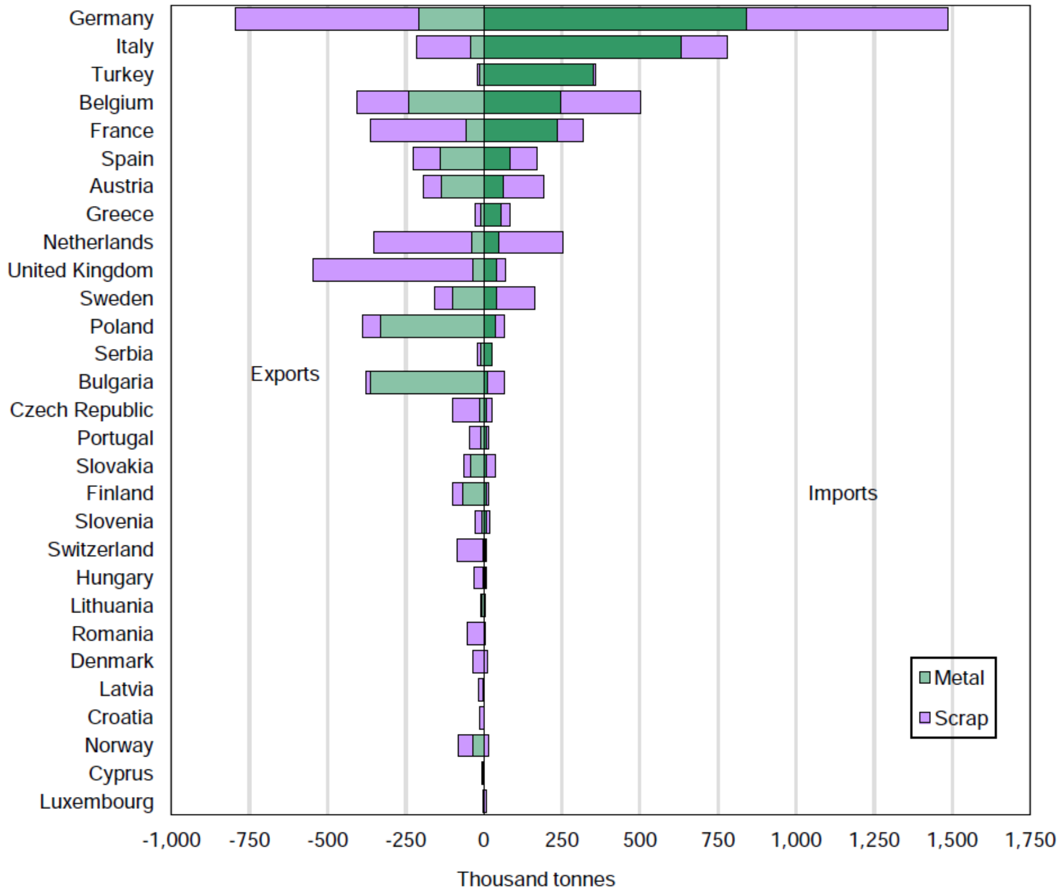
Source: British Geological Society (2013) European Mineral Statistics 2007-2011

Since 2013, an estimated 41% of the EU27's copper demand has been met through the recovery and recycling of value-chain offcuts, plus end-of-life products (Glöser, S. *et al* 2013).

Lead

Figure A1.48 (below) illustrates that Germany and the UK are both the largest exporters and importers of lead in the EU, exporting 229,072 tonnes and 224,570 tonnes respectively. Additionally, a quarter of UK exports are scrap metal – 74,789 tonnes were exported in 2011.

Figure A1.48 **Lead - EU 35 trade in 2011**

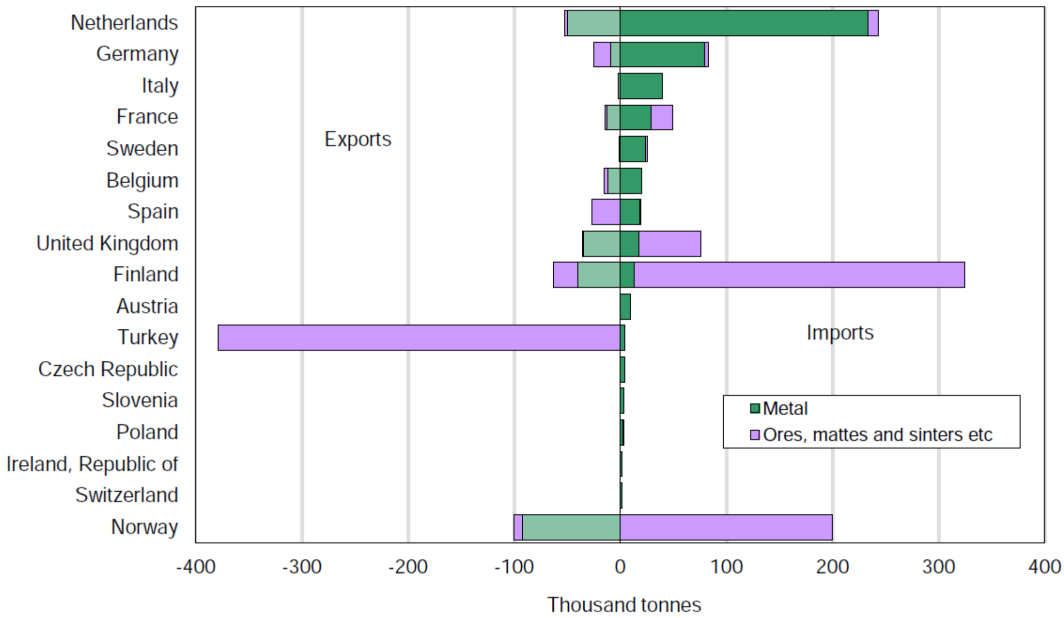


Source: British Geological Society (2013) European Mineral Statistics 2007-2011

Nickel

Figure A1.49 (below) illustrates overall, the EU27 are net importers of nickel. The Netherlands and Finland are both the largest exporters in the EU accounting for 53874tonnes and 63116 tonnes respectively. Both are also the largest importers of nickel, however imports far exceed exports.

Figure A1.49 Nickel- EU 35 trade in 2011

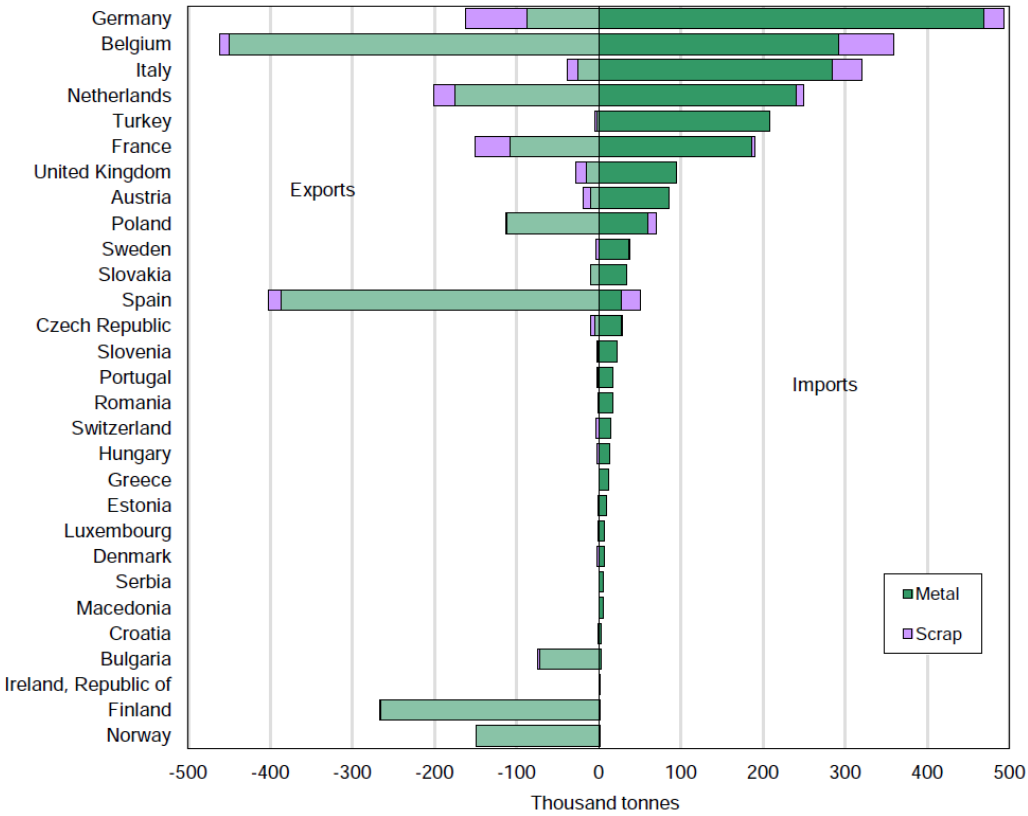


Source: British Geological Society (2013) European Mineral Statistics 2007-2011

Zinc

Figure A1.50 (below) illustrates that Germany, Belgium and Italy are the highest importers of Zinc metal in the EU27. Belgium is the largest exporter, followed by Spain and Finland.

Figure A1.50 Zinc - EU 35 trade in 2011



Source: British Geological Society (2013) European Mineral Statistics 2007-2011

A1.5.2.6 Product type and consumer groups

Table A1.39 provides an overview of the key uses of NFM in different industries.

Table A1.39 Figure Sector usage of NFM

Metal	Sector Usage
Aluminium	■ **Building & construction**: Window frames, building structures, roofs, etc. ■ **Transportation**: Airplanes, trains, boats, cars and trucks. It is also used in smaller vehicles like bicycles, motorbikes and other mobility devices such as wheelchairs. ■ **Packaging**: Aluminium is used mostly in the form of cans and foil. ■ **Electricity**: Since 1945, aluminium has replaced copper in high-voltage transmission lines.
Copper	■ **Electrical applications**: Wires, circuits, switches and electromagnets. ■ **Piping**: Plumbing fittings and also in refrigeration, air conditioning and water supply systems. ■ Roofing and insulation. ■ **Household items**: cookware, doorknobs, and cutlery.
Lead	■ **Car batteries**: Lead is still used extensively in the plates that work as electrodes. ■ **Colouring**: Although less common today, it is used in ceramic and glass glazing. ■ **Radiation protection**: Lead offers protection against X-rays.
Nickel	■ **Plating metals and plastics**, combined with copper in cupro-nickel alloys
Zinc	■ **Galvanisation**: Zinc is commonly applied as a coating to protect iron and steel from corrosion in a process known as galvanisation.

Metal	Sector Usage
	■ **Batteries**: As an anode component material in batteries. ■ **Brass**: Created by alloying zinc and copper.
Tin	■ **Cans**: by covering steel sheet with a thin layer of tin one obtains tinplate, the raw material to make cans ■ **Car production**: tin increases the resistance of the motor block, piston rings and clutch plates; ■ **Springs** of any kind become tougher through the addition of tin ■ **Glass**: tin oxide coatings of glass surfaces to make them more resistant
Precious metals	■ **Jewellery**, specialist electronic applications. Platinum and palladium have important applications as catalysts (used in catalytic converters in motor vehicles and industrial processes).

Source: Bureau of International Recycling (n.d.) and British Geological Society (2013)

A1.5.2.7 Market developments and sector growth rates

The EU has a mature NFM industry with strong links to other industires, it accounts for 2% of EU GDP (Eurometaux, 2011). However competitive pressures from emerging economies; resource scarcity for primary materials; regulatory pressures and rising energy prices are negatively impacting the industry.

China is the largest producer of most base NFMs, while it currently focuses on primary production, its capacity for secondary production is improving rapidly.

There is little evidence of new major investments in the upstream segments of the NFM industry in the EU. Large scale smelter instillations are taking place in markets such as the Middle East, Russia and China who are increasingly becoming dominant players. Joint ventures and greenfield investments by European companies in the Middle East have been driven by low cost and abundant energy sources (Ecorys, 2011). Expansion of upstream activities for aluminium, copper and zinc will most likely occur in Russia, the Middle East and China, while imports of these metals are likely to increase in the EU in the future (Ecorys, 2011). EU investments have occurred in recycling and secondary production, these include facilities that process increasingly complex materials (Ecorys, 2011).

Expansion of productive capacity in upstream activities, particularly for aluminium, copper and zinc is likely to occur outside of the EU (Ecorys, 2011).

Market developments for the NFM are described in more detail taking each base metal in turn.

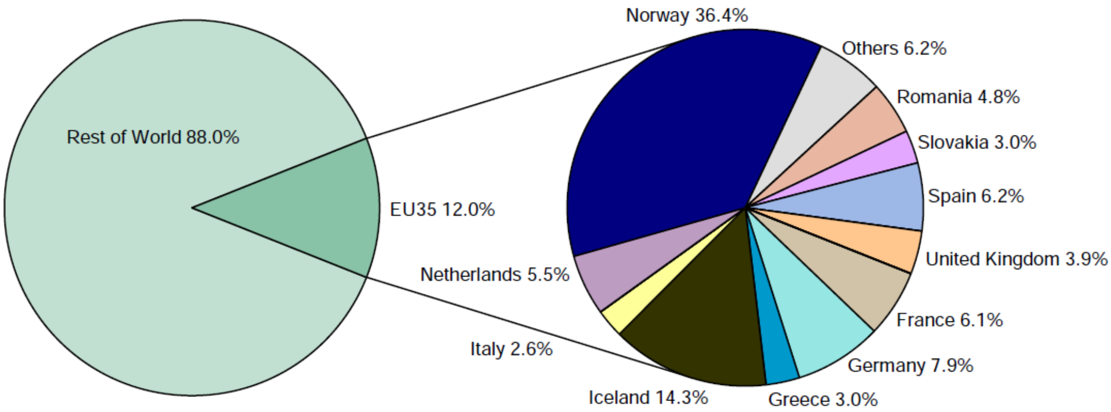
Aluminium

The EU's share of aluminum global production fell from 16% in 2000 (2.96 mt) to 12% in 2007 and 10% in 2009 (Ecorys, 2011). Since the economic crisis in 2008, primary aluminium production has fallen by 1.2 million tonnes in Europe[260], to 4 million tonnes in 2012. Primary smelting has been impacted because of structural problems and 'artificially high' electricity prices in Europe (EAA, 2013).

In 2011, China produced 40% of total world aluminium output, followed by Russia (9%) and Canada (7%). E shows that aluminium production in the EU35 accounted for 12% of total global production; of the EU27, Germany accounted for the largest share of this (7.9%) followed by France (6.1%) and the Netherlands (5.5%) (BGS, 2013). In 2012, Europe also produced 16% of world-wide aluminium, half of which was from recycled sources (EAA, 2013).

[260] Note this value is for the Europe as a whole not specifically related to the EU27

Figure A1.51 EU35 production of primary aluminium



Source: British Geological Society (2013) European Mineral Statistics 2007-2011

During 2012, primary aluminium production decreased by a further 10% in Europe and by 20% in EU-27 compared to the previous year. 'The large majority of the closures occurred in the EU: primary production was 2 million tonnes in 2012, 1 million less than 5 years earlier' (EAA, 2013).

Copper

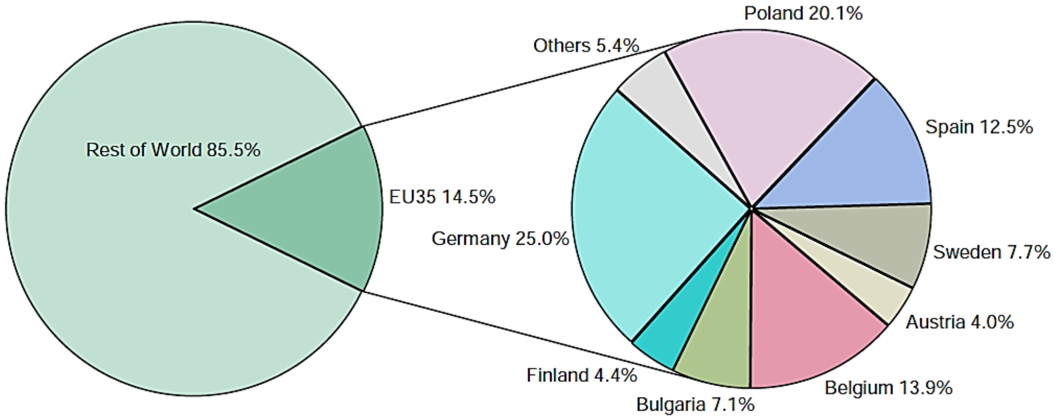
Over 2000-2007, EU27 refined copper production fluctuated, with falls in 2003 and 2007. However, overall production remained stable at 2.4-2.5 million tonnes (mt) p.a. (Ecorys, 2011). Stronger growth in refined copper production in China and Chile over 2000-2009 meant that the EU share of global production declined from 16% in 2000 to under 14% in 2009 (Ecorys, 2011).

In 2011, Chile was the largest producer of copper at 32%, followed by China (8%), Peru (8%), USA (7%) and Australia (6%). Mine production of copper in EU35 represented 5.7% of the world production (926,868 tonnes); of the EU27, Poland accounted for the largest share of this (46%) followed by Bulgaria (12.4%) and Sweden (9%) (BGS, 2013).

Smelter production of copper in EU35 represented 13.6 % of the world production (1796160 tonnes); of the EU27, Poland accounted for the largest share of this (26.8%) followed by Germany (19.3%) and Bulgaria (15.9%) (BGS, 2013).

Production of refined copper in EU35 represented 14.5 % of the world production (2836426 tonnes); Figure A1.52 shows that of the EU27, Germany accounted for the largest share of this (25%) – 708,800 tonnes, followed by Poland (20.1%) and Belgium (13.9%)(BGS, 2013).

Figure A1.52 EU35 production of refined copper



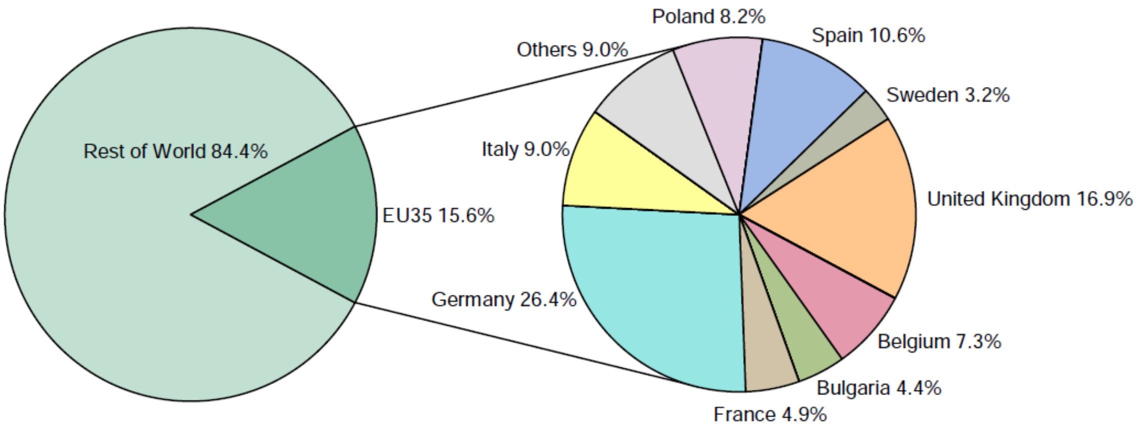
Source: British Geological Society (2013) European Mineral Statistics 2007-2011

Lead

EU lead production declined between 2001 and 2009 falling to 1.5 mt in 2009 (Ecorys, 2011).

In 2011, China was the largest producer refined lead, accounting for 45% of world output followed by USA (12%) and Germany, India and South Korea (4% each). EFigure A1.53 illustrates that refined lead production in EU35 represented 15.6% of the world production (1624947 tonnes); of the EU27, Germany accounted for the largest share of this (26.4% - 429100 tonnes) followed by the U.K (16.9%) and Italy (9%) (BGS, 2013).

Figure A1.53 EU35 production of refined Lead

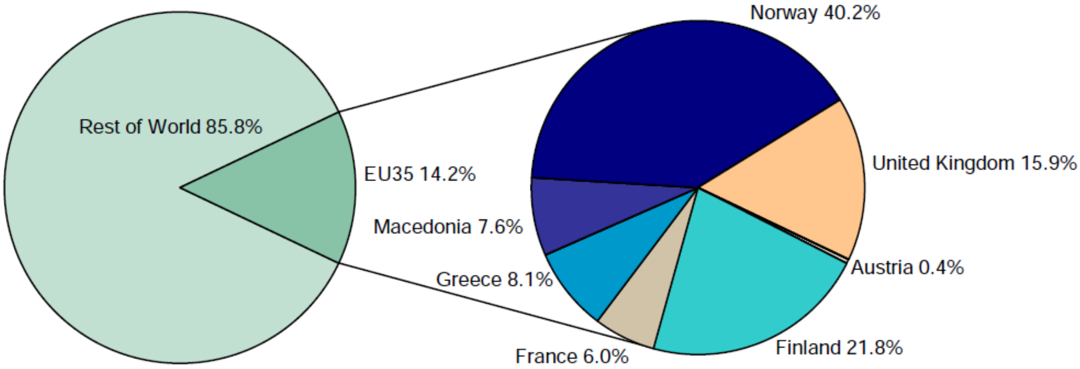


Source: British Geological Society (2013) European Mineral Statistics 2007-2011

Nickel

In 2008 the EU was ranked seventh for Nickel production 0.081 mt (Ecorys, 2011). In 2011, China was the largest producer refined nickel, accounting for 25% of world output followed by Russia (16%) and Japan (10%). Refined nickel production in EU35 represented 14.2% of the world production (228645 tonnes); of the EU27, the UK accounted for the largest share of this (15.9% - 36300 tonnes) followed by Finland (21.8%) and Greece (8.1%) (BGS, 2013).

Figure A1.54 EU35 smelter/refinery production of nickel 2011



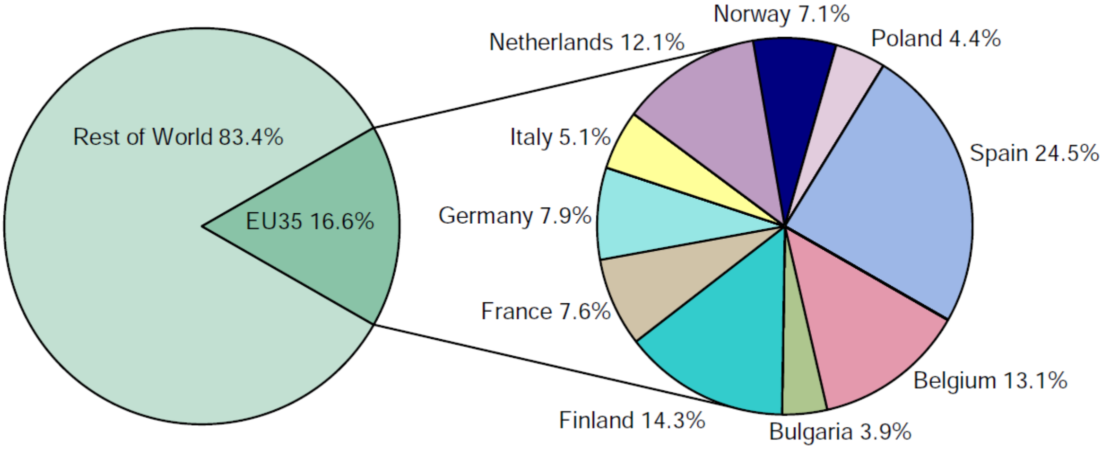
Source: British Geological Society (2013) European Mineral Statistics 2007-2011

Zinc

In 2000, EU zinc production was 2.4mt this fell to 1.7mt in 2009, when the EU accounted for 15% of world Zinc production (Ecorys, 2011). In 2011, China was the largest producer mined zinc, accounting for 34% of world output followed by Australia (12%) and Peru (10%). Zinc production in EU35 represented 7.5% of the world production; of the EU27, Ireland accounted for the largest share of this (36.1%) followed by Sweden (20.3%) and Poland (9.2%) (BGS, 2013).

In 2011, China was the largest producer refined zinc, accounting for 40% of world output followed by South Korea and India (6% each). Refined zinc production in EU35 represented 16.6% of the world production (2,152,252 tonnes); of the EU27, Spain accounted for the largest share of this (24.5% - 527,100 tonnes) followed by Finland (12.1%) and the Netherlands (12.1%) (BGS, 2013).

Figure A1.55 EU production of refined zinc in 2011



Source: British Geological Society (2013) European Mineral Statistics 2007-2011

Tin

In 2009, the EU produced almost 8,500 tonnes of tin, accounting for around 2.5% of global production.

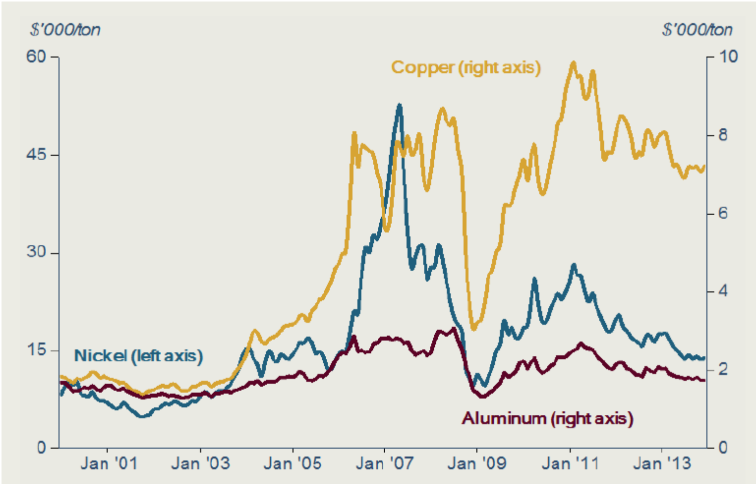
In 2011, China was the largest producer of mined tin and refined tin, producing 42% and 47% of world output respectively (BGS,2013).

Prices

The NFM industry is highly globalised and prices for raw material inputs and NFM primary products are set or referenced through international exchanges (e.g. London Metals Exchange, the Shanghai Metals Exchange e.t.c.) However, cost factors are predominantly determined locally making them important factors of competitiveness, especially for upstream sectors of the value chain (Ecorys, 2011). High cost producers are generally located in mature economies such as the EU, where there may be a lack of natural resources or energy (Ecorys, 2011).

Metal prices collapsed in 2008-2009 during the economic crisis, but have since regained strength reaching a peak in early 2011, when the World Bank metals price index reached a new high of 126. This was up by 164% from the December 2008 low (World Bank, 2014). However, metal prices have declined by 30% between the peaks in early 2011 and November 2013 (See Figure A1.56). In 2013 prices for zinc, copper, aluminium and nickel declined 2%, 8%, 9%, and 14% respectively. However, lead and tin prices proved resilient in 2013, increasing by 3.6% and 5.5% respectively (World Bank, 2014).

Figure A1.56 NFM (base metal) prices from 2000-2013



Source: World Bank (2014) Global Economic Perspectives: Commodity Markets Outlook 2014

Price declines in 2013 were strongly related to Chinese demand. If robust supply trends and weaker-than-expected demand trends continue, metal prices may decline more than anticipated having a negative impact on exporters but a positive impact on importers. In 2014, the prices of aluminium, copper and nickel are expected to decline, very little change is expected in lead prices, while tin and zinc prices are expected to increase by 1% and 5% respectively (World Bank, 2014).

Drivers:

Between 2009 to 2011 NFM production was driven by new mining, smelting and refining projects launched in anticipation of stronger demand. The supply-demand balance for many NFM is cyclical. New players generally enter the market when prices are high, which occasionally results in oversupply. On the whole, global demand shows an upward trend and this is set to continue over the long term (Ecorys, 2011).

The prospects of global metal markets are dependent on Chinese demand, since the country accounted for 45% of refined metal consumption in 2012 (World Bank, 2014).

In Europe, the demand for aluminium was weakened due to the economic recession and euro crisis. In 2012 the demand for ‘extruded products declined by 9%’ because the building and construction sector were still recovering from the crisis (EAA, 2013). Additionally, uncertainty surrounding renewable energy legislation in the EU member states ‘hampered further growth of aluminium demand'. Demand for rolled products declined by 4% for Europe as a whole. There were positive growth rates in the transport and packaging sectors, and weaker performances in sales in the building, construction and engineering sectors (EAA, 2013).

The European copper institute stated that 2012 was a 'difficult year' for the copper industry due to government austerity programs, stricter borrowing conditions for customers and lower activity levels in national construction markets (ECI, 2012).

Energy growth rates for the NFM industry

The EU NFM used some 500 PJ of final energy in 2009, which represents 3% of total industrial consumption. Aluminium, zinc and copper were the most important subsectors in terms of energy use and CO2 emissions (Ecofys, 2009).

Table A1.40 (below) shows energy consumption by the NFM industry over 2000-2011. In 2000, the industry in four Member States consumed more than 1,000Mtoe, where Germany, France, Spain and the UK accounted for almost 55% of total energy consumption in the EU. By 2011 however, Germany, France and the UK reduced energy consumption significantly – by 22%, 33% and 24% respectively. However, emissions in Spain increased by 6%.

Amongst the countries with energy consumption lower than 1,000Mtoe, 6 countries noted an increase; these were Slovakia, Finland, Austria, Slovenia, Croatia and Spain. Energy consumption in Slovakia increased the most significantly with a rise of 626% followed by Finland and Austria with 68% and 37% respectively.

Table A1.40 Table Energy consumption in MToe by the Non-ferrous metals industry per Member State over 2000-2011

GEO/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Change from 2000 to 2011
Denmark	13	15	15	14	14	11	13	13	11	6	6	6	-54%
Portugal	41	35	23	23	26	24	25	32	35	27	26	27	-34%
France	1,466	1,298	1,321	1,174	1,211	1,298	1,176	1,110	985	972	882	979	-33%
Hungary	245	218	268	261	264	236	204	192	191	139	167	165	-33%
Czech Republic	83	85	73	89	85	90	92	90	69	60	63	61	-27%
Poland	765	789	745	733	730	704	721	731	669	583	529	574	-25%
United Kingdom	1,106	1,236	1,083	1,061	946	982	974	923	930	772	829	843	-24%
Germany (until 1990 former territory of the FRG)	2,633	2,707	2,675	2,594	2,499	2,675	2,338	2,380	2,339	1,717	2,195	2,057	-22%
Sweden	331	322	320	316	317	339	335	341	334	266	274	266	-20%
Greece	819	807	835	843	862	851	811	861	745	607	764	673	-18%
Bulgaria	161	159	124	137	160	157	156	147	128	136	140	144	-11%
Ireland	411	360	353	350	373	376	532	383	405	322	405	379	-8%
Italy	965	979	955	962	968	964	982	947	931	858	843	944	-2%
Netherlands	639	616	611	618	678	681	615	653	683	439	528	634	-1%
Belgium	328	310	322	353	340	303	389	380	325	232	267	327	0%
Latvia	4	6	7	7	7	5	5	5	3	2	3	4	0%
Spain	1,164	1,344	1,566	1,448	1,520	1,179	1,157	1,274	1,158	1,226	1,244	1,230	6%
Croatia	13	14	16	13	16	15	15	16	15	13	11	14	8%
Slovenia	119	121	145	173	204	206	202	239	183	111	107	138	16%
Austria	131	136	140	146	157	160	165	182	179	184	174	180	37%
Finland	181	168	167	190	201	183	211	288	291	266	291	304	68%
Slovakia	34	169	187	214	241	241	241	218	259	223	246	247	626%
Estonia	0	0	1	0	1	1	3	3	2	3	3	1	-
Lithuania	0	0	0	0	0	0	0	0	0	0	1	1	-
Romania	0	0	0	0	0	0	0	1	0	0	0	0	-

(Eurostat, available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home)

Note: *Cyprus, Malta and Luxembourg do not have a NFM industry, so were not included in the table above.*

A1.5.3 Business environment

A1.5.3.1 Competitive strengths

The EU NFM industry is **mature and technologically advanced with a skilled labour force,** therefore it has the ability to produce high quality products. NFM producers provide vital inputs for high-tech industries and are therefore considered of to be of great economic importance for emerging technologies. The EU NFM sector is technologically is at forefront in many sub-sectors and segments; particularly in higher value added (e.g. precious metals) and high quality tailor made products. Therefore this provides an important incentive for many companies to retain their production capacity and R&D activities in the EU (Ecorys, 2011).

T**he EU has some of the most efficient NFM production in the world.** For example, since 1990, the aluminium industry has reduced their CO2e emissions by 50% (EAA, 2012). However, this is mainly attributed to process improvements which leads to a drastic reduction of PFC emissions (which carries a Global Warning Potential range of 6,000 – 10,000) and closure of non-well performing smelters.

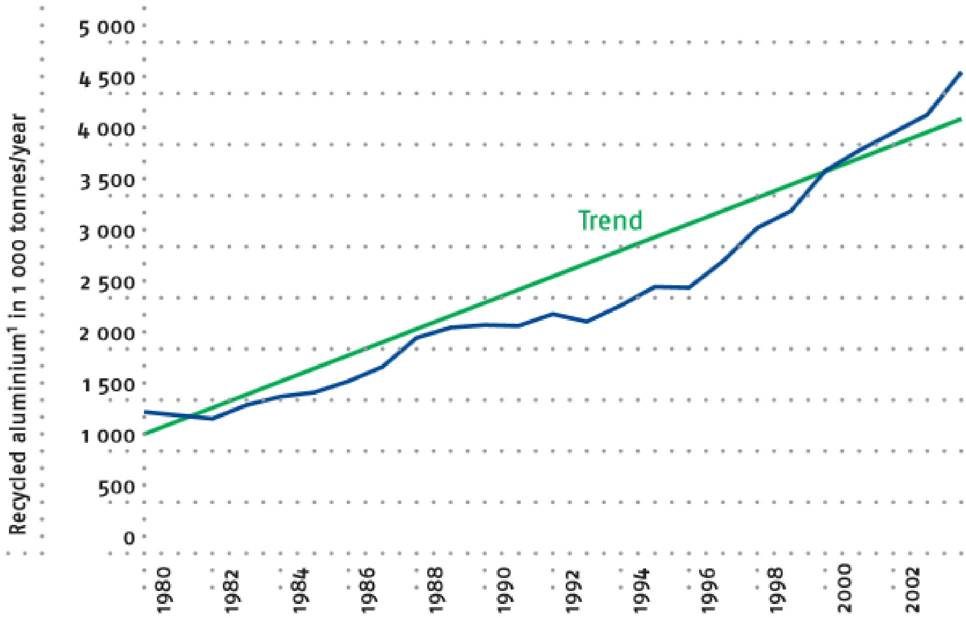
This means that it is more resilient to energy shocks in the future compared to less efficient producers and EU companies also have a positive reputation (ICCM, 2013).

The **EU has strong value chain** integration which has contributed greatly to the strength of the sector.[261] The most demanding consumers of NFM, in terms of quality and specialised material needs are based in the EU. As such, EU NFM producers have worked with clients (in manufacturing, aerospace and transport sectors) and developed the ability to produce tailored, high quality and technologically advanced solutions. The strong integrated value chain has also allowed scrap metals to enter the value chain during the refining and processing stages, significantly reducing energy and resource use to benefit the environment and enhance competitiveness (Ecorys, 2011).

The **EU recycling industry is one of the most advanced in the world**, even compared to industries in developed countries such as the US, Canada and Japan. Additionally, recycling recovery rates within the EU are also amongst the highest in the world. For example, the average share of re-cycled metal in Europe is 40%, whereas the global average is 30%. As such, the NFM industry has developed strong links with its supply chain, providing clients with closed loop solutions (Ecorys, 2011). This is reflected in Figure A1.57, which highlights the increasing recycling trend in the EU.

[261] This excludes mining activities since the bulk of raw NFM are sourced from outside the EU.

Figure A1.57 EU production of aluminium from scrap



Source: EAA, 2006

The EU NFM industry has strong roots and capacity in the EU. Compared to competitors like China and Russia, the EU has a relatively stable market; skilled labour force; productive smelters; high recycling and recovery rates for recycling processes; strong links with EU clients; high technology and quality requirements and emergence of closed loops (Ecorys, 2011).

- **<u>How are these advantages envisaged as changing over the next 10-15 years?</u>**

In recent years the EU has seen a **disintegration of the it's value chain**, as a result of primary production expanding outside of the EU (Ecorys, 2011).

With environmental regulations - possibly even ETS-like schemes being introduced in countries like China (Guardian, 2013), there are **opportunities for EU NFM sectors to provide experiences and skills to foreign markets** on how best to deal with regulations (Ecorys, 2011).

There is **growing competition from low labour cost counties for the sorting of scrap metal** using labour intensive methods. Therefore scrap handlers may find it more profitable to export unprocessed scrap rather than sort it in the EU. This would lead to the loss of scrap for EU producers to countries that have lower recovery rates and lower environmental and labour standards (Ecorys, 2011).

A1.5.3.2 Threats

- **<u>What are the main threats which currently impact on the sector?</u>**

Environmental regulations in the EU have put pressure on the NFM industry both in terms of regulatory compliance and increased energy costs. The EU ETS in particular has a significant impact because it increases direct production costs compared to producers outside of the EU. Additionally, the industry also faces indirect CO2 costs due to increased electricity prices (as the power sector passes on its ETS costs) as well as cost burdens related to self-generation (Ecorys, 2011). Smelting from primary raw material in the NFM industry is extremely energy intensive. For example approximately 15 MWh are needed to produce one tonne of aluminium and 4 MWh are required for one tonne of copper. Electricity costs represent a third of total production costs for the EU primary aluminium industry, making it a key factor impacting the competitiveness of the sector. Therefore EU policies impacting energy prices are of particular importance to the sector. The EU ETS is accountable for 45% of the increase in energy prices faced by the sector (CEPS, 2013).

Regulations also adversely benefit emerging industries outside of the EU. The prices for NFM are determined globally, while costs are determined locally. Since competing regions do not have to compete to absorb the costs of emissions trading and NFM producers in the EU cannot pass on their costs downstream, they have a competitive disadvantage compared to non-EU competitors creating the potential for carbon leakage (Ecorys, 2011 and EAA, 2012). Additionally, **labour costs and environmental compliance costs in the EU are higher than emerging economies** such as China, India and Russia whose industries are subject to less regulation Ecorys, 2011). All of these factors have negative impacts on EU competitiveness.

Eurometaux[262] state that the **EU is becoming overly dependent on metal imports** even for basic commodities such as zinc, aluminium and copper. Simultaneously, the trade body feels that the EU is discouraging investment in the industry at home due to unilateral policies, such as the EU ETS (Metalbulletin, 2012).

Primary aluminium production is of importance in the EU because world demand for aluminium is increasing and secondary production (e.g. recycling) is not sufficient to meet this demand. Since primary production of aluminium is closely linked to downstream industries (e.g. through high tech use of aluminium in the mechanical industry), a **loss of primary production could lead to a loss of the entire value chain in Europe.**

- **How are these envisaged as changing over the next 10-15 years?**

Primary aluminium producers in the EU will be at **risk of closing down** if there is not an improvement in power market conditions; since current electricity prices reduce EU producer margins to an unsustainable level (EC, 2013b).

The shift of production outside of the EU to emerging economies (e.g. China) could lead to an **increase in global emissions** (EC, 2013b). For example, without European aluminium primary production and recycling, Europe would be responsible for 178% more emissions since imported metal would have a larger CO2 footprint compared to European production (EAA, 2012).

The **threats from carbon leakage have been acknowledged by the EC** under EC COM Decision 2010/2/EC where the NFM sector was included in a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage under the EU ETS (EC COM Decision 2010/2/EC, 2009). The sectors at risk will receive a higher share of free allowances in the third trading period between 2013 and 2020.

The EC have further stated that that due to the economic crisis and related output and emissions reductions, 'most energy intensive sectors covered by the EU ETS have accumulated a significant surplus of free allowances' additionally the carbon price has declined in line with reduced demand for allowances (EC, 2014). Therefore, the risk of carbon leakage - in the absence of any free allocation to industry – 'is estimated to be considerably lower than when the climate and energy package was adopted in 2009' (EC, 2014).

A1.5.3.3 Business strategy and decision making

In 2013**, leading EU NFM industry called for a revision of the EU ETS** to preserve the competitiveness of the industries, in an open letter to President Barroso. They urged the need for EU climate policy to be better aligned with the Commission's goal of increasing

[262] Europe's non-ferrous metals body

industry's share in the EU GDP to 20% by 2020 (Eurometaux, 2013). In their letter, they stated that a review of the EU ETS should include:

- 'Free EU-based allocation for direct and indirect emissions to the Energy Intensive Industries based on benchmarks;
- Allocation must be based on actual – rather than historic – industry production; and
- Linkage to other carbon schemes only on the basis of symmetry and reciprocity in terms of privileges and burdens on the industry' (Eurometaux, 2013).

The European Aluminium association add that full compensation for the indirect effect of the EU ETS scheme on electricity prices is needed to 'ensure short-term survival of the industry, as long as the rest of the world has not adopted equivalent measures' (EAA, 2012).

Recycling rates could be improved through improved collection and waste stream management. More needs to be done to promote separate collection of waste metal in member states (Ecorys, 2011). More R&D investment is needed towards improving the process of separating more complex materials as well as towards improved design of products with the explicit objective of making recycling easier (Ecorys, 2011).

More stable electricity prices and less volatile production environment is needed (Ecorys, 2011).

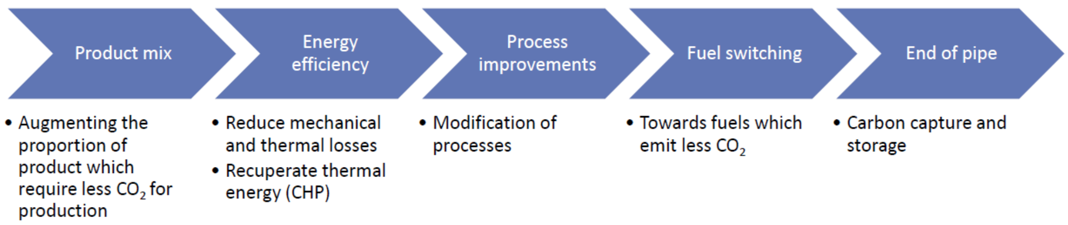
European policy should **continue to focus on knowledge sharing and fostering partnerships between various segments of the value chain** (Ecorys, 2011)

Import tariffs should be reduced or eliminated, at least for aluminium because they do not address the basic competitiveness issue behind the high cost environment in the EU (e.g. those related to energy, climate change, environmental legislation or labour). These would be better addressed through EU energy policy, labour laws or other trade policies (Ecorys, 2011)

A1.5.3.4 Mitigation activities

Activities related to the mitigation of CO2 emissions are illustrated by Figure A1.58. These illustrate the reduction levers that can be applied to reduce emissions in the NFM industry; starting with an increase in recycling to end of pipe solutions such as CCS.

Figure A1.58 Mitigation activities for NFM industry



Source: Vito and Climact (2012)

1. **Recycling of metals is essential** for sustainable development. For example recycling aluminium saves up to 95% of the energy required for primary production (EAA, 2012). Therefore it is important to ensure that the export of metal scraps from Europe be decreased. Exported scrap metal should be considered as exported European electricity, without compensation for the embodied CO2 emissions (EAA, 2012).
2. **Technological breakthroughs are required** to increase energy efficiency and reduce mechanical and thermal and electrochemical losses (Vito and Climact, 2012). Therefore promotion and development of an innovation policy is needed to enable the industry to retain its current technological advantage and develop new technologies to reduce electricity consumption (EAA, 2012).

Aluminium

Currently, Aluminium plants are designed according to Point Fed Prebake (PFPB) technology. From 2015 the new technologies of Prebake Reduced Temperature Electrode (PBRTE) will become available and in 2020 Prebake Anode (PBANOD) will become available (Ecofys, 2009).

Currently the electrolysis is performed at an average temperature of 1220K which is significantly above the melting point of aluminium (933K), which implies a high heat loss. PBRTE ensures a lower electrolysis temperature by using new additives for the electrolytes, as such, the PBRTE technology saves up to 20% of electricity and 23% of direct CO2 emissions compared with PFPB (Ecofys, 2009).

When an inert anode is combined with the wettable cathode, even higher efficiency gains can be achieved. However, Prebake Anode technology (PBANOD) is not yet on the market. PBANOD saves over 30% of electricity and more than 80% of direct CO2 emissions, compared to PFPB (Ecofys, 2009).

Copper

The reference electricity consumption in the copper production process is estimated at 6.8 GJ/t and the fuel consumption in energy use are estimated at 10.2 GJ/t. Reducing energy consumption and CO2 emissions of the copper production may be achieved by a combination of retrofitting the current installations of the pyrometallurgical route (e.g. the Outokumpu process) or building new plants that use the hydrometallurgical route (e.g.energy efficient HydroCopper™ process). Estimations show that future average consumption of these technologies are 5.4 GJ/t of fuels and 0.96 MWh/t of electricity, resulting in 49% electricity savings and 47% fuels savings (Ecorys, 2009).

3. **The modification of processes can be used to reduce emissions**. For example a portion of the pyrometallurgical processes - which are extremely heat intensive (Bref 2013) can switch to electricity (Vito and Climact, 2012). Activities related to the revision of the NFM BREF are continuing. This document will contain all of the Best Available Techniques (BAT) for the NFM sector (EAA, 2013 and Bref, 2013).

Zinc

The Imperial Smelting Furnace process (ISF) and electrolytic process are the main primary production processes of zinc in the EU. The Electrolytic process accounts for about 80% and the ISF process about 20% of the primary zinc production in the EU. Total electricity consumption could be decreased by approximately 0.4 MWh per tonne of zinc (10%) by reducing the current density of the electrolysis process[263] (Ecofys, 2009).

4. **Fuel switching** may be used to use fuels which emit less CO2 emissions. For example switches could be made from liquid fuels to gas, or the use of biogas may be used where possible (Vito and Climact, 2012).
5. Finally, emissions from the NFM industry could be captured and stored through carbon capture and storage (CCS) techniques, reducing end of pipe emissions from the sector (Vito and Climact, 2012).

A1.5.4 Sector projections

The NFM industry is mature and technologically advanced with a skilled labour force with the ability to produce high quality products. NFM producers provide vital inputs for high-tech industries and are therefore considered to be of great economic importance for emerging technologies. The EU NFM sector is technologically is at forefront in many sub-sectors and

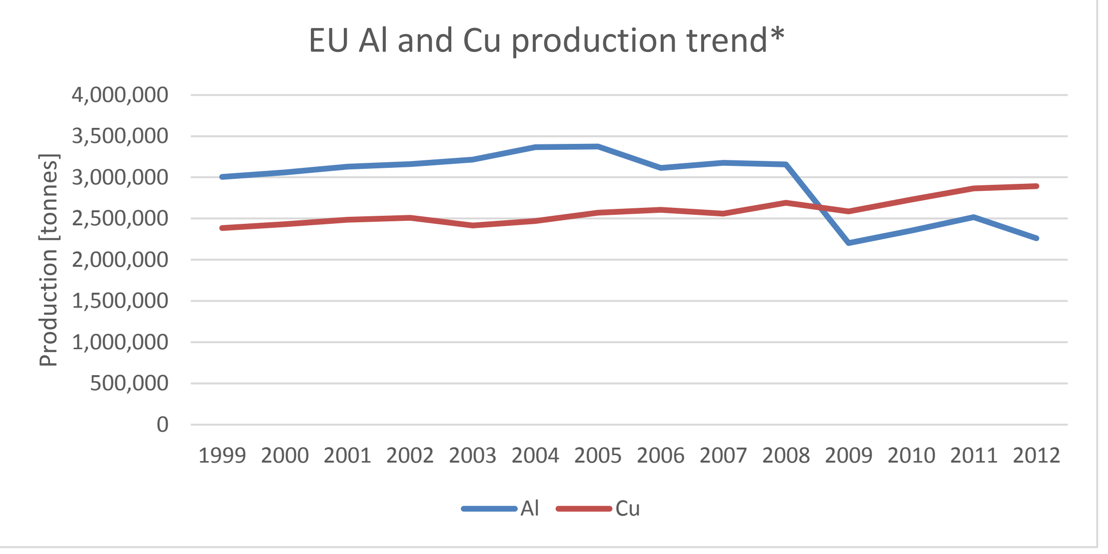
[263] An average total electricity consumption of 4.1 MWh per tonne of zinc is used as the reference case (IPPC, 2001a).

segments; particularly in higher value added (e.g. precious metals) and high quality tailor made products. Therefore this provides an important incentive for many companies to retain their production capacity and R&D activities in the EU. The EU has strong value chain integration which has contributed greatly to the strength of the sector. The most demanding consumers of NFM, in terms of quality and specialised material needs are based in the EU. As such, EU NFM producers have worked with clients (in manufacturing, aerospace and transport sectors) and developed the ability to produce tailored, high quality and technologically advanced solutions. The strong integrated value chain has also allowed scrap metals to enter the value chain during the refining and processing stages, significantly reducing energy and resource use to benefit the environment and enhance competitiveness. The EU recycling industry is one of the most advanced in the world, even compared to industries in developed countries such as the US, Canada and Japan.

On the other hand, primary metal producers in the EU will be at risk of closing down if there is not an improvement in power market conditions; since current electricity prices reduce EU producer margins to an unsustainable level. EU is also facing growing threats from extra EU countries. Although EU has high recycling rate of scrap metals, growing competition from low labour cost countries (for the sorting of scrap metal using labour intensive methods) is driving scrap handlers to export unprocessed scrap rather than sort it in the EU as this may be a more profitable route. As such, this would lead to the loss of scrap for EU producers to countries that have lower recovery rates and lower environmental and labour standards.

Figure A1.59 provides a historic EU production trend (excluding Norway) for aluminium and copper from 1999 – 2012. EU's production has been relatively flat throughout this period (apart from a dip in primary aluminium production during the recession) despite an increase of 50% in EU GDP. EU is also heavily reliant on NFM import. Environmental regulations in the EU have added pressure on the NFM industry both in terms of regulatory compliance and increased energy costs. The EU ETS in particular has a significant impact because it increases direct production costs compared to producers outside of the EU. Additionally, the industry also faces indirect CO2 costs due to increased electricity prices (as the power sector passes on its ETS costs) as well as cost burdens related to self-generation. Smelting from primary raw material in the NFM industry is extremely energy intensive. For example approximately 15 MWh are needed to produce one tonne of aluminium and 4 MWh are required for one tonne of copper. Electricity costs represent a third of total production costs for the EU primary aluminium industry, making it a key factor impacting the competitiveness of the sector. On the balance of the above factors, it is expected that the trade deficit will continue to increase as the economy grows and production as a whole will continue to stagnate with no increased production capacity due to the lack of evidence in new investment within the sector and expansion of upstream production of NFM is likely to occur outside of EU.

Figure A1.59 EU aluminium and copper production vs. EU GDP trend

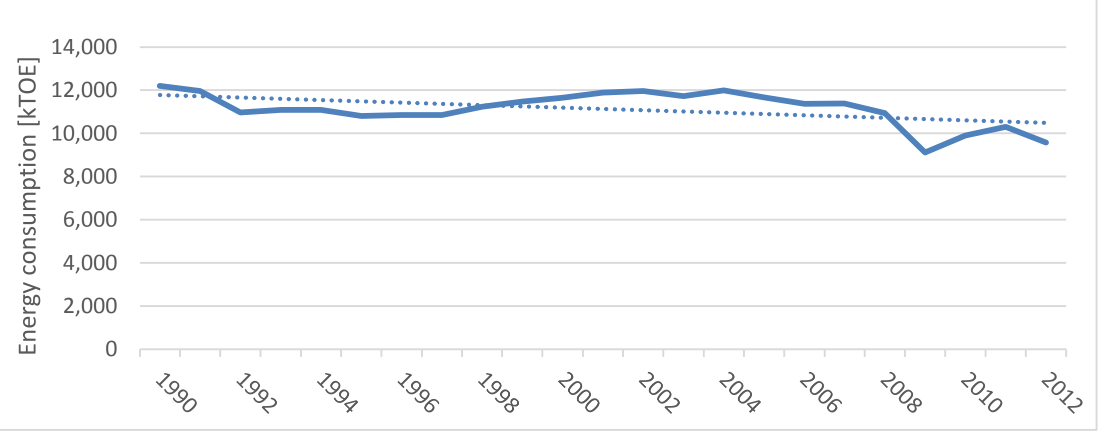


Source: ICF analysis on EU Mineral Statistics 1999 - 2012

** Note: Production figures for aluminium only includes primary aluminium. Aluminium produced from secondary sources (scrap or recycled) are excluded.*

Although the aluminium industry has reduced their CO2e emissions by 50% since 1990, this is mainly attributed to process improvements in drastic reduction of PFC emissions and closure of non-well performing smelters. Although the EU has some of the most efficient NFM production in the world, the core technology in production of NFM, aluminium and copper in particular, hasn't gone through any drastic improvement in energy intensity. However, recycling recovery rates within the EU are amongst the highest in the world. For example, the average share of re-cycled metal in Europe is 40%, whereas the global average is 30%. From 1980 – 2002, the production of secondary aluminium has increased by over 4 times (from approximately 1 mil tonnes to 4 mil tonnes p/a). As production of secondary aluminium is far less energy intensive than primary aluminium production, this is expected to improve the overall NFM sector's energy intensity trend. Figure A1.60 provides a historic trend of the energy consumption for NFM sector from 1990 – 2012.

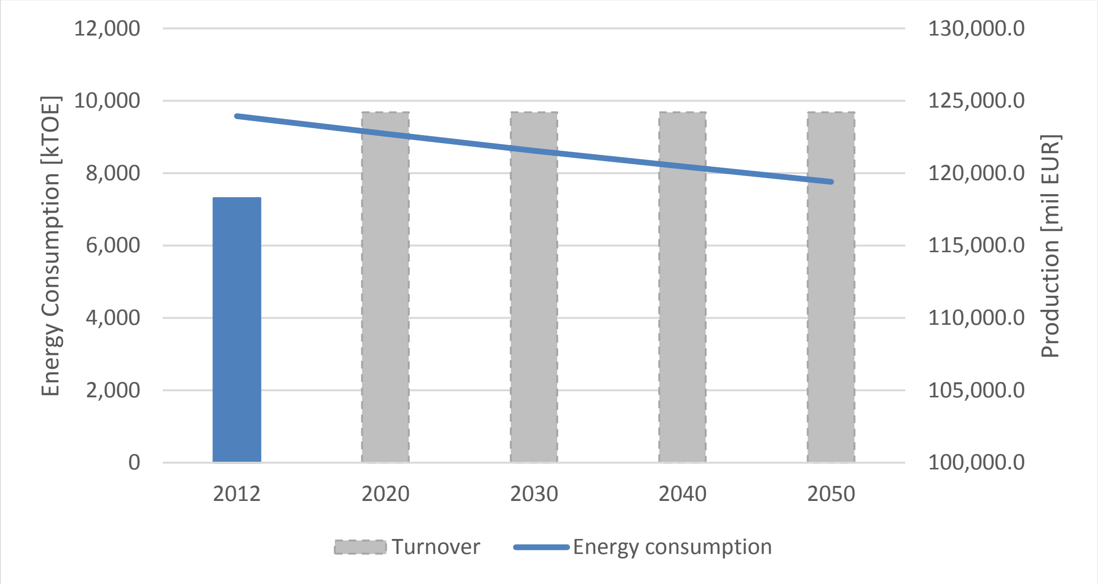
Figure A1.60 Historical trend of Energy consumption for NFM sector



Source: EUROSTAT, accessed on Dec 2014

Over this 22 year period, the energy consumption trend has been gradually reducing by an approximate rate of 0.5% p/a while production of aluminium and copper has been relatively constant over the same period.). This gradual reduction trend is expected to continue as EU continues its strong growth in production of secondary metal through improved waste management schemes in recycling and recovering useful scrap metal, resulting in a continual reduction in energy consumption as projected in Figure A1.61 (below).

Figure A1.61 Projected EU NFM sector energy consumption



A1.6 Petroleum refineries

A1.6.1 Overview of key sectoral policy measures/incentives

Table A1.41 presents the main EU policies applicable across sectors ("generic" EU policies) and Table A1.42 provides information on EU policies specific to a given sector/subsector.

Table A1.41 "Generic" EU policies and their applicability to the Petroleum Refineries sector

EED	EU-ETS[1,2]	IED[3,4]	Ecodesign Directive	Energy Labelling Directive	Energy Performance Building Directive
Yes	Yes	Yes	N/A	N/A	N/A

[1]Manufacture of petroleum refined products is on the list of sectors and sub-sectors deemed to be exposed to a significant risk of carbon leakage.

[2] Manufacture of coke oven products is on the list of sectors and sub-sectors deemed to be exposed to a significant risk of carbon leakage.

[3]Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries (2003)

[4]Reference Document on Best Available Techniques for the Production of Iron and Steel (2012) covers coke oven plants.

Table A1.42 Table : EU policies specific to Petroleum Refineries sector

Policy name	Policy description	Measure
Manufacture of refined petroleum products		
Fuel Quality Directive (Directive 2009/30/EC)	Aim: to establish new environmental requirements for gasoline and diesel	As of 2011, fuel suppliers are required to report lifecycle GHG

Policy name	Policy description	Measure
	fuel, ensuring a reduction in their air pollutant emission In force: 25 Jun 2009 Type: Regulation; Mandatory	emissions per unit of fuel supplied. They have to meet a lifecycle GHG reduction target of at least 6% by 2020 compared to a 2010 baseline.
Marine Fuels Directive (Directive 2012/33/EC)	Aim: to reduce emissions of harmful pollutants from marine fuels In force: 17 Dec 2012 Type: Regulation; Mandatory	It limits the maximum sulphur content of marine fuel.
Renewable Energy (Directive 2009/28/EC)	Aim: to promote of the use of energy from renewable sources In force: 25 Jun 2009 Type: Regulation; Mandatory	The Directive requires EU Member States to boost the share of renewable energy in their overall energy consumption to 20% by 2020, and to 10% in the transport sector. EU fuel suppliers are to contribute to the share of renewable-sourced fuels in transport fuels.
Energy Taxation Directive (Directive 2003/96/EC)	Aim: to improve the functioning of the internal market by reducing distortions in competition between mineral oils and other energy products; to encourage more efficient use of energy so as to reduce dependence on imported energy products and limit greenhouse gas emissions In force: 31 Oct 2003 Type: Regulation; Mandatory	Tax levels are set for the "traditional" energy products. A revision is being discussed.[264] Existing energy taxes would be split into two components that, taken together, would determine the overall rate at which a product is taxed. The Commission wants to promote energy efficiency and consumption of more environmentally friendly products and to avoid distortions of competition in the Single Market.
Strategic Oil Stocks Directive (Directive 2006/67/EC)	Aim: to ensure security of supply of petroleum resources to the European Union In force: 28 Aug 2006 Type: Regulation; Mandatory	It imposes an obligation on Member States to maintain minimum stocks of crude oil and/or petroleum products
REACH Regulation 1907/2006	Aim: to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances In force: 1 Jun 2007 Type: Regulation; Mandatory	It affects the activities related to chemical substances used.
Manufacture of coke oven products		
Air Quality Directive (Directive 2008/50/EC)	Aim: to define and establish objectives for ambient air quality designed to avoid, prevent or reduce harmful effects on human health and the environment as a whole In force: 11 Jun 2008 Type: Regulation; Mandatory	It sets legally binding limits for concentrations of major air pollutants

Manufacture of refined petroleum products

[264] http://ec.europa.eu/taxation_customs/taxation/excise_duties/energy_products/legislation/index_en.htm

- Europia[265] argues that cumulative impact of EU environment and energy legislation is burdensome to the European refining industry (Fuelling Europe's Future); especially now in the aftermath of economic crisis. The cost of legislation is much higher versus other regions, increasing operating costs and margins (Europia; 2012). For example, according to Britain's refining industry association the UK industry needs to invest 11.4 billion pounds between now and 2030 to comply with regulation (Reuters; 2013).
- In October 2012 the Commission announced its decision to undertake a fitness check of the refining sector, which is scheduled to end in late 2014 (DG Enterprise and Industry; 2013).

Manufacture of coke oven products (Hein M. and Kaiser M.; 2012):

- In Germany: Technical Instruction for Air Quality Control – Technische Anleitung zur Reinhaltung der Luft – the so-called TA Luft is applicable to the subsector.

In releasing Industrial Policy Communication 'A Stronger European Industry for Growth and Economic Recovery' the European Commission made it clear that the increasingly difficult competitive situation of industry in the European Union needs to be addressed. The aim is to move the industry in Europe from its current level of around 16% of GDP to as much as 20% by 2020, driven by recovery in investment levels, expansion of trade in goods in the internal market and significant increase in the number of SMEs exporting to third countries.(EC; 2012)

A1.6.2 Overview of the EU28 market

A1.6.2.1 Contribution to GDP, employment:

- There were approximately 412 enterprises in the EU-27's coke and refined petroleum products manufacturing sector in 2011. These enterprises generated EUR 2.8 billion of value added and employed 36.6 thousand persons. See Table A1.43. The coke oven products subsector contributed 14% of sectoral employment, 10% of sectoral value added, and 2% of sectoral turnover in 2011.[266]
- The EU-27's activity in the coking subsector is heavily concentrated in Poland, which accounted for more than two thirds of the EU-27's value added and close to three fifths of the workforce. (Eurostat; 2013).
  - In 2010, Germany had the largest share of EU-27 value added in the coke and refined petroleum products manufacturing sector (25.4%), followed by France (12.6%) and the United Kingdom (12.0%). **Error! Reference source not found.** resents largest and most specialised Member States in the sector.

Table A1.43 Largest and most specialised Member States in manufacture of coke and refined petroleum products; 2010

	Highest value added	(% share of EU-27 value added)	Most specialised	(% share of non-financial business economy value added((2)
Manufacture of coke and refined petroleum products	Germany	25.4	Hungary	2.9
Manufacture of coke oven products	Poland	68.4	Poland	0.2
Manufacture of refined petroleum products	Belgium	6.6	Hungary	2.9

[265] The European Petroleum Industry Association that represents the European refining and marketing industry

[266] These figures reflect the aggregated data for C19.1 and C19.2. These are much smaller from the Eurostat figures for the total C19. Refer to the Note under the Table 3 for an explanation of this discrepancy.

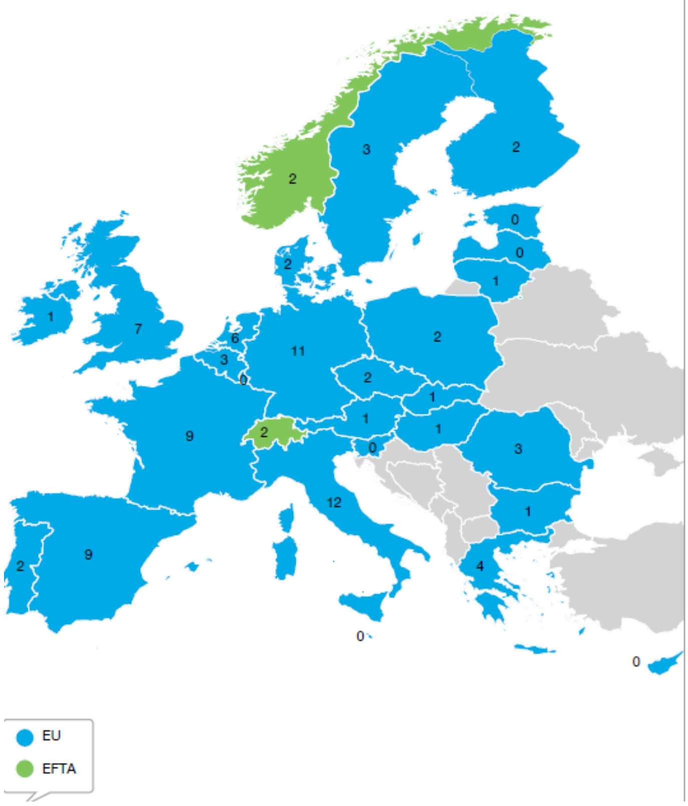
(1) The data set is incomplete with some missing combinations of Member State, activity, indicator, the information is drawn from available data;

(2) Estimates made for the purpose of this publication

Source Eurostat (online date code: sbs_na_ind_r2); 2013

- In 2010, the relative importance of the coke and refined petroleum products manufacturing sector was particularly high in Hungary (2.9 % of non-financial business economy value added, about 7.3 times the average for the EU-27). Estonia (1.1 %), Belgium (0.9 %) and Portugal (0.6 %) were also relatively specialised in this sector. As noted above, Poland dominated the coking subsector within the EU-27: it contributed 68.4 % of EU-27 value added in this subsector and 59.9 % of the workforce; as a consequence Poland was by far the most specialised Member State in this subsector. (Eurostat; 2013)
- According to Europia (2013) refineries employ in Europe around 600,000 people[267]. In 2012 there were 83 mainstream refineries in EU-27, with 703.2 million tonnes of primary refining capacity (Figure A1.62). There are no refineries in Estonia, Latvia, Luxembourg, Slovenia, Malta and Cyprus (CONCAWE; 2013)

Figure A1.62 Number of refineries and primary refining capacity in the EU



Country	Refineries
Italy	12
Germany	11
France	9
Spain	9
United Kingdom	7
Netherlands	6
Greece	4
Belgium	3
Romania	3
Sweden	3
Denmark	2
Finland	2
Norway	2
Poland	2
Switzerland	2
Czech Rep.	2
Portugal	2
Bulgaria	1
Ireland	1
Slovakia	1
Austria	1
Hungary	1
Lithuania	1
Cyprus	0
Estonia	0
Latvia	0
Luxemburg	0
Malta	0
Slovenia	0

Country	Capacity
Germany	102.3
Italy	93.5
United Kingdom	80.1
France	77.6
Spain	70.5
Netherlands	66.0
Belgium	39.2
Poland	24.7
Greece	24.0
Sweden	21.6
Norway	17.3
Portugal	16.0
Finland	13.3
Austria	10.2
Lithuania	10.0
Luxemburg	10.0
Denmark	8.8
Czech Rep.	8.3
Hungary	8.1
Switzerland	6.2
Slovakia	5.6
Bulgaria	5.0
Romania	15.0
Ireland	3.6
Cyprus	0
Estonia	0
Latvia	0
Luxemburg	0
Malta	0
Slovenia	0

Source: Concawe

Range of subsectors:

[267] Including employees in refineries, and marketing and logistics

Table A1.44 (below) presents the key economic indicators per sector and subsector within the Petroleum Refineries industry.

Table A1.44 Table : Key economic indicators per sector and subsector

Description	NACE	Number of enterprises	Number of persons employed	Turnover	Value added	Personnel costs	Investment in tangible goods	Production value
				EUR million				
Manufacture of coke and refined petroleum products	C19	412	36,641	118,891	2,822	1,305	2,564	96,743
Manufacture of coke oven products	C19.1	41	5,127	2,835	294	103	138	2,121
Manufacture of refined petroleum products	C19.2	371	31,514	116,056	2,528	1,202	2,427	94,621

Source: 2011 Eurostat Data

Note: *Eurostat provides data per Member State for indicators (e.g., annual turnover, number of persons employed) based on NACE codes of the format AXX.XX (e.g., NACE C17.12). In addition to this level of granularity, Eurostat provides aggregated values of the overarching NACE codes. This would be codes C17 and C17.1 in the case of C17.12. Due to limitations inherent to the current Eurostat database, however, these aggregated values do not always exactly match the sum of the parts. For example, the sum of C17.1 and C17.2 does not always exactly match the Eurostat-provided aggregated value for C17. In most cases, such discrepancies have been found to be minor. Therefore, the selected approach for analysis has been to use sums of the parts (i.e., sum of C17.1 and C17.2 to represent the overall code C17). This approach ensures consistency between data and intends to maximize accuracy.*

Key economic indicators for the Manufacture of coke and refined petroleum products (NACE Division C19), per Member State.

Table A1.45 Table : Key indicators, Manufacture of coke and refined petroleum products (NACE Division C19

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	22	59,830	53,610	1,103	593	168	4,060
BG - Bulgaria	12	0	0	0	0	0	0
CZ - Czech Republic	30	0	0	0	0	0	0
DK - Denmark	8	0	0	0	0	0	0
DE - Germany	0	0	0	0	0	574	0
EE - Estonia	5	247	249	128	22	143	1,483
IE - Ireland	0	0	0	0	0	0	0
EL - Greece	0	0	0	0	0	0	0
ES - Spain	0	0	0	0	0	0	0
FR - France	0	0	0	0	0	0	0
HR - Croatia	16	0	0	0	0	0	0
IT - Italy	0	0	0	0	0	0	0
CY - Cyprus	0	0	0	0	0	0	0
LV - Latvia	7	0	0	0	0	0	26
LT - Lithuania	7	0	0	0	0	0	0
LU - Luxembourg	0	0	0	0	0	0	0
HU - Hungary	11	9,316	8,707	1,214	204	107	6,450
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	36	0	0	0	0	535	5,661
AT - Austria	4	0	0	0	0	0	0
PL - Poland	146	35,745	24,562	-10	343	391	13,724
PT - Portugal	10	9,374	9,614	386	142	648	1,831
RO - Romania	40	4,380	0	0	0	0	3,406
SI - Slovenia	4	0	0	0	0	0	0
SK - Slovakia	0	0	0	0	0	0	0
FI - Finland	14	0	0	0	0	0	0
SE - Sweden	40	0	0	0	0	0	0
UK - United Kingdom	0	0	0	0	0	0	0

Source: 2011 Eurostat data

Main players:

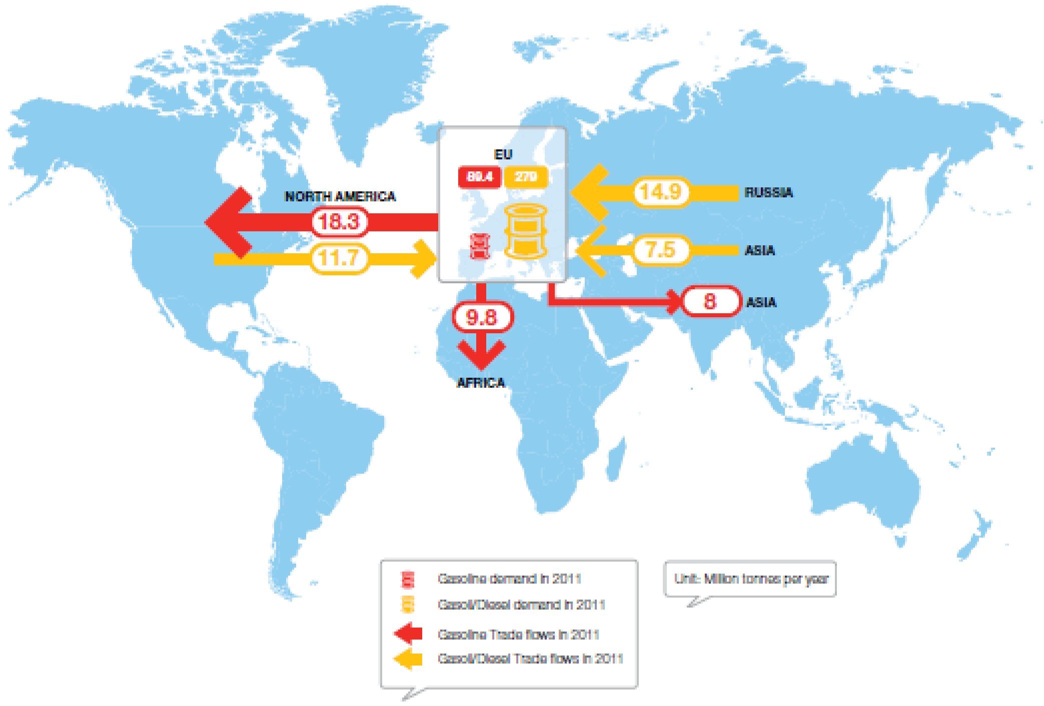
- The sector is dominated by large enterprises (83.4 % of the workforce and 91.1 % of total value added in 2010). These were the second highest shares for any of the manufacturing NACE divisions, while among all non-financial business economy NACE divisions they marked the third highest share of value added for large enterprises and the fifth highest share of employment.

Trade flows:

Manufacture of refined petroleum products (Europia; 2013):

- Gasoline is mainly exported to North America (USA is a key export market; 31% of EU gasoline was exported in 2011), followed by Africa and Asia
- Diesel is being imported mainly from Russia (47% in 2011), followed by North America, and Asia. Diesel is also exported to non-EU European countries.
- Jet fuel is increasingly imported from Middle East (49% in 2011). Relatively small amounts are exported to non-EU European countries.

Figure A1.63 Major gasoline and diesel trade flows to and from EU



Source: Europia; 2013

Manufacture of coke oven products (Jones, A.; 2013):

- Coke has been sourced from Colombia, Russia and Ukraine in last few years; minor quantities from China and Japan.

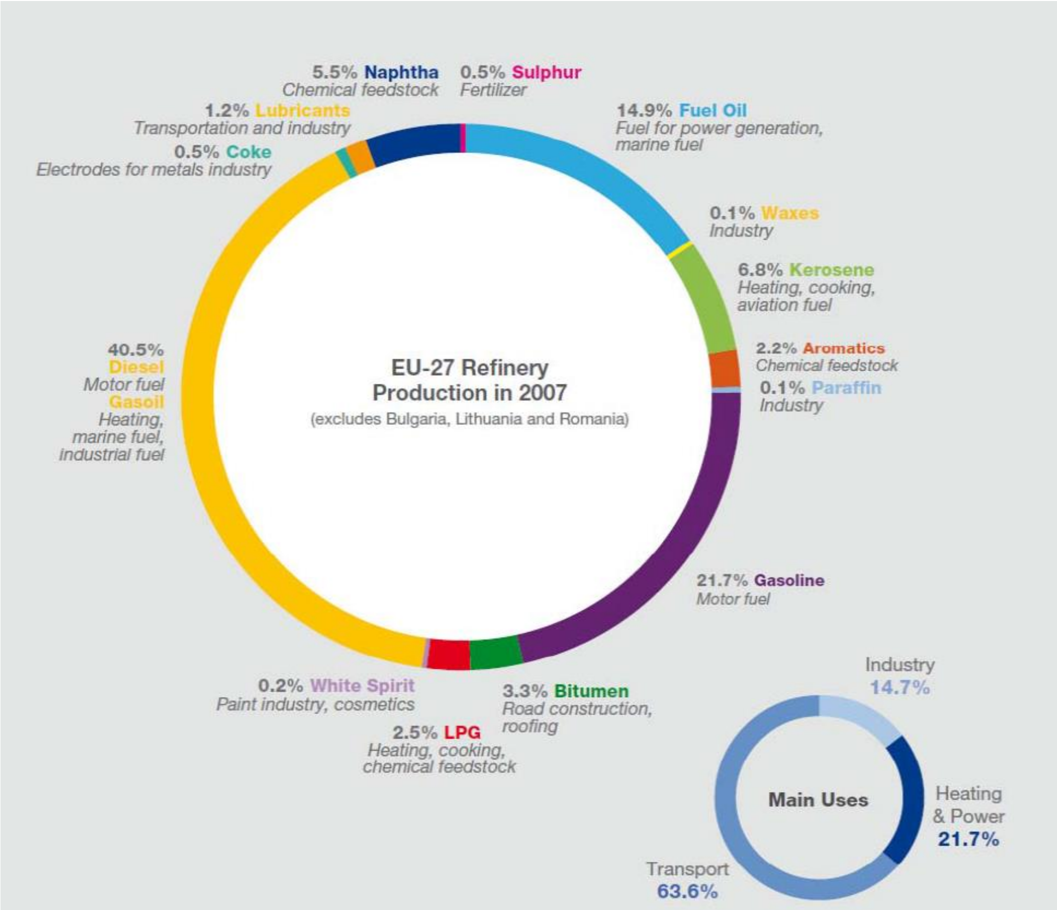
Product type and consumer groups:

Manufacture of refined petroleum products (Europia):

- Main products include: gasoline, diesel, kerosene, marine fuel. Others cover: liquefied petroleum gas (LPG); naphtha; fuel oils; lubricating oils; paraffin wax; asphalt and tar; petroleum coke; and sulphur. These products have the following applications:

- For agriculture: Agricultural diesel; Fertilisers; Fungicides and herbicides
- For Construction: Asphaltl; Asphalt membranes; Paint
- In everyday life: Fibreglass; Heating oil; Plastics; PET plastic; Polycarbonates; Raw material for detergents; Synthetic fibres
- For Medical: Pharmaceuticals; Medical devices; Bandages
- For Other energy sources: Electricity; Natural gas
- For Other industries: Lubricants; Industrial oil; Marine oil;
- For Transport: Automotive diesel; Aviation fuel; Bunker fuels; Butane; Gasoline; Propane

Figure A1.64 Refined products from EU refineries and their uses



Source: Europia; 2012

<u>Manufacture of coke oven products</u>:

- Products include coke and a number of by-products.
- Coke breeze are the fine screenings that result from the crushing of coke. “Other coke” does not meet size requirements of steel producers and thus is sold as a fuel source to non-steel producers. Coke oven gas is mainly used to heat the coke oven batteries; any surplus is used to fuel heating plants. A variety of oils are recovered from coal tar, as well as solid coal tar pitch that is used in steel and aluminium production. After distillation of crude benzene, pure benzene is recovered, one of the main components used in the

chemical industry. After purification of rude coke oven gas, there is a recovery of ammonia which subsequently ends up in ammonium sulphate, used as a fertiliser in agriculture.

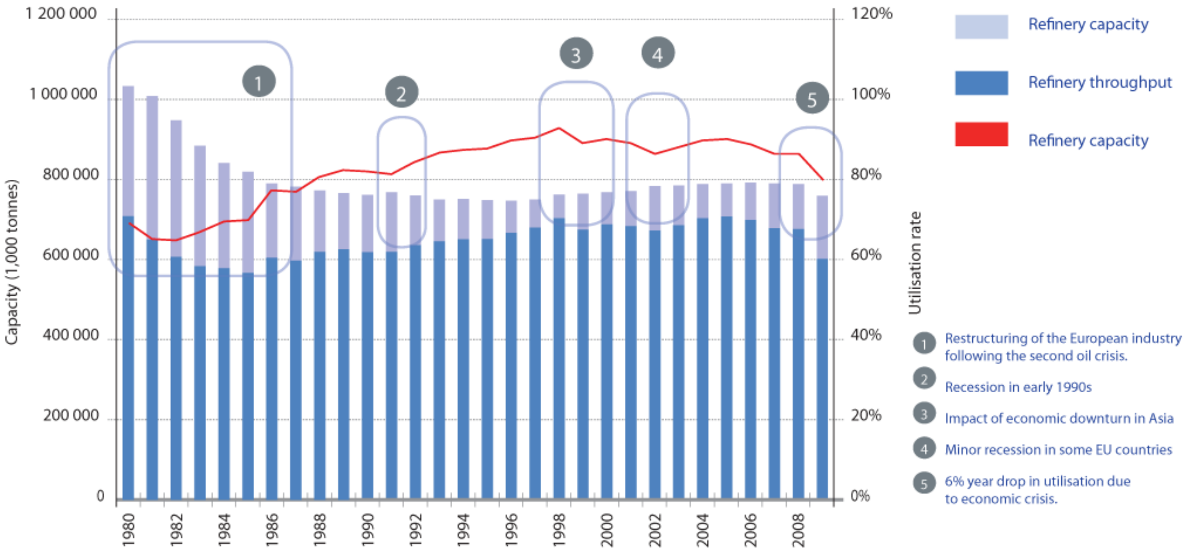
A1.6.2.2 Market developments and sector growth rates

Manufacture of refined petroleum products

Market development

- Many of Europe’s refineries were built in the 1960s and 1970s, set up to meet the region’s demand for gasoline. Yet, an increasing shift to cleaner fuels and more efficient engines in recent decades has led to a surplus of gasoline and shortage of diesel. The latter now is met by imports. While, in the past the excess of European gasoline was exported in the United States, their demand has been shrinking, following the 2008 financial crisis and trend towards more efficient cars.
- The tough conditions in the EU refining industry have been further deepened by the 2008 financial and economic crisis and its aftermath.
- In 2012, Europe’s largest independent refiner (Petroplus) bankrupted, which was read as a testimony of the continuing structural and competitive problems facing the refining sector as a consequence of numerous factors: declining demand for oil products, diesel and gasoline demand/supply imbalances, on-going legislative pressure from the EU authorities and economic difficulties in many European countries. (Europia; 2013) Figure A1.65 illustrates the impacts of external shocks on EU refining capacity over the years.

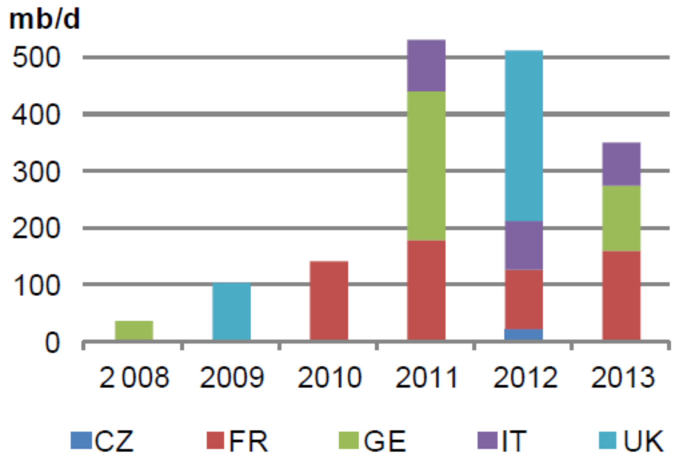
Figure A1.65 Impact of external shocks on European refining capacity



Source: Europia; 2011

- In response, a number of EU refining companies have put refinery units up for sale or halted operations, sometimes for indefinite periods of time. Yet, actual complete closures of refineries haven’t taken place, due to the large, and costly, site remediation clean-up which owners would have to incur (DG Ener; 2012).
  - By 2009, there were 98 refineries operating in the EU. Between 2009 and 2011, 13 have changed ownership: UK, France, Germany, Netherlands, Sweden and Spain and 3 more are for sale without buyers: UK and France. (Europia; 2011). IEA (2013) further reports that 15 refineries were shut down over 2008-2013 (Figure A1.66).

Figure A1.66 Refinery closures

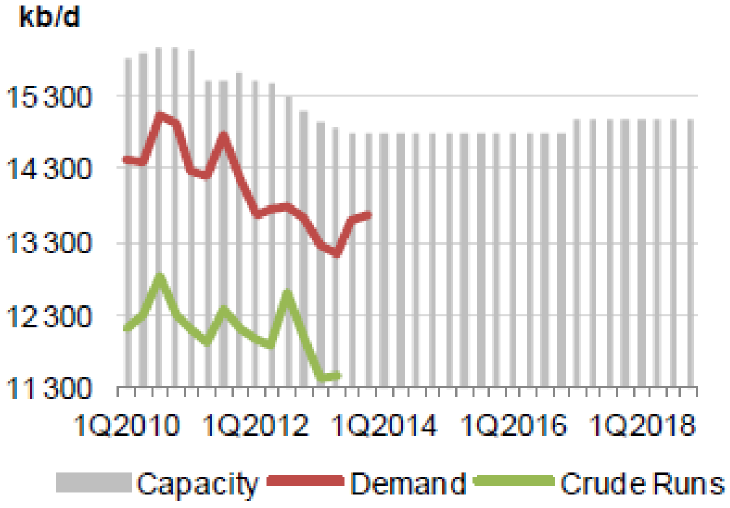


Source: IEA; 2013

- A change in "traditional" ownership is being noted: many of the sellers have been vertically integrated oil companies, whereas a number of the buyers have limited or no experience in refining. Also, since 2008 a large proportion of the EU refining capacity has been bought by non-EU companies (DG Ener; 2012). Europia (2011) reported:
  - Withdrawal of majors: BP, Shell, ConocoPhillips, Chevron, ExxonMobil and Total have sold or shutdown capacity in EU in past 5 years;
  - New ownership with different business models: ESSAR (India conglomerate); PETROCHINA (largest oil/gas producer in China); Rosneft/Lukoil (Russian oil "majors")
  - "Integrated" oil companies are detaching refining from upstream into new downstream only companies: ConocoPhillips and Marathon (similar model to Valero and Petroplus), which may induce change in resources and financial strength of industry.
  - The future of refineries that have been temporarily closed ("idled") or severely cut back in 2011-2012 due to adverse economic conditions is uncertain. Some may resume refining operations while others may be permanently closed or converted to storage terminals (CONCAWE; 2013). For example, the Hungarian MOL Group, owner of Mantua refinery in Italy, said it would convert the plant into storage.
- In 2011, 17% of global refining capacity was based in Europe (Europia; 2013). In Q1 2013, Europe refining crude runs hit an all-time low due to planned maintenance and economically-driven shutdowns (Figure A1.67)
  - Generally, there is over capacity in Europe comparing with 2012 demand. IEA (2013) reports that 2/3 of countries have over capacity compared with their local demand; while 1/3 of countries have both over capacity and a low complexity index[268] (IEA; 2013). Annex 1 illustrates European refining configuration: country position versus average in general, as well as in the case of middle distillates and light oils.

[268] The flexibility of the refining infrastructure, i.e. the ability of refineries to deal with different kinds of crude oil, is calculated using the Nelson complexity index. It is an industry standard: if a higher grade crude would be disrupted, a refinery with a high-complex index can substitute with lower-grade crude. The methodology published by Reliance Industry Limited is available for download here: http://www.ril.com/downloads/pdf/business_petroleum_refiningmktg_lc_ncf.pdf

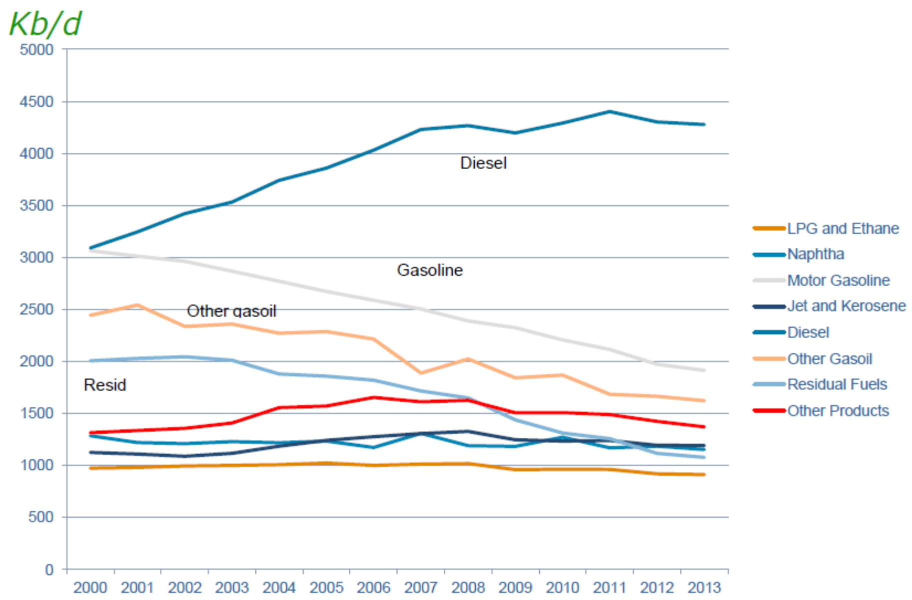
Figure A1.67 EU refining capacity



Source: IEA; 2013

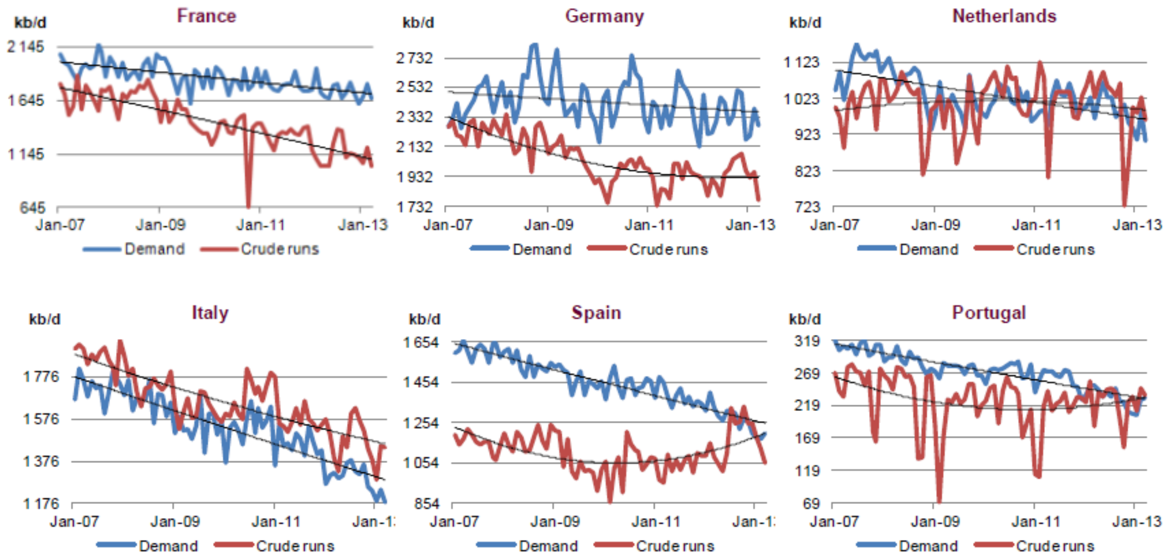
- A decline of 7% in demand for oil refined products was recorded in 2011, compared to 2009 (Europia; 2012). Some products are increasingly in shortage in Europe; which is compensated by imports, especially jet-fuel/kerosene (already representing 40% of consumption for the EU but as much as 80% in FR, 60% in the UK) (DG Ener; 2013). Figure A1.68 presents Europe oil demand by product. Figure A1.69 shows EU refining response to demand drop.

Figure A1.68 Europe oil demand by product



Source: IEA; 2013

Figure A1.69 EU refining response to demand drop (



Source: IEA; 2013

- Refiners operate between two global commodity markets: crude market and refined products market. The resultant spread between crude and petroleum product prices (which has to cover all associated costs of running a refinery and marketing business), is highly volatile and has traditionally translated in consistently low returns.
- Another difficulty that the refining industry is facing relates to increasing obstacles and costs of supplies of vacuum gas oil (feedstock for complex, cracking capacity normally produced by simpler refineries). Currently, simple refineries are closing down and exports from Russia are being reduced as the country focuses on upgrading capacity. Furthermore, it is expected that tax subsidies in Russia, supporting exports, will disappear in 2015. (DG Ener; 2013)
- The US East Coast refineries, which compete with the EU, have gained from both significantly lower energy operating costs from cheap shale gas, and from access to cheap tight oil feed stocks. This adds to the crisis of the refining industry in Europe (DG Ener; 2013)

Drivers

- Demand in transport (road, air and marine) – “traditional” as well as biofuels
- Demand for industrial fuel
- Demand from the heating sector
- Economic growth, population growth and trends in fuel substitution

Manufacture of coke oven products

Market development

- Coke production in Europe was high in 1980s, yet since 1990s it has been declining (ca. -3.3%/a). In this decade, it is expected that production will stabilise at a typical level of 42-45mtpy (Jones A.; 2013)

- Through most of the past decade, the coke demand in Europe exceeded production. Europe had a net deficit of coke of 4-7m tonnes per year in 2001-05. In 2009 and 2012 they almost equalized. Utilization of capacity in Europe was around 90% until 2007. In the past three years, it has been 80-85%.(Jones A.; 2013)
- Capacity closures were at their peak in 2009-10. There were also substantial closures in the early years of the last decade (2001-03) due to low prices and demand. In 2013, there is likely to be net decline, despite investment at HKM in Germany. No major investments in pipeline. More closures can be expected. (Jones A.; 2013)
- Since 2012, all commodity prices – coke, coal, oil and steel – have been falling, as economic growth has slowed down around the world. Off a high relative value, coking coal has declined the most among commodities indicated. Coke has declined by 10-15% compared to 2012. (Jones A.; 2013)

Drivers:

- Demand for coke is a derived demand that is largely dependent on production of steel from blast furnaces and iron castings

Energy growth rates for Petroleum Refineries[269] industry

- Manufacture of petroleum refined products contributes to almost 17% of total energy consumption by the EU-28 industry.
- In EU-28, final energy consumption by the industry has increased by 3% in 2011 compared to 2000.
- Table A1.46 presents energy consumption by the industry over 2000-2011. In 2000 the industry in ten Member States consumed more than 1,000Mtoe, with Germany and the UK being the largest energy consumers. By 2011, the industry in half of these countries recorded a decline in energy consumption compared to 2000 levels (from -7% in and the Netherlands to -28% in Romania). Petroleum refineries in four countries noted increases (from 3% in Spain to 51% in Poland). Greece energy consumption remained almost unchanged.
  - Amongst the countries with energy consumption lower than 1,000Mtoe in 2000, the majority noted an increase (Portugal, Austria, Finland, Croatia, Sweden, Lithuania, the Czech Republic, Denmark, Bulgaria, and Slovakia. The latter recorded the relatively highest increase in the EU-28 of 255%). The industry in Ireland and Hungary reduced its energy consumption (-50% and -1%, respectively); while in Cyprus and Slovenia completely disappeared.

[269] Eurostat does not compile energy consumption data for manufacturing of coke oven products

Table A1.46 Energy consumption in MToe by the petroleum refineries industry per Member State over 2000-2011

GEO/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Change in 2011/2000
Germany (until 1990 form	8,155	7,828	8,121	8,450	8,371	8,540	8,263	8,402	8,270	8,290	7,792	7,605	-7%
United Kingdom	6,328	6,503	7,176	6,790	6,683	6,933	6,287	5,816	6,154	5,602	5,880	5,750	-9%
France	5,863	5,799	5,231	5,371	5,474	4,990	4,952	5,326	6,235	6,016	5,543	5,079	-13%
Italy	5,147	5,670	5,952	5,743	6,502	6,989	6,706	7,077	6,754	6,612	7,028	6,576	28%
Spain	4,484	4,357	4,030	4,360	4,455	4,586	4,698	4,533	4,610	4,424	4,528	4,624	3%
Netherlands	3,999	4,103	4,392	4,579	4,691	4,751	5,113	3,327	3,419	3,569	3,565	3,710	-7%
Romania	1,756	1,616	1,712	1,698	1,649	1,766	1,706	1,632	1,676	1,429	1,476	1,267	-28%
Poland	1,705	1,835	1,799	1,881	1,990	1,942	2,019	2,289	2,227	2,157	2,481	2,572	51%
Belgium	1,690	1,711	1,715	1,827	1,657	1,482	1,750	1,845	2,024	1,873	2,083	1,831	8%
Greece	1,152	1,181	1,226	1,185	1,231	1,302	1,519	1,532	1,420	1,350	1,390	1,154	0%
Portugal	847	919	881	1,015	940	1,070	612	1,027	785	987	1,092	1,130	33%
Austria	817	777	881	806	890	814	891	988	985	878	832	986	21%
Finland	803	790	846	845	820	797	892	1,137	1,130	1,176	1,152	1,216	51%
Hungary	686	635	649	558	624	574	702	577	625	645	658	682	-1%
Croatia	612	552	614	644	652	618	564	630	494	575	497	625	2%
Sweden	584	505	405	628	786	750	805	732	866	922	832	772	32%
Lithuania	452	569	585	588	670	709	634	557	711	675	629	611	35%
Czech Republic	427	418	425	422	417	474	493	480	535	512	512	492	15%
Denmark	380	388	376	402	390	379	395	403	366	375	341	390	3%
Bulgaria	268	279	293	257	276	288	348	342	354	410	382	378	41%
Slovakia	149	559	598	608	665	808	770	582	505	531	500	529	255%
Ireland	120	131	143	145	143	157	149	141	142	123	114	60	-50%
Cyprus	39	24	42	42	11	0	0	0	0	0	0	0	-100%
Slovenia	20	2	3	2	0	0	0	0	0	0	0	0	-100%

Source: Eurostat, available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home)

Note: Estonia, Latvia, Luxembourg and Malta are not included, as there has been no petroleum refineries industry present (0Mtoe consumed over the period)

A1.6.3 Business environment

A1.6.3.1 Competitive strengths

What are the key competitive strengths?

Manufacture of refined petroleum products:

- Oil is not only a key energy source for transport, but is vital for other uses and sectors; petrochemicals, industrial & construction products, agriculture. To illustrate, e.g. very close link to petrochemical industry: out of 58 installed steam crackers, 41 are integrated with refineries (Europia; 2012). As a result a viable EU refining industry is essential for a safe access to oil products. (Europia; 2011)
- Competitive in energy efficiency. The most energy efficient EU refineries are the best in the world (Europia; 2011)
- In transport: liquid fuels (gasoline and diesel) are superior in their energy density compared to other energy sources. Refined products facilitate the mobility of EU citizens and goods therefore play an important role in EU growth (Europia; 2011)
- Committed to innovation: investing in R&D, refining transport and distribution; setting worldwide standards for fuels and engines with the automotive industry (Europia; 2011)
- Technology leadership in fuel product specifications (Europia; 2011)
- A major provider of highly skilled jobs and scientific and engineering expertise. Europia (2011) reported that the industry provides employment for 100.000 people in refineries and 500.000 in marketing and logistics, and 778.000 in the petrochemical sector which represents €241 billion in annual sales.
- Major contributor to MS revenues with €240 billion/year duties and taxes in 2010 collected by the EU oil refining and distribution industry (Europia; 2011)

Manufacture of coke oven products:

- Coke is a necessary component for the production of iron and steel. Majority of the worldwide steel production takes place via so-called pig iron (hot-metal route), which is produced in the blast furnace from iron ore by use of coke.
- High standards for emission control techniques to comply with strict air quality regulations (Hein M. and Kaiser M.; 2012)
- Unlike other process plants, by-product recovery batteries cannot be allowed to run cold without risking damage to their structure. Therefore, even in a market downturn - as in 2009 - production of coke continues at a rate above that required by the market. (Jones A.; 2013)

How are these advantages envisaged as changing over the next 10-15 years?

Manufacture of refined petroleum products:

- A forecast says that crude oil derived products will continue to play an important role in the EU for decades to come. Oil could still represent close to 30% of EU primary energy demand and potentially 20% by 2050, even though a drop of 11% in the demand for oil products by 2030 is predicted. Yet, oil demand in Europe could change drastically between 2030 and 2050 depending upon assumptions made (-30% to -55%). (Europia; 2011)
- In transport: oil is predicted to prevail as the main energy source for transport in 2050 even in ambitious scenarios considered (84% in 2030; 55% in 2050). Economic constraints will limit the penetration of substitutes for fossil liquid fuels (Europia; 2011)

- The use of oil in other sectors (industrial, petrochemical, agriculture, construction) is also foreseen to play a significant role. The opposite will be the case of oil for heating and electricity. (Europia; 2011)
- The EU needs to ensure that in 2050 it will still have access to the secure, cost-effective energy supplies that are essential to industry, consumers and mobility. (Europia; 2011)

Manufacture of coke oven products:

- Further extension of the current cokemaking capacities in the world will depend on the global economics and on the future behaviour of export willing countries to sell coke for reasonable prices, of China in particular. (Hein M. and Kaiser M.; 2012)
- It is assumed, if there is a need for additional coke-making capacity, the relevant plants will be built in countries with an increasing steel demand. Besides China, this will be the case for India, Southeast-Asia and South America. Another trend that will be inevitable worldwide is the replacement of older and smaller plants by modern high capacity batteries for coke-making. This will be necessary not only for economic but notably for ecological reasons. (Hein M. and Kaiser M.; 2012)

A1.6.3.2 Threats

What are the main threats which currently impact on the sector?

Manufacture of refined petroleum products:

- Fierce competition: new refineries in developing countries are bigger, newer and less affected by environmental policies; US East Coast refineries have significantly lower energy operating costs from cheap shale gas, and access to cheap tight oil feed stocks; rise of refining mega-hubs
- Legislative burden: for example EU refining sites will on average pay for 30% of their CO_2 emissions, resulting in an average 13% rise in operating costs and reduced competitiveness vs. non-EU sites (Europia; 2011)
- Fierce competition from imported products
- Depressed margins, which continue to decline:
- Closely linked to economic growth - collapsing demand, overcapacity (idled capacity 1.7 mb/d[270]); poor utilisation rate
- Diesel and gasoline demand/supply imbalances; overproduction for unleaded gases; gasoline becoming a by-product
- High energy costs (about 60% of total cash operating cost compared to 20% in the USA)[271]
- Declining demand for oil products in the European market due to penetration of alternative road fuels (-23% in 2030 compared to 2005); reduced road fuel demand (-26%); reduced inland heavy fuel oil demand (-24%); reduced heating oil demand (-21%); and reduced demand for other products (-8%). (CONCAWE; 2013)
- Declining demand in export markets in North America; Latin America; Nigeria (currently a significant outlet for Europe's gasoline and middle distillate production, is also looking to upgrade and expand its own capacity).
- High crude prices: North Sea reserves are in in decline; turmoil in North Africa and Middle East affecting the supplies

[270] IEA; 2013

[271] DG Ener; 2013

- Vanishing vacuum gas oil (VGO), an important feedstock: closures of European vacuum distillation units (VDU); flows from Former Soviet Union countries are expected to dwindle as refiners there are preparing to launch a large upgrade programme for their plants. As a result, VGO prices are expected to soar, and the availability soon enough may become problematic
- European capacity to decline further: the most significant capacity reductions are in units that boost gasoline production (8 Mt of closed FCC capacity) and distil crude (36 Mt of closed CDU capacity). The CDU and FCC capacity reductions could more than double if the nine refineries temporarily closed in 2011-2012 are not restarted.[272] The capacity reduction affects security of supply (such as middle distillates and naphta); and leads to the loss of jobs by the employees of those refineries.
- Import dependence on the rise; reduced flexibility to deal with short-term market swings or supply disruptions; increased storage requirements
- Aging and unsophisticated plants; low investment; difficulty in accessing funds

Manufacture of coke oven products:

- Closely linked with iron and steel production; impacted by a declining trend of demand
- Chinese export and their impact on coke prices: China is by far the largest producer of coke (almost 70% in 2012). At the end of 2012, the 40% export tax was cancelled, opening up the possibility of more exports. (Jones, A.; 2013)
- Production does not meet the demand; no capacity addition investment is the pipeline, imports to close the gap
- Lack of investment; access to funding becoming an issue.

How are these envisaged as changing over the next 10-15 years?

Manufacture of refined petroleum products:

- There is a need to determine an optimal investment framework, which will encourage industry to invest in Europe to improve its competitiveness rather than to invest exclusively to remain in business (Europia; 2013). The tax incentivized dieselisation trend which has contributed to a fundamental change in the EU demand structure. Diesel consumption in road fuel demand has significantly surpassed gasoline consumption and the trend does not look to be reversed (Figure A1.70). Fitness check on refining laws is currently ongoing (Reuters; 2013).

[272] CONCAWE; 2013

Figure A1.70 Diesel and gasoline consumption in the EU road fuel demand

Source: Europia; 2013

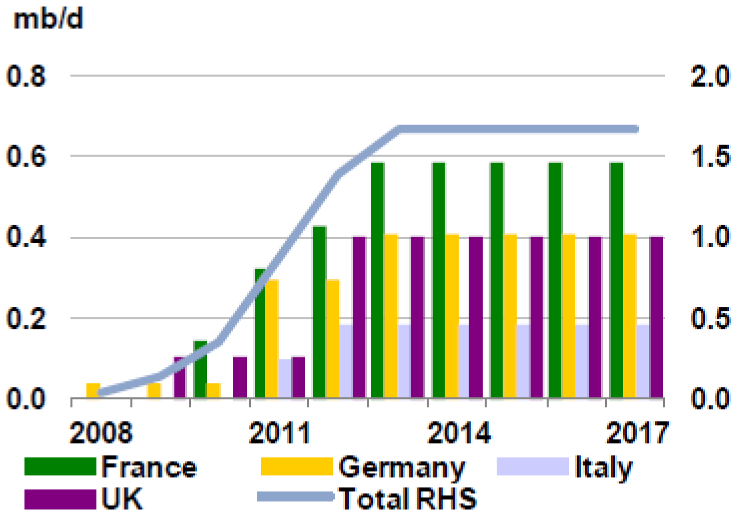
- There is a significant need to invest; as Europe's refineries were mostly built between the 1950s and 1970s and geared to producing as much gasoline as possible. To change the gasoline/diesel output mix, hydro-cracking technology would be required but its cost is estimated to be around 1 billion pounds per refinery; which is not economically justified considering the condition of European refineries. (The News; 2013).
  - $30 billion in investments in EU refining have been announced for 2009-2015 to increase capacities of EU refinery units that boost distillate production and reduce residue production. These additions are a major contribution to meeting future requirements; but they will not meet the additional equipment for Coking and Residue Desulphurisation units needs for marine fuel sulphur reduction in 2020. (CONCAWE; 2013).
  - The cumulative refining investment required from 2008 to 2020 is estimated at $51 billion 2011, excluding the costs incurred by refiners to achieve compliance with revised pollutant emission limit values under the terms of the Industrial Emissions Directive (IED). The majority of this capital expenditure is required to address the challenges imposed by the production of marine fuel to the new IMO sulphur specifications in 2015 and 2020.(CONCAWE; 2013)
  - Part of the cumulative refining investment of $51 billion in 2020 is likely to be under-utilised by 2030 as a result of declining demand. The prospect of under-utilisation of added capacity is likely to have a negative influence on investment decisions prior to 2020, with the potential outcome that total cumulative investment in 2020 could fall short of $51 billion. (CONCAWE; 2013)
  - Refiners could have difficulty justifying this additional expenditure in a post-2015 environment marked by declining demand, uncertainties regarding the implementation of on-board scrubbers and risks of future under-utilisation of capacity. If these additional capital expenditures do not materialise then the 2020 market

demand would need to be satisfied by substantial increases in diesel imports and a further reduction in refinery utilisation rates. (CONCAWE; 2013)

 – The EU's import dependence on certain products such as gasoil/diesel will increase, unless the industry is able to invest in further conversion capacity, to produce more middle distillates; Such investments are also necessary to decrease the high gasoline yield of the EU refining industry, which would reduce the EU refining industry's 'export dependence' in that fuel; (DG Ener; 2012) Such investments can only be justified if they are supported by positive long term demand prospects for middle distillates. The positive factors for refined middle distillate demand over the 2005-2030 period are aviation fuel (an increase of 28% or 16 Mt) and distillate marine fuel (an increase of 280% or 20 Mt). (CONCAWE; 2013)

- Refining margins would improve with further reductions in EU capacity; which would make easier access to financing, in particular for non-integrated oil companies. In that case, those refineries would most likely carry out the investments which would increase their output of more valuable products such as middle distillates. Although with reductions of capacity, there will be some initial loss of supply of those products, in time the increased conversion capacity should contribute to lessening or, at least, preventing, significant deterioration in the EU's security of supply position with regard to the imports of petroleum products. (DG Ener; 2012)
 – Additional 1.5 mb/d net shutdowns by 2017 (**Error! Reference source not found.**)

Figure A1.71 Cumulative European refinery shutdowns



Source: IEA; 2013

- Projections for future EU petroleum demand imply further falls, except growth in middle distillates. Yet, it will continue to be positive only for a few more years (even taking into account future demand from the shipping industry for very low sulphur fuel). This is in contrast to non-EU markets, where the demand for products such as diesel, gasoil and naphtha is projected to grow significantly (DG Ener; 2012)
- Export markets in Asia will come under pressure from refining capacity coming on stream in the Middle East. By 2020, there will be, among others, the Gargantuan 615,000bbl/day, Al Zour refinery in Kuwait, and the 415,000bbl/day Al Jubail refinery in Saudi Arabia. The North American and Latin American markets are projected to also

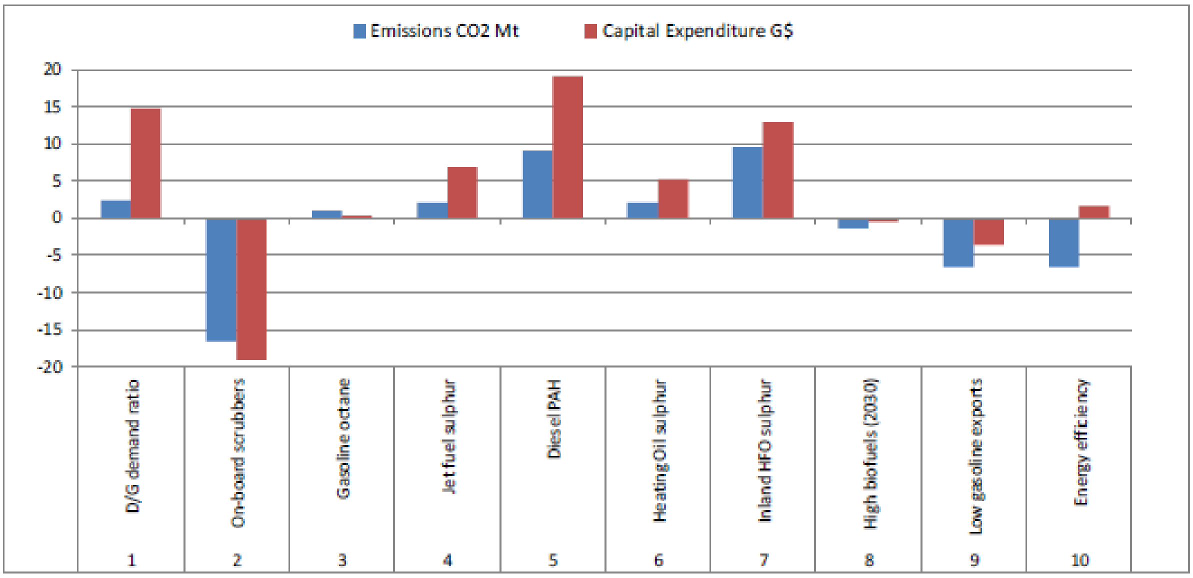
significantly reduce their imports. As such, finding new outlets for gasoline exports is deemed a difficult challenge.

A1.6.3.3 Business strategy and decision making

Manufacture of refined petroleum products:

- The bankruptcy of Petroplus in January 2012 prompted the EU-wide discussion on the situation and the need for a coordinated approach to the issue of restructuring of EU refining. Several initiatives have been established: EU Refining Roundtable (May 2012); Conference Future of EU Refining: safeguarding competitiveness (November 2012); EU Refining Forum (first meeting in April 2013).[273]
- The industry's roadmap (Europia; 2011) proposes six policy recommendations:
  - The EU should focus on achieving the goals of the Climate and Energy Package for 2020; yet no binding targets beyond should be set due to too much uncertainty;
  - The impact of global competition must be recognised in all policies and assessed beforehand and then measured throughout their life;
  - The limits of EU-only action and the interdependence of the EU with the rest of the world must be recognised;
  - EU policy should not pick technology winners or pathways;
  - The EU-wide, national and regional impact of all measures should be carefully assessed
  - The EU should act as one with a competitive, open internal market.
- Total CO_2 emissions from EU refining are expected to grow by 8% over the 2008-2020 period to reach a peak of 163Mt in 2020, in spite of the overall decrease in total refinery energy consumption. With the decline in refining throughput beyond 2020, total refining CO_2 emissions will fall by 6% from the 2020 peak to 154 Mt in 2030.(CONCAWE; 2013)
- CONCAWE (2013) describes sensitivity cases, which explore potential alternative scenarios for product demand and quality around the 2020 base scenario (Figure A1.72).

Figure A1.72 Changes in EU27+2 refinery emissions and refinery capital expenditure in each sensitivity case relative to the 2008 base case



[273] Details can be found at: http://ec.europa.eu/energy/observatory/oil/refining_processing_en.htm

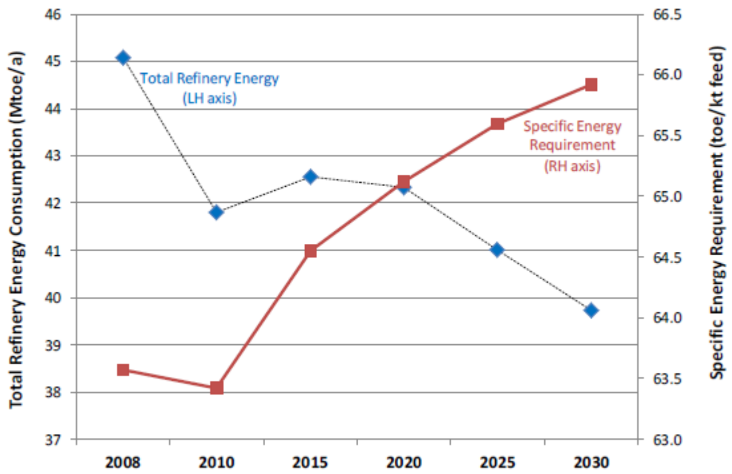
Source: CONCAWE; 2013

A1.6.3.4 Mitigation activities

Manufacture of refined petroleum products:

- The average efficiency of electricity generation in EU refineries is substantially higher than the EU average efficiency of electricity production from conventional thermal plants (Europia; 2012).
- There is a trend towards severe under-utilisation of key refinery units such as Crude Distillation units (CDU), Reforming (REF) and Fluid Catalytic Cracking (FCC) units. On the other hand, there are substantial increases in production of conversion units such as Distillate Hydrocracking (DHC), Coking (COK), Residue Desulphurisation (RES HDS) and Hydrogen production units (H2U), far exceeding their current capacity. It would require a major adaptation of EU refineries to completely accommodate these throughput trends, by investing in additional DHC, COK, RES HDS and H2U unit capacity while at the same time closing unused CDU, REF and FCC unit capacity. (CONCAWE; 2013)
- The total energy requirement of EU refineries is forecasted to decrease from 45Mtoe/a in 2008 to 39Mtoe/a in 2030. However, the specific energy requirement increases slightly from 6.3% of total feed in 2008 to 6.6% in 2030, as more energy-intensive processing is required to satisfy the increasing demand for lighter and lower sulphur products. These trends assume a constant level of refinery energy efficiency (0).

Figure A1.73 Evolution of total energy requirement (Mtoe/a) and specific energy requirement (toe/kt feed) in EU refineries (no energy efficiency improvement))

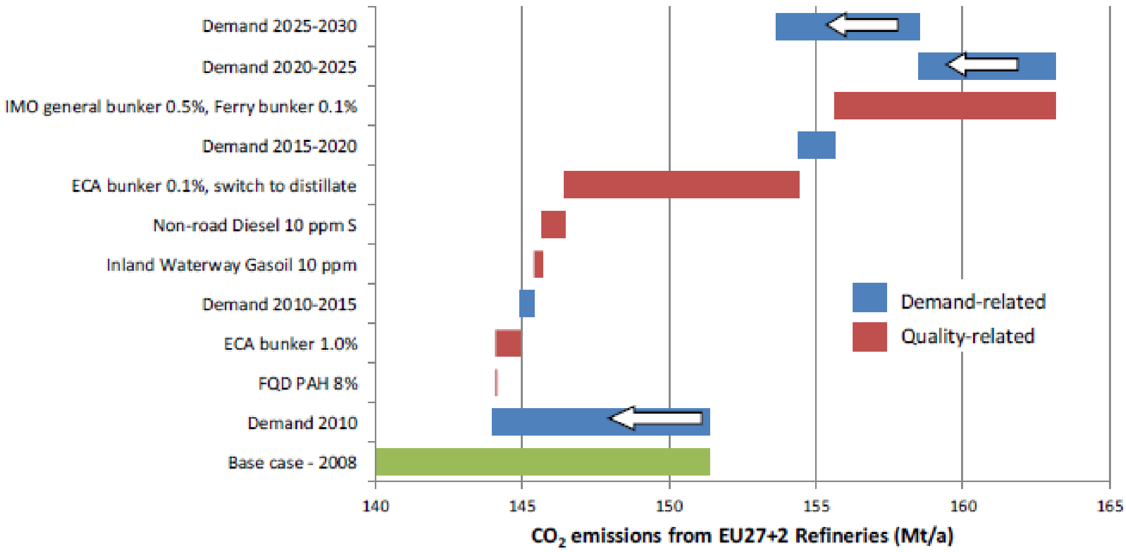


Source: CONCAWE; 2013

- Total EU refining CO_2 emissions fell by about 6 Mt from 2008 to 2010, tracking the steep decrease in demand and refinery throughput and the consequent decrease in energy consumption. The demand-related decrease in emissions was 7Mt, mitigated by a 1Mt increase due to the introduction of the 1.0% specification for Emission Control Area marine bunker. (CONCAWE; 2013)
- Total CO_2 emissions from EU refining are expected to grow from 151Mt in 2008 to 163 Mt in 2020, in spite of the overall decrease in total refinery energy consumption in the 2008-2020 period. This increase of 12Mt is the net result of a 19Mt increase in emissions related to hydrogen manufacture and a 7Mt decrease in emissions related to energy consumption in all other refinery units. With the decline in refining throughput beyond 2020, total refining CO_2 emissions will fall by about 9Mt from the 2020 peak, ending at 154Mt in 2030. (CONCAWE; 2013)

- Refinery CO_2 emissions per tonne of throughput will increase in line with the increasing middle distillate to gasoline (MD/G) and middle distillate to residue (MD/R) production ratios, mainly due to the switch from residual to distillate marine fuel. This is a result of the high incremental input of energy and hydrogen required to produce an incremental tonne of light products, particularly middle distillates, from residual product streams. (CONCAWE; 2013)

Figure A1.74 The chronological contributions of demand and quality changes to the evolution of EU refining CO_2 emissions

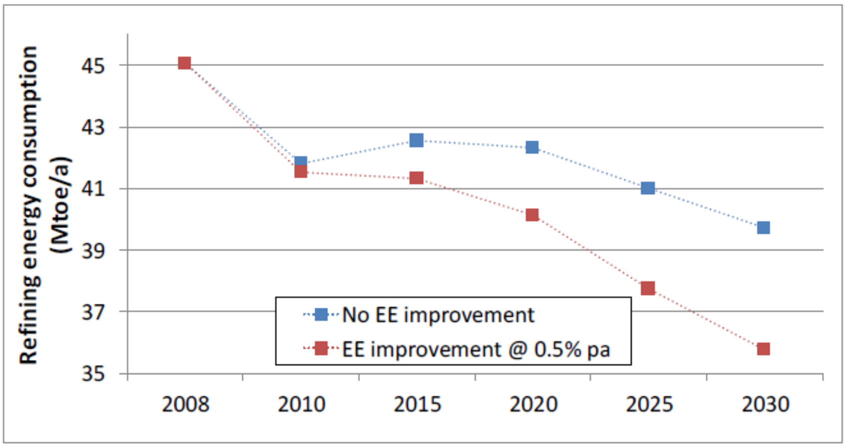


Source: CONCAWE; 2013

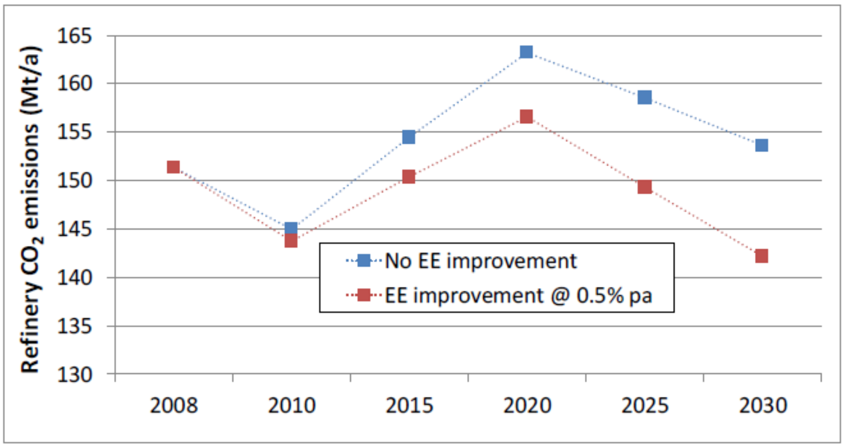
- Between 1992 and 2010, EU refiners have increased the efficiency of their operations by an estimated 10%. Part of this is the result of a sustained focus on energy saving in everyday operation as well as investments in improved heat integration or energy efficient pumps and compressors. The “low-hanging fruits” have long been picked though, and improvements in recent years have already involved complex and expensive schemes. A significant part of the efficiency improvements has been achieved by installing highly efficient combined heat and power plants (CHP) in replacement of simple steam boilers and imported electricity. Further opportunities still exist but are increasingly difficult to achieve and less cost-effective. Energy management is, however, a site-specific issue and it is difficult to take an overall view of what might be achievable. (CONCAWE; 2013)
- Assuming that historical improvement trends can continue to be achieved in the future (0.5% per year) the following Figure A1.75 shows their impact on energy consumption and CO_2 emissions.

Figure A1.75 Impact of EE improvement measures in the manufacture of petroleum refining products

Impact of energy efficiency (EE) improvement measures on EU refining energy consumption



Impact of energy efficiency (EE) improvement measures on EU refining CO_2 emissions



- In the context of legislative requirements to reduce CO_2 emissions from refining by 2020, the operations required in EU refineries to satisfy changes in demand and quality constraints will be increasingly energy-intensive and CO_2-intensive. In spite of declining throughput and potential energy efficiency improvements, total CO_2 emissions from EU refining are estimated to increase through to 2020. Declining demand will subsequently lead to a reduction in emissions to levels in 2030 that are, at best, close to those of 2010. (CONCAWE; 2013)

Manufacture of coke oven products

- Worldwide the legal demands for improvements in emission control on coking plants have been tightened in the last years. Improvements in emission control could be achieved by application of the Best Available Techniques for emission control on coking plants during the last years in Europe, and in Germany in particular. By consequent compliance with future standards, as described in the draft of the revised BREF document, further improvements in air quality in the surrounding of the plants will be achieved. (Hein M. and Kaiser M.; 2012)

A1.6.4 Sector projections

The petroleum refineries sector contributes coke and refined petroleum products, which contributed 0.02% and 0.8% to the EU's GDP in 2011, respectively.[274] Both subsectors are energy–intensive, with high capital costs and long investment cycles. The sector accounted for over 18% of total industrial energy consumption in 2011.[275]

Since the 1980s, coke production in Europe has been in decline. Although production has stabilised recently, at around 40 million tonnes/ annum, between 2012 and 2013, coke prices dropped by 10-15%[276], due to a glut of low priced Chinese coke on the market, and slowing economic growth. These declines in price and demand have fuelled EU capacity closures, which were at their peak during the economic crisis of 2009-10. Continuing declines are anticipated moving forward as the domestic market is impacted by cheap imports. Furthermore, high capital costs are providing a significant barrier for investment, with nothing planned in the pipeline.[277] As such, production is assumed to decline by nearly 60% from current levels by 2050.

In 2011, 17% of global refining capacity was based in Europe.[278] However, this reflects a midpoint during a period of contraction, as over 15% of the EUs refineries closed between 2008 and 2013. Although crude oil derived products are expected to play an important and continuing role in the EU through 2050, demand is likely to change due to an increasing shift towards diesel, and cleaner fuels, such as biofuels.[279] The majority of the 83 EU refineries are old, and built to address a predominantly gasoline-based market. Of these, approximately half are "complex" refineries, with the remainder considered "simple".[280] Since complex refineries are better positioned to handle changes in product supply and demand by shifting its product slate, "simple" refineries are susceptible to economic and market fluctuations. Gasoline surplus, diesel deficits and tightening margins will likely lead to increasing plant closures[281]. To address some of these issues will require significant investment; on the order of $51 billion through 2020.[282] As such, production is assumed to continue declining into the future at a rate of 1% per year.[283] By 2050, production is assumed to be 21% below current levels.

Overall, production of coke and refined petroleum products is assumed to decline by 23% through 2050. Table A1.47 presents the anticipated Business-as-Usual (BAU) production profile for the sector.

Table A1.47 Projected BAU production of coke and refined petroleum products in EU (million tonnes)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Production (MT)	700	700	696	685	657	625	601	580	560	540

[274] Energy, transport and environment indicators; Eurostat; 2013

[275] Ibid

[276] Ibid

[277] Ibid

[278] Europia, 2013; Annual Report 2012

[279] Europia; 2011; *2030-50 Europia contribution to EU Energy Pathways to 2050*

[280] IEA; 2013; *Recent developments in EU Refining and Product Supply*; Presentation at EU Refining Forum, 12 April 2013

[281] Between 2008 and 2013, 15% of EU refineries shut down (IEA, 2013; Recent developments in EU Refining and Product Supply; Presentation at EU Refining Forum, 12 April 2013)

[282] Concawe; 2013; *Oil refining in the EU in 2020; with perspectives to 2030*

[283] Rate of decline aligns with Concawe (2013) projections for fixed demand scenario

Source: Concawe, 2013; DG ENER, 2011[284]

Energy costs during the manufacture of refined petroleum products are estimated to account for 60% of operating costs.[285] Consequently, it is not surprising that industry has been focused on energy efficiency. Between 1992 and 2010, EU refiners have reduced energy consumption by 10%. However, these improvements reflect "low hanging fruits" opportunities. Further opportunities are present, but are assumed difficult to achieve due to not being cost-effective. Considering this, Concawe (2013) predicts total energy consumption in EU refineries to decrease from 45Mtoe/a in 2008 to 39Mtoe/a in 2030.[286] Although this reflects a 13% decline in energy requirement, energy intensity is anticipated to increase slightly from 6.3% of total feed in 2008 to 6.6% in 2030, as more energy-intensive processing is required to satisfy the increasing demand for lighter and lower sulphur products. This trend is assumed to continue through 2050. In the coking subsector, energy intensity is assumed to remain relatively stable through 2050, as limited investment is made to improve operations. Table A1.48 presents the anticipated BAU energy intensity trend through 2050.

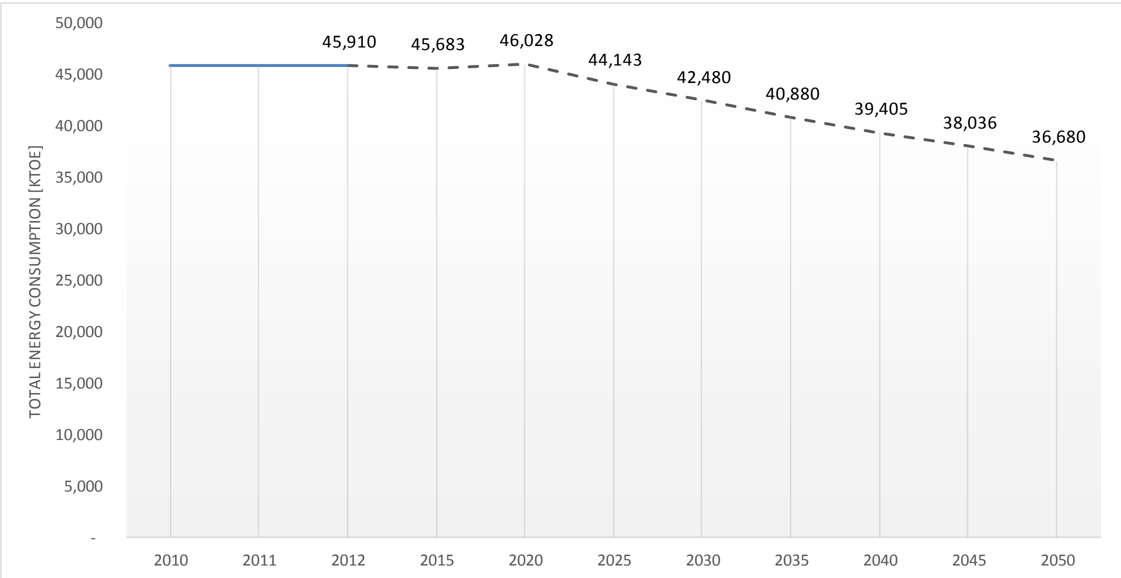
Table A1.48 Projected BAU energy intensity trends for production of coke and refined petroleum products (Million tonnes oil equivalent per million metric tonne)

	2011	2012	2015	2020	2025	2030	2035	2040	2045	2050
Energy intensity (Mtoe/ Mtonne)	0.066	0.066*	0.066	0.067	0.067	0.068	0.068	0.068	0.068	0.068

Source: CONCAWE, 2013

Figure A1.76 illustrates the projected energy consumption trend for the petroleum refineries sector for EU28 over the period 2012 to 2050, based on a Business-as-Usual (BAU) scenario.

Figure A1.76 Projected BAU energy consumption trend for production of coke and refined petroleum products



[284] DG Ener, 2011; *The Market for Solid Fuels in the European Union in 2010 and the Outlook for 2011*

[285] DG Ener; 2013; *Summary and conclusions of the first meeting of the EU Refining Forum held on the 12th of April 2013*

[286] Concawe; 2013; *Oil refining in the EU in 2020; with perspectives to 2030*

A1.7 Food and Beverage

A1.7.1 Overview of key sectoral policy measures/incentives

Table A1.49 presents the main EU policies applicable across sectors ("generic" EU policies) and Table A1.50 provides information on EU policies specific to a given sector/subsector.

Table A1.49 "Generic" EU policies and their applicability to Food, Drink and Tobacco sector

EED[1]	EU-ETS[2]	IED[3]	Ecodesign Directive[4]	Energy Labelling Directive	Energy Performance Building Directive
Yes	Yes	Yes	Indirectly	N/A	N/A

[1]Member States have to declare energy consumption by industry (including FBT) in their reports on progress towards their national energy efficiency target (Article 24(4)).

[2] The sector is subject to the EU ETS, as some of its activities are on the list of activities liable to carbon leakage in Commission Decision 2010/2/EU.

[3] The IED is applicable to slaughterhouses; treatment and processing of animal and vegetable raw materials intended for the production of food or feed; treatment and processing of pigs (Annex 1, Article 6).

[4] The sector activities are not regulated by the ED; however, machinery used in such activities may fall under the scope of the ED (e.g., refrigeration equipment).

Table A1.50 EU policies specific to Food, Drink and Tobacco sector

Policy name	Policy description	Measure
Food and Drink		
General Food Law Regulation (178/2002/EC)	Aim: Set out the general principles of food law, and provides the legal basis for the creation of the European Food Safety Authority (EFSA). In force: 2002 Type: Regulation; Mandatory	Defines requirements on 'safe food', responsibilities, traceability, labelling and packaging.
Feed and food controls regulation (EU 882/2004)	Aim: Sets out the approach that competent authorities of member states must adopt for official controls for feed and food law (and animal health and animal welfare) In force: 2004 Type: Regulation; Mandatory	The regulation defines official controls of food and feed so as to integrate controls at all stages of production and in all sectors. The Regulation defines the European Union's duties as regards the organisation of these controls, as well as the rules which must be respected by the national authorities responsible for carrying out the official controls.
Food labelling (EU 1169/2011)	Aim: Provision of food information to consumers changes existing legislation on food labelling In force: December 2014 Type: Regulation; Mandatory	Mandatory nutrition information on processed foods; mandatory origin labelling of unprocessed meat from pigs, sheep, goats and poultry; highlighting allergens e.g. peanuts or milk in the list of ingredients; better legibility i.e. minimum size of text; and requirements on information on allergens also cover non pre-packed foods including those sold in restaurants and cafés.

Policy name	Policy description	Measure
Hygiene of food regulation (HACCP) (852/2004;853/2004)	Aim: Food at all stages of the production process. Hygiene procedures on e.g. microbiological criteria for food, analysing and sampling. Put in place procedures based on HACCP methodology In force: December 2004 Type: Regulation; Mandatory	General hygiene procedures for food at all stages of the production process, from primary production to sale to the EU consumer (so-called "from farm to fork approach"). Defines specific requirements for food businesses dealing with food of animal origin. Honey and fishery products are the only products of animal origin that fall under the product groups
Tobacco		
Tobacco Products Directive (2001/37/EC)	Aim: Define laws, regulations concerning the maximum tar, nicotine and carbon monoxide yields of cigarettes and the warnings regarding health and other information to appear on unit packets of tobacco products, together with certain measures concerning the ingredients and the descriptions of tobacco products, taking as a basis a high level of health protection In force: 5 June 2001 Type: Regulation; Mandatory	It applies to the manufacture, presentation and sale of tobacco products – cigarettes, roll-your-own tobacco, pipe tobacco, cigars, cigarillos as well as various forms of smokeless tobacco such as oral tobacco (snuff), chewing tobacco and nasal snuff

A1.7.2 Overview of the EU28 market

Contribution to GDP, employment:

Food

- In 2011, the manufacture of food products contributed 4 million jobs and 161 billion Euro of value added to the overall EU-28 economy (see Table A1.51), which is equivalent to 1.3% of EU-28 GDP in 2011[287];
- Key economic indicators for the food industry in Member States are shown in Table A1.51. Grey-shaded cells indicate a lack of data for a particular parameter. France, Germany, Italy, United Kingdom and Spain together account for more than 68% of turnover in the EU-28 food industry, and this pattern is also true for most sub sectors.

[287] As calculated using values from Eurostat.

Table A1.51 Key indicators, manufacture of food products (NACE 10) in 2011

	No. enterprises	Turnover (€M)	Production value (€M)	Value added (€M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	7,482	38,151	35,882	5,449	3,357	1,239	85,614
BG - Bulgaria	4,816	3,868	3,447	635	317	208	84,651
CZ - Czech Republic	7,099	11,747	9,876	2,013	1,185	378	100,130
DK - Denmark	1,499	15,369	12,953			344	43,485
DE - Germany	30,184	160,298	147,113	29,600	20,662	3,942	817,024
EE - Estonia	382	1,192	1,080	208	136	64	12,430
IE - Ireland	641	22,800	19,867	5,967	1,387	338	35,260
EL - Greece							
ES - Spain	23,163	85,752	80,626	15,992	8,978	2,712	318,104
FR - France	56,447	143,800	132,275	27,801	19,974	4,316	560,247
HR - Croatia	2,783	4,518	3,735	982	606	183	56,347
IT - Italy	55,203	106,497	101,950	18,703	10,615	3,248	396,557
CY - Cyprus	742	1,242	1,124	291	209	46	11,001
LV - Latvia	731	1,180	1,144	224	145	60	23,077
LT - Lithuania	1,203	3,215	3,074	527	287	134	38,447
LU - Luxembourg	134	319	295	147	119	29	3,647
HU - Hungary	4,412	9,050	7,893	1,471	833	350	88,397
MT - Malta							
NL - Netherlands	4,288	58,184	51,963	8,795	4,905	1,175	118,253
AT - Austria	3,472	14,445	13,106	3,516	2,256	497	68,563
PL - Poland	13,219	42,369	38,689	7,522	3,646	1,630	387,500
PT - Portugal	9,582	11,791	10,584	2,041	1,329	526	94,763
RO - Romania	7,508	8,388	7,527	1,513	793	640	165,633
SI - Slovenia	1,162	1,728	1,465	356	236	80	13,852
SK - Slovakia	2,646	3,622	2,906	703	373	163	36,817
FI - Finland	1,671	5,189	4,842	1,145	830	166	22,834
SE - Sweden	3,410	14,887	13,072	3,148	2,349	457	56,217
UK - United Kingdom	6,459	84,497	78,356	22,027	10,867	2,247	364,018
EU-28	**250,338**	**854,099**	**784,840**	**160,776**	**96,392**	**25,171**	**4,002,868**

Source: Eurostat, 2011 (available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home)

Beverages

In 2011, the manufacture of beverages contributed around 373,000 jobs and 30 billion Euro of value added to the overall EU-28 economy (see Table 4 below), which is equivalent to 0.23% of EU-28 GDP in 2011[288];

[288] As calculated using values from Eurostat.

Key economic indicators for the beverage industry in Member States are shown in Table A1.52. France, Germany, Italy, United Kingdom and Spain together account for more than 70% of turnover in the EU-28 drink sector.

Table A1.52 Table : Key indicators, manufacture of beverages (NACE 11) in 2011

	No. enterprises	Turnover (€M)	Production value (€M)	Value added (€M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	329	4,811	4,527	1,358	662	284	10,454
BG - Bulgaria	776	812	775	192	81	63	14,655
CZ - Czech Republic	1,263	2,499	2,494	765	282	177	15,106
DK - Denmark	112	1,541	1,453	:	:	65	3,586
DE - Germany	2,019	20,118	19,366	4,867	3,255	1,037	70,492
EE - Estonia	29	225	187	57	24	10	1,341
IE - Ireland	30	3,128	2,869	950	309	123	3,605
EL - Greece	:	:	:	:	:	:	:
ES - Spain	4,557	15,796	15,393	4,558	1,989	677	47,800
FR - France	2,959	25,126	22,633	5,721	2,498	906	44,128
HR - Croatia	485	844	790	281	135	42	8,303
IT - Italy	2,871	18,908	18,784	4,007	1,567	631	35,878
CY - Cyprus	76	236	207	76	56	13	1,689
LV - Latvia	59	282	264	35	29	8	2,363
LT - Lithuania	94	440	427	88	43	23	3,504
LU - Luxembourg	28	168	156	54	22	22	480
HU - Hungary	2,334	1,955	1,675	379	175	100	13,716
MT - Malta	:	:	:	:	:	:	:
NL - Netherlands	189	4,743	4,428	1,299	424	98	6,791
AT - Austria	365	4,873	4,731	1,250	469	149	8,978
PL - Poland	489	7,282	6,967	1,492	448	217	27,048
PT - Portugal	1,144	2,926	2,715	668	320	187	14,275
RO - Romania	651	2,088	2,044	492	195	177	22,309
SI - Slovenia	115	305	277	87	43	17	1,715
SK - Slovakia	441	717	646	173	79	29	5,527
FI - Finland	80	1,290	1,220	397	191	49	3,746
SE - Sweden	174	1,839	1,792	578	289	112	5,557
UK - United Kingdom	1,033	21,278	:	:	2,121	:	:
EU-28	**22,702**	**144,230**	**116,820**	**29,823**	**15,706**	**5,215**	**373,046**

Source: Eurostat (available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home)

- For a combined food and beverage sector, the EU-wide trade association FoodDrinkEurope gives these values (FoodDrinkEurope; 2012a):
  - Number of enterprises: 287,000 (as opposed to 273,000 calculated from Eurostat);
  - Employment: 4.25 million (as opposed to 4.38 million);
  - Value added: 1.9% of all EU-28 gross value added; 12.9% of EU-28 gross value added from manufacturing.

Tobacco

- In 2011, the manufacture of tobacco products contributes around 373,000 jobs and 30 billion Euro of value added to the overall EU-28 economy (see Table A1.53 below), which is equivalent to 0.23% of EU-28 GDP[289];
- Key economic indicators for the food industry in Member States are shown in Table A1.53.

Table A1.53 Key indicators, manufacture of tobacco products (NACE 12) in 2011

	No. enterprises	Turnover (€M)	Production value (€M)	Value added (€M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	28	610	615	158	68	24	1,524
BG - Bulgaria	21	630	611	63	42	25	3,696
CZ - Czech Republic	5	:	:	:	:	:	:
DK - Denmark	16	447	491	:	:	15	377
DE - Germany	32	17,886	15,000	1,472	746	212	10,576
EE - Estonia	0	0	0	0	0	0	0
IE - Ireland	:	:	:	:	:	:	:
EL - Greece	:	:	:	:	:	:	:
ES - Spain	47	969	994	326	175	23	2,826
FR - France	:	:	:	:	:	:	:
HR - Croatia	7	:	:	:	:	:	:
IT - Italy	3	110	110	53	22	2	444
CY - Cyprus	:	:	:	:	:	:	:
LV - Latvia	2	:	:	:	:	:	30
LT - Lithuania	1	:	:	:	:	:	:
LU - Luxembourg	1	:	:	:	:	:	:
HU - Hungary	5	135	138	24	8	5	658
MT - Malta	:	:	:	:	:	:	:
NL - Netherlands	18	3,278	3,245	516	210	70	3,046
AT - Austria	1	:	:	:	:	:	:
PL - Poland	23	2,896	2,538	793	118	154	5,284
PT - Portugal	4	161	125	57	32	9	631
RO - Romania	9	546	:	:	:	:	1,458

[289] As calculated using values from Eurostat.

	No. enterprises	Turnover (€M)	Production value (€M)	Value added (€M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
SI - Slovenia	0	0	0	0	0	0	0
SK - Slovakia	:	:	:	:	:	:	:
FI - Finland	1	:	:	:	:	:	:
SE - Sweden	17	:	:	:	:	:	:
UK - United Kingdom	10	12,004	:	:	152	:	:
EU-28	**251**	**39,670**	**23,865**	**3,462**	**1,572**	**540**	**30,552**

Source: Eurostat (available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home)

Range of subsectors

Table A1.54 (below) presents the key economic indicators per sector and subsector within the Food, Beverage and Tobacco sector for the EU-28 in 2011.

Table A1.54 Table : Key economic indicators per NACE Group for the food, beverages and tobacco sector in 2011

NACE Code	Indicators						
	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
C10 - Manufacture of food products	250,338	854,099	784,840	160,776	96,392	25,171	4,002,868
C10.1 - Processing and preserving of meat and production of meat products	38,199	201,173	190,481	28,859	20,457	4,249	929,291
C10.2 - Processing and preserving of fish, crustaceans and molluscs	3,486	23,295	21,426	3,557	2,265	568	108,352
C10.3 - Processing and preserving of fruit and vegetables	9,579	61,313	57,675	12,761	6,983	2,371	248,957
C10.4 - Manufacture of vegetable and animal oils and fats	6,673	43,685	37,747	3,437	1,690	934	52,143
C10.5 - Manufacture of dairy products	11,857	133,967	121,604	17,907	10,745	3,568	343,550
C10.6 - Manufacture of grain mill products, starches and starch products	5,926	45,955	42,631	7,091	3,496	1,160	95,952
C10.7 - Manufacture of bakery and farinaceous products	146,441	109,475	103,395	38,376	26,818	5,779	1,518,961
C10.8 - Manufacture of other food products	23,131	161,941	147,113	39,804	19,549	5,119	582,691
C10.9 - Manufacture of prepared animal feeds	5,046	73,294	62,769	8,984	4,389	1,421	122,971
C11 - Manufacture of beverages	22,702	144,230	116,820	29,823	15,706	5,215	373,046

C12 - Manufacture of tobacco products	251	39,670	23,865	3,462	1,572	540	30,550

Source: Eurostat (available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home)

Main players

Food

- There were >245,000 small and medium-sized enterprises (SMEs, employing fewer than 250 persons) within the EU-27's food products manufacturing sector in 2010;
- Together these SMEs employed 2.6 million persons (equivalent to 64.1% of the total number of persons employed in the manufacture of food products) and contributed 52.1% of sectoral value added (Eurostat; 2013b);
- Regardless of the NACE sub-sector, the number of SMEs was around 98 – 99% of the total number of companies (FoodDrinkEurope; 2012a).
- However large companies, with more than 250 employees, account for more than 50% of total production in the food and drink industry while only accounting for less than 5% of companies in the industry (Vilnius, 2008)
- Bakery (C10.7), dairy (C10.5), and meat products (C10.1) are the largest subsectors, accounting for 52% of annual turnover, and 70% of employment.
- Larger companies are found to a greater extent in the North and West of Europe. The number of food and drink processing entities in the New Member States is thus proportionally much higher than in the EU-15.

Beverages

- There were 22,700 SMEs within the EU-27's food products manufacturing sector in 2010, representing just under 99% of the total number of companies;
- Together these SMEs employed 430 thousand persons (equivalent to 52.9 % of the total number of persons employed in the manufacture of food products) and contributed 34.0% of sectoral value added (Eurostat; 2013c).

Tobacco

- The manufacture of tobacco products is dominated by a few very large international companies;
- Large enterprises employed 85.8 % of the tobacco products manufacturing sector's workforce and generated 93.9 % of total value added in 2010; these were the highest shares for any of the manufacturing NACE divisions (Eurostat; 2013d)

Industry associations

Table A1.55 lists the EU-wide and national industry associations related to food and beverage processing.

Table A1.55 Food and Beverage Sector Associations in the EU

Location	Name of Association
European Union	Food Drink Europe (http://www.fooddrinkeurope.eu/)
Austria	Fachverband der Nahrungs- und Genussmittelindustrie (www.dielebensmittel.at)
Belgium	Fédération de l'Industrie Alimentaire/Federatie Voedingsindustrie (www.fevia.be)
Bulgaria	Bulgarian Association of Food and Drinks Industry (mentioned online but no website)
Croatia	Hrvatska Udruga Poslodavaca (www.hup.hr)
Czech Republic	Potravinářská komora České republiky (www.foodnet.cz)

Location	Name of Association
Cyprus	No infromation
Denmark	DI-Fødevarer (www.foedevarer.di.dk)
Estonia	Eesti Toiduainetööstuse Liit (www.toiduliit.ee)
Finland	Elintarviketeollisuusliitto (www.etl.fi)
France	Association Nationale des Industries Alimentaires (http://www.ania.net/)
Germany	undesvereinigung der Deutsche Ernaehrungsindustrie (http://www.bve-online.de/)
Greece	SEVT (www.sevt.gr)
Hungary	Élelmiszer-feldolgozók Országos Szövetsége (www.efosz.hu)
Ireland	Food and Drink Industry Ireland (www.fdii.ie)
Italy	Federazione Italiana dell'Industria Alimentare (www.federalimentare.it)
Latvia	Latvian Federation of Food Enterprises (http://www.lpuf.lv/)
Lithuania	Association of Lithuanian Food Manufacturers (http://www.litfood-fair.com/lithuanian_food/)
Luxembourg	Féderation des Industries Agro-Alimentaires Luxembourgeoises (www.fedil.lu)
Malta	No information
Netherlands	Federatie Nederlandse Levensmiddelen Industrie (www.fnli.nl)
Poland	Polska Federacja Producentów Żywności Związek Pracodawców (www.pfpz.pl)
Portugal	Federaçâo das Indústrias Portuguesas Agro-Alimentares (www.fipa.pt)
Romania	Federația Patronală din Industria Alimentară (www.romalimenta.ro)
Slovenia	Gospodarska zbornica Slovenije (www.gzs.si)
Slovakia	Potravinárska Komora Slovenska (www.pks.sk) & Slovenská Poľnohospodárska a Potravinárska Komora (www.sppk.sk)
Spain	Federación Española de Industrias de la Alimentación y Bebidas (www.fiab.es)
Sweden	Livsmedelsföretagen (www.li.se)
United Kingdom	FDF - Food and Drink Federation (www.fdf.org.uk)

Trade flows

Food and Beverages

In 2011, the EU had a trade deficit in manufactured food products of €4.69 billion with the rest of the world (€54.6 billion of exports and €59.3 billion of imports);

By contrast, also in 2011, the EU had a trade surplus in beverages of €17.6 billion with the rest of the world (€22.3 billion of exports and €4.7 billion imports);

In the ten-year period 2002–2011, the combined trade balance in food products and beverages narrowed from €5 billion in 2002 to zero in 2008 and has widened since to €13 billion in 2011, and the EU's market share of global exports has declined from 20.5% to 16.5%.

Table A1.56 gives a breakdown by first-level NACE code of EU imports and exports of food products and beverages (FoodDrinkEurope; 2012a).

Table A1.56 2011 trade figures by NACE Code for Food & Beverages

NACE Code	Exports from EU-28 in 2011 (in €M)	Imports into EU-28 in 2011 (in €M)
C10 - Manufacture of food products	54,643	59,333
C10.1 - Processing and preserving of meat and production of meat products	10,379	7,110
C10.2 - Processing and preserving of fish, crustaceans and molluscs	2,970	15,649
C10.3 - Processing and preserving of fruit and vegetables	4,363	7,565
C10.4 - Manufacture of vegetable and animal oils and fats	3,665	15,544
C10.5 - Manufacture of dairy products	8,782	769
C10.6 - Manufacture of grain mill products, starches and starch products	2,613	1,550
C10.7 - Manufacture of bakery and farinaceous products	2,967	540
C10.8 - Manufacture of other food products	16,453	9,872
C10.9 - Manufacture of prepared animal feeds	2,451	734
C11 - Manufacture of beverages	22,327	4,682

Source: FoodDrinkEurope; 2012a

Table A1.57 shows the Top 10 Countries for exports and imports into the EU (FoodDrinkEurope; 2012a) and the values of those exports and imports.

Table A1.57 Top EU Trading Partners)

Exports to:	Value (€M)	Imports from:	Value (€M)
USA	12,001	Brazil	6,998
Russia	7,242	Argentina	5,378
Switzerland	4,679	USA	4,085
Japan	3,705	China	4,064
China	3,545	Switzerland	3,557
Hong Kong	2,787	Indonesia	3,140
Norway	2,711	Thailand	2,830
Canada	2,282	Turkey	2,133
Australia	1,723	Norway	1,972
Saudi Arabia	1,677	New Zealand	1,761

Source: FoodDrinkEurope; 2012a

Product types and consumers:

- Grain mill products, starches and starch products (NACE 10.6) and prepared animal feeds (NACE 10.9) are classed as "Intermediate Goods" by Commission Regulation 656/2007, meaning that they will be used to produce other goods;
- All other categories of food product (NACE 10.1 – 10.5, 10.7 & 10.8), beverage (NACE 11.0) and tobacco product (NACE 12.0) are classed as Consumption Goods by Commission Regulation 656/2007. There are four routes to the consumer: directly, or through a retailer, wholesaler, or through a catering service provider.

A1.7.2.2 Market developments and sector growth rates

<u>Market developments</u>

- Output growth across sectors (DG ENTR; 2011):
  - Average annual growth rate for the combined FBT sector is 0.5% over period 1995 - 2009
  - EU average annual production growth rate over the same period is +1.3% for food products, +1% for beverages and -3.7% for tobacco products.
  - Within food products, several subsectors were within the 25 strongest-growing manufacturing subsectors: fish (1.8%), bakery (1.4%), meat (1.3%), fats and oils (1.3%), grain mill products (1.2%), Fruit and vegetables (1.1%), other food products (1%), with dairy and animal feeds <1%.
- Sectoral competitiveness indicators (DG ENTR; 2011):
  - Annual growth in EU labour productivity per person employed over period 2000 – 2010 for the combined FBT sector was 0.3%;
  - Annual growth in EU labour productivity per hour worked over period 2000 – 2010 was 2.1% for food products, 3.0% for beverages and -0.7% for tobacco products;
  - Average annual growth in labour costs over the period 2001 – 2010 was 1.2% for food products, 0.6% for beverages and 5.7% for tobacco products.

<u>Drivers</u>

- **Economic:** The general economic outlook for Europe in the medium-term is promising. This will have a positive effect on the development of the food, beverages and tobacco sector. GDP for the euro area is forecast to grow through 2050 (European Commission, 2011). However, a number of factors are dampening the overall positive outlook, including increasing oil prices, growth in competition from emerging markets, and public health policy, which specifically aims to reduce consumption of tobacco products.

- **Population:** As global population rises so does demand for food (see Table A1.58). Europe's population is expected to peak in 2022 (European Commission, 2011) leading to increasing demand for products from Europe's food and beverage sector. However, through 2050 Europe's overall population is expected to decline by 4% (UN; 2013).

  Demographic and social changes will also have an influence on the kinds of food demanded and produced. These include increases in the number of women working, smaller families, growth in single person households and increasing aging of the European population (European Commission, 2011).

Table A1.58 shows historical trends in food consumption from 1971 to 2001 and then projects those trends forward to 2015, 2030 and 2050 (Alexandratos; 2009)

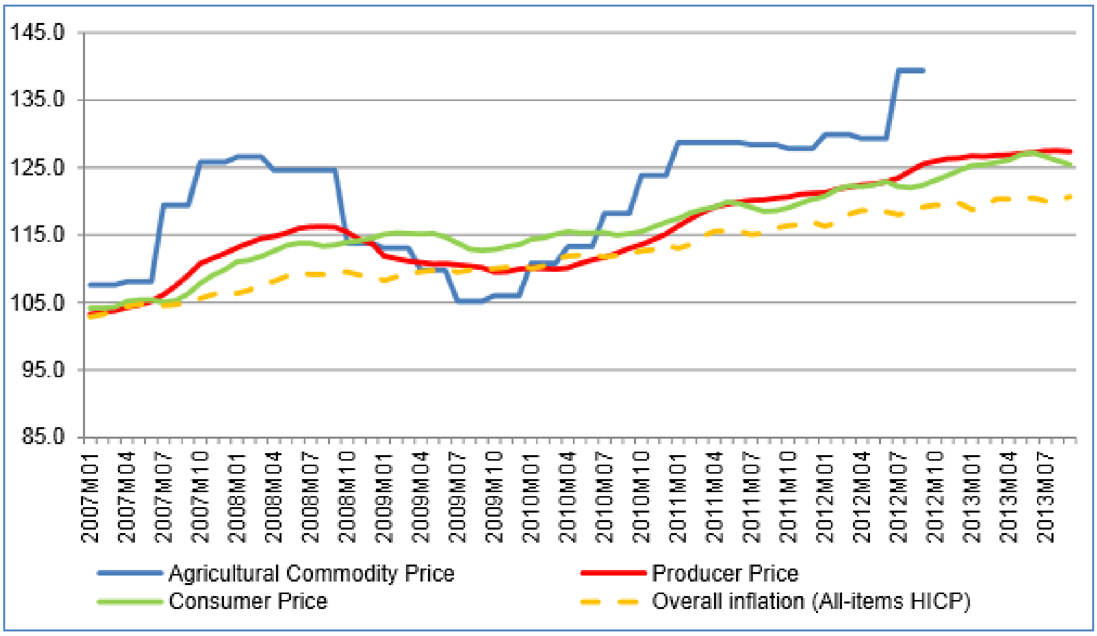
Table A1.58 Per capita food consumption (kcal per person per day)

	1999/2001	2003/2005	*2015*	*2030*	*2050*
World	**2725**	**2771**	***2884***	***2963***	***3047***
Developing countries	2579	2622	*2770*	*2864*	*2966*
Sub-Saharan Africa	2128	2167	*2319*	*2494*	*2708*
Excluding Nigeria	2016	2061	*2206*	*2406*	*2643*
Near East/ North Africa	2991	2995	*3072*	*3134*	*3197*
Latin America, Caribbean	2798	2899	*2953*	*3084*	*3151*
South Asia	2334	2344	*2532*	*2656*	*2843*
East Asia	2764	2839	*3034*	*3112*	*3144*
Excluding China	2475	2538	*2614*	*2740*	*2870*
Industrial countries	3429	3462	*3501*	*3548*	*3569*
Transition countries	2884	3045	*3043*	*3159*	*3283*

Raw materials

Increasing competition for raw materials from other sectors are having an increasing impact on the food, beverages and tobacco sector. Such competition is pushing up the price of the food industry's raw materials, which places new pressures on food companies to remain competitive and profitable (Figure A1.77).

Figure A1.77 Price developments in the food supply chain across EU27



Source: FoodDrink Europe; 2013

Retailers

Despite the presence of large food manufacturing companies, large food retailers will increasingly control the food chain with their ability to exert enormous influence over both consumers and suppliers.

- **Globalisation/Regionalisation**: Increasing international integration of markets in recent years has meant that agricultural and food products are increasingly traded across national borders. While oil prices have been rapidly rising recently, over the past 30 years, energy has been relatively cheap and has fuelled the creation of an increasingly global food chain. Relatively low oil costs made it possible to provide all-year round foods (e.g., vegetables and fruits to be flown in from Africa, etc). However, recent rising energy prices has had the effect of the food system reverting to an older model which prioritises local produce.
- **Research and development**: Investments in innovations are important to maintaining the EU food and drink industry's international competitiveness, although, until recently, spending on R&D in the food and beverage sector was minimal. Generally, only around 1% to 1.5% of the food industry's total investments are on R&D (Vilnius, 2008).
- **Technological developments**: Biotechnology, including genetics and breeding technologies, has grown rapidly in recent years and has had a great impact on the food and beverage sector. This technology has potential to produce more and better food products at lower costs, including genetically modified (GM) crops and animals; however, there are fears about the effects of the technology on animal and human health and on the environment. Although, the food industry needs to develop the competence to both harness and regulate this new technology, its role and importance will likely grow in the long term.

  Improved production and processing technologies (e.g., improved preservation techniques, which reduce losses and wastage) are increasing the ability of the sector to meet customer demands for guaranteed food safety, assured freshness and quality.
- **Consumer trends**: The factors that influence consumer demand for food and drink products are complex, but include:
  - Demographic and socio-economic change;
  - Busier lifestyles;
  - Health, nutrition and safety concerns (e.g., consumption of tobacco products).
  - Environmental and ethical concerns; and
  - Migration and demand for 'ethnic foods'.

  Generally, when the income of undernourished consumers rises, they buy more food, usually of vegetable origin; when the income of richer consumers rises, they buy more animal-based foods and processed foods (Kearney; 2010) – as well as beverages, which are not necessary for sustenance.

Energy growth rates for food, beverage and tobacco industry

- At 28.3 Mtoe of energy consumed, the food, beverage and tobacco sector accounted for 10% of total energy consumption by the EU-28 industrial sector in 2011 (Eurostat; 2013a)
- Annex 1 presents a breakdown of energy consumption by the food, beverage and tobacco industry in the EU-28 over the period 2000 – 2011.
  - Overall, energy consumption declined from 30.9 Mtoe in 2000 to 28.3 Mtoe with an intermediate peak of 32.6 Mtoe in 2002 and an intermediate trough in 27.8 Mtoe in 2009;
  - In 2000, the sector consumed more than 1.9 Mtoe in seven of the 28 countries (Poland, Netherlands, Spain, UK, Italy, Germany and France) and less than 0.8 Mtoe in the 20 other countries. (The sector is not present in Malta).

- In each of the seven “high-consumption” countries, the sector consumed between 10% and 22% less energy in 2011 than in 2000, with the exception of Germany, which consumed 9% more;
- In each of the 20 “low-consumption” countries, the industry consumed less than 0.8 Mtoe in 2000. The sector’s energy consumption in thirteen of those countries was lower in 2011 than 2000 (between -7% and 38%) and higher in seven (between 6% and 67%). The latter sub-group includes Belgium where, uniquely, the energy consumption by the sector rose out of the “less than 0.8Mtoe” bracket to over 1.2 Mtoe in 2011.

A1.7.3 Business environment

A1.7.3.1 Competitive strengths

- **What are the key competitive strengths?**

The food, beverage and tobacco industry is traditionally strong in the EU; as such, it has a dominant and open position in the world market, the impact of which is reflected in simultaneously growing exports and imports (DG ENTR; 2007). Its prominence also enables it to attract capital and labour. As the European sector is mature, it benefits from positive, long term relationships across the value chain (e.g., with agricultural sector), and fully developed and integrated processes, such as quality/ assurance systems (Vilnius; 2008).

There is significant open competition, at least in the food and beverage sector, as evidenced by the large number of SMEs. Growing demand in high value-added, niche markets such as natural foods and convenience foods to meet consumer tastes. New technologies (micro-machine processing) and consumer preferences for differentiated and healthy products enhance exploiting the economies of scope (DG ENTR; 2007).

European companies are technological advanced, and at the forefront of innovations, which will improve productivity, and ensure high standards for food safety and quality are met. This becomes increasingly important as incomes rise across the world in emerging economies, such as China, India and Central and Eastern European countries.

In the Tobacco industry, although consumption is decreasing in Europe, the primary strengths relate to its strong and well developed distribution networks, the variety of brands, growing international markets, the financial strength of EU companies, and the addictive nature of the product.

A1.7.3.2 Threats

- **What are the main threats which currently impact on the sector?**

Slowing population growth in EU is threatening domestic demand which accounts for 70% of total demand. Compounding this problem are World Trade Organisation agreements, which will likely to lead to increased exposure to international competition.

Rising energy prices are likely to reduce profit margins. Companies are constantly moving parts of the supply chain to the countries where costs are lowest and the necessary competencies are available. The general pattern is that manufacturing is in China, ICT business activities are in India, and product development is in the US or Western Europe. However, product development is increasingly moving to Asian countries because of the lack of specialised scientists in Europe.

The fragmentation of consumer segments allows a lot of food companies to operate, ranging from multinational, multiproduct manufacturers to one-product micro enterprises. However, the medium sized, small, and micro enterprises usually cannot cut costs to the same extent as large companies so they cannot compete on price. The only option for these companies is product innovation.

Increasing competition for land to grow bio fuels and other food products is resulting in increased grain-based food prices.

The policy landscape is crowded, leading to a lack of clarity on the long term detail of policy even though the direction is understood; thus, preventing companies from making effective strategic investment decisions.

Specifically, in the tobacco industry, primary weaknesses stem from the hazardous nature of the product, and the increasing social taboo of its use. Although there are pockets of increasing demand; globally, the market is declining due to growing anti-smoking sentiment, more stringent government restrictions (e.g., advertising), and higher taxes and duties.

A1.7.3.3 Business strategy and decision making

Energy and investment in low carbon technologies are low down the priority list of objectives for the sector, due to the following challenges: rising costs of agricultural raw materials and produce; increasing competitiveness; changing consumer preference, based on diet and health; price conscious customers; regulatory focus on food labelling and food quality and safety; and environmental sustainability. Also, energy spend generally forms a relatively small proportion of the overall production cost, but is rising and some of the sectors (e.g., dairy, brewers, distillers) are setting challenging targets via roadmaps. However, strength of evidence for long term decarbonisation in the food sector, in terms of potential and cost, is currently weak.

Research and development (R&D) spending is dominated by a small number of large companies (e.g. Unilever, Arla Foods, Danone and Heinz). However, expenditure in smaller businesses is higher relative to sales. Technological innovation activities amongst food manufacturers, in particular, are focused primarily on the incremental development of new product variants, involving innovation in packaging and reformulation and improvement of existing products and brands. The policy landscape is crowded; and leads to a lack of clarity on the long term detail of policy even though the direction is understood. This is considered a major barrier that prevents organisations making investment decisions

Reflecting these overarching issues, the sector association, FoodDrink Europe, has set out strategic opportunities for food and beverage companies as part of its environmental sustainability vision towards 2030 (FoodDrink Europe; 2012b), which it has grouped into seven areas. One of these is Energy but all contain opportunities to reduce carbon emissions directly or indirectly:

- Sourcing:
  - Design sustainable supply chains and ensure that ingredient crops are cultivated responsibly with particular attention to halting deforestation;
  - Mobilise public and private investment in agricultural productivity and yield growth;
  - Improve communication and transparency about certification scheme achievements at field level;
  - Providing technical assistance to farmers, especially smallholders, and advice on farming best practice;
  - Support ongoing efforts to improve collaboration, synergies and the establishment of common priorities between different biodiversity-related Conventions
- Energy:
  - Share and encourage the spread of best practice and technology transfer, especially among SMEs;
  - Enhance focus, R&D, investment and cooperation among all stakeholders;

  - Improve commercial competitiveness of alternative energy sources, such as from by-products and waste;
  - Promote energy efficiency by public authorities, and incentives for businesses that apply resource efficiency measures
- Water:
  - Further roll-out national, sector-wide and company guidance on good water management practices;
  - Call for economic incentives for water efficient eco-innovation and investment and water prices that reflect real costs in line with the EU Water Framework Directive;
  - Establish an internationally harmonised standard for assessing water impacts;
  - Fill data gaps on water availability, where water comes from, and whether good water management practices are used
- Waste:
  - Call for support for research and innovation for new uses for by-products and food waste;
  - Launch joint campaigns and a toolkit for tackling food waste along the food chain;
  - Work with supply chain partners to maximise resource efficiency;
  - Identify opportunities to centralise by-product utilisation (e.g. centralise biogas production from food and drink facility by-products in a given area)
- Packaging:
  - Roll-out R&D and innovation in lightweight materials, biodegradable materials, materials' reduction, recyclability and recoverability, as well as for bio-based materials
  - Cooperate with other stakeholders to prevent packaging waste through the promotion of re-use, recycling and recovery
  - Share best practice packaging waste management with national recycling and recovery programmes
  - Call on policymakers to improve reporting procedures in Member States and data quality
  - Ensure sufficient investment by public authorities in recycling and recovery infrastructures)
- Transport:
  - Increase cooperation with transport and logistics operators to optimise loading rates and increase back-hauling
  - Improve availability of alternative fuels and rail networks
  - Prioritise rail and water-based transport (where feasible) and optimise from a life-cycle perspective
  - Widen delivery windows to retailers to avoid peak commuting hours
  - Improve vehicle design and the use of technology for optimal route planning)
- Consumers:
  - Work with stakeholders to help avoid food waste at every stage of the value chain, particularly at the household level

  - Optimise packaging and ensure commercial viability of technological innovations that could help reduce food waste
  - Roll-out joint, multi-faceted consumer communications and campaigns to promote sustainable consumption
  - Enhance collaboration between food banks, food and drink manufacturers, logistics operators and retailers to redirect surplus food to the needy)

A1.7.3.4 Mitigation activities

- In comparison to other manufacturing sectors, where there are a small number of process routes that comprise the majority of product output and use the majority of energy, the food, beverage and tobacco sector is far more disparate in its processes and therefore its potential abatement technologies (AEA; 2010);
- Furthermore, due to energy (and water) costs being lower as a proportion of total costs, the incentives to improve energy efficiency are lower than in other manufacturing sectors (AEA; 2010);
- Almost half of the energy used in this sector is supplied by boilers. Gas fired CHP is an increasing feature. Refrigeration (e.g. for frozen foods), ohmic heating and use of motors are also among the significant emitters. Some of the key processes linked to these are baking, cooking, distilling, drying, evaporation, pasteurising, frying and chilling;
- In addition, the highly regulated nature of the products (and consumer discrimination and conservatism) lead food and beverage producing companies to be risk averse, not wanting to install new technology that has any chance of contaminating food or altering its taste, texture etc. (AEA; 2010);
- Notwithstanding these barriers, simple and straightforward opportunities for saving energy exist (Carbon Trust; 2012):
  - Refrigeration – implementing a thorough maintenance programme, checking for leaks, checking insulation, planning loads, controlling lighting, avoiding overcooling, and minimising the rate of air change
  - Process measurement and control – assessing the quality of measurements, establishing a programme of staff training and preventative maintenance, scheduling production for energy efficiency, and considering automation
  - Compressed air – Cutting down unnecessary usage and switching off whenever possible, ensuring maintenance is undertaken, reducing pressure, checking for leaks, considering erring external air feeds, and re-using waste heat;
  - Motors and drives – Switching off whenever not needed, ensuring maintenance, using the appropriate size, replacing failed motors with high-efficiency motors, installing variable-speed drives
  - Boilers and heat distribution – inspecting and maintaining boilers, matching boiler inputs to process and/or site requirements, fitting and regularly inspecting insulation, installing an isolation damper to reduce heat loss while on standby, improving quality of water used, recovering waste heat, installing automatic controls and using isolation procedures, and replacing old boilers with combined heat and power.
  - Cooking – planning so as to minimise the number of product change-overs in baking, recovering heat through condensing the steam given off in frying or steaming, maintenance and inspection of equipment, scheduling so as to fully utilise oven capacity, and improving process control
  - Distillation, drying and evaporation – checking that equipment is well insulated and maintained, investigating whether waste heat from separation equipment could be used elsewhere on the site; for distillation – checking the product yield of distillation

against energy use and considering reduced-pressure distillation; and – for drying – considering using less water in the initial product mixture

– Combined heat and power – has been implemented by some of the larger sites, but further opportunities are available.

– Fuel switching – has taken place at many sites by the use of their own processing waste (dry and wet) to convert to energy (thermally or biologically). Biogas from wet wastes has recently become a key discussion feature for deployment by linking with the wider food supply chain.

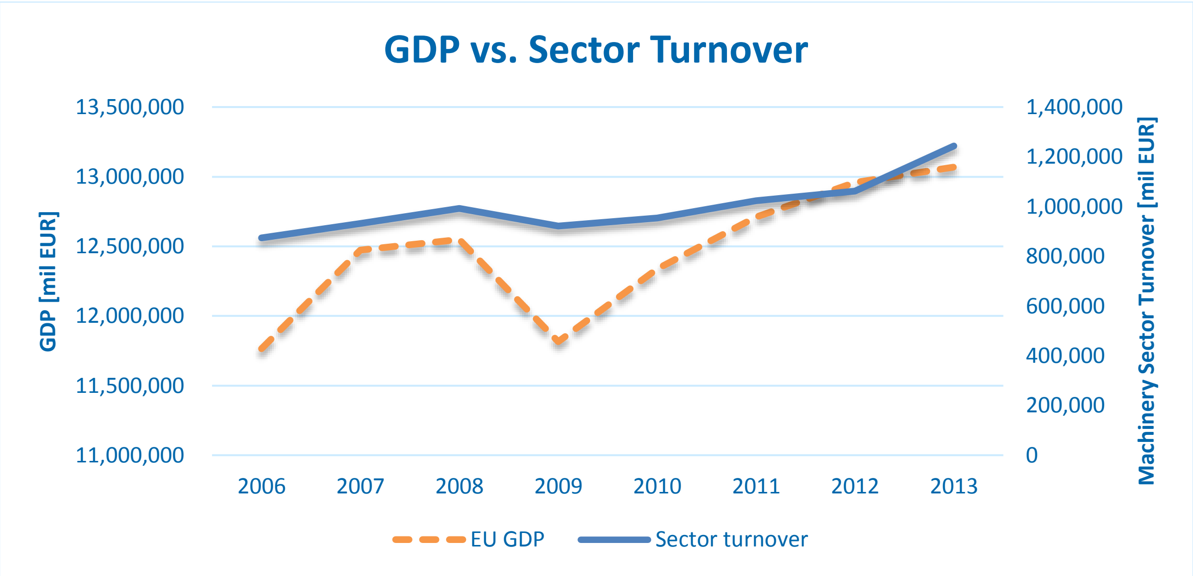
A1.7.4 Projection of energy consumption trend

The following details are an extracted summary of the sector profile in .

The food and beverage industry is traditionally strong in the EU and has a dominant position in the world market. As the EU market is mature, it benefits from positive, long term relationships across the value chain and fully developed integrated processes, from agriculture sector to production and quality assurance systems. Regulation on food and drink sector will become more stringent pressuring the sector to further innovate on their production processes. The demand in high value-added, niche markets such as natural foods and convenience foods continues its strong growth. The high fragmentation of consumer segments continues to increase a wide range of food enterprises to operate, ranging from multinational, multiproduct manufacturers to one-product micro enterprises. However, the medium, small, and micro enterprises will not be able to compete on cost to the same extent as large companies, and therefore the only option for these companies is product innovation. Growing consumer demand for locally sourced products will retain the growth of the 2 largest group (in terms of turnover), which is production of meat and dairy products. In summary, the sector will continue to grow on par with EU's long term economical trend.

Figure A1.78 provides a comparison of EU GDP trend vs. the sector's turnover for the period of 2006 – 2012. While EU's GDP fluctuates over the financial crisis period, the sector's turnover trend maintains a relatively steady growth. The sector's historical linear growth trend, limited to available statistics from 2006 to 2013, indicates a growth rate of 4.86% p/a.

Figure A1.78 EU GDP trend vs. Food sector turnover from 2006 - 2012



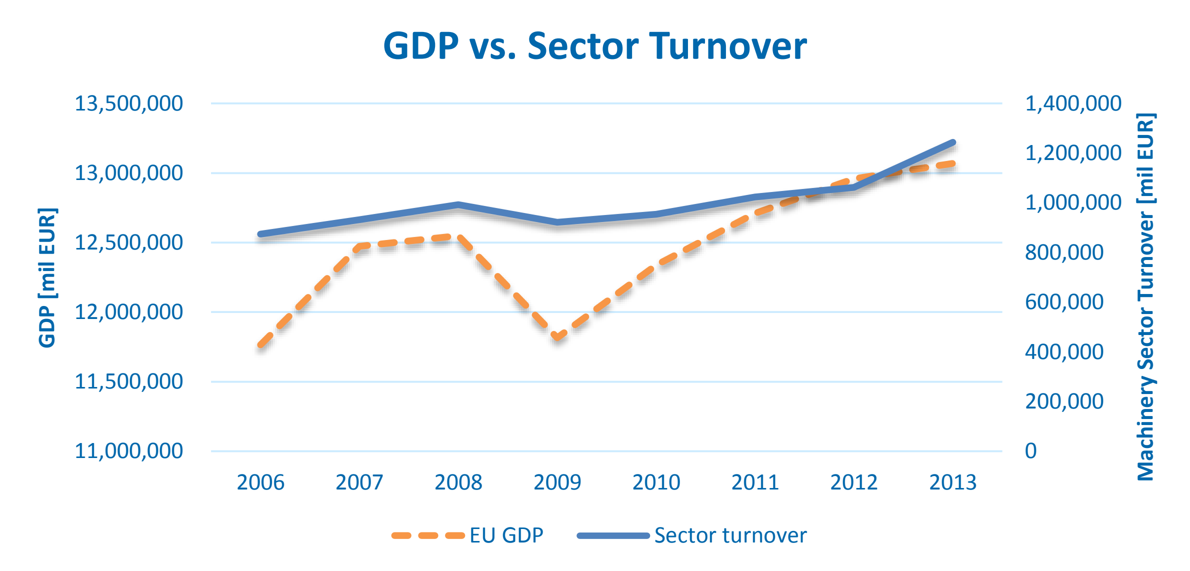
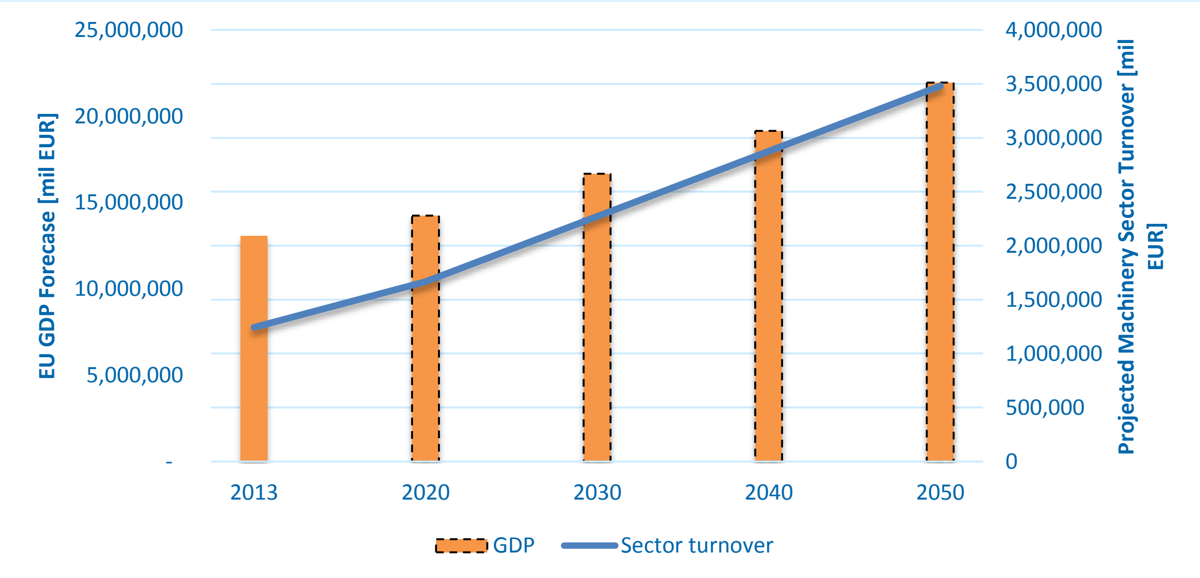


Figure A1.79 provides a projection of EU's food and drink sector turnover assuming this growth rate maintains on par with the Commission's reference scenario of EU's GDP growth of approximately 1% p/a to 2050 [EC, 2013].

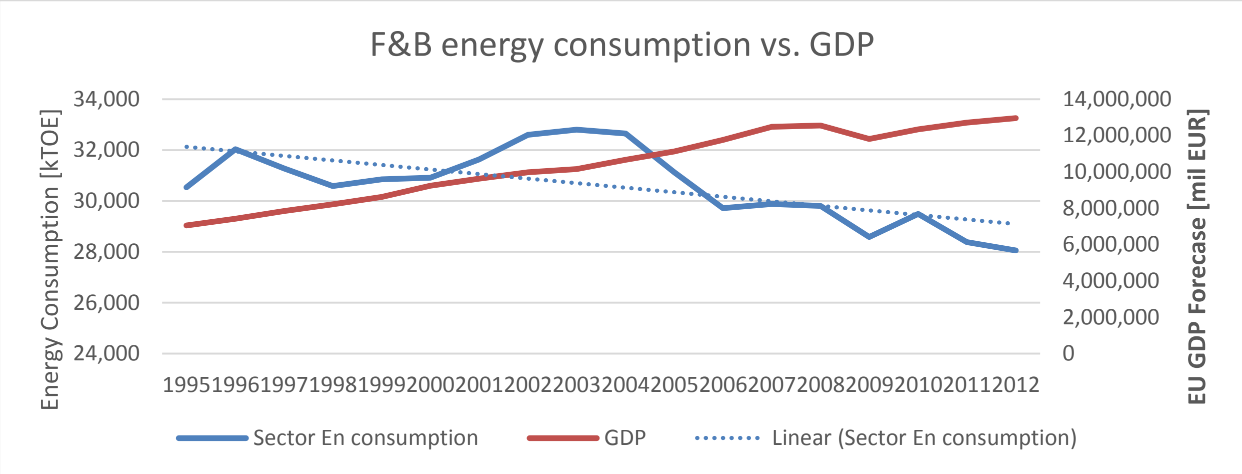
Figure A1.79 Projected EU food and drink sector turnover vs. EU GDP trend



European companies are technological advanced and at the forefront of product innovation, resulting in continuous improved productivity and high standards for food safety and quality. This becomes increasingly important as incomes rise across the world in emerging economies, such as China, India and Central and Eastern European countries. Consumer choices are shifting towards higher quality, healthier products, organic, locally sourced, fair trade and sustainably produced products, driving enterprises to further improve on its production process.

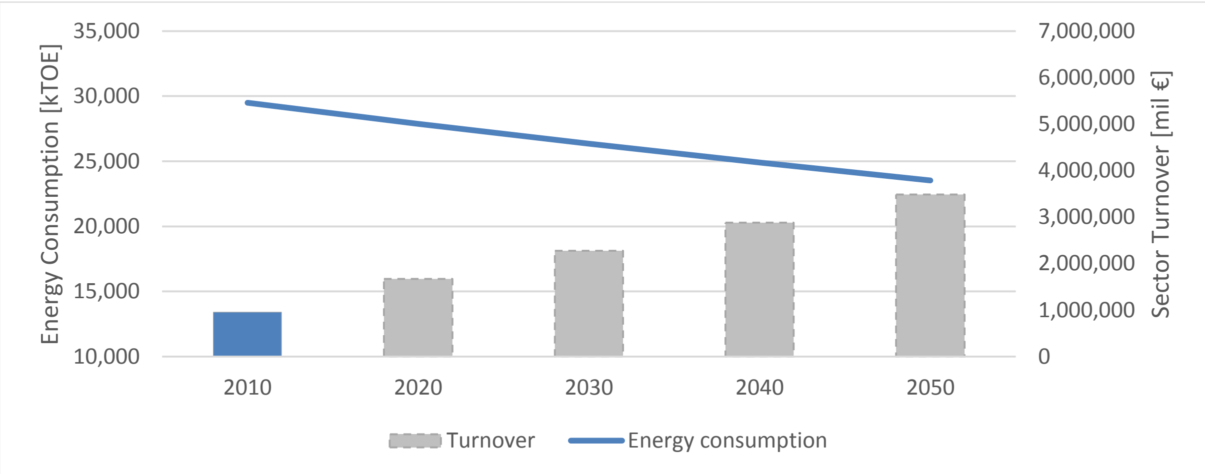
Figure A1.80 provides a historical trend for energy consumption and EU GDP for the past 17 years (1995 – 2012). The energy consumption trend fluctuates year-on-year primarily due to the production fluctuation in the wide range of product scope within the sector, in which the specific energy intensity and energy consumption is fully dependent on the product output type and the associated processes in manufacturing the finished product to the specification as dictated by the consuming market on the specific year. However, analysing the longer term linear trend line, it can be observed that energy consumption has reduced by approximately 0.6% despite an increase of 85% in EU GDP over the same 17-year period. The sector has demonstrated a good track record in reduction of energy intensity and consumption, effectively de-coupling all of these aspects from production growth. There are also very limited emerging technologies within the sector and energy intensity is primarily driven by innovation of new products and quality, which may not necessarily result in lower energy consumption.

Figure A1.80 Historical trend of Energy consumption for Food and Beverage sector vs. EU GDP



On the balance of the above factors, the energy consumption will remain volatile but it is expected that the sector will continue its strong reduction trend in energy intensity in the longer term, resulting in a constant reduction in energy consumption trend as production continues to increase as projected in Figure A1.81.

Figure A1.81 Projected BAU energy consumption trend for food and beverage sector



A1.8 Machinery

A1.8.1 Overview of key sectoral policy measures/incentives

Table A1.59 presents the main EU policies applicable across sectors (“generic” EU policies) and Table A1.60 provides information on EU policies specific to a given sector/subsector.

Table A1.59 Table "Generic" EU policies and their applicability to the Machinery industry

EED	EU-ETS[1]	IED[2]	Ecodesign Directive	Energy Labelling Directive	Energy Performance Building Directive
Yes	Yes	Yes	Relevant	Relevant	Relevant

Notes:

[1]Machinery sectors are on the list of sectors deemed at risk of carbon leakage.

[2]Orgalime, European Engineering Industries Association, is an official member of the IED "Article 13 Forum" which is a stakeholder committee.

Table A1.60 Table EU policies specific to the Machinery industry

Policy name	Policy description	Measure
Energy Infrastructure Package	Aim: to promote the completion of Europe's 'transport core network', the 'energy priority corridors' and the 'digital infrastructure' In force: 19 Oct 2011 Type: Proposal	The package includes legislative proposals that determine fundamental parameters for future smart grids in Europe, their interoperability, flexibility and capacity to handle an increasing share of energy generated from renewable energy sources and an ever more decentralised production of energy as well as access to ICT.
REACH Regulation 1907/2006	Aim: to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances In force: 1 Jun 2007 Type: Regulation; Mandatory	It affects activities using chemical substances.
Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Directive 2011/65/EU	Aim: to contribute to the protection of human health and the environment, including the environmentally sound recovery and disposal of waste EEE In force: 21 Jul 2011 Type: Mandatory	It restricts the use of six hazardous substances (lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls and polybrominated diphenylethers) in certain electrical and electronic equipment, such as TVs, laptops, washing machines, fridges and lighting equipment.
Waste electrical and electronic equipment Directive 2012/19/EU	Aim: to contribute to the protection of human health and the environment, including the environmentally sound recovery and disposal of waste EEE In force: 2012/19/EU: 13 Aug 2012 Repealed version: 13 Feb 2003 Type: Regulation Mandatory	The 2012/19/EU Directive sets collection, recycling and recovery targets for all types of electrical goods.

A1.8.2 Overview of the EU28 market

***Contribution to GDP, employment*:**

- The engineering industry's turnover value in the European Union (EU) reached some €1,840 billion in 2012. The number employed stood about 10.3 million people. (Orgalime; 2013). Below a more detailed view on the Machinery industry sectors is provided.

Fabricated metals and metalworking industry

- Almost 379 thousand enterprises in 2011 were operating in the EU-28 (in 2010 it was the largest population of enterprises among any of the manufacturing (Section C) NACE divisions). They employed about 3.6 million persons, generated €155 billion of value.
  - In 2010, the sector was the second largest EU-27 manufacturing NACE division in employment terms, after food products manufacturing, and had the third highest level of value added, after the manufacture of machinery and equipment and food products manufacturing. (Eurostat; 2013a)
- The manufacture of structural metal products (Group 25.1) and the treatment and coating of metals and machining (Group 25.6) subsectors were the largest subsectors in the EU-28's fabricated metal products manufacturing sector in 2011: together these two subsectors accounted for almost 70% of sectoral employment and over 50% of sectoral value added. The next largest subsector was the manufacture of cutlery, tools and general hardware (Group 25.7), followed by the manufacture of other fabricated metal products (Group 25.9), each with more than 10% of sectoral value added and employment. These were followed in the ranking by the forging, pressing, stamping and roll-forming of metal and powder metallurgy (Group 25.5) with a share of just under 5% of employment and exactly 10% of value added. The three remaining subsectors each contributed less than 4% of sectoral value added and employment in the EU-28 in 2011.
  - Germany had the highest value added of any EU Member State in the fabricated metal products manufacturing sector in 2011: the German share of EU-28 value added within the whole sector was 30%. The next largest shares of value added within the EU-28's fabricated metal products sector were recorded by Italy (16%), France (11%) and the United Kingdom (10%).
- For the relative importance of the fabricated metal products manufacturing sector in Member States in 2010, see Figure A1.82.

Figure A1.82 Largest and most specialised Member States in manufacture of fabricated metal products, 2010

	Highest value added	(% share of EU-27 value added)	Most specialised	(% share of non-financial business economy value added((2)
Manufacture of fabricated metal products, except machinery and equipment	**Germany**	**28.2**	**Slovenia**	**4.5**
Manufacture of structural metal products	Germany	21.4	Estonia	1.5
Manufacture of tanks, reservoirs and containers of metal	Germany	20.9	Slovakia	0.2
Manufacture of steam generators, excepts central heating hot water boilers	Germany	13.2	Finland	0.2
Manufacture of weapons and ammunition	U.K.	:	Bulgaria	0.5
Forging, pressing, stamping and roll-forming of metal, powder metallurgy	Germany	40.4	Slovenia	0.6
Treatment and cating of metals; machining	Germany	27.2	Slovenia	1.1
Manufacture of cutlery, tools and general hardware	Germany	42.0	Austria	0.8
Manufacture of other fabricated metal products	Germany	27.2	Slovenia	1.1

(1) The data set is incomplete with some missing combinations of Member State, activity, indicator, the information is drawn from available data;

(2) Estimates made for the purpose of this publication

Source Eurostat (online date code: sbs_na_ind_r2); 2013

Electrical, electronics and instrument industries

a. *Manufacture of computer, electronic and optical products*

- In 2011, 41.5 thousand enterprises in the EU-28 employed 1.03 million persons and generated €68.3 billion of value added.
- Regarding the number of enterprises, the manufacture of instruments and appliances for measuring, testing and navigation, and watches and clocks (Group 26.5, hereafter referred to as the manufacture of measuring instruments), and the manufacture of electronic components and boards (Group 26.1) were the two largest subsectors within the EU-28's computer, electronic and optical products manufacturing sector in 2011. Together, these two subsectors employed 63% of the sectoral workforce and generated a slightly higher proportion of value added, 64%. Behind these two large subsectors was the manufacture of communication equipment (16%) of the sector's workforce, followed by the manufacture of computers and peripheral equipment (Group 26.2) and the manufacture of consumer electronics (Group 26.4), with 7% and 5% shares of the sectoral workforce respectively. The three smallest subsectors — the manufacture of irradiation, electromedical and electrotherapeutic equipment (Group 26.6), optical instruments and photographic equipment (Group 26.7) and magnetic and optical media (Group 26.8) — collectively employed 9% of the sectoral workforce.
  - Within the EU-28's computer, electronic and optical products manufacturing sector the largest Member States in 2011 (in value added terms) were Germany (36% of the EU-28 total), France (15%) and the United Kingdom (14%).
- For the relative importance of the computer, electronic and optical products manufacturing sector in Member States in 2010, see Figure A1.83.

Figure A1.83 Largest and most specialised Member States in manufacture of computer, electronic and optical products, 2010

	Highest value added	(% share of EU-27 value added)	Most specialised	(% share of non-financial business economy value added((2)
Manufacture of computer, electronic and optical products	**Germany**	**29.6**	**Finland**	**3.7**
Manufacture of electronic components and boards	Germany	30.5	Ireland	1.7
Manufacture of computers and peripheral equipment	Germany	26.3	Ireland	1.2
Manufacture of communication equipment	Germany	:	Finland	2.8
Manufacture of consumer electronics	U.K.	37.2	Slovakia	1.8
Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks.	Germany	38.4	Germany	0.7
Manufacture of irradiation, electromedical and electrotherapeutic equipment	Germany	:	Denmark	0.4

Manufacture of optical instruments and photographic equipment	Germany	68.7	Germany	0.2
Manufacture of magnetic and optical media	Germany	29.4	Czech Republic	0.0

(1) The data set is incomplete with some missing combinations of Member State, activity, indicator, the information is drawn from available data;

(2) Estimates made for the purpose of this publication

Source Eurostat (online date code: sbs_na_ind_r2); 2013b

b. Manufacture of electrical equipment

- In 2011, there were 50 thousand enterprises in the EU-28‘s electrical equipment manufacturing sector, employing 1.43 million persons, and generating €85.6 billion of the value added.
- The largest subsector is the manufacture of electric motors, generators, transformers and electricity distribution and control apparatus. It contributed almost half of the EU-28’s sector’s value added and employment in 2011 (49% and 47%, respectively). The smallest subsector is batteries and accumulators manufacturing which contributed 2% of sectoral value added and employment. The remaining four subsectors – the manufacture of: wiring and wiring devices; electric lighting equipment; domestic appliances; and other electrical equipment – each contributed between 9% and 14% of sectoral value added and between 10% and 14% of sectoral employment.
  - In 2011 Germany was by far the largest Member State, in value added terms, for the whole sector (45% of the total EU-28’ sectoral value added). The next one was Italy, contributing more than six times less than Germany (7%).
- For the relative importance of the electrical equipment manufacturing sector in Member States in 2010, see Figure A1.84.

Figure A1.84 Largest and most specialised Member States in manufacture of electrical equipment, 2010

	Highest value added	(% share of EU-27 value added)	Most specialised	(% share of non-financial business economy value added((2)
Manufacture of electrical equipment	**Germany**	**43.1**	**Slovenia**	**3.9**
Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	Germany	50.9	Germany	1.7
Manufacture of batteries and accumulators	Germany	23.7	Bulgaria	0.2
Manufacture of wiring and wiring devices	Germany	45.9	Germany	0.4
Manufacture of electrical lighting equipment	Germany	30.8	Slovakia	0.4
Manufacture of domestic appliances	Germany	28.8	Slovakia	1.7
Manufacture of other electrical equipment	Germany	35.9	Austria	0.4

(1) The data set is incomplete with some missing combinations of Member State, activity, indicator, the information is drawn from available data;

(2) Estimates made for the purpose of this publication

Source Eurostat (online date code: sbs_na_ind_r2); 2013c

Mechanical Engineering industry

- About 94 thousand enterprises were operating in 2011. Together they employed 2.89 million persons, and generated over €190 billion of value added.
  - In 2010, it was the largest NACE division within the manufacturing sector in terms of value added. In employment terms, this sector was the third largest manufacturing NACE division in 2010 after food products manufacturing and the manufacture of fabricated metal products. (Eurostat; 2013d)
- In 2011, two general-purpose machinery manufacturing subsectors were the largest subsectors, accounting for a combined share of 63% of total value added and 61% of the total workforce. The manufacture of other special-purpose machinery followed with 26% share of the sectoral value added and workforce. The remaining subsectors accounted for less than 10% of the sectoral value added and employment.
  - The highest level of value added in the machinery and equipment manufacturing sector was generated in Germany, at almost €80 billion, equivalent to 41% of the EU-28 total in 2011. Italy was the second largest contributing almost one fifth of the EU-28's sectoral value added.
- For the relative importance of the machinery and equipment manufacturing sector in Member States, see Figure A1.85.

Figure A1.85 Largest and most specialised Member States in manufacture of machinery and equipment n.e.c, 2010

	Highest value added	(% share of EU-27 value added)	Most specialised	(% share of non-financial business economy value added((2)
Manufacture of machinery and equipment	**Germany**	**40.6**	**Germany**	**5.4**
Manufacture of general purpose machinery	Germany	43.4	Hungary	3.7
Manufacture of other general purpose machinery	Germany	38.1	Germany	1.4
Manufacture of agricultural and forestry machinery	Germany	28.3	Finland	0.3
Manufacture of metal forming machinery and machine tools	Germany	55.1	Germany	0.5
Manufacture of other special purpose machiners	Germany	40.5	Finland	1.4

(1) The data set is incomplete with some missing combinations of Member State, activity, indicator, the information is drawn from available data;

(2) Estimates made for the purpose of this publication

Source Eurostat (online date code: sbs_na_ind_r2); 2013d

Range of subsectors:

Table A1.61 (below) presents the key economic indicators per sector and subsector within the Machinery industry.

Table A1.61 Key economic indicators per sector and subsector

Description	NACE	Number of enterprises	Number of persons employed	Turnover	Value added	Personnel costs	Investment in tangible goods	Production value
				EUR million				
Manufacture of fabricated metal products, except machinery and equipment	**C25**	**378,686**	**3,547,809**	**460,354**	**155,168**	**106,686**	**17,406**	**443,834**
Manufacture of structural metal products	C25.1	114,203	1,029,239	120,272	37,030	27,316	3,686	115,775
Manufacture of tanks, reservoirs and containers of metal	C25.2	5,216	125,314	18,723	5,566	3,872	519	17,169
Manufacture of steam generators, except central heating hot water boilers	C25.3	991	26,295	4,722	1,359	985	144	4,235
Manufacture of weapons and ammunition	C25.4	1,184	46,320	8,922	3,569	2,322	226	9,722
Forging, pressing, stamping and roll-forming of metal; powder metallurgy	C25.5	14,301	273,310	57,844	15,973	11,045	2,106	56,490
Treatment and coating of metals; machining	C25.6	141,498	1,016,387	107,094	43,387	28,685	5,212	105,381
Manufacture of cutlery, tools and general hardware	C25.7	51,857	416,005	49,569	20,357	14,080	2,224	47,406
Manufacture of other fabricated metal products	C25.9	49,436	614,939	93,209	27,927	18,381	3,288	87,655
Manufacture of computer, electronic and optical products	**C26**	**41,508**	**1,031,004**	**250,960**	**68,249**	**47,242**	**8,533**	**218,006**
Manufacture of electronic components and boards	C26.1	10,190	290,689	63,176	16,762	11,885	4,737	55,208
Manufacture of computers and peripheral equipment	C26.2	6,142	69,426	22,365	4,313	2,826	369	19,784
Manufacture of communication equipment	C26.3	6,369	160,353	60,404	10,066	8,311	625	42,958
Manufacture of consumer electronics	C26.4	2,618	56,288	20,293	3,030	1,906	407	18,986

Description	NACE	Number of enterprises	Number of persons employed	Turnover	Value added	Personnel costs	Investment in tangible goods	Production value
				EUR million				
Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	C26.5	11,480	358,317	65,343	26,736	18,185	1,818	62,815
Manufacture of irradiation, electromedical and electrotherapeutic equipment	C26.6	1,956	51,859	11,551	4,036	2,309	267	10,728
Manufacture of optical instruments and photographic equipment	C26.7	2,374	42,670	7,664	3,257	1,789	304	7,361
Manufacture of magnetic and optical media	C26.8	379	1,402	165	48	31	6	165
Manufacture of electrical equipment	**C27**	**50,016**	**1,429,454**	**300,690**	**85,563**	**59,717**	**8,125**	**273,269**
Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	C27.1	22,769	664,992	139,000	42,148	30,141	3,339	129,667
Manufacture of batteries and accumulators	C27.2	472	23,471	8,327	1,626	1,165	373	7,357
Manufacture of wiring and wiring devices	C27.3	4,476	201,413	51,291	12,133	8,201	1,395	47,486
Manufacture of electric lighting equipment	C27.4	7,339	137,979	27,028	8,064	5,517	794	22,795
Manufacture of domestic appliances	C27.5	3,384	206,982	45,000	11,269	7,987	1,281	37,172
Manufacture of other electrical equipment	C27.9	11,576	194,617	30,043	10,324	6,707	943	28,792
Manufacture of machinery and equipment n.e.c	**C28**	**94,074**	**2,886,467**	**617,393**	**191,298**	**128,181**	**16,751**	**579,382**
Manufacture of general-purpose machinery	C28.1	11,849	845,196	203,427	63,666	41,253	6,876	180,824
Manufacture of other general-purpose machinery	C28.2	37,468	912,751	177,331	55,919	38,793	3,945	169,626
Manufacture of agricultural and forestry machinery	C28.3	6,831	168,703	39,896	9,615	6,079	978	36,318

Description	NACE	Number of enterprises	Number of persons employed	Turnover	Value added	Personnel costs	Investment in tangible goods	Production value
				EUR million				
Manufacture of metal forming machinery and machine tools	C28.4	8,402	219,472	38,080	13,237	9,654	936	37,927
Manufacture of other special-purpose machinery	C28.9	29,524	740,345	158,659	48,862	32,404	4,016	154,687

Source: 2011 Eurostat data

Note: Eurostat provides data per Member State for indicators (e.g., annual turnover, number of persons employed) based on NACE codes of the format AXX.XX (e.g., NACE C17.12). In addition to this level of granularity, Eurostat provides aggregated values of the overarching NACE codes. This would be codes C17 and C17.1 in the case of C17.12. Due to limitations inherent to the current Eurostat database, however, these aggregated values do not always exactly match the sum of the parts. For example, the sum of C17.1 and C17.2 does not always exactly match the Eurostat-provided aggregated value for C17. In most cases, such discrepancies have been found to be minor. Therefore, the selected approach for analysis has been to use sums of the parts (i.e., sum of C17.1 and C17.2 to represent the overall code C17). This approach ensures consistency between data and intends to maximize accuracy.

Key economic indicators for the sectors within the Machinery industry per Member State are given in tables below.

Table A1.62 Key indicators, Manufacture of fabricated metal products, except machinery and equipment (NACE Division 25)

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	7,167	11,876	11,213	3,447	2,424	625	57,087
BG - Bulgaria	3,879	1,320	1,251	396	214	79	54,630
CZ - Czech Republic	43,342	12,067	11,624	3,434	2,075	720	171,783
DK - Denmark	3,019	5,738	5,819	2,151	1,632	195	38,205
DE - Germany	41,765	128,085	124,392	47,044	32,894	4,788	857,074
EE - Estonia	962	1,052	1,009	242	156	46	11,140
IE - Ireland	642	1,260	1,209	508	381	29	9,755
EL - Greece	0	0	0	0	0	0	0
ES - Spain	37,536	32,722	32,234	10,801	8,176	931	263,072
FR - France	20,256	53,239	49,530	17,075	13,841	1,813	314,143
HR - Croatia	3,649	1,289	1,156	430	281	48	29,296
IT - Italy	71,971	80,309	81,035	24,798	16,634	2,955	548,801
CY - Cyprus	1,211	328	306	108	79	9	4,191
LV - Latvia	751	470	474	124	67	27	8,639
LT - Lithuania	1,267	445	451	132	81	30	10,973
LU - Luxembourg	203	567	558	181	144	11	3,232
HU - Hungary	8,481	4,236	3,663	1,159	687	268	68,245
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	9,678	20,113	18,431	6,089	3,883	413	90,449
AT - Austria	3,814	13,458	12,925	4,856	3,255	584	71,705
PL - Poland	29,958	19,371	17,563	5,645	2,795	990	283,560
PT - Portugal	13,146	5,663	5,401	1,798	1,343	303	83,801
RO - Romania	5,414	3,532	3,288	854	479	268	87,227
SI - Slovenia	4,052	3,157	2,902	847	578	154	30,908
SK - Slovakia	25,709	3,817	3,547	1,223	483	192	62,764
FI - Finland	4,849	5,643	5,438	1,936	1,402	189	38,265
SE - Sweden	11,156	14,132	13,618	4,943	3,723	536	81,901
UK - United Kingdom	24,809	36,468	34,798	14,945	8,982	1,203	266,963

Source: 2011 Eurostat data

Table A1.63 Key indicators, Manufacture of fabricated metal products, except machinery and equipment (NACE Division 25)

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	7,167	11,876	11,213	3,447	2,424	625	57,087
BG - Bulgaria	3,879	1,320	1,251	396	214	79	54,630
CZ - Czech Republic	43,342	12,067	11,624	3,434	2,075	720	171,783
DK - Denmark	3,019	5,738	5,819	2,151	1,632	195	38,205
DE - Germany	41,765	128,085	124,392	47,044	32,894	4,788	857,074
EE - Estonia	962	1,052	1,009	242	156	46	11,140
IE - Ireland	642	1,260	1,209	508	381	29	9,755
EL - Greece	0	0	0	0	0	0	0
ES - Spain	37,536	32,722	32,234	10,801	8,176	931	263,072
FR - France	20,256	53,239	49,530	17,075	13,841	1,813	314,143
HR - Croatia	3,649	1,289	1,156	430	281	48	29,296
IT - Italy	71,971	80,309	81,035	24,798	16,634	2,955	548,801
CY - Cyprus	1,211	328	306	108	79	9	4,191
LV - Latvia	751	470	474	124	67	27	8,639
LT - Lithuania	1,267	445	451	132	81	30	10,973
LU - Luxembourg	203	567	558	181	144	11	3,232
HU - Hungary	8,481	4,236	3,663	1,159	687	268	68,245
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	9,678	20,113	18,431	6,089	3,883	413	90,449
AT - Austria	3,814	13,458	12,925	4,856	3,255	584	71,705
PL - Poland	29,958	19,371	17,563	5,645	2,795	990	283,560
PT - Portugal	13,146	5,663	5,401	1,798	1,343	303	83,801
RO - Romania	5,414	3,532	3,288	854	479	268	87,227
SI - Slovenia	4,052	3,157	2,902	847	578	154	30,908
SK - Slovakia	25,709	3,817	3,547	1,223	483	192	62,764
FI - Finland	4,849	5,643	5,438	1,936	1,402	189	38,265
SE - Sweden	11,156	14,132	13,618	4,943	3,723	536	81,901
UK - United Kingdom	24,809	36,468	34,798	14,945	8,982	1,203	266,963

Source: 2011 Eurostat data

Table A1.64 Key indicators, Manufacture of computer, electronic and optical products (NACE Division 26)

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	218	1,280	1,275	398	314	83	4,990
BG - Bulgaria	348	280	273	108	49	25	8,180
CZ - Czech Republic	3,390	10,234	9,955	801	613	195	40,065
DK - Denmark	570	4,016	3,856	1,788	1,083	102	21,910
DE - Germany	7,934	74,455	68,144	24,668	17,071	4,326	311,314
EE - Estonia	102	335	330	62	39	6	3,192
IE - Ireland	61	1,096	1,096	479	123	8	2,450
EL - Greece	0	0	0	0	0	0	0
ES - Spain	2,600	4,252	4,270	1,530	1,148	185	30,444
FR - France	2,776	33,179	29,897	10,107	9,035	906	134,528
HR - Croatia	711	344	247	108	72	8	5,376
IT - Italy	5,759	22,399	22,336	7,077	5,085	619	112,296
CY - Cyprus	0	0	0	0	0	0	0
LV - Latvia	110	23	25	8	4	2	1,246
LT - Lithuania	133	142	138	58	34	19	2,601
LU - Luxembourg	10	0	0	0	0	0	0
HU - Hungary	1,539	11,416	10,321	1,508	761	193	53,397
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	1,454	8,315	5,674	2,081	1,338	115	27,485
AT - Austria	561	4,931	4,546	2,117	1,151	327	19,557
PL - Poland	2,812	9,349	8,535	1,521	692	220	61,792
PT - Portugal	333	1,874	1,713	317	210	65	8,887
RO - Romania	834	2,673	658	248	153	86	27,265
SI - Slovenia	303	535	480	161	117	19	5,039
SK - Slovakia	804	6,041	5,826	498	227	147	17,632
FI - Finland	567	28,009	13,970	1,639	2,149	193	30,481
SE - Sweden	1,704	3,710	3,694	1,356	1,045	82	17,462
UK - United Kingdom	5,875	22,074	20,748	9,610	4,729	604	83,415

Source: 2011 Eurostat data

Table A1.65 Key indicators, Manufacture of electrical equipment (NACE Division 27)

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	562	5,423	5,170	1,732	1,105	120	18,610
BG - Bulgaria	472	983	940	200	105	48	18,603
CZ - Czech Republic	15,213	9,611	9,068	2,495	1,380	392	97,326
DK - Denmark	445	2,765	2,407	866	612	66	13,516
DE - Germany	6,027	116,761	105,078	38,098	28,040	3,246	502,546
EE - Estonia	95	500	476	128	73	14	4,731
IE - Ireland	106	782	746	219	149	10	3,602
EL - Greece	0	0	0	0	0	0	0
ES - Spain	2,438	17,040	16,212	3,786	2,869	459	69,824
FR - France	2,439	32,976	26,566	7,805	6,566	768	120,087
HR - Croatia	449	845	776	219	132	30	8,435
IT - Italy	9,162	40,909	40,838	10,299	6,504	947	168,176
CY - Cyprus	70	39	37	13	9	2	454
LV - Latvia	69	142	132	41	25	6	2,522
LT - Lithuania	96	198	201	57	31	6	3,732
LU - Luxembourg	14	72	66	28	21	1	443
HU - Hungary	902	3,713	3,280	806	445	134	37,551
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	1,190	5,335	4,400	1,524	995	63	21,653
AT - Austria	469	11,717	10,890	3,918	2,701	400	45,360
PL - Poland	2,101	11,563	10,362	2,568	1,198	487	95,788
PT - Portugal	773	3,743	3,458	758	444	101	18,856
RO - Romania	618	2,762	1,806	395	228	113	37,503
SI - Slovenia	397	2,771	2,392	670	430	116	18,311
SK - Slovakia	1,537	2,651	2,474	535	367	144	28,675
FI - Finland	418	4,881	4,381	1,403	882	85	18,605
SE - Sweden	1,001	6,479	6,204	2,017	1,473	103	25,110
UK - United Kingdom	2,953	16,028	14,910	4,987	2,930	269	49,435

Source: 2011 Eurostat data

Table A1.66 Key indicators, Manufacture of machinery and equipment n.e.c. (NACE Division 28)

	Number of enterprises	Turnover (in €M)	Production value (in €M)	Value added (in €M)	Personnel costs (in €M)	Investment in tangible goods (in €M)	Number of persons employed
BE - Belgium	1,496	12,093	11,337	3,434	2,079	313	36,850
BG - Bulgaria	877	1,103	1,066	316	175	54	29,914
CZ - Czech Republic	6,165	11,360	11,101	3,092	1,931	569	119,341
DK - Denmark	1,682	17,783	16,977	4,905	3,393	938	72,098
DE - Germany	16,413	238,933	225,033	78,791	58,077	5,960	1,056,755
EE - Estonia	128	254	250	78	53	12	3,163
IE - Ireland	304	2,333	2,225	943	449	44	10,384
EL - Greece	0	0	0	0	0	0	0
ES - Spain	5,782	17,447	16,753	5,851	4,066	384	101,646
FR - France	5,355	49,079	41,317	13,200	9,803	1,553	183,081
HR - Croatia	790	668	615	225	142	47	11,051
IT - Italy	24,684	107,692	107,384	29,810	19,675	2,337	458,237
CY - Cyprus	61	65	57	28	14	3	608
LV - Latvia	130	141	143	55	29	20	3,078
LT - Lithuania	150	293	277	92	51	20	5,410
LU - Luxembourg	24	158	163	53	41	3	732
HU - Hungary	2,705	9,079	6,853	2,492	877	276	60,055
MT - Malta	0	0	0	0	0	0	0
NL - Netherlands	2,964	26,156	24,999	7,993	4,399	921	76,649
AT - Austria	1,322	19,439	19,107	6,710	4,187	486	72,900
PL - Poland	4,823	9,502	8,847	3,029	1,568	425	125,430
PT - Portugal	1,679	1,827	1,733	578	400	89	20,743
RO - Romania	1,270	2,550	2,824	1,092	420	350	55,025
SI - Slovenia	751	1,584	1,475	480	323	76	14,306
SK - Slovakia	1,525	3,117	3,013	816	554	236	37,062
FI - Finland	1,522	16,084	15,072	4,124	2,571	202	50,021
SE - Sweden	3,213	24,236	22,057	7,353	4,736	447	83,273
UK - United Kingdom	8,259	44,420	38,705	15,758	8,167	989	198,655

Source: 2011 Eurostat data

Main players:

Fabricated metals and metalworking industry

- Small and medium-sized enterprises (<250 employed persons) are predominant in this subsector. They employed 82.5 % of the sector's workforce and generated 76.7 % of sectoral value added in 2010. Small enterprises (employing 10 to 49 persons) were particularly important: 32.3% of the EU-27's sector's workforce and provided 30.7 % of sectoral value added. The employment and value added shares of large enterprises in this sector were both lower than the equivalent shares for small enterprises and medium-sized enterprises (employing 50 to 249 persons). (Eurostat; 2013a)
- In 2010, SMEs dominated the sector in every EU Member State. The share of SMEs in total value added ranged from 60.7 % in Austria and 66.0 % in Poland to 92.3 % in Hungary, with Ireland and Cyprus reporting no large enterprises active in this sector. (Eurostat; 2013a)

Electrical, electronics and instrument industries

a. *Manufacture of computer, electronic and optical products*

- Large enterprises (>249 employed persons) are prevailing in the EU-27's computer, electronic and optical products manufacturing sector. They contributed 62.5 % of the value added generated in the sector and employed 54.2 % of the sectoral workforce in 2010. (Eurostat; 2013b)
- The prevalence of large enterprises was the case in most Member States in 2010. In Hungary and Slovakia large enterprises contributed 85.3% and 87.3 of sectoral value added, respectively, and more than 75% in Poland and Ireland. No large enterprise was based in Cyprus and Latvia. In the latter, medium-sized enterprises were dominant, accounting for 80.8 % of the value added. The contribution of small enterprises (employing 50 to 249 persons) passed one fifth of the total in Spain and the Netherlands.(Eurostat; 2013b)

b. *Manufacture of electrical equipm*ent

- Large enterprises (employing >249 persons) dominate the sector. They contributed 67.2% of the EU-27's sectoral value added and employed 58.3% of the workforce in 2010. (Eurostat; 2013c)
- In the majority of Member States, large enterprises are prevailing in the sector. In 2010, value added shares in excess of three quarters were recorded for large enterprises in Germany, Slovenia and Austria. In 15 countries the share exceeded 50%. Only in Lithuania, medium-sized enterprises (employing 50 to 249 persons) generated more value added; whereas in Cyprus small enterprises (employing 10 to 49 persons) provided more sectoral value added. (Eurostat; 2013c)

Mechanical Engineering industry

- Large enterprises (>249 employed persons) generated 54.6% of the EU-27's value added within the machinery and equipment manufacturing sector and employed 45.5% of workforce in 2010. Medium-sized enterprises (employing 50 to 249 persons) were also relatively important for the EU-27's machinery and equipment manufacturing sector: 27% of sectoral value added and 29.2% of the sectoral employment. (Eurostat; 2013d)
- Regarding the number of enterprises, the industry is predominantly made of small and medium size companies.
- Medium-sized enterprises in Italy, Lithuania, Portugal, Slovenia and Croatia provided more value added in 2010 than large enterprises. Small enterprises (employing 10 to 49 persons) in Spain provided more value added than any of the other size class, while in Greece this was the case of micro enterprises (employing fewer than 10 employees). Aside from these Member States and Cyprus (where there were no large enterprises),

large enterprises made the greatest contribution to sectoral value added in all of the remaining Member States. (Eurostat; 2013d)

Trade flows:

- The engineering industry counts for some 28% of the output and a third of the exports of the EU manufacturing industries. Total trade (intra + extra trade) of the industry reached €1,290 billion in 2012. Growth was noted in the US as well as in a few markets in Asia and Latin America; while exports to China declined in numerous Member States.(Orgalime; 2013)
- In 2011, the EU-27 had a comparative advantage in metal products and machinery (RCA>1)[290]; but comparative disadvantage in electrical and electrical and electronic goods (RCA<1; Note: RCA of electrical equipment was almost 0.99, whereas computers, electronic & optical products – 0.58) (EC; 2013)

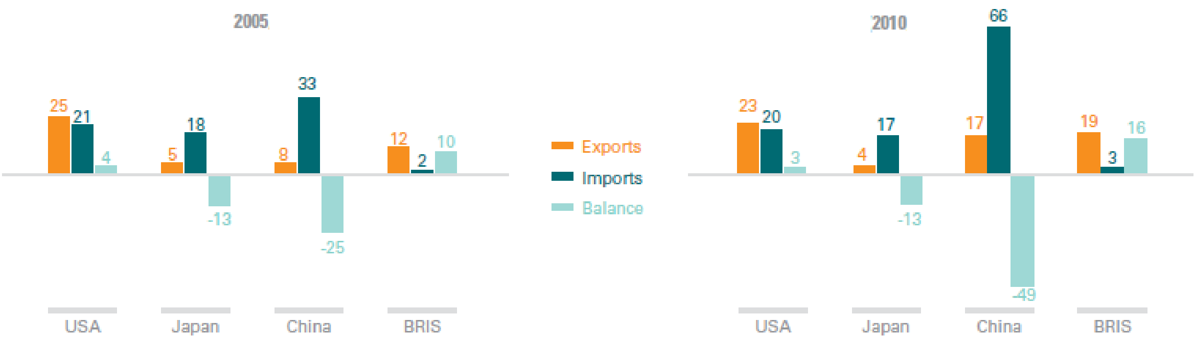
Fabricated metals and metalworking industry

- Overall, exports grew by a modest 4% in 2012 compared to an increase of 13% in 2011.(Orgalime; 2013). Intra-EU trade accounts for 60% (Electra; 2008).
- The majority (75-80%) of trade is intra-EU (Ecorys; 2009). In terms of non-EU imports in metal products, China accounts for large portion of it (42% in 2011). Relatively large export markets are USA (13.8% in 2011) and BRIC countries (21.7% in total; Russia being the biggest recipient, 8.9%) (EC; 2013).

Electrical, electronics and instrument industries

- EU-27 trade balance: in both 2005 and 2010, there was a surplus in trade with the USA and the BRI (Brazil, Russia and India) countries and deficits in trade with Japan and China. Yet, in particular, the trend with the USA and Japan remained, whereas the deficit with China in this period doubled and the surplus with the BRI countries has risen by 60%. (Figure A1.86)

Figure A1.86 EU-27 foreign trade by regions in 2005 and 2010 in billion €



Source: Electra, 2012

- China still accounts for a large portion of EU imports in electrical equipment (45% in 2011) and computer, electronic and optical equipment (47% in 2011). USA and BRI countries remain a relatively large export markets (Russia being the biggest recipient over 8% in 2011) (EC; 2013).

[290] Revealed Comparative Advantage (RCA) is an indicator of competitiveness, which compares the exports of a given sector in the EU, expressed as a proportion of the EU's total manufacturing exports, with the exports of the same sector in a group of reference countries, expressed as a proportion of their total manufacturing exports. Values over 1 mean that the EU sector performs better than the same sector in the group of reference countries, which is interpreted as a sign of comparative advantage. The RCA indicator is used to rank EU products by degree of export specialization

- Export in consumer electrical and electronic goods was growing since 2001; recording annual growth rates over 5% until 2007. In 2009, export rate declines by more than 25%. (Ecorys; 2011)

Mechanical Engineering industry

- Since the early 1990s deliveries to non-EU countries have grown much stronger than the domestic market, with the emerging economies becoming more and more important. Main export markets are MENA (Middle East and North Africa), Russia, Turkey, South Korea, India and Brazil. Other emerging economies (Taiwan, Australia, Canada, Mexico and Indonesia) have been gaining on importance. (Ecorys; 2012)
- The EU mechanical engineering (ME) is in the lead in international trade – it still accounts for more than a third of global machinery valued-added that is exported (excluding intra-trade) (EC; 2013b). The share of ME of total manufactured exports had grown throughout the past decade and reached 15% in 2010. For imports the share had fallen down to around 6%. (Ecorys; 2012)

Product type and consumer groups:

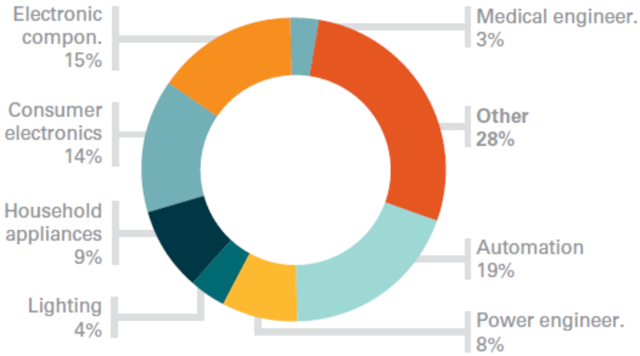
Fabricated metals and metalworking industry

- Products include: cast iron parts, stainless steel technological equipment for food, chemical, etc. industries, pressure vessels, industrial and household boilers and other heating equipment, tools for metal machining, welded metal structures, railway turnouts and joints as well as various metal articles on subcontracting. Weapons and ammunition are also produced within this industry.
- The components are supplied essentially to the automotive, aerospace, transport and engineering, including in particular mechanical engineering. Steel profiles and sheets are essential to the civil engineering industry (steel frame buildings, reinforcing bars, steel frame infrastructure, cladding for buildings, hardware, etc.). Vessels are provided for the processing industries, such as food, pharmaceuticals, chemicals, oil refining industries, etc. Products such fasteners (screws, nuts and bolts) and tools are used both by industry and by consumers. (Orgalime; 2007)
- The automotive industry appears to be the most important: in Germany the automotive sector accounted for 75% of demand for sector’s products; in France it was 42% (Ecorys; 2009).

Electrical, electronics and instrument industries

- The most important supplier of high-technology inputs to other industry sectors such as mechanical engineering, transport means, health, chemicals or IC; as well as to buildings (commercial & industrial); residential sector; power generation, transmission and distribution
- Manufacture of computer, electronic and optical products includes: electronic components and loaded boards; computers and peripheral equipment; communication equipment; consumer electronics; instruments and appliances for measuring, testing and navigation; watches and clocks; irradiation, electromedical and electrotherapeutic equipment; optical instruments and photographic equipment; magnetic and optical media
- Manufacture of electrical equipment includes: electric motors, generators and transformers; electricity distribution and control apparatus; batteries and accumulators; fibre optic cables; other electronic and electric wires and cables; wiring devices; electric lighting equipment; electric domestic appliances; non-electric domestic appliances; other electrical equipment

Figure A1.87 Consumption within EU-27 by sub-branches; 2010



Source: Electra, 2012

Mechanical Engineering industry:

- Roughly one third of ME output is intermediary products that are delivered to other companies, such as bearings, gears, taps, valves, fluidics and engines. Many of these deliveries are intra-sectoral and are made for other ME firms. Other industries that procure intermediary products from ME are electrical engineering, the automotive industry and medical equipment, precision instruments and others. (Ecorys; 2012). In particular:
  - The Manufacture of general-purpose machinery includes:
    - internal-combustion engines (ICE) for industry, for ships (up to 80 MW), locomotives and mobile off-road machinery (around 50 to 500 kW and even up to a maximum of 2 MW); engines for the generation of electricity and emergency power generators; small ICEs for forestry, agriculture and gardening (e.g. chainsaws); and turbines for industry as stand-alone power stations;
    - pumps and compressors applied in manufacturing as components in machines and plant builders, power generation, waste processing and the construction industry for heating, cooling etc.
    - taps and valves used by utilities, suppliers of electricity, gas and water, the chemical and mineral oil processing industries, the sanitary and heating trades and private households
    - bearings, gears and drives assembled into all kinds of capital goods and delivered to the transport equipment industries for the manufacture of cars, ships, railways and aircrafts, used for power generation, waste recycling, warehousing etc.; applied also in consumer goods industries (e.g. multi-media applications);
    - fluid power equipment includes hydraulic and pneumatic components such as pumps, seals
  - The Manufacture of other general-purpose machinery includes:
    - lifting, handling and storage equipment used in four distinct market segments: (i) materials for handling and lifting equipment in mining and quarrying, e.g. large conveyor belts for the transport of coal and other minerals; (ii) lifts, escalators and conveyer belts for the in-house transportation of passengers, for instance in airports; (iii) in-house transport and storing for manufacturing industries; and (iv) in-house transport and warehousing for service industries;
    - non-domestic cooling and ventilation equipment applied in construction (e.g. residential and office buildings) and manufacturing sites, procured by construction

companies and engineering firms specialized in heating, cooling and AC-systems, as well as contractors that install and run such systems for real estate owners;

  - ovens, furnaces and furnace burners; office machinery and equipment (except computers and peripheral equipment); power-driven hand tools; other general-purpose machinery not else specified.

- The Manufacture of agricultural and forestry machinery includes: machines and devices for working the soil, such as seeding and drilling, for plant care, harvesting, fertilizing, milking, animal husbandry and transport of produce.
- The Manufacture of metal forming machinery and machine tools includes:
  - metal forming machinery such as turret punch presses, laser cutting systems, automated bending machines, stamping and shearing machines; forging machines, rolling mills, crankshaft milling machines, ultrasonic cutting machines, sheet metal routing machines, core routing machines as well as custom machine tools.
  - machine tools used by manufacturers of machinery and equipment (electrical and mechanical engineering), of transport equipment (cars, ships, railways, air and spacecraft), of power generation and distribution equipment (conventional and renewable), the die and mould industry (med-tech industry, domestic appliances, metal goods, defence sector, jewellery, watch-making, optical industry and others).
- The Manufacture of other special-purpose machinery includes:
  - machinery for mining, quarrying and construction applied in three segments: (i) construction of buildings and civil engineering; (ii) manufacture of building materials (machines for crushing, sorting, sifting and mixing earth, stones or ores and plants for the processing of non-metallic minerals); and (iii) mining and quarrying (e.g. earth moving equipment (excavators, shovel loaders)
  - machinery for metallurgy; machinery for food, beverage and tobacco processing
  - machinery for textile, apparel and leather production includes spinning machines, looms, knitting machines, textile finishing machines, sewing machines and automatic sewing machines
  - machinery for paper and paperboard production; plastics and rubber machinery; other special-purpose machinery not else specified

A1.8.3 Market developments and sector growth rates

- All Machinery sectors were steadily increasing their outputs until 2008; when they suffered drops in production due to global economic and financial crisis. As of March 2013, they still didn’t manage to recover their pre-recession throughput levels: electrical, electronics and instrument industries as well as mechanical engineering industries were still 15-20% below their peak levels; whereas the fabricated metals were more than 20%. (EC; 2013)
- Below further information on the Machinery industry sectors performance is provided.

Fabricated metals and metalworking industry:

<u>Market developments</u>

- When considering the 2001-2012 period the output in fabricated metals has experienced yearly 1.5% growth on average (EC; 2013).Yet, the average 2007-2012 growth rate was -1.6% (EC; 2013b).
- The global financial crisis has hit the metalworking and metal articles sector in various ways: reduced output; an indirect impact from the automobile scrapping schemes; job losses (although not in line with falls in production as many companies have been able to retain their qualified personnel); price-cost squeeze (higher cost of energy, materials and other inputs on the one hand; and pressure from end-users to reduce selling prices on the other); reduced liquidity and restricted access to credit and capital markets experienced by many SMEs. (EC; 2010)
- In 2012, performance in engineering sectors, such as machinery and the motor car industry faded; hence metal goods' production is estimated to have fallen by 3% compared to 2011. A production drop was noted in all major subsectors, with forging, pressing and stamping activities experiencing the biggest fall. (Orgalime; 2013). Yet, over the 2001-2012 period the sector has been increasing its output by over 1.5% per year on average (EC; 2013).
- Sectoral employment in the EU-27 dropped by 8% in 2011/12 compared to 2000; Ireland and the UK recording the highest drops (-45% and -34%, respectively). Yet, the changes in employment hasn't been homogenous across Member States – some countries recorded increase, e.g. Estonia and Greece (EC; 2013)
- The sector has been dominated by SMEs. A degree of consolidation has already occurred, principally to attempt to earn economies of scale, to raise productivity, and to increase their size and power. Yet, although there is still scope for further consolidation, it is rather limited due to structural and high specialisation reasons. (Ecorys; 2009)

Drivers:

- Sector's output is used in other sectors in engineering, such as machinery and automotive industry. Therefore, growth in these recipients sector drives demand in metalworking and metal articles industry.
- The metalworking industry consumes large amounts of steel, among other resources, and it heavily depends on steel produced in the EU. Therefore, it is essential for the sector to source steel and other resources such as iron ore at reasonable prices and relatively quickly. Otherwise it cannot compete at EU level for labour costs, achieve economies of scale like its suppliers can, and ensure fast delivery of products.

Electrical, electronics and instrument industries:

Market developments

- The production in 2012 decreased by 1.8% compared to 2011. Specifically: (i) the volume of production of electrical engineering machinery contracted by 2% in 2012 (NB: the subsector noted the expansion of 4.5% in 2011); (ii) motors, generators and transformers contracted by 3% (for the first time in two years); (iii) cutbacks were also noted for wiring and wiring devices, electrical machinery such as electrical lighting and domestic appliances, (iv) all major ICT subsectors recorded a contraction in output, with consumer electronics receiving hardest hit, (v) instrument engineering for testing and measuring, as well as medical instruments continued their expansion in 2012 but at a slightly lower rate than in 2011. (Orgalime; 2013)
- Over the 2001-2012 period the output in computers, electronic and optical products has experienced over 2% growth per year on average; similarly the production in electrical equipment – ca. 1.5% annually on average. The computers, electronic and optical sector has in fact been amongst the fastest growing sectors – the highest growth in value added amongst all EU industrial and service sectors. (EC; 2013).
- Yet, the average 2007-2012 growth rates were: -3.6% in computer, electronics and optical products) and -1.7% in electrical equipment (EC; 2013b).
- Employment in electrical equipment in the EU-27 dropped by 13% in 2011/12 compared to 2000; Ireland and the UK recording the highest drops (-77% and -44%, respectively). Yet, the changes in employment hasn't been homogenous across Member States – some countries recorded increase, e.g. Austria and Denmark (EC; 2013)
- Employment in computer, electronic and optical in the EU-27 dropped by 23% in 2011/12 compared to 2000; Lithuania and the UK recording the highest drops (-69% and -56%, respectively). Yet, the changes in employment hasn't been homogenous across Member States – some countries recorded increase, e.g. Czech Republic and Slovakia (EC; 2013)

Drivers:

- Driven by industry and consumer behaviours, depending on end product. Lead customer markets for the sector – those markets with high demand and fast application of new technologies – are deemed to include (Electra; 2012):
  - Automation, industrial IT: growing need for information processing and the increasing complexity in production processes, rising pressure on productivity gains and a requirement for cost savings, the demands on this sector will continue to rise. Demand to serve decentralised production facilities throughout the world will result in wider use of internet-based and radio frequency identification (RFID)
  - Digital radio and TV, high definition television (HDTV): the further development of the European information society is creating a stronger demand for new content, broader diversity, more interactive media, better quality and flexible viewing.
  - E-health infrastructures (e.g. the electronic patient record (EPR), electronic health care record (EHR), smart cards, radio frequency identification (RFID) and, increasingly, mobile computing) and nano-diagnostics: aging society and shift from hospital to home care will rely more and more on combination of ICT and new medical technologies; nanotechnologies will bring more accurate and less expensive diagnostics and treatment
  - Energy generation, transmission and distribution infrastructures, including critical power and carbon capture and storage (CCS), smart grids, high voltage direct current (HVDC), renewables, low-carbon technologies and storage systems: the need to renew Europe's electricity networks, enable a trans-European electricity

market, integrate more sustainable generation resources (including renewables), and increase system efficiency will drive a growth in this sector

  - Civil protection, homeland security and defence: arising new security threats to the EU from terrorist attacks, illegal migration and others will affect the development in areas such as protection of critical infrastructures (networks, sensitive sites), the development of building security, IT, tracking and tracing, scanning and detection technologies
  - Buildings, intelligent living, ambient assisted living: the increase in single person households and the increase in working from home will trigger demand for home infrastructures including door locks, alarm, remote access to heating, lighting, work sites, etc.. Also, rising cost of energy will call for energy efficient solutions controlled by a single person..
  - Trans-European networks, transportation infrastructure, telematics (e.g. as car-to-car and car-to-infrastructure communications, eCall, the Galileo satellite navigation system and the European train control system (ETCS): growing urbanisation and increasingly complex mobility requirements lead to a strong demand for new intelligent and flexible transport solutions and services.

- Electronic vs electrical equipment: households tend to own multiple electronic goods (several cameras or computers), while only one electrical product. Personal electronics enjoy higher sales per person than electrical goods, despite the fact that electrical goods are generally in wider use in households (with the possible exception of televisions).
  - Home appliances show stable demand; while there is much more fluctuation in consumer electronics (i.e. new products stimulate short-term demand driving changes in market size and demand)
  - Consumer electronics: shortened life cycles for products help generate increased demand as people look to replace products before they have ceased to function.
  - Computers: increased mobility of people had led to a decline in desktop computers and high demand for notebooks and even more portable and affordable technologies, such as netbooks and new tablets. Computers are essential for business, which drives up their sales.
  - Consumer preferences in home appliances (i.e. electrical goods): price, energy efficiency, loyalty to brands produced close to home. Less frequent replacement rate.
  - Consumer preferences in electronic goods: functionality, marketing and price.

Mechanical Engineering industry:

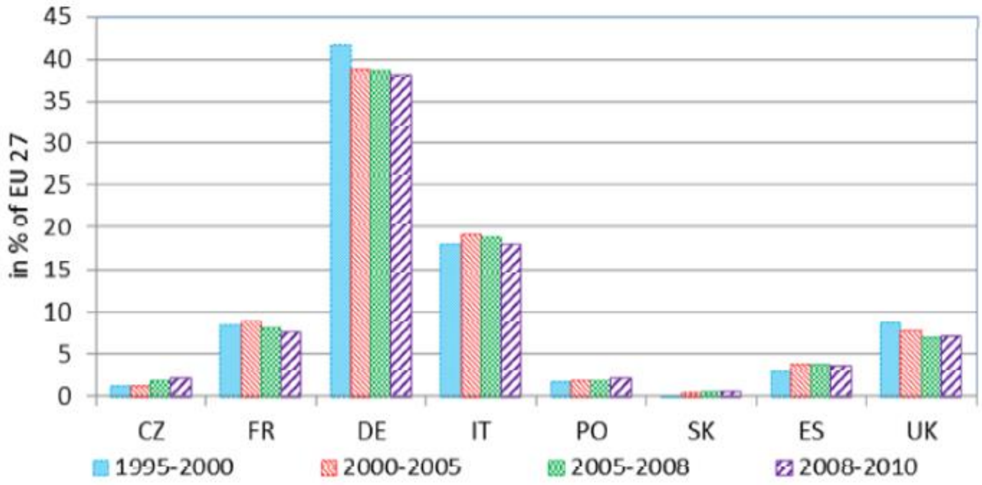
<u>Market developments</u>

- ME is one of the major branches of industry in the EU-28. For the period from 1995 to 2000, ME recorded comfortable growth rates (4% annual increase in production over 1995-2000; and 2.3% over 2000-2005). At the end of this period demand soared and a strong upsurge – 10.4% annually – was noted until 2008. In the aftermath of the global financial and economic crisis production fell by more than one fifth, on average, for all Member States in 2009. Although, ME benefitted from an early recovery and high growth momentum in 2010, former levels have not yet been reached. (Ecorys; 2012). In 2012, ME reached the same production level as in the year before, following contraction in domestic demand and exports compared to 2011 levels (Orgalime; 2013)
  - There was an uneven evolution among ME sub-sectors in 2012: sectors such as material handling, power driven hand tools, metalworking machinery and machine tools performed well keeping the growth steady; while special purpose machinery

declined its output in response to lower demand from other manufacturing sectors, mining and construction sectors.

- Sectoral employment in the EU-27 dropped by 6% in 2011/12 compared to 2000; Romania, Latvia and Cyprus recording the highest drops (-64%, -45 and -44%, respectively). Yet, the changes in employment hasn't been homogenous across Member States – some countries recorded increase, e.g. Estonia and Greece (EC; 2013)
- Traditionally, mechanical engineering meant only supplying hardware, machinery and equipment. Yet, recently, the industry has been evolving in the direction of a service industry, providing services such as the installation of manufacturing systems, training of operators, maintenance and repair, and even the supply of finance, have become more important. (Ecorys; 2012)

Figure A1.88 Regional distribution of mechanical engineering production



Source: Ecorys, 2012

- Since the early 1990s the ME sectpr has been consolidating and cross-border mergers and acquisitions have changed the structure of the industry. Numerous mergers and acquisitions have been done by private equity firms and investment funds. Globalization has driven European companies to access foreign markets through local production.(Ecorys; 2012)

<u>Drivers</u>:

- Development of ME is largely dependent on a country's overall economic development.
- Strong linkage with other industries such as power generation, iron & steel, automotive, chemical, off-road construction, and ME itself. A vital manufacturing sector within the EU contributes to ME's potential to stay at the leading edge of competitiveness. For example, the off-road machinery and portable machinery depends on economic development in areas, such as mining and quarrying, forestry, agriculture, construction, municipal services etc.
- The long-term perspectives of this industry are dependent on the final destination of the products. The majority of output consists of capital goods dedicated for investment in a broad range of industries. There are subsectors that provide capital goods for specific client industries such as the textile, commercial paper, pulp and paper, construction and mining and agricultural industry. They are strongly dependent on clients' investment behaviour.

  - Agriculture and forestry machinery depends on farms' income and external variables such as agricultural policy (e.g. EU Common Agriculture Policy), weather and public policies (e.g. on energy and environment)
  - Construction machinery is strongly affected by regional discrepancies in demand.
  - Recently, in response to lower capacity utilisation in total EU manufacturing industry and reduced needs for manufacturing capacity expansion, demand for capital goods has been driven mainly by equipment rationalisation and replacement.

Energy growth rates for the Machinery industry

- In EU-28, final energy consumption has increased by 3% in 2011 compared to 2000.
- Machinery industry contributed 7% of total energy consumption by the EU-28 industry.
- Table E presents energy consumption by Machinery industry (C25-C28) over 2000-2011. The industry in five Member States consumed more than 1,000Mtoe: Germany, Italy, France, the UK and Spain. By 2011, All these countries, except Germany, recorded a decline in energy consumption (from -2% in Spain to -23% in the UK). Germany consumption rose by 82% in 2011 compared to the 2000 level.
  - Amongst the countries with energy consumption lower than 1,000Mtoe, ten noted a decrease (from -2% in Denmark to -67% in Lithuania); while eleven recorded an increase (from 3% in Slovakia to 110% in Estonia). Cyprus was the only one maintaining flat energy consumption over the period.

Table A1.67 Energy consumption in MToe by the Machinery industry per Member State over 2000-2011

GEO/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	change 2011/2000
Estonia	20	22	25	35	32	36	40	42	38	36	40	42	110%
Germany (until 1990 forn	3,132	3,170	3,162	3,124	3,108	3,100	3,262	3,232	3,599	2,897	5,572	5,686	82%
Austria	377	405	386	411	459	493	522	524	526	578	606	595	58%
Sweden	286	261	267	303	296	279	279	263	211	264	437	443	55%
Finland	257	248	250	256	253	246	250	314	379	348	385	388	51%
Hungary	173	197	204	222	226	277	271	271	246	232	257	260	50%
Croatia	41	38	34	42	53	52	56	63	64	58	61	61	49%
Portugal	113	121	124	160	160	163	170	171	171	167	158	166	47%
Ireland	191	207	220	214	215	228	276	307	275	266	260	272	42%
Slovenia	124	114	108	147	157	173	190	177	163	124	148	141	14%
Czech Republic	659	650	630	708	647	762	779	815	790	674	721	685	4%
Slovakia	173	168	172	194	140	151	161	176	206	146	177	178	3%
Cyprus	2	2	2	2	2	2	3	3	3	3	2	2	0%
Spain	1,036	1,376	1,222	1,404	1,413	1,383	1,181	1,234	1,200	1,155	1,095	1,015	-2%
Denmark	313	327	317	332	331	312	322	322	343	301	311	296	-5%
Bulgaria	133	124	119	121	114	124	122	122	129	92	95	125	-6%
Latvia	21	27	23	25	25	29	30	26	25	15	17	19	-10%
France	2,473	2,461	2,335	2,334	2,309	2,100	2,257	2,187	2,245	2,013	2,237	2,129	-14%
Belgium	264	250	272	343	369	241	312	328	291	236	267	223	-16%
Netherlands	697	686	686	637	640	1,258	617	551	589	654	656	557	-20%
Poland	890	835	786	818	779	772	770	771	735	633	702	705	-21%
Italy	4,723	4,812	4,874	4,945	4,871	4,794	4,791	4,751	4,655	3,735	3,896	3,677	-22%
United Kingdom	2,657	2,628	2,562	2,457	2,401	2,508	2,425	2,363	2,399	2,072	2,114	2,047	-23%
Luxembourg	13	15	15	12	12	9	9	9	9	8	10	9	-31%
Greece	68	71	73	88	58	59	62	69	67	12	19	46	-32%
Romania	701	789	812	637	597	519	506	474	465	325	365	362	-48%
Lithuania	60	60	66	67	76	72	46	28	22	15	18	20	-67%

Source: Eurostat, available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home

Note: Malta is not included, as there is no Machinery industry in the country (0Mtoe consumption over the period)

A1.8.4 Business environment

A1.8.4.1 Competitive strengths

- **What are the key competitive strengths?**

Fabricated metals and metalworking industry

- Significant employer in the regions delivering essential products and parts to other sectors
- High degree of flexibility and adaptability to change
- High level of expertise
- High quality output and strong position in high end markets
- A link between many industries and hence playing a key role in the infrastructure and competitiveness of EU manufacturing as a whole
- Efficient use of input materials and high degree of recycling
- Technology intensity and a strategic focus on innovation

Electrical, electronics and instrument industries

- Provider of energy and resource efficiency technologies to industry and households
- Major global player in electrical and electronic goods: high levels of value added; largest consumer market in the world, one of the top exporters (Ecorys; 2011)
- Innovative: electrical, electronics and instrument industries are amongst top ten sectors of highest proportion of innovating companies per sector (over 60% based on 2010 data) (EC; 2013)
- Strong science base across sub-sectors of the computer, electronic and optical products sector
- Strong brands
- High purchasing power in home market potential for lead market and market for high end products

Mechanical Engineering industry:

- Relatively high manufacturing depth: in-house production is key; difficult outsourcing
- Innovative, so-called ‘enabler’: close links with both high-tech upstream industries and a broad range of client industries; key player in the transmission of basic inventions and innovations to improve energy efficiency and reduce damage to the environment. (Ecorys; 2012)
- Leading industry at the level of patent filings; world leader in technology
- Key supplier for many industries: the share of ME in total investment in machinery and equipment is well above 50%. In manufacturing, the industries’ refined petroleum, printing, metal products and other transport equipment are lower with around 30%. (Ecorys; 2012)
- Qualified workforce and strong industrial base; less prone to relocation

- Evolved towards the service-provider industry (e.g. training of operators, maintenance & repair): as such leading to higher productivity as well as reducing the exposure to low-cost competition
- Sophisticated division of labour between companies and complex value chain: ability to build on strong industrial clusters with a broad range of specialized companies supplying high performance parts, components and final products.(Ecorys; 2012)
- Not an energy-intensive sector; yet providing solutions for sustainable production
- Strong presence in global export: the 2010 share of EU deliveries on total ME imports was 50% and higher in case of MENA, Russia, Turkey, South Korea, India and Brazil. Significant increases in Chinese and Japanese markets penetration have been also noted. (Ecorys; 2012)

- H**ow are these advantages envisaged as changing over the next 10-15 years?**

Fabricated metals and metalworking industry

- Innovation is necessary to further increase productivity and reduce costs to face up to the effects of globalisation and stronger competition from upcoming economies like China and India. Also, innovation is needed in order to comply with certain regulations (mainly environmental or safety regulations). Regulations and global will remain the main drivers for innovation in the sector.

Electrical, electronics and instrument industries

- By 2020, it is predicted that automation, digital infrastructure, e-health, energy infrastructure, and security market will increase their market volume – measured in billion Euro – considerably (from 42% in automation to 227% in e-health). Yet, such growth will be dependent on regulation, economic and fiscal incentives, and attractive investment conditions in lively capital markets, a strengthened and deeper EU single market, harmonisation, standardisation, individual demand and public acceptance. (Electra; 2012)
- High value added products require strong design, creativity, product development competences at which European firms are good at. There are prevailing trends that have a high potential growth rates for many subsectors, such as digitalisation of production and consumption; energy and environmental policies driving changes in energy and industrial markets. (EC; 2009b)

Mechanical Engineering industry (Ecorys; 2012).

- The long-term prospects for the sector are positive, due to (i) increasing global demand for energy impacting the deliveries to power generation sector (conventional and alternative), and (ii) future global growth and the ongoing industrialization and urbanisation of the emerging economies. Other trends:
  - refurbishment of residential buildings will impact demand for taps, valves, pumps; interest in improving indoor climate will impact the demand for cooling and ventilation equipment
  - shift towards electric cars will require more gears and drives;
  - growth in cross-border trade and passenger traffic, which necessitates building new or expanding existing hubs, will yield growth in lifting, handling and storage equipment

  - interest in turf care, creation of green spaces, smart irrigation and protection of ecosystems will provide new opportunities for the garden, forestry and turf machinery
  - falling European demography, advanced infrastructure, and tight public budget constraints will negatively impact the growth prospects for the mining, quarrying and construction machinery in Europe
  - growth in machine tools will follow the growth in the aerospace, shipbuilding and automotive industries. The advancement of manufacturing systems to higher levels of precision (meso, micro, nano-machining) to cater the needs of electronics, computer and biomedical industries will bring further growth opportunities
  - traditional demand for textile machinery in developed world is dwindling in the light of competition from non-EU countries and relocation of large parts of the production process. This is being compensated by growth in technical textiles that are becoming more important.
- The free circulation of products in the Single Market has tightened competitive pressure on smaller manufacturing firms that have been specializing in niche markets. Numerous of these very small firms will evolve towards handicraft businesses in the long-run. Instead of manufacturing own products they will concentrate more on installation, services and repair.(Ecorys; 2012)

The global market size is estimated to grow steadily, going from €527bn in 2010 to €928bn in 2025. Even though all individual countries and the EU-27 are able to grow, China will be clearly dominating the world output of mechanical engineering products by 2025. (Ecorys; 2012)

A1.8.4.2 Threats

- **What are the main threats which currently impact on the sector?**

Fabricated metals and metalworking industry

- Dominated by SMEs: squeezed between large clients and large suppliers; difficult access to financial markets; more difficult to organise the sector and weak tradition of business cooperation (politically weak), lack of strong branding, single client/market dependency, limited capacity, resources and skills to engage in R&D activities
- So-called “invisible” sector: in many cases, sector’s products are not visible to end user, as they are embedded in other products
- Decreasing workforce and declining interest in natural science and engineering among young people
- Insufficient Intellectual Property Protection
- Vulnerable to changes in international competition such as competition from low-cost countries, infringement of IPR rights, and imitations.
- At risk of losing customer base in case of relocation of the sector's customers activities to Asia: the SME structure will be put under pressure since proximity to clients and customers is necessary and difficult to maintain for SMEs.
- High level of input material dependency increasing sensitivity to price fluctuations
- Hit twice by artificially high energy costs in the form of higher input prices and higher costs of manufacturing the metal itself

- Threatened by metal substitutes (e.g. plastic in packaging)

Electrical, electronics and instrument industries

- Rising competition from low-cost countries: China caught up EU export levels in 2009 (Ecorys; 2011)
- Availability of skilled workers, in particular engineers
- Obstructed access to Research & Development and its financing due to sectoral SME nature
- Counterfeiting, weak IPR enforcement
- Administrative burden obstructing companies' ability to innovate (instead of developing products resources are allocated to regulatory compliance; complex administrative procurement process hinder SMEs' participation in tenders)
- Trade barriers, e.g. China Compulsory Certification being a tedious, expensive and burdensome measure for European companies; discrepancies in standardisation
- Short development / product cycles increasing competitive pressures

Mechanical Engineering industry

- Aging workforce and decreasing interest in natural science and engineering among young people; competition for skilled engineers with automotive and aerospace industries
- Globalisation being a challenge to smaller enterprises: as contractors to larger companies they are required to meet foreign competitors' product prices, follow suit clients' activities in foreign countries and relocate production to better meet stricter cost requirements. For the latter two, high investment is necessary, which is not feasible for many small players (restricted access to finance, too high risks involved)
- Dependent on energy intensive industries such as steelworks, castings industry and others, which are subject to strict environmental legislation, which in turn impacts their investment behaviours
- Rising growth opportunities in emerging markets might lead to dismantling EU capacities and relocating production
- Vulnerable to changes in international competition such as competition from low-cost countries, infringement of IPR rights, and imitations.
- Lack of regulatory stability and predictability (Orgalime; 2012)
- Obstructed access to finance for SMEs; e.g. implementation of BASEL II rules requiring banks to hold substantially higher levels capital and liquidity in the short term

- **How are these envisaged as changing over the next 10-15 years?**

Engineering industry (encompassing analysed sectors):

- The industry is moving very fast towards the fourth industrial revolution, which will provide the jump to mass customisation, enabling industry to answer societal challenges with tailor made solutions. Europe has the necessary scientific knowledge and research competence for the change to a greener economy, but the path to innovative products requires more than that. Europe has in many technologies a clear scientific advantage, but the industries profiting from this research settled abroad, i.e. Europe is not attractive enough as a production place to bring such innovations to the market and the outflow of knowledge to rival economies becomes a real menace.(EESC; 2009)

Fabricated metals and metalworking industry

- In response to threat pose by metal substitutes being used by its supply chain clients; the metals sector has reacted by developing its own products with more advanced physical and technical properties. This type of innovation will have to continue.
- China is a seen as a significant competitiveness threat. Its ability to produce manufactured metal products at lower cost than most EU producers inevitably has direct implications for the demand of finished goods produced in the sector. Also, China indirectly affects the metalworking and metals sector due to the major foothold it has in world steel production and its access to raw materials.(Ecorys; 2009)
- The discrepancy between environmental legislation in Europe and emerging countries will be increasing; thus further distorting the level playing field. On the other hand, energy and climate regulations are a driver for innovation and development of new products. Similar effect has the globalisation which has motivated companies to specialise and innovate in order to prosper. The trend will continue. Innovation resulting in high value products and higher productivity is a way to reduce competition from low-cost producers outside EU.
- Price of raw materials will be rising due to increasing demand from emerging economies. This together with gradually increasing cost of energy will further put a pressure on SME’s profitability.
- The administrative burdens of providing authorities with the data required under local and EU regulation is already heavy and is tending to become worse. Also given the general investment climate in many countries, it is increasingly easier for companies to purchase part of their products abroad, rather than to increase production. (Orgalime; 2007)

Electrical, electronics and instrument industries

- There has been a severe contraction of the EUs position as a location for the manufacturing of consumer electronics goods, and significant relocation within the EU (and further) of production activities. These developments are a reflection of the strong growth in the importance of emerging South East Asian countries and the rapid development of China as global suppliers of electrical and electronics goods. Not least, the rise of these countries as the main locations for the manufacture of consumer electronics goods has been accompanied by a virtual withdrawal of more developed regions from substantial manufacturing activities. (Ecorys; 2011)
- EC (2009) argues that EU climate and energy policies should be seen as an opportunity for the sector to develop new businesses, new industries and new jobs.
- Shortening of product life cycles leading to a higher production volume that will lead to either more employment, or a productivity increase of employees (working better, smarter, longer or harder). (EC; 2009b)
- Outsourcing and off-shoring of manufacturing activities will impact levels and composition of employment as manufacturing moves to low(er) wage countries and to emerging markets; the skills need will shift towards managing outsourcing / offshoring; as well as towards abilities / skills to work in (national and international) value networks

- Globalisation will continue to play a major role in this sector, along fierce international competition.

Mechanical Engineering industry

- ME has become an industry with a strongly growing share of services over the past decades (i.e. provision of products together with their installation, set-up and training of operators). Such trends will continue, as it allows companies to build comparative advantage and reduce price competition with emerging players. (Ecorys; 2012)
- One of the major threats for the European manufacturers lies in their distance to emerging markets with high growth potentials. Proximity to clients is an important factor for innovation, the development of new solutions and customized systems in this sector. As a consequence, manufacturers serving these markets have to go beyond product exports and offer pre- and after-sales services. (Ecorys; 2012)

A1.8.4.3 Business strategy and decision making

Fabricated metals and metalworking industry

- Collaboration with vocational colleges and tertiary institutions is essential to attract an adequate supply of well-trained professionals in the medium to long term. Best practices of drawing and retaining high-skilled people, from and out of Europe, should be identified and disseminated. (Ecorys; 2009).
- Heavy investment in R&D (machinery and training) is needed. This should go in pair with funding and increased access including knowledge about existing financing regimes. Innovation is necessary to further increase productivity and reduce costs to effectively address risks posed by globalisation and stronger competition from upcoming economies like China and India.
- Enforcement of intellectual property rights protection is therefore crucial for the ability to reap the profits from R&D and to further stimulate it.
- Strategic opportunities have been identified in: increased consolidation, improved market surveillance to support enforcement of regulation; increased competitiveness through a modern IPR system; higher energy efficiency solutions; better products/services through enabling technologies, and innovation networks and collaboration. (Ecorys; 2009)
- A trade policy with few or no barriers to trade, in particular one that ensures reliable and timely supplies of steel at competitive market conditions is in the interest of our sector.

Electrical, electronics and instrument industries

- In 2008, the first Electra (2008) report was issued, focusing on developing an industrial policy framework for growth and jobs in the electrical and electronics industries, as well as providing industry's response to a number of policy issues in the EU that affect the electrical and electronics engineering sector. It describes how the sector can contribute to more sustainable Europe. 20 key recommendations have been listed to be undertaken at the EU, Member State and sector level (regulatory, financial and institutional needs). The progress was assessed in the Electra II report: in all cases work has been ongoing, with "ensuring stable and predictable regulatory framework conditions" proving to be the biggest challenge (Electra; 2012).
- Necessary changes in the framework conditions in the internal market include: simplifying regulatory requirements; improving EU educational and engineering base; stimulating investments in EU electrical and electronics application markets; supporting

entrepreneurship; liberalising infrastructure markets; strengthening the capital markets; transferring technology to EU markets more rapidly. (Electra; 2008)

- European research funding should be linked more to the industrial needs, involving companies at an early stage of the innovative process and supporting the creative engineering in SMEs in order to bring easier and faster new ideas to new products. Clusters joining manufacturing companies and research structures should be promoted and supported. (EESC; 2013)

Mechanical Engineering industry

- In 2007, the EC report identified major challenges which would affect the European ME sector to 2015. These included:
  - Creating a strategic industrial and technological base, including a better regulatory framework for competition and technology transfer;
  - Improving access to export markets, including IPR issues;
  - Ensuring employment and top class technical education to satisfy the need for skilled staff;
  - Boosting research and innovation.

  To address effectively these challenges, policy recommendations have been drawn up for European institutions, Member States and stakeholders of the industry.

  Similar findings have been reiterated by Orgalime in 2012.

- For the European ME sector maintaining its position and potential as one of the major economic and political forces in the world, there is a need to a develop a vision for a strong European manufacturing base in those technologies that will provide growth and jobs in the future, rather than on supporting sectors, which will, due to the process of globalisation or to policies developed at the level of the EU (e.g. energy policy), inevitably become redundant. (EC; 2007)
- The sectoral competitiveness study assumes three growth scenarios for the European ME sector (Ecorys; 2012):
  - Baseline scenario: ME growth only linked to economic prospects, GDP
  - Trade scenario: 60% of the ME’s growth is generated domestically, whereas one third is generated by increased demand of the world market

Figure A1.89 Historical and projected growth rates for the ME

	Value added in bn. €					
	2000	2005	2010	2015[1)]	2020[2)]	2025[2)]
EU27	158.0	160.8	157.5	178.3	193.2	204.7
EU27 with trade				183.5	208.4	232.0

[1)] Based on GDP forecasts from IMF; [2)] Based on GDP forecasts from Goldman Sachs

	Share of value added in %[1)]					
	2000	2005	2010	2015	2020	2025
EU27 with trade	37.0%	34.0%	29.9%	26.6%	24.2%	22.0%
EU27 with trade	37.0%	34.0%	29.9%	27.2%	25.6%	24.3%

1) GVA in focal country divided by GVA of all analysed countries

Source: Ecorys, 2012

A1.8.4.4 Mitigation activities

- According to the EC research, machinery branches were amongst industrial sectors that achieved largest energy improvements between 1990 and 2010. The Energy Efficiency Index (ODEX) dropped by 31%. (Odysee; 2013)
- Energy consumption in the machinery industry was about 25MToe in 1990; dropped to 20MToe in 2000, and slightly rose in 2010 (Odysee; 2013). Electricity's share is around 50%. Machinery had the lowest intensity level (energy/value added) amongst industrial sectors in 2008. In 2009 and 2010 the industry increased its energy intensity by 4% and 10% respectively. (Odysee; 2012)
- Karampoutakis (2008) estimated energy use and carbon dioxide emissions in EU industry to 2030, assuming increasing costs for emitting carbon dioxide, in three scenarios: baseline, medium carbon cost, and high carbon cost. Under the baseline scenario, equipment goods sector (covering NACE codes 25-30) showed positive trend – increase of 14.9% in CO_2 emissions by 2020.
- Below further information on the Machinery industry sectors performance is provided, where available.

Fabricated metals and metalworking industry

- Some energy saving measures are well-known. But there is no budget for SMEs to implement the measures. Their budgets are needed for major investments in new products and manufacturing technologies. The return on investment is too low or payback periods are too long. Energy efficiency requires very often long-term investments and continuing improvements. (Ecorys; 2009)
- In some cases long-term power-supply contracts avoid energy savings (the delivered quantity shall not exceed or fall short of the ordered quantity). SME do have a little negotiating power to change power-supply contracts.(Ecorys; 2009)
- The UK study estimated that the UK metalforming sector has a potential of reducing its energy consumption by 20% compared to its current levels. The main opportunities include changes to core processes such as further uptake of heat recovery, induction

heating, and servo drives, as well as good practice energy management measures such as monitoring and targeting, optimisation of compressed air and behaviour change. (Carbon Trust; 2011) Annex 1 presents the summary for core and non-core process opportunities.

<u>Electrical, electronics and instrument industries</u>

- Carbon Trust (2011b) reports that the UK microelectronics subsector proactively implements energy saving measures. An energy reduction of 69.3% has been achieved in the sector over the last 10 years. Further 15% can be found through innovative solutions. Annex 2 presents the summary for process and facilities opportunities.

A1.8.5 Projection of energy consumption trend

Metal working and metal articles industry

The industry continues to play a crucial role in the supply chain between producers of raw material and manufacturing of finished goods due to the sectors flexibility and consolidated resource sharing effort. The relationship between this sector and its customers is expected to improve as the manufacturing sector is competing on providing high value goods as opposed to just cost alone. Due to the relatively weak representation of SMEs, innovation within the sector is limited but is expected to improve as policy makers develop a stronger approach to support EU SMEs. However, the industry is facing a shortage of highly skilled workforce due to the sector's visibility in comparison with other industry despite strong continued effort in engaging with education institutes.

Electrical and electronic production

In the near term, the EU will maintain its lead as a provider of electrical and electronic goods. The electrical goods production has seen a steady increase between 2000 – 2008, and will remain competitive in the long run. EU companies will continue to produce high value chain items within the EU, while assembling or manufacturing of final product shifted abroad. However, the prevailing threats of low-cost countries, lack of innovation and extra-EU trade restrictions poses a negative impact on the growth. The EU electronic goods sectors currently lagging behind US and Japan. The sector will lose further market ground to China, Japan and South Korea. EU energy policies continues to play a crucial role in driving moderate innovation for the electrical goods sector but will have less impact on the electronic goods sector where energy efficiency is much less of a concern. Overall, the electrical goods sector will see modest growth while the electronic sector's growth will stagnate or decline.

Machinery and equipment production

EU's machinery and equipment trade will continue to perform well in the international trades (despite higher cost structure) due to growing Asian demands and higher trends of EU machinery exports. Structural reforms (mergers and acquisitions) within the sector continues to strengthen the sector's turnkey offering, increasing share of engineering services provision further to increase in product trade. EU will also continue to its technological and innovation effort and dominance against competing US and Japanese market. However, the price competitiveness remains weak as EU wages will continue to rise and the sector's employment trend continues to decline, forcing further consolidation within the sector.

Figure A1.90 provides a comparison of EU GDP trend vs. the EU machinery sector's turnover over the period of 2006 – 2012. We can observe a direct correlation between the sector's turnover and EU GDP. Given the sector's retaining strength within the internal EU market, the sector is expected to grow in direct correlation to the projected GDP growth. Assuming this correlation is consistent, Figure A1.91 provides a projection of EU's machinery sector turnover based on the Commission's projected GDP trends to 2050 [EC, 2013].

Figure A1.90 EU GDP trend vs. machinery sector turnover from 2006 - 2012

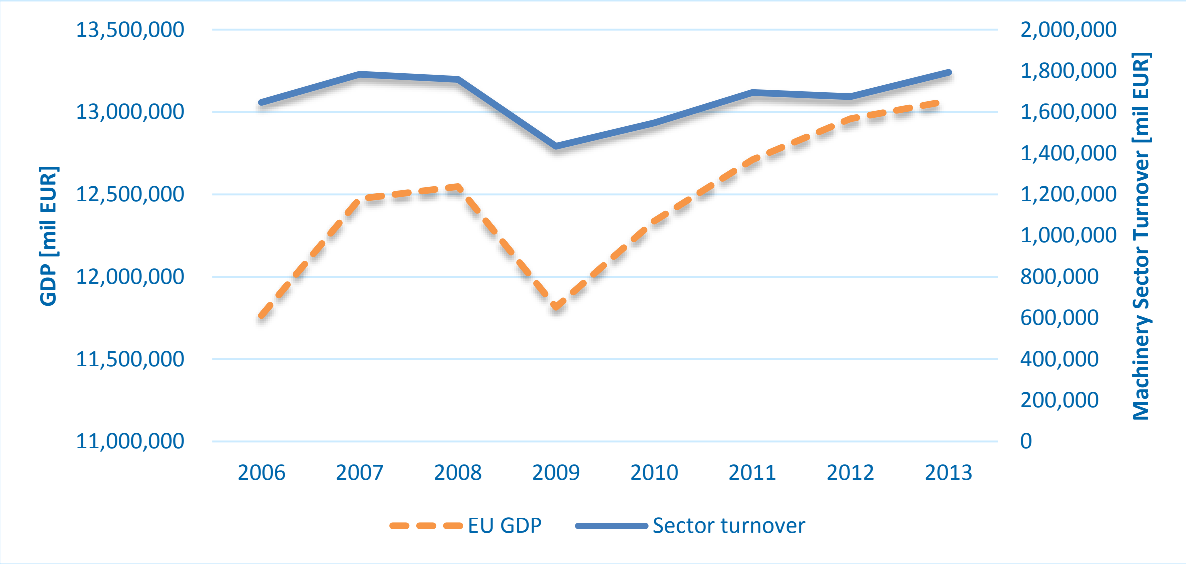
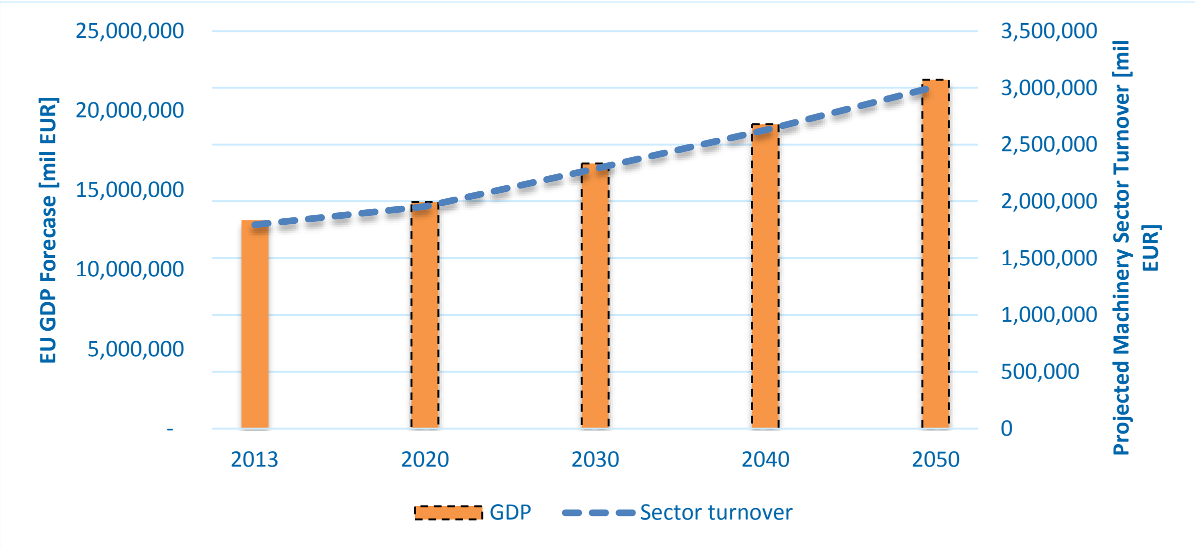
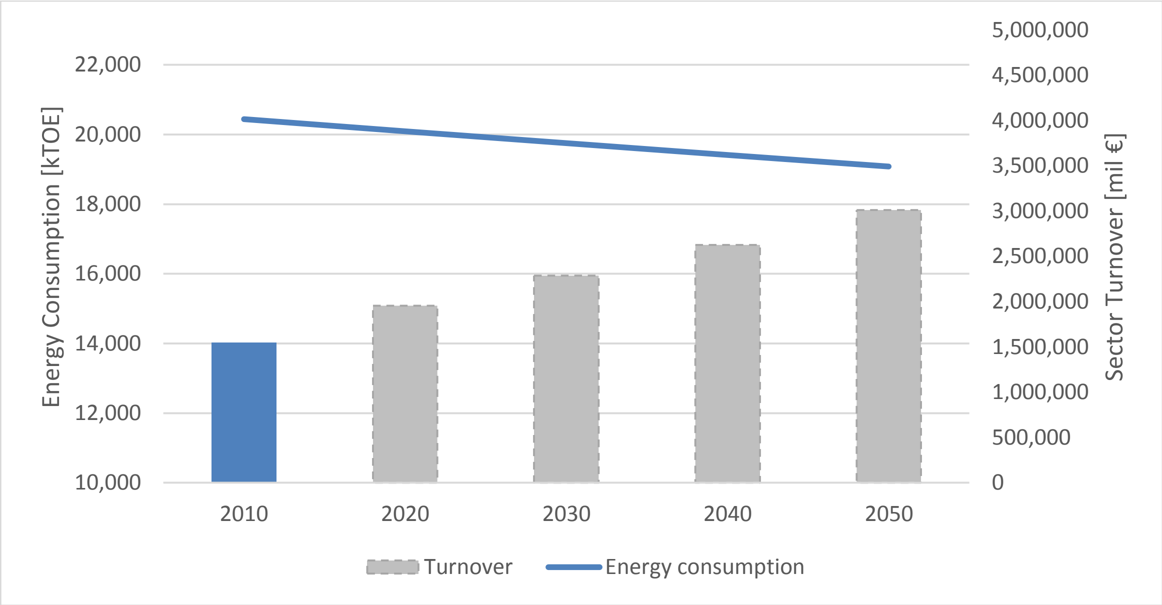


Figure A1.91 Projected EU machinery sector turnover trend vs. EU GDP



In general, the machinery sector is a non-energy intensive sector in comparison with other manufacturing sectors. The sector's year-on-year energy consumption trend fluctuated tremendously from 1995 - 2012. This is primarily due to the wide range of product scope within the sector, in which the specific energy intensity and energy consumption is fully dependent on the product output type and the associated processes in manufacturing the finished product to the specification as dictated by the consuming market on the specific year. However, the longer term linear trend line indicates that energy consumption has reduced by 2.9% despite an increase of 85% in EU GDP over the same 17-year period. The sector requires constant change in their production process in responding to evolving consumer demands and technological trends, presenting opportunities for constant improvement of its manufacturing process through uptake of existing or emerging technologies. However, it may also be likely that newer product specification could demand higher energy requirements. On the balance of the above factors, the energy consumption will remain volatile on a year-on-year basis, however it is expected that the sector will continue with its strong reduction trend in energy intensity in the longer term, resulting in a relatively flat energy consumption trend as production continues to increase as illustrated in Figure A1.92

Figure A1.92 Projected BAU energy consumption trend for machinery sector



Annex 2 Evaluation of energy price projection methodologies

<table>
<tr><td>Report Name</td><td>European Commission (2014) Commission Staff Working Document: Energy Prices and Costs report (accompanying document) SWD 20final/2 available at: http://ec.europa.eu/energy/doc/2030/20140122_swd_prices.pdf [accessed on 08.10.14]</td></tr>
<tr><td>Projection years</td><td>Oil and Gas until 2025
Electricity until 2050</td></tr>
<tr><td>Model used</td><td>Primes 2013 (for EU)
Prometheus (world)
GEM-E3 Model (comparative analysis for alternative scenarios)</td></tr>
<tr><td>Fossil Fuel Prices projected</td><td>International fossil fuel price in reference scenario (prices are average import prices to the EU, not world average)

<table>
<tr><th></th><th>2010</th><th>2015</th><th>2020</th><th>2025</th></tr>
<tr><td>Oil</td><td>100</td><td>103</td><td>137</td><td>168</td></tr>
<tr><td>Gas</td><td>100</td><td>100</td><td>123</td><td>145</td></tr>
</table>

Average EU electricity price in the Reference scenario

<table>
<tr><th>Annual growth rates</th><th>2011-2020</th><th>2021-2030</th><th>2031-2050</th></tr>
<tr><td>Average end-consumer prices</td><td>2.76%</td><td>-0.04%</td><td>-0.09%</td></tr>
<tr><td>Electricity generation costs</td><td>2.40%</td><td>-0.17%</td><td>-0.19%</td></tr>
<tr><td>of which fuel costs</td><td>1.36%</td><td>-0.78%</td><td>-0.49%</td></tr>
<tr><td>Grid and supply costs</td><td>2.35%</td><td>1.01%</td><td>0.57%</td></tr>
<tr><td>Taxation and ETS costs</td><td>22.02%</td><td>7.86%</td><td>0.93%</td></tr>
<tr><td>Recovery of RES support</td><td>22.57%</td><td>-4.70%</td><td>-23.45%</td></tr>
</table>

Source: GEM-E3 and PRIMES

The price of electricity is calculated on the basis of generation costs, the recovery of investment expenditures in grid infrastructure, the costs of renewable support schemes, the ETS auction payments and the applicable taxes. In the reference scenario electricity prices are shown to increase mainly until 2020 as a consequence of rising gas prices, assumed in the reference scenario context and the increased costs for renewables.</td></tr>
<tr><td>Industrial growth assumptions</td><td>The GEM-E3 reference scenario is consistent with the PRIMES 2013 reference scenario for the EU. The growth and activity projections by sector and by EU Member-State are identical to the growth assumptions driving energy projections in the PRIMES 2013 reference scenario and the energy-related (consumption, electricity generation mix, prices) projections using the GEM-E3 model have been calibrated so as to be very close to energy projections of PRIMES 2013 reference scenario. The reference scenario projects a restructuring of the EU economy towards higher shares of services in the future and a shift towards higher value added and less resource intensive production. Energy intensive industries, which are mostly depending on energy costs, represent a small share in total value added (4% in 2010) which is projected to further decrease over time.

EU28 trade balance (exports - imports) in commodities and services</td></tr>
</table>

Trade Balance (in b$ 2010)	2010	2015	2020	2025
Metals	-48	-8	-9	-19
Chemicals	73	139	172	186
Non Metallic Minerals	-6	-7	-6	-8
Paper and Pulp	18	10	12	17

Source: GEM-E3

Policy assumptions

Primes assumes:
full achievement of EU objectives (2020 policy package)
implementation of current legislation including the Energy Efficiency Directive
full implementation of the ETS Directive.
In this policy context the Reference scenario projects increasing electricity prices in the EU until 2020 relative to 2010 levels and full stabilization of prices after 2020.

Macroeconomic assumptions

Over the 2015-2050 time period the EU28 GDP is projected to grow annually by 1.5% on average. This rate is lower than the average world GDP growth rate which is 2.6% for the same time period. The projection is consistent with Ageing Report 2012 projection in the long term and with DG ECFIN short term projections as available in early 2013.

EU28 GDP growth and components in the Reference scenario

EU 28	b$2010			Annual % changes		
	2010	2020	2025	2020	2025	2010-2025
Gross Domestic Product	16259	19169	20758	1.7	1.6	1.6
Investment	3178	3791	4111	1.8	1.6	1.7
Public Consumption	3421	3906	4235	1.3	1.6	1.4
Private Consumption	9463	11191	12114	1.7	1.6	1.7
Trade Balance (% of GDP)	1.2%	1.5%	1.4%			

Source: GEM-E3

Population
Labour force and unemployment rate projections have been based on the Ageing report 2012 of DG ECFIN for EU member states.

Report Name	**DECC (2014) Fossil Fuel Price Projections available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/360598/DECC_2014_fossil_fuel_price_projections.pdf [accessed on 08.10.14]**
Projection years	Oil, Coal and Gas up to 2035
Model used	Methodology for each projection is outlined under ‘Assumptions and methodology section’.
Fossil Fuel Prices projected	See attachment DECC_2014_fossil_fuel_price_projections
Assumptions and methodology	**Oil** ■ Central scenario starting price: The starting price is based on the Brent futures curve for 2014 (the average of the twelve monthly contracts covering the next 12 months averaged across the first three trading days in January 2014). ■ Between 2015 and 2020 the central scenario is an average of 11 expert external projections (IEA, EIA, WoodMac and 8 financial institutions). ■ beyond 2020 DECC were guided by the long term projections for the oil price of the IEA and the EIA. The long term is taken as 2035 for these projections. The projection for years between 2020 and 2035 is then interpolated (using a constant compound growth rate). **Gas** ■ The projections for 2014 and 2015 are based respectively on an average of spot National Balancing Point (NBP) prices and NBP forward prices observed in 2014. ■ From 2016-2019 prices are an average of a basket of six external expert projections (Three of the six project from 2014 to -2030: Wood Mackenzie, IHS CERA, National Grid. The other three, projections from three financial institutions sourced through Bloomberg, project from 2014 to 2017.) for NBP prices. These projections are consistent with a medium term outlook of downward pressure on global gas markets in the second half of this decade as large sources of liquefied natural gas (LNG) supply are due to come online during this period, increasing global LNG capacity by up to 45%. ■ The long-run (2025 onwards) price projection is anchored against the cost of LNG exported from the US. This reflects the likelihood of substantial US LNG exports over that horizon. DECC expects that these volumes will provide a check to incumbent suppliers at the margin, and thus the cost of US gas can be used as a price reference. For this reason DECC have linked GB prices to US prices (Henry Hub) from 2025, adding a margin to allow for costs (liquefaction, transport and regasification) required to ship US gas to the GB system. ■ Estimates of the long run cost of US LNG exports are higher than the average of external forecasts for NBP for 2019. With robust global demand growth the market is likely to tighten with global gas prices rising to provide sufficient incentive for further large scale LNG investment. The timescale over which this happens is uncertain and during the interval 2020-2024 DECC have interpolated between the price projection for 2019 (the last year in which external projections are used) and the 2025 price projection. ■ Beyond 2030 the ability to project market developments significantly diminishes, hence DECC flat-line from 2030-2035 to indicate this level of uncertainty.

Report Name	DECC (2014) Fossil Fuel Price Projections available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/360598/DECC_2014_fossil_fuel_price_projections.pdf [accessed on 08.10.14]
	Coal ■ The price in 2014 is based on a weighted average of spot prices and forward prices. The prices in 2014-2017 are based on CIF ARA[291] forward prices as observed in 2014. Prices were linearly interpolated in 2018 and 2019. ■ A long run marginal cost (LRMC) approach was used to calculate the central estimate in 2020. The LRMC of coal imports into NW Europe from different coal-producing countries was calculated by adding the cash cost for FOB (free on board) coal exports from each country, freight rates from each country to NW Europe and an assumed margin covering capital costs. ■ A supply curve was generated using this data which was then compared to import demand for coal in the IEA New Policies Scenario. This comparison showed that in order to satisfy import demand into Europe, the marginal unit of coal would be imported from Russia. Therefore the central estimate in 2020 is calculated as the sum of the average cost of coal produced in Russia, freight rate from Russia to NW Europe and a margin covering capital cost. Data on cash costs for coal exports and coal import demand into Europe was taken from the IEA World Energy outlook (WEO) 2013. ■ A 1% real growth rate was applied on coal prices beyond 2020. The use of a non-zero growth rate beyond 2020 reflects the expectations of external forecasters such as IEA, EIA Wood-Mackenzie. The three external sources assume upward sloping trajectories for coal prices beyond 2020 as the current oversupply in the market is expected to be absorbed over the next few years, with demand for coal increasing in the Pacific basin.

[291] Method of selling coal i.e. cost insurance freight basis to major coal importing ports in northwest Europe - Antwerp/Rotterdam/Amsterdam.

Report Name	IEA (2012) World Energy Outlook 2012
Projection years	Fossil fuels (coal, oil and natural gas) up to 2035
Model used	IEA's World Energy Model (WEM)
Fossil Fuel Prices projected	These end-use prices take into account local market conditions, including taxes, excise duties, CO_2 emissions penalties and pricing, as well as any subsidies for fossil fuels and/or renewables. The rates of value-added taxes and excise duties on fuels are assumed to remain unchanged throughout the projection period, except where future tax changes have already been adopted or are planned.

Fossil-fuel import price assumptions by scenario (dollars per unit)

	Current policies scenario				
	2015	**2020**	**2025**	**2030**	**2035**
Europe imports (Real term 2011 prices, MBtu)	11.2	12.1	12.9	13.4	13.7
Europe imports (Nominal Terms, MBtu)	12.3	14.9	17.7	20.6	23.6

Note: Gas prices are weighted averages expressed on a gross calorific-value basis. All prices are for bulk supplies exclusive of tax. The US price reflects the wholesale

price prevailing on the domestic market. Nominal prices assume inflation of 2.3% per year from 2011.

Industrial growth assumptions	**Technology** Projections are sensitive to assumptions about how quickly existing and new technologies will be deployed and fully used. These assumptions vary by fuel, end-use sector, location and scenario, and are based on an assessment of the current stage of technological development, how far the optimal scope for deployment will be realised and the potential for further gains, as well as our analysis of how effectively different policy assumptions will drive technological advances. While no breakthrough technologies are deployed in any of the scenarios, we assume that technologies that are in use today or are approaching the commercialisation phase will achieve further cost reductions as a result of increased learning and deployment. On the supply side, exploration and production techniques are also expected to improve, which could lower unit production costs and open up new opportunities for developing resources.
Policy assumptions	The current policy scenario takes into account the effects of only those government policies and measures that had been enacted or adopted by mid-2012. Without implying that total inaction is probable, it does not take into account any possible, potential or even likely future policy actions. Current Policies Scenario, only the existing and the planned programmes (e.g. EU ETS) are taken into consideration. The price of CO2 is assumed to rise under each programme over the projection period; in Europe it increases from an average of \$19/tonne in 2011 to \$30/tonne (in year-2011 dollars) in 2020 and \$45/tonne in 2035 **CO2 price assumptions in selected regions and countries by scenario (\$2011 per tonne)**

Report Name	IEA (2012) World Energy Outlook 2012
	Current policy scenario — **Region:** European Union; **Sectors:** Power, industry and aviation; **2020:** 30; **2030:** 40; **2035:** 45
Macroeconomic assumptions	see below

Current policy scenario	**Region**	**Sectors**	**2020**	**2030**	**2035**
	European Union	Power, industry and aviation	30	40	45

Real GDP growth assumptions

	Compound average annual growth rate			
	1990-2010	2010-15	2010-20	2010-35
European Union	1.8%	1.3%	1.7%	1.8%

Sources: IMF (2012b); OECD (2012); Economist Intelligence Unit and World Bank databases; IEA databases and analysis.

Population growth

Population assumptions

	Population growth			Population (million)		Urbanization rate	
	2010-20	2020-35	2010-35	2010	2035	2010	2035
European Union	0.2%	0.1%	0.1%	502	518	74%	81%

Sources: UNPD and World Bank databases; IEA databases.

Annex 3 ICF Industrial Energy Efficiency Database (IEED)

A3.1 Generic improvement Energy Saving Opportunities

Table A3.1 List of generic improvement opportunities categorised by end use

End Use	Generic Energy Efficiency Improvement Opportunity Description
Chillers & Compressors	High Efficiency Chiller
	Optimized Distribution System
	Floating Head Pressure Controls
	Premium Efficiency Refrigeration Control System
	Optimized Chilled Water Temperature and/or Optimized Condenser Temperature
	Preventative Refrigeration/Cooling System Maintenance
	Optimized Condenser Pressure
	VSD on Chiller Compressor
Compressor for Pneumatic Systems	Premium efficiency ASD compressor
	Optimized Distribution System
	Minimize operating air pressure
	Optimized sizing of compressor system
	Optimized sizes of air receiver tanks
	Compressor heat recovery
	Premium Efficiency Air Dryer (compressors)
	Replace compressed air use with mechanical or electrical
	Sequencing Control
	Eliminate air leaks
	Preventative Compressor Maintenance
	Synchronous Belts for Air Compressors
Compressor for Process Air or Gas System	Premium efficiency ASD compressor
	Compression ratio optimization (gas compressor)
	Retrofit inernal parts of existing centrifugal compressors
	Gas compressor right sizing
	Volume pocket adjustments
	Minimum cylinder clearance
	Compressor heat recovery

End Use	Generic Energy Efficiency Improvement Opportunity Description
	Preventative Compressor Maintenance
	Synchronous Belts for Air or Gas Compressors
Indirect Heating (Boilers)	Boiler right sizing
	Boiler load management
	Advanced boiler controls
	High Efficiency Burner
	Economizer
	Process Heat Recovery to Preheat Makeup Water
	Boiler combustion air preheat
	Blowdown Heat Recovery
	Automated Blowdown Control
	Condensate Return
	Steam Trap Survey and Repair
	Minimize Deaerator Vent Losses
	Boiler Water Treatment
	Insulation
	Preventative Boiler Maintenance
	Steam Trap Survey and Repair (imported steam)
	Condensate Recovery (imported steam)
	Efficient Boiler System
	Flue gas monitoring (boiler)
	Heat exchanger maintenance
	Heat exchanger optimization
Direct Heating (Ovens/Kilns/Dryers/Furnaces)	High Efficiency Burner (Dryer)
	Air Curtains (Dryer)
	Exhaust Gas Heat Recovery (Dryer)
	Insulation (Dryer)
	Advanced Heating and Process Control (Dryer)
	Combustion Optimization (Dryer)
	Preventative Dryer Maintenance
	Preventative Furnace Maintenance

End Use	Generic Energy Efficiency Improvement Opportunity Description
	High Efficiency Burner (Furnace)
	Exhaust Gas Heat Recovery (Furnace)
	Insulation (Furnace)
	Advanced Heating and Process Control (Furnace)
	Combustion Optimization (Furnace)
	Preventative Kiln Maintenance
	High Efficiency Burner (Kiln)
	Exhaust Gas Heat Recovery (Kiln)
	Insulation (Kiln)
	Advanced Heating and Process Control (Kiln)
	Combustion Optimization (Kiln)
	High Efficiency Burner (Oven)
	Air Curtains (Oven)
	Exhaust Gas Heat Recovery (Oven)
	Insulation (Oven)
	Advanced Heating and Process Control (Oven)
	Combustion Optimization (Oven)
	Preventative Oven Maintenance
	Flue gas monitoring (Dryer)
	Flue gas monitoring (Furnace)
	Flue gas monitoring (Kiln)
	Flue gas monitoring (Oven)
Pumps	High/Premium Efficiency Motors (Pumps)
	Impeller Trimming (Pump)
	Optimization of Pumping System
	Premium Efficiency Control with ASDs (Pumps)
	Preventative Pump Maintenance
Fans / Blowers	High/Premium Efficiency Motors (Fans)
	Impeller Trimming or Inlet Guide Vanes
	Optimized duct design to improve efficiency
	Premium efficiency control, with ASD (Fans)

End Use	Generic Energy Efficiency Improvement Opportunity Description
	Synchronous Belts (Fans)
	Preventative Fan Maintenance
Motors / Other	Premium Efficiency Control with ASDs (Other motors)
Machine Drive	High/Premium Efficiency Motors
	Correctly sized motors
	Optimized motor control
	Synchronous Belts
	Preventative Motor Maintenance
Ventilation	Ventilation Optimization
	Premium Efficiency Ventilation Control With VSD
	Demand-Controlled Ventilation
Packaged HVAC	Seasonal Temperature Settings Adjustments
	Ventilation Heat Recovery
	Automated Temperature Control
	Reduced Temperature Settings
	Destratification Fans
	Warehouse Loading Dock Seals
	Air Curtains
	Preventative Packaged HVAC Maintenance
Lighting	High Efficiency Light fixtures
	Efficient Lighting Design
	Lighting Controls: On/Off Timer Settings
	Lighting Controls: Occupancy Sensors
	Lighting Control According To Zones
System	Sub-Metering and Interval Metering
	Integrated control system
	HE Dry-Type Transformers
	Power Factor Correction
	Electricity demand management control system
	Process Integration and Pinch Analysis
	Implementation of Management Best Practices to Support Energy Efficiency

A3.2 Sector specific Energy Saving Opportunities

Table A3.2 List of sector specific improvement opportunities

End Use	Sector Specific Energy Efficiency Opportunity Description
Iron and Steel	State-of-the-Art Power Plant
	Coke Dry Quenching (CDQ)
	BOF Waste Heat and Gas Recovery
	Continuous Casting
	Scrap Pre-Heating
	Sinter Plant Waste Heat Recovery
	Optimized Sinter Pellet Ratio (Iron Ore)
	Top Gas Recovery Turbine (TRT)
	Stove Waste Gas Heat Recovery
	State-of-the-Art Power Plant
Non-Ferrous Metal	Optimized Heating Operating Practices
	Waste Heat Recovery for Pre-heating (Combustion Air and Charge Material)
	Waste Heat Boiler for Power Generation
	Low Temperature Waste Heat Recovery
	Oxygen Enrichment of Combustion Air
	Recovery and Combustion of Carbon Monoxide
	Separate Drying of Concentrates
	Selection of Optimal Furnace Design
	Improvements to Alumina production from Bauxite
	Prevention and Minimization of Salt Slag
	Use Clean Scrap
	Increased Recycling
	Inert Anode Technology (Emerging)
Chemical and Petrochemical	Distillation columns operational optimization
	Distillation column improved controls
	Improved EE of existing distilation column with retrofit
	Improved distillation column design
	Optimised heating in distallation column and pre-heating feed
	Improved reactor design

End Use	Sector Specific Energy Efficiency Opportunity Description
	Improved Catalysts
	Optimised heating in furnace (cracking) and pre-heating feed
	CHP for Electricity Generation
	Process optimisation and improved process design
	Waste heat recovery
	Advanced Process Operation
	Membranes and other Pharmaceutical Process Developments
	Novel Separation Processes (Emerging)
	Improved Naptha Cracking Technologies (Emerging)
	More Efficient Low Grade Waste Heat Recovery Technologies (Emerging)
	Inter-plant Process Integration
Non-Metallic Mineral	Replacement of furnace/kiln/dryer with Optimized Design
	Retrofit of furnace/kiln/dryer to Improve Design (Wet to Semi-dry process)
	Increasing Number of Preheater Stages in Rotary Kilns
	Recovery of excess heat from kilns cooling zone for Increased Preheating (Other than Rotary Kilns)
	Conversion to Reciprocating Grate Cooler for Clinker Making in Rotary Kilns
	Using high efficiency equipment for grinding and other electrical uses
	Fuel subsititution for more efficient thermal energy consumption
	Low Temperature Heat Recovery for Power Generation
	Use of increasing levels of cullet for Glassmaking
	Improved Materials (Substitutes) and Product Design for more Efficient Manufacturing
	Advanced Oxyfuel Combustion Technologies (Emerging)
	Smart Design and Clustering of Manufacturing Facilities
Food, Beverage and Tobacco	Increased Combined Heat and Power (CHP)
	Adsorption Chillers and Trigeneration to Meet Cooling Requirements
	Fuel switching, subsititution, and combustion of waste gases
	Optimized Facility Operating Procedures
	Optimization of Operating Practices for Cooking and Baking
	Optimization of Operating Practices for Distillation, drying and evaporation
	Optimization of Operating Practices for Refrigeration

End Use	Sector Specific Energy Efficiency Opportunity Description
	Improved Mechanical Equipment Efficiency
	Improved Cleaning, Washing, and Sterilizing Equipment Efficiency
	Contact Dryer for Improved Drying Efficiency
Pulp, Paper and Print	TMP Refiner Heat Recovery
	Efficient TMP refiner and pre-treatment
	Efficient Screening of Recovered Fibers
	Paper Process Heat Recovery and Integration
	Paper Drying Section Shoe Press
	Efficient Paper Process Refiners
	Energy efficient vacuum systems for dewatering.
	Thermo Compressors
	Combined Heat and Power
	Heat recovery for the biomass and sludge drying process
	Heat recovery from radial blowers used in vacuum systems
	High Efficiency Grinding (GW) for Mechanical Pulp
	Enzymatic Pre-treatment for TMP Refiner
	Black Liquor Gasification
Machinery	High Efficiency Process Equipment (Electrical)
	Implement Lean Manufacturing System
	Optimized Process Re-Design
	Optimized Techniques for Efficient Equipment Operation
	High Efficiency Process Equipment (Thermal)
Petroleum Refineries	Distillation columns operational optimization
	Improved EE of existing distillation column with retrofit
	Advanced Distillation Column Designs
	Heat Integration and Waste Heat Recovery
	CHP for Electricity Generation
	Integrated Gasification Combined Cycle (IGCC)
	Power recovery using backpressure turbogenerator
	Advanced (Predictive) Process and Maintenance Control Systems
	Inter-plant Process Integration

End Use	Sector Specific Energy Efficiency Opportunity Description
	Cogeneration using gas turbine exhaust gas as combustion air for heating furnace
	Progressive crude distillation
	Fouling mitigation in the crude distillation preheat train and fired heater
	Catalytic Reforming: replace horizontal feed/effluent heat exchangers with vertical plate and frame exchanger
	More Efficient Low Grade Waste Heat Recovery Technologies (Emerging)
	Improved Water Treatment System Operation and Design
	Improved Catalysts (Emerging)
	Novel Hydrogen Production Technologies (Emerging)
	Novel Desulphurization Technologies (Emerging)

Source: ICF

Annex 4 Energy Saving Opportunities in the economic scenarios

A4.1 Pulp and Paper

Opportunities	2-yr. Payback	5-yr. Payback
Advanced boiler controls		x
Advanced Heating and Process Control (Dryer)	x	x
Air Curtains	x	x
Air Curtains (Dryer)	x	x
Automated Temperature Control	x	x
Blowdown Heat Recovery		x
Boiler combustion air preheat		x
Boiler load management	x	x
Combustion Optimization (Dryer)	x	x
Condensate Recovery (imported steam)		x
Demand-Controlled Ventilation	x	x
Destratification Fans	x	x
Economizer	x	x
Efficient Boiler System	x	x
Eliminate air leaks	x	x
Exhaust Gas Heat Recovery (Dryer)	x	x
Floating head pressure controls	x	x
Flue gas monitoring (boiler)	x	x
Flue gas monitoring (Dryer)	x	x
HE Dry-Type Transformers	x	x
Heat recovery for the biomass and sludge drying process	x	x
Heat recovery from radial blowers used in vacuum systems		x
High Efficiency Burner		x
High Efficiency Burner (Dryer)	x	x
High Efficiency Chiller	x	x
High efficiency non-packaged HVAC equipment		x
Impeller Trimming (Pump)	x	x
Impeller Trimming or Inlet Guide Vanes	x	x
Implementation of Management Best Practices to Support Energy Efficiency	x	x
Insulation	x	x
Insulation (Dryer)	x	x
Integrated control system	x	x
Minimize operating air pressure	x	x
Optimization of pumping system		x

Opportunities	2-yr. Payback	5-yr. Payback
Optimized chilled water temperature and/or optimized condenser temperature		x
Optimized condenser pressure	x	x
Optimized Distribution System		x
Optimized motor control	x	x
Paper Drying Section Shoe Press		x
Premium Efficiency Control with ASDs (Other motors)		x
Premium Efficiency Control with ASDs (Pumps)		x
Premium efficiency control, with ASD (Fans)		x
Premium efficiency ventilation control with VSD	x	x
Preventative Compressor Maintenance	x	x
Preventative Dryer Maintenance	x	x
Preventative Motor Maintenance	x	x
Preventative Packaged HVAC Maintenance	x	x
Preventative Pump Maintenance	x	x
Preventative refrigeration/cooling system maintenance	x	x
Process Heat Recovery to Preheat Makeup Water		x
Sequencing Control		x
Steam Trap Survey and Repair	x	x
Steam Trap Survey and Repair (imported steam)	x	x
Sub-Metering and Interval Metering	x	x
Synchronous Belts		x
Synchronous Belts for Air Compressors		x
Thermo Compressors	x	x
TMP Refiner Heat Recovery		x
Use Radiant Heat Instead of Convection Heating		x
Vehicle system efficiency maintenance programs	x	x
Ventilation Heat Recovery	x	x
Ventilation Optimization	x	x
VSD on chiller compressor		x
Warehouse Loading Dock Seals	x	x
Total	**43**	**64**

Source: ICF

A4.2 Iron and steel

Opportunities	2-yr. Payback	5-yr. Payback
Advanced boiler controls		x
Advanced Heating and Process Control (Furnace)	x	x
Air Curtains	x	x
Automated Temperature Control	x	x
Blowdown Heat Recovery		x
Boiler load management	x	x
Combustion Optimization (Furnace)	x	x
Condensate Recovery (imported steam)		x
Demand-Controlled Ventilation	x	x
Destratification Fans	x	x
Economizer		x
Efficient Boiler System	x	x
Eliminate air leaks	x	x
Exhaust Gas Heat Recovery (Furnace)	x	x
Floating head pressure controls	x	x
Flue gas monitoring (boiler)	x	x
Flue gas monitoring (Furnace)	x	x
HE Dry-Type Transformers	x	x
High Efficiency Burner		x
High Efficiency Burner (Furnace)	x	x
High Efficiency Chiller		x
High efficiency non-packaged HVAC equipment		x
Impeller Trimming (Pump)	x	x
Impeller Trimming or Inlet Guide Vanes	x	x
Implementation of Management Best Practices to Support Energy Efficiency	x	x
Insulation	x	x
Integrated control system	x	x
Minimize operating air pressure	x	x
Optimization of pumping system		x
Optimized chilled water temperature and/or optimized condenser temperature		x
Optimized condenser pressure	x	x
Optimized Distribution System		x
Optimized motor control	x	x
Optimized Sinter Pellet Ratio (Iron Ore)	x	x
Premium Efficiency Control with ASDs (Other motors)		x

Opportunities	2-yr. Payback	5-yr. Payback
Premium Efficiency Control with ASDs (Pumps)		x
Premium efficiency ventilation control with VSD	x	x
Preventative Compressor Maintenance	x	x
Preventative Furnace Maintenance	x	x
Preventative Motor Maintenance	x	x
Preventative Packaged HVAC Maintenance	x	x
Preventative Pump Maintenance	x	x
Preventative refrigeration/cooling system maintenance		x
Process Heat Recovery to Preheat Makeup Water		x
Sequencing Control		x
Sinter Plant Waste Heat Recovery	x	x
Steam Trap Survey and Repair	x	x
Steam Trap Survey and Repair (imported steam)	x	x
Sub-Metering and Interval Metering	x	x
Synchronous Belts		x
Synchronous Belts for Air Compressors		x
Use Radiant Heat Instead of Convection Heating		x
Vehicle system efficiency maintenance programs	x	x
Ventilation Heat Recovery	x	x
Ventilation Optimization	x	x
VSD on chiller compressor		x
Warehouse Loading Dock Seals	x	x
Total	**38**	**57**

Source: ICF

A4.3 Non-Metallic Minerals

Opportunities	2-yr. Payback	5-yr. Payback
Advanced boiler controls		x
Advanced Heating and Process Control (Kiln)	x	x
Air Curtains	x	x
Automated Temperature Control	x	x
Blowdown Heat Recovery		x
Boiler load management	x	x
Combustion Optimization (Kiln)	x	x
Condensate Recovery (imported steam)		x
Demand-Controlled Ventilation	x	x
Destratification Fans	x	x
Economizer		x
Efficient Boiler System	x	x
Exhaust Gas Heat Recovery (Kiln)	x	x
Floating head pressure controls	x	x
Flue gas monitoring (boiler)	x	x
Flue gas monitoring (Kiln)	x	x
HE Dry-Type Transformers	x	x
High Efficiency Burner		x
High Efficiency Burner (Kiln)	x	x
High Efficiency Chiller		x
High efficiency non-packaged HVAC equipment		x
Impeller Trimming (Pump)	x	x
Impeller Trimming or Inlet Guide Vanes	x	x
Implementation of Management Best Practices to Support Energy Efficiency	x	x
Insulation	x	x
Insulation (Kiln)	x	x
Integrated control system	x	x
Minimize operating air pressure	x	x
Optimization of pumping system		x
Optimized chilled water temperature and/or optimized condenser temperature		x
Optimized condenser pressure	x	x
Optimized Distribution System		x
Optimized motor control	x	x
Premium Efficiency Control with ASDs (Other motors)		x
Premium Efficiency Control with ASDs (Pumps)		x
Premium efficiency ventilation control with VSD	x	x

Opportunities	2-yr. Payback	5-yr. Payback
Preventative Packaged HVAC Maintenance	x	x
Process Heat Recovery to Preheat Makeup Water		x
Sequencing Control		x
Smart Design and Clustering of Manufacturing Facilities	x	x
Steam Trap Survey and Repair	x	x
Steam Trap Survey and Repair (imported steam)	x	x
Sub-Metering and Interval Metering	x	x
Synchronous Belts		x
Synchronous Belts for Air Compressors		x
Use of increasing levels of cullet for Glassmaking		x
Use Radiant Heat Instead of Convection Heating		x
Vehicle system efficiency maintenance programs	x	x
Ventilation Heat Recovery	x	x
Ventilation Optimization	x	x
VSD on chiller compressor		x
Warehouse Loading Dock Seals	x	x
Total	**33**	**52**

Source: ICF

A4.4 Chemical and pharmaceutical

Opportunities	2-yr. Payback	5-yr. Payback
Advanced boiler controls		x
Advanced Heating and Process Control (Furnace)	x	x
Advanced Process Operation	x	x
Air Curtains	x	x
Automated Temperature Control	x	x
Boiler load management	x	x
Combustion Optimization (Furnace)	x	x
Condensate Recovery (imported steam)		x
Demand-Controlled Ventilation	x	x
Destratification Fans	x	x
Distillation column improved controls	x	x
Distillation columns operational optimization	x	x
Efficient Boiler System	x	x
Eliminate air leaks	x	x
Exhaust Gas Heat Recovery (Furnace)	x	x
Floating head pressure controls	x	x
Flue gas monitoring (boiler)	x	x
Flue gas monitoring (Furnace)	x	x
Gas compressor right sizing	x	x
HE Dry-Type Transformers	x	x
High Efficiency Burner		x
High Efficiency Burner (Furnace)	x	x
High Efficiency Chiller	x	x
High efficiency non-packaged HVAC equipment		x
Impeller Trimming (Pump)	x	x
Impeller Trimming or Inlet Guide Vanes	x	x
Implementation of Management Best Practices to Support Energy Efficiency	x	x
Improved Catalysts	x	x
Improved EE of existing distilation column with retrofit		x
Insulation	x	x
Insulation (Furnace)	x	x
Integrated control system	x	x
Inter-plant Process Integration	x	x
Membranes and other Pharmaceutical Process Developments	x	x
Minimize operating air pressure	x	x
Optimization of pumping system		x

Opportunities	2-yr. Payback	5-yr. Payback
Optimized chilled water temperature and/or optimized condenser temperature		x
Optimized condenser pressure	x	x
Optimized Distribution System		x
Optimized motor control	x	x
Premium efficiency ASD compressor	x	x
Premium Efficiency Control with ASDs (Other motors)		x
Premium Efficiency Control with ASDs (Pumps)		x
Premium efficiency control, with ASD (Fans)		x
Premium efficiency ventilation control with VSD	x	x
Preventative Compressor Maintenance	x	x
Preventative Furnace Maintenance	x	x
Preventative Motor Maintenance	x	x
Preventative Packaged HVAC Maintenance	x	x
Preventative Pump Maintenance	x	x
Preventative refrigeration/cooling system maintenance	x	x
Process Heat Recovery to Preheat Makeup Water		x
Sequencing Control		x
Steam Trap Survey and Repair	x	x
Steam Trap Survey and Repair (imported steam)	x	x
Sub-Metering and Interval Metering	x	x
Synchronous Belts		x
Synchronous Belts for Air Compressors		x
Synchronous Belts for Air or Gas Compressors	x	x
Use Radiant Heat Instead of Convection Heating		x
Vehicle system efficiency maintenance programs	x	x
Ventilation Heat Recovery	x	x
Ventilation Optimization	x	x
VSD on chiller compressor		x
Warehouse Loading Dock Seals	x	x
Waste heat recovery	x	x
Total	**49**	**66**

Source: ICF

A4.5 Non Ferrous Metals

Opportunities	2-yr. Payback	5-yr. Payback
Advanced boiler controls		x
Advanced Heating and Process Control (Furnace)	x	x
Air Curtains	x	x
Automated Temperature Control	x	x
Blowdown Heat Recovery		x
Boiler load management	x	x
Boiler Water Treatment		x
Combustion Optimization (Furnace)	x	x
Demand-Controlled Ventilation	x	x
Destratification Fans	x	x
Economizer		x
Efficient Boiler System	x	x
Eliminate air leaks	x	x
Exhaust Gas Heat Recovery (Furnace)	x	x
Floating head pressure controls	x	x
Flue gas monitoring (boiler)	x	x
Flue gas monitoring (Furnace)	x	x
HE Dry-Type Transformers	x	x
High Efficiency Burner		x
High Efficiency Burner (Furnace)	x	x
High Efficiency Chiller		x
High efficiency non-packaged HVAC equipment		x
Impeller Trimming (Pump)	x	x
Impeller Trimming or Inlet Guide Vanes	x	x
Implementation of Management Best Practices to Support Energy Efficiency	x	x
Improvements to Alumina production from Bauxite	x	x
Increased Recycling	x	x
Inert Anode Technology (Emerging)	x	x
Insulation	x	x
Insulation (Furnace)	x	x
Integrated control system	x	x
Minimize operating air pressure	x	x
Optimization of pumping system		x
Optimized chilled water temperature and/or optimized condenser temperature		x
Optimized condenser pressure	x	x
Optimized Distribution System		x

Opportunities	2-yr. Payback	5-yr. Payback
Optimized Heating Operating Practices	x	x
Optimized motor control	x	x
Premium Efficiency Control with ASDs (Other motors)		x
Premium Efficiency Control with ASDs (Pumps)		x
Premium efficiency ventilation control with VSD	x	x
Preventative Compressor Maintenance	x	x
Preventative Furnace Maintenance	x	x
Preventative Motor Maintenance	x	x
Preventative Packaged HVAC Maintenance	x	x
Preventative Pump Maintenance	x	x
Preventative refrigeration/cooling system maintenance		x
Process Heat Recovery to Preheat Makeup Water		x
Sequencing Control		x
Steam Trap Survey and Repair	x	x
Sub-Metering and Interval Metering	x	x
Synchronous Belts		x
Synchronous Belts for Air Compressors		x
Use Clean Scrap	x	x
Use Radiant Heat Instead of Convection Heating		x
Vehicle system efficiency maintenance programs	x	x
Ventilation Heat Recovery	x	x
Ventilation Optimization	x	x
VSD on chiller compressor		x
Warehouse Loading Dock Seals	x	x
Waste Heat Recovery for Pre-heating (Combustion Air and Charge Material)	x	x
Total	42	61

Source: ICF

A4.6 Petroleum Refineries

Opportunities	2-yr. Payback	5-yr. Payback
Advanced (Predictive) Process and Maintenance Control Systems		x
Advanced boiler controls		x
Advanced Heating and Process Control (Furnace)	x	x
Air Curtains	x	x
Automated Temperature Control	x	x
Boiler load management	x	x
Cogeneration using gas turbine exhaust gas as combustion air for heating furnace	x	x
Combustion Optimization (Furnace)	x	x
Condensate Recovery (imported steam)		x
Demand-Controlled Ventilation	x	x
Destratification Fans	x	x
Economizer	x	x
Efficient Boiler System	x	x
Eliminate air leaks	x	x
Exhaust Gas Heat Recovery (Furnace)	x	x
Floating head pressure controls	x	x
Flue gas monitoring (boiler)	x	x
Flue gas monitoring (Furnace)	x	x
Gas compressor right sizing	x	x
HE Dry-Type Transformers	x	x
High Efficiency Burner		x
High Efficiency Burner (Furnace)	x	x
High Efficiency Chiller	x	x
High efficiency non-packaged HVAC equipment		x
Impeller Trimming (Pump)	x	x
Impeller Trimming or Inlet Guide Vanes	x	x
Implementation of Management Best Practices to Support Energy Efficiency	x	x
Insulation	x	x
Insulation (Furnace)	x	x
Integrated control system	x	x
Minimize operating air pressure	x	x
Optimization of pumping system		x
Optimized chilled water temperature and/or optimized condenser temperature		x
Optimized condenser pressure	x	x
Optimized Distribution System		x

Opportunities	2-yr. Payback	5-yr. Payback
Optimized motor control	x	x
Premium efficiency ASD compressor	x	x
Premium Efficiency Control with ASDs (Other motors)		x
Premium Efficiency Control with ASDs (Pumps)		x
Premium efficiency control, with ASD (Fans)		x
Preventative Compressor Maintenance	x	x
Preventative Furnace Maintenance	x	x
Preventative Motor Maintenance	x	x
Preventative Packaged HVAC Maintenance	x	x
Preventative Pump Maintenance	x	x
Preventative refrigeration/cooling system maintenance	x	x
Process Heat Recovery to Preheat Makeup Water		x
Sequencing Control		x
Steam Trap Survey and Repair	x	x
Steam Trap Survey and Repair (imported steam)	x	x
Sub-Metering and Interval Metering	x	x
Synchronous Belts		x
Synchronous Belts for Air Compressors		x
Synchronous Belts for Air or Gas Compressors	x	x
Use Radiant Heat Instead of Convection Heating		x
Ventilation Heat Recovery	x	x
Ventilation Optimization	x	x
VSD on chiller compressor		x
Warehouse Loading Dock Seals	x	x
Total	**42**	**59**

Source: ICF

A4.7 Food and Beverage

Opportunities	2-yr. Payback	5-yr. Payback
Advanced boiler controls		x
Advanced Heating and Process Control (Oven)	x	x
Air Curtains	x	x
Automated Temperature Control	x	x
Blowdown Heat Recovery		x
Boiler load management	x	x
Combustion Optimization (Oven)	x	x
Condensate Recovery (imported steam)		x
Contact Dryer for Improved Drying Efficiency	x	x
Demand-Controlled Ventilation	x	x
Destratification Fans	x	x
Economizer		x
Efficient Boiler System	x	x
Eliminate air leaks	x	x
Exhaust Gas Heat Recovery (Oven)	x	x
Floating head pressure controls	x	x
Flue gas monitoring (boiler)	x	x
Flue gas monitoring (Oven)	x	x
Fuel switching, subsititution, and combustion of waste gases	x	x
HE Dry-Type Transformers	x	x
High Efficiency Burner		x
High Efficiency Burner (Oven)	x	x
High Efficiency Chiller		x
High efficiency non-packaged HVAC equipment		x
Impeller Trimming (Pump)	x	x
Impeller Trimming or Inlet Guide Vanes	x	x
Implementation of Management Best Practices to Support Energy Efficiency	x	x
Improved Cleaning, Washing, and Sterilizing Equipment Efficiency	x	x
Increased Combined Heat and Power (CHP)	x	x
Integrated control system	x	x
Minimize operating air pressure	x	x
Optimization of Operating Practices for Cooking and Baking	x	x
Optimization of Operating Practices for Distillation, drying and evaporation	x	x
Optimization of pumping system		x
Optimized chilled water temperature and/or optimized condenser temperature		x
Optimized condenser pressure	x	x

Opportunities	2-yr. Payback	5-yr. Payback
Optimized Distribution System		x
Optimized Facility Operating Procedures	x	x
Optimized motor control	x	x
Premium Efficiency Control with ASDs (Other motors)		x
Premium Efficiency Control with ASDs (Pumps)		x
Premium efficiency ventilation control with VSD	x	x
Preventative Compressor Maintenance	x	x
Preventative Motor Maintenance	x	x
Preventative Oven Maintenance	x	x
Preventative Packaged HVAC Maintenance	x	x
Preventative Pump Maintenance	x	x
Preventative refrigeration/cooling system maintenance		x
Process Heat Recovery to Preheat Makeup Water		x
Sequencing Control		x
Steam Trap Survey and Repair	x	x
Steam Trap Survey and Repair (imported steam)	x	x
Sub-Metering and Interval Metering	x	x
Synchronous Belts		x
Synchronous Belts for Air Compressors		x
Use Radiant Heat Instead of Convection Heating		x
Vehicle system efficiency maintenance programs	x	x
Ventilation Heat Recovery	x	x
Ventilation Optimization	x	x
VSD on chiller compressor		x
Warehouse Loading Dock Seals	x	x
Total	**42**	**61**

Source: ICF

A4.8 Machinery

Opportunities	2-yr. Payback	5-yr. Payback
Advanced boiler controls		x
Advanced Heating and Process Control (Furnace)	x	x
Air Curtains	x	x
Automated Temperature Control	x	x
Blowdown Heat Recovery		x
Boiler load management	x	x
Boiler Water Treatment		x
Combustion Optimization (Furnace)	x	x
Condensate Recovery (imported steam)		x
Demand-Controlled Ventilation	x	x
Destratification Fans	x	x
Economizer		x
Efficient Boiler System	x	x
Eliminate air leaks	x	x
Exhaust Gas Heat Recovery (Furnace)	x	x
Floating head pressure controls	x	x
Flue gas monitoring (boiler)	x	x
Flue gas monitoring (Furnace)	x	x
HE Dry-Type Transformers	x	x
High Efficiency Burner		x
High Efficiency Burner (Furnace)	x	x
High Efficiency Chiller		x
High efficiency non-packaged HVAC equipment		x
Impeller Trimming (Pump)	x	x
Impeller Trimming or Inlet Guide Vanes	x	x
Implement Lean Manufacturing System	x	x
Implementation of Management Best Practices to Support Energy Efficiency	x	x
Insulation	x	x
Insulation (Furnace)	x	x
Integrated control system	x	x
Minimize operating air pressure	x	x
Optimization of pumping system		x
Optimized chilled water temperature and/or optimized condenser temperature		x
Optimized condenser pressure	x	x
Optimized Distribution System		x
Optimized motor control	x	x

Opportunities	2-yr. Payback	5-yr. Payback
Optimized Process Re-Design		x
Optimized Techniques for Efficient Equipment Operation	x	x
Premium Efficiency Control with ASDs (Other motors)		x
Premium Efficiency Control with ASDs (Pumps)		x
Premium efficiency ventilation control with VSD	x	x
Preventative Compressor Maintenance	x	x
Preventative Furnace Maintenance	x	x
Preventative Motor Maintenance	x	x
Preventative Packaged HVAC Maintenance	x	x
Preventative Pump Maintenance	x	x
Preventative refrigeration/cooling system maintenance		x
Process Heat Recovery to Preheat Makeup Water		x
Sequencing Control		x
Steam Trap Survey and Repair	x	x
Steam Trap Survey and Repair (imported steam)	x	x
Sub-Metering and Interval Metering	x	x
Synchronous Belts		x
Synchronous Belts for Air Compressors		x
Use Radiant Heat Instead of Convection Heating		x
Vehicle system efficiency maintenance programs	x	x
Ventilation Heat Recovery	x	x
Ventilation Optimization	x	x
VSD on chiller compressor		x
Warehouse Loading Dock Seals	x	x
Total	**39**	**60**

Source: ICF