# EU ETS REVIEW

## Report on International Competitiveness

December 2006

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# PREFACE

The EU Emissions Trading Scheme (EU ETS) was launched in January 2005. It is the largest cap-and-trade scheme in the world and the core instrument for Kyoto compliance in the EU.

This first environmental market established in the EU involves thousands of operators who have obligations for limiting the carbon dioxide emissions from their plants. In an average week, more than 10 million allowances are traded, resulting in a market worth several billion Euro already in the first year of operation.

Article 30 of the Directive implementing the EU ETS requires the Commission to review the application of the EU Emissions Trading Scheme and report to the European Parliament and to the Council. The report may be accompanied by proposals for amendments to the scheme.

The European Commission's DG Environment appointed McKinsey & Company and Ecofys to support it in developing the review. Amongst other things, they were asked to develop an understanding of the impact of the scheme on the competitive position of participants and to analyse possibilities for the design of the scheme after the second trading period.

Their work deals with a number of the issues listed in Article 30 as ones that should be addressed in the Commission's report, as well as other relevant issues. Each report discusses approaches taken in the first phase and important lessons learnt. The analyses focus on the post-2012 design. For each design element, future options are investigated. This involves discussion of the advantages and disadvantages of design options, harmonization opportunities, and impact on competitiveness. The work conducted in the period June 2005–July 2006 consists of a web survey to consult stakeholders on their views on the EU ETS, as well as extensive topical analyses.

DG Environment, McKinsey, and Ecofys would like to thank Dr. Barbara Buchner, Prof. Frank Convery, Prof. Denny Ellerman, Prof. Olivier Godard, Prof. Michael Grubb, Dr. Felix Christian Matthes and Prof. Pablo del Rio Gonzales for their contribution.

This report reflects the views of McKinsey & Company and of Ecofys and does not constitute official views or policy of the European Commission.

Other reports delivered in the scope of this work are available at
http://ec.europa.eu/environment/climat/emission/review_EN.htm.

# 1   EXECUTIVE SUMMARY

## 1.1 INTRODUCTION

This *"Report on International Competitiveness"* provides input for the Commission's review of Directive 2003/87/EC on emissions trading.[1]

This document presents a non-exhaustive view of the potential impact of implementing the Kyoto Protocol targets with the EU Emissions Trading Scheme (EU ETS) on the international competitiveness of industries, based on assumptions and economic dynamics valid as of today.

The measure used in this analysis in order to detect a change in international competitiveness is a change in operating margin[2] resulting from a change in output, and/or a change in costs, and/or a change in prices. In this analysis, changes in margins are expressed as a percentage of total cost.

Production decisions are, however, not based on average industry or company's margins, but on the individual company's marginal costs for the last unit produced. Production decisions are ultimately driven by the value of $CO_2$ allowances, because a company can sell any surplus rights it may have at a profit. Therefore, even for an industry in which EU ETS has zero impact on company profit margins, it cannot be assumed that there will be no shifting of production into regions without $CO_2$ costs.

"International competitiveness" is defined in this report as "extra-Community competitiveness". Changes in intra-Community competitiveness have not been analysed.

All cost and earnings figures provided are outside-in estimates based on public information and McKinsey expert estimates and therefore reflect typical average cost and earnings data for the industries examined. The figures can be different for specific market participants. In addition, data are based on regional averages and can vary for different geographical sub-regions. As a result, the impacts on industries as laid out in this report represent average effects and can vary significantly for individual players.

## 1.2   OVERVIEW OF IMPACT ON COMPETITIVENESS

### 1.2.1   General View of Impact on Competitiveness

In the analysis of the impact of the EU ETS on competitiveness, the bottom-line impact on margins for a given industry – expressed as percentage of total costs – was determined in the following way: First, we added all the cost increases for input factors, e.g., electricity, to the cost of direct emissions, the allowances. We used 100% of the direct costs, regardless of the level of free allocation, because the allowances can be sold if not used internally. Then, we estimated the potential to pass through the cost increase to customers on the basis of the competitive situation and the market mechanism in the industry. Finally, we calculated the value of free allowances to obtain the overall net impact on cost.

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1   This document does not provide specific recommendations for any party possibly interested in engaging in any of the industries described in any region. Firstly, any move should be considered in the context not only of the EU ETS, but also of other relevant factors, such as market access and, factor costs. Secondly, any move should be based on a tailored, specific business plan and not on the high-level view provided in this document.

2   Before interests and taxes

It is not in the scope of the project to review or judge the general competitiveness of the power market. For the analysis of the impact of the EU ETS on industry competitiveness, we assume a competitive power market. The effects we point out in this document will occur naturally in competitive power markets, which will see the full pass through of $CO_2$ cost into electricity prices. This means that carbon costs are taken fully into account in production decisions. This is different from recovering or passing through the full opportunity cost incurred by all generation. Carbon cost will be fully recovered at the margin, but that does not mean that infra-marginal generators will recover all of their carbon opportunity cost. For instance, when gas is on the margin, coal generators would recover only the carbon cost of the gas on the margin. Inevitably some of the infra-marginal rent that coal generators would receive if there were no carbon charge is given up.

For the aluminium industry, which, of the ETS industries, is most dependent on electric power, we have shown an alternative scenario in paragraph 3.6.8 on page 51, if only 50% of the value of $CO_2$ is priced into electricity prices. In a similar manner the reader can easily derive the effects for other analysed sectors.

Assuming industry can partially pass through the cost increase to customers and assuming 95% of required allowances covered granted for free[3], the overall average impact on industry margins across Europe in the short and medium term for the industries analysed is limited. The exceptions are primary aluminium production and integrated pulp & paper production based on mechanical or thermo-mechanical pulp. It is important to stress the dependency of various industries on the level of free allocation.

The limited average impact on industry margins within the ETS industries across Europe may not be true for individual players and locations. However, from an individual player's perspective, there will be a redistribution of margins within industry.

Even though the impact on average industry margins is limited under the above-mentioned assumptions for most industries, the increase in pressure in the direction of potential production shifts might be significant for some industries in international competition. With the allocation of $CO_2$ allowances based on historic emissions – which is largely the case in the current EU ETS – the marginal cost increase can be very significant: in particular, primary steel production and cement production face an average cost increase on their marginal production in the order of 17% and 37%.

The envisaged effects of the EU ETS on industry sectors have their place within a broader context of measures aiming at emission reduction. Certain players are affected by several of these measures. The sum of all the effects – combined with other considerations, such as market outlooks – will drive management decisions, not the "stand-alone" effects of the EU ETS.

## 1.2.2   Short- and Mid-term Impact on Industry Competitiveness

Based on a $CO_2$ price of 20 Euro/ton, an electricity price increase of 10 Euro/MWh and further assumptions as laid out in chapter 2.4, the average impact on industry margins is shown in the Table 1-1 (Short- and Mid-term Overview of Findings Across Sectors).

The **power sector** is likely to benefit in the short and medium term and regain the ability to invest in new power plants. However, the impact on electricity generation will be very dependent on the level of free allowances to existing installations, since the total cost increase is substantial for fossil fuel power plants.

In the **steel sector**, the integrated production route (BOF) is expected to be impacted in its

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3    For the purpose of the report 95% of the required allowances in a given year were assumed to be granted for free. The actual number might vary by country, industry, current production. etc.

competitiveness. In some cases, production might be relocated to other areas. The situation could worsen over time given the usual continuous debottlenecking of capacity that might not be covered by free allowances. The additional costs of about 17% on the marginal unit of steel production may create an incentive to shift marginal production into regions without those costs.

The minimill route (EAF) is expected to be impacted only to a small extent. Nevertheless, a further replacement of BOF by EAF is not a viable solution because of the current scarcity of scrap, which is expected to continue.

The short- and mid-term effect on competitiveness in the **pulp & paper sector** is on average across the industry compensated only to a small extent by free allowances – even assuming 95% free allocation. The remaining cost increase is in the order of 0.3 to 1.0% in processes with chemical pulp and up to 1.9% in pulp and paper production based on recovered fibre. Mechanical pulping (6% of total pulp) and thermo-mechanical pulping (12% of total pulp) are affected by a 3-4% and 5-6% net cost increase, respectively.

**SHORT- AND MID-TERM OVERVIEW OF FINDINGS ACROSS SECTORS**
Percent of total costs

| Industry | Indirect cost increase | Direct cost increase | Total cost increase | Offset by product price increase | Offset by allowance endowment at 95% free allowances | Net cost increase |
|---|---|---|---|---|---|---|
| **Power** | | | | | | |
| • New CCGT | 0.0 | 20.1 | 20.1 | 28.5 | 19.1 | <0 |
| • New hard coal | 0.0 | 38.6 | 38.6 | 25.7 | 36.7 | <0 |
| • New lignite | 0.0 | 59.3 | 59.3 | 32.6 | 56.4 | <0 |
| • New nuclear | 0.0 | 0.0 | 0.0 | 24.6 | 0.0 | <0 |
| • Gas ST old | 0.0 | 24.1 | 24.1 | 19.1 | 22.9 | <0 |
| • GT | 0.0 | 15.7 | 15.7 | 12.1 | 15.0 | <0 |
| • Hard coal old | 0.0 | 46.1 | 46.1 | 25.5 | 43.8 | <0 |
| • Lignite old | 0.0 | 92.7 | 92.7 | 41.9 | 88.0 | <0 |
| • Nuclear old | 0.0 | 0.0 | 0.0 | 43.8 | 0.0 | <0 |
| **Steel** | | | | | | |
| • BOF (mainly flat) | 2.0 | 15.3 | 17.3 | 1.1 | 14.5 | 1.7 |
| • EAF (mainly long) | 2.5 | 0.4 | 2.9 | 1.9 | 0.4 | 0.6 |
| **Pulp & paper** | | | | | | |
| • Chemical pulp for market | 0.5 | 0.5 | 1.0 | 0.5 | 0.5 | 0.0 |
| • Paper from chem. pulp | 1.0 | 1.1 | 2.1 | 0 to 0.4 | 1.0 | 0.7 to 1.1 |
| • Chemical P&P* | 1.0 | 1.4 | 2.4 | 0 to 0.5 | 1.3 | 0.6 to 1.1 |
| • Mechanical P&P* | 4.1 | 1.4 | 5.5 | 0 to 1.1 | 1.3 | 3.1 to 4.2 |
| • Thermo-mech. P&P* | 6.1 | 1.4 | 7.5 | 0 to 1.5 | 1.3 | 4.7 to 6.2 |
| • Recovered fibre P&P* | 1.8 | 1.6 | 3.4 | 0 to 0.7 | 1.5 | 1.2 to 1.9 |

\* Integrated pulp & paper production based on pulp as shown in table
Assuming a $CO_2$ price of 20 Euro/ton and 95% free allocation (95% of required allowances)

Table 1-1: Short- and Mid-term Overview of Findings Across Sectors

Depending on the level of potential cost pass through, the **cement industry** on average across Europe might face a cost increase, come out neutral or experience a net benefit. The probability of a cost increase is highest in areas close to seaports or outer EU borders, such as Greece, Italy, southern France and Spain, where competition from imports is highest. The level of free allowances is crucial for the impact of the EU ETS on the cement industry's profitability.

At the same time, however, the impact on the cost of the marginal unit of production in the cement industry is very significant at over 36% or 12 Euro per ton of cement, which is roughly equal to freight costs from northern Africa or the eastern European countries outside the EU

to Antwerp. Therefore, under an allocation method based on historic emissions – which is the current preferred method in the EU ETS – the possibility of production shifts and $CO_2$ leakage in the cement industry is real.

The impact of the EU ETS on the **refining sector** on average is expected to be more or less neutral, as product price increases and allowances endowments might offset additional costs.

**Primary aluminium** production is under heavy pressure in the short and mid term, because the probable large indirect cost increase resulting from the EU ETS is not covered by any free allowances. This might accelerate a migration of primary aluminium to countries with lower electricity cost and/or higher $CO_2$ efficiency, typically producing electricity from hydro or stranded gas, e.g., Iceland or the Middle East.

The impact on **secondary aluminium** production from scrap is expected to be rather marginal.

Apart from these numbers, a big short-term issue for all industries is the real and perceived uncertainty about the future rules and settings of the EU ETS (and the national allocation plans), which makes it difficult for companies to decide on any long-term commitments to new investments or long-term contracts. This change in behaviour by market participants cannot be quantified. Since it is subject only to speculation and anecdotal evidence, this effect has not been included in the report. However, it is certainly real and, for the dynamics of the European markets, it would clearly be beneficial to reduce this uncertainty.

# 2   SCOPE, ASSUMPTIONS, METHODOLOGY AND CROSS-INDUSTRY ANALYSIS

## 2.1   INTRODUCTION TO EU ETS

The European Emissions Trading Scheme (EU ETS) became operational in January 2005. In the first phase from 2005 to 2007, the EU ETS covers the sectors power generation, mineral oil refineries, coke ovens, ferrous metal processing, cement, glass, ceramics, and pulp & paper (referred to as "trading sectors"). The scheme also covers emissions from large combustion installations (larger than 20 $MW_{th}$) found, for instance, in the chemical industry, food processing, etc. Emission allowances have been allocated by governments to companies in those sectors to a large extent based on past emissions, discounted to meet Kyoto targets.

Europe, including the new Member States (EU25), emits a $CO_2$ equivalent of 4,800 M tons of greenhouse gases p.a., of which around 3,950 M tons are $CO_2$. The rest consists of $CH_4$, $NO_2$, PFC, HFC, and $SF_6$. According to the national allocation plans for the first trading period, companies in the trading sectors are allocated about 2,200 M tons of $CO_2$ p.a. The power sector accounts for more than 50% of the allocated emission allowances.

## 2.2   REFERENCE POINT FOR THE ANALYSIS

Climate action is necessary given the short- and mid-term legal obligations under the Kyoto Protocol and given the long-term potentially threatening effects of climate change on the global environment. Therefore, it is not a relevant option for industry to assume that they can revert to a status in which $CO_2$ has no cost. The EU ETS was introduced as the overall most cost-effective instrument for the industries covered to contribute to emissions abatement.

The investigation of cost and revenue impacts of the EU ETS is meant to understand the change in competitiveness that industry has to absorb versus extra-Community competitors. Therefore, for a quantitative analysis, the status in 2004, i.e. a status without any $CO_2$ cost, is used as a reference point.

Finally, the analysis does not account for voluntary measures that are taken by or government regulations imposed on competitors of European industry.

## 2.3   SCOPE OF THE ANALYSIS

The analysis presented in this document is an analysis for a limited number of sectors and not a comprehensive analysis of the macro-economy.

The industry sectors covered in this document are power generation, steel production, pulp & paper production, cement production, refining, and aluminium production. These sectors account for the vast majority (over 90%) of the emissions from the trading sectors. Aluminium is included as a very large electricity consumer.

Other sectors – some of which might be benefiting from the EU ETS, some of which will see additional pressure – were not analysed in this study. Suppliers of gas, carbon abatement technology and traders are likely to benefit from the EU ETS, while coal suppliers and electricity users are likely to see additional pressure.

Regarding industry competitiveness, the focus of the analysis is on existing businesses. This is because new investments are influenced/determined by other factors than $CO_2$ considerations only.

## 2.4 ASSUMPTIONS

### 2.4.1 $CO_2$ Prices

**$CO_2$ PRICES IN EU ETS 2005 – 2006**
OTC trades; Euro/ton
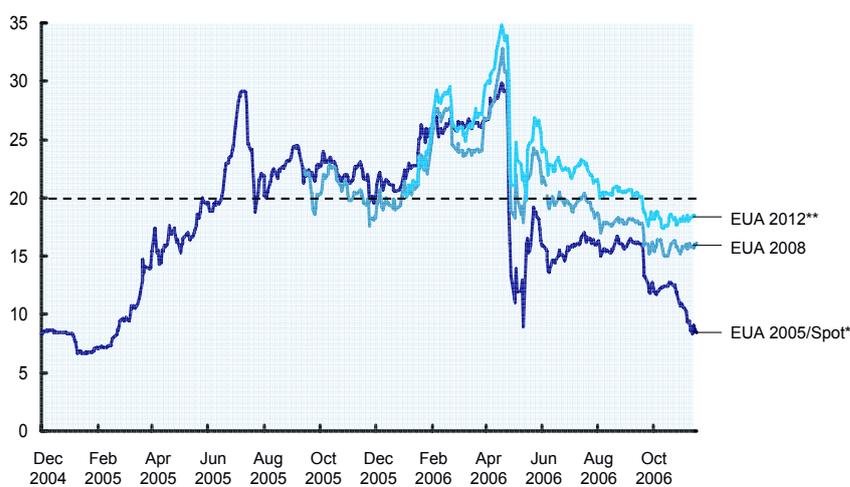


*  Spot since Sept 2005; before Sept 2005 forwards on EUA 2005
** EEX futures
Source: PointCarbon, EEX

Figure 2-1: $CO_2$ Market Prices in EU ETS 2005/06

Over the years 2005 and 2006, the level of 20 Euro/ton has proved to be well in the range of the real market prices at the given supply/demand balance, coal and gas prices, JI/CDM project development, etc., as the graph above shows.

For the purpose of this analysis, we use a $CO_2$ price of 20 Euro/ton. This price is also well in the range of potential mid and long-term $CO_2$ prices, and a long-term view is most relevant to investment decisions in capital-intensive industries.

**IN EUROPE, CO₂ EMISSION CAPS AND GERMANY'S NUCLEAR PHASE OUT WILL LEAD UTILITIES TO TURN MASSIVELY TO GAS WITH A 130% PRODUCTION INCREASE BY 2020**

**CO₂ emissions**
Million tons per year

| | 1,190 | 1,225 | 1,225 |
|---|---|---|---|
| | 2002 | 2010 target | 2020 target |

**Power production changes**
Percentage, from 2002

+14%     +30%

**Germany\* nuclear phase out**
GW installed capacity

| 23 | 20 | 3 |
|---|---|---|
| 2005 | 2010 plan | 2020 plan |

**Europe electricity production**
TWh

CAGR 1.4%

|  | 2005 (2,963) | 2010 (3,219) | 2020 (3,666) |
|---|---|---|---|
| Oil | 40 | 8 | 0 |
| Renewable | 52 | 88 | 187 |
| Hydro | 433 | 432 | 432 |
| Lignite | 316 | 297 | 350 |
| Hard Coal | 507 | 511 | 411 |
| Gas | 710 | 1,020 | 1,636 |
| Nuclear | 904 | 863 | 650 |

\*  Includes CEU European region
Source: McKinsey European Power Model

Figure 2-2: CO₂ Emission Targets and Resulting Electricity Production

The price level of 20 Euro/ton of CO₂ is supported by our fundamental analysis. The power sector, as the swing producer in the EU ETS, has to deliver most of the emission reduction. Because it balances CO₂ emissions and abatement costs in its hourly dispatch decisions, it therefore sets the market prices through its abatement cost.

In order to keep emissions in the power sector constant until 2020 – which is a rather conservative assumption and probably not strict enough – a massive shift is needed from coal- to gas-fired electricity production.

**A STRONG SUPPORT FOR RENEWABLES COMBINED WITH AN ACCOMMODATING NUCLEAR POLICY WOULD HELP EUROPE REGAIN ITS COMPETITIVE EDGE AGAINST THE U.S.**

— Base Europe
— Low GHG competitive Europe
— PJM (U.S.)

**Europe electricity production – 2020**
TWh

|  | EU Base (3,666) | Low GHG competitive EU (3,683) |
|---|---|---|
| Oil | 0 | 8 |
| Renewable\*\* | 187 | 555 |
| Lignite | 350 | 207 |
| Hydro | 432 | 433 |
| Hard Coal | 411 | 645 |
| Nuclear\*\* | 650 | 817 |
| Gas | 1,636 | 1,019 |

**EU Germany vs. PJM (U.S.)**
Average annual wholesale power prices;
USD/MWh\*

PJM (U.S.)
Europe
- 21%

2002  2006  2010  2014  2018

**Europe aggregate CO₂ emissions 2020**
Million tons p.a.

- 8%

| EU Base | Low GHG competitive EU |
|---|---|
| 1,225 | 1,123 |

- EU is competitive with U.S. power prices from a dispatch standpoint
- Emissions are contained
- Subsidies are required to fund renewables (or nuclear) as these technologies are unlikely to be market competitive on a full cost basis

\*  Assumes exchange rate of $1.20:€1.00
\*\*  All nuclear licenses extended past 2020, renewable production reaches 15% of demand
Source: McKinsey European power model

Figure 2-3: Alternative Scenario with Higher Renewables and Nuclear Share

If, alternatively, Europe would go for a combination of increasing the share of renewables, while suspending nuclear phase-out, the amount of emissions from the power sector could be reduced by another 8%, the dependency on gas would increase only marginally and electricity prices would be more than 20% lower at the wholesale market level in 2020 than if renewables are expanded as currently planned and nuclear power is phased out as currently planned.

**EUROPE ELECTRICITY PRODUCTION – 2020**
TWh p.a.

|  | 3,666 | 3,666 |
|---|---|---|
| Oil | 6 | 0 |
| Renewable | 187 | 187 |
| Lignite | 398 | 350 |
| Hydro | 431 | 432 |
| Hard Coal | 731 | 411 |
|  |  | 650 |
| Nuclear | 647 |  |
| Gas | 1,266 | 1,636 |
|  | EU No Kyoto** | EU Base |

Limiting emissions at the Kyoto level results in much lower electricity production from coal than without emissions limits

**Coal Fuel Consumption**
Million tons: 263 → 134  **-49%**
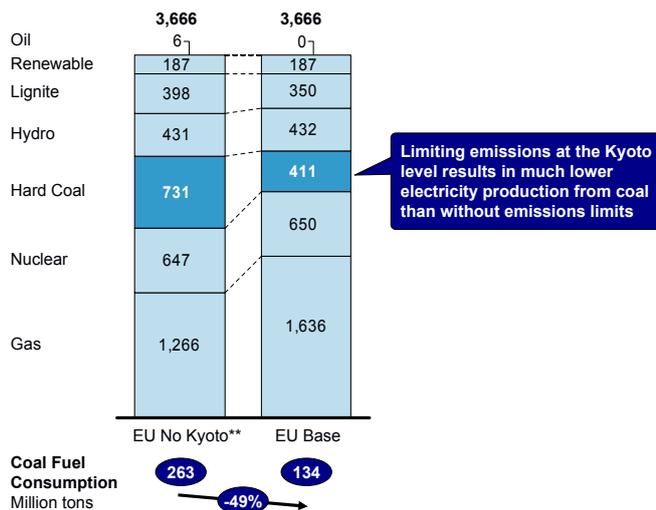
\* Assumes exchange rate of $1.20:€1.00
\*\* Low focus on CO$_2$ emissions without Kyoto renewal
Source: McKinsey European power model v356, v357

Figure 2-4: Electricity Production Europe 2020 With and Without Emissions Targets

Leaving aside the alternative scenario and going back to our base case assumptions, at the expected commodity prices for coal and gas, the shift from coal to gas does not come for free, but only by means of the EU ETS cap and trade system. Relative to a case without CO$_2$ constraints, the EU ETS will have to have reduced emissions from coal in 2020 by 50% in order to meet emissions targets in the power sector.

The mechanism within the EU ETS to make that shift happen is the CO$_2$ price. It places more additional cost on coal-fired and highly CO$_2$-emitting electricity production than on more CO$_2$-efficient gas.

**POTENTIAL EUROPEAN CO$_2$ PRICES**
Price per ton of CO$_2$; Euro
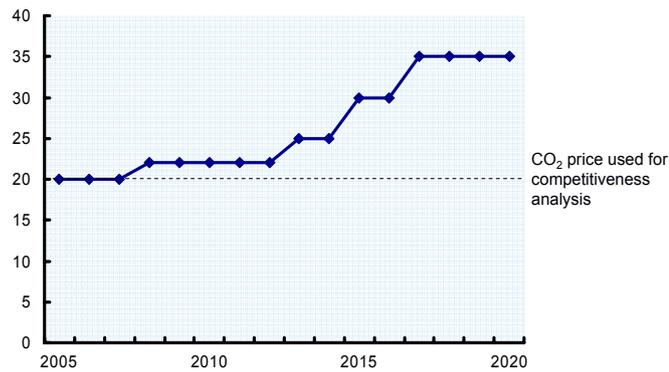


Figure 2-5: Potential EU CO$_2$ Prices

The CO$_2$ price will tend to balance the attractiveness of coal and gas as an electricity generating choice and ultimately makes coal less, and gas more, attractive. In addition it will favour other, lower CO$_2$-emitting choices such as nuclear and renewables. In order to keep emissions in the power sector just constant and still fullfil the increasing demand for electricity, CO$_2$ prices would have to rise far beyond 20 Euro/ton.

We have nevertheless based the analysis of competitiveness on a 20 Euro/ton CO$_2$ price because we assume that either measures would be taken to avoid prices significantly above that level for longer periods (e.g., a combination of the abolishment of nuclear phase-out in Germany, a higher share of renewables, a push for energy conservation measures, more JI/CDM investment) or demand reactions, including production shifts by industrial companies, and technological advances would reduce CO$_2$ price pressure.

## 2.4.2  Nature of CO$_2$ Costs

For the analysis it is assumed that CO$_2$ costs are meant to be opportunity costs: it is assumed that the allocation of CO$_2$ allowances in future periods will not depend on this period's emissions for existing facilities, as long as the facility keeps operating. Therefore, industry players can sell an allowance in this period and will still receive the corresponding allowance in the next period. This is in line with the allocation guidance document published by the European Commission in December 2005, which explicitly discourages updating of the base period in any way that will include a year later than 2004.

**PRICE-IN OF $CO_2$ IN CURRENT MARGINAL PRICING DECISIONS**
Companies

**Question: Are you already now "pricing in" the value of $CO_2$ allowances into your daily operations?**
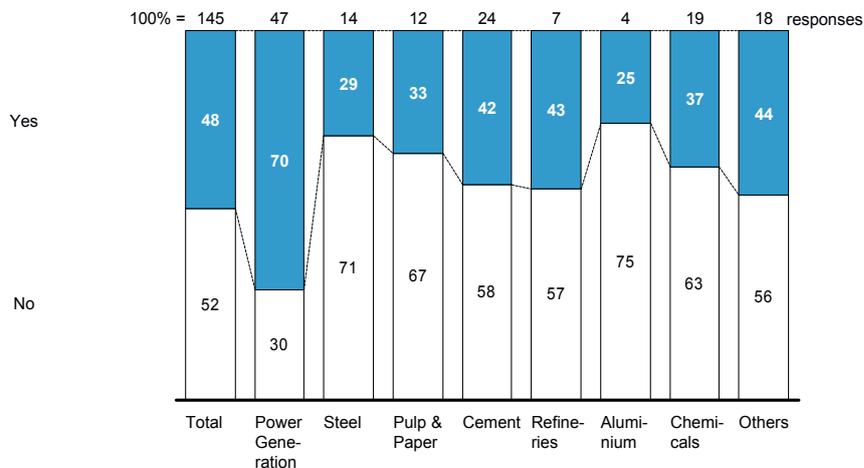


Figure 2-6: Current Pricing Behaviour within EU ETS

Furthermore, we assume that companies will price the $CO_2$ opportunity costs into their products, if possible, given the more or less competitive market situation. It is only in the event of a possibility of having to shut down a facility (thereby losing the emission allowances for the future) that companies will not consider the $CO_2$ costs in their pricing behaviour.

**PRICE-IN OF $CO_2$ IN FUTURE MARGINAL PRICING DECISIONS**
Companies

**Question: What are your plans going forward: Will you "price in" the value of $CO_2$ allowances into your daily operations, meaning will you factor it into your marginal production decisions (irrespective of how many allowances you get for free)?**
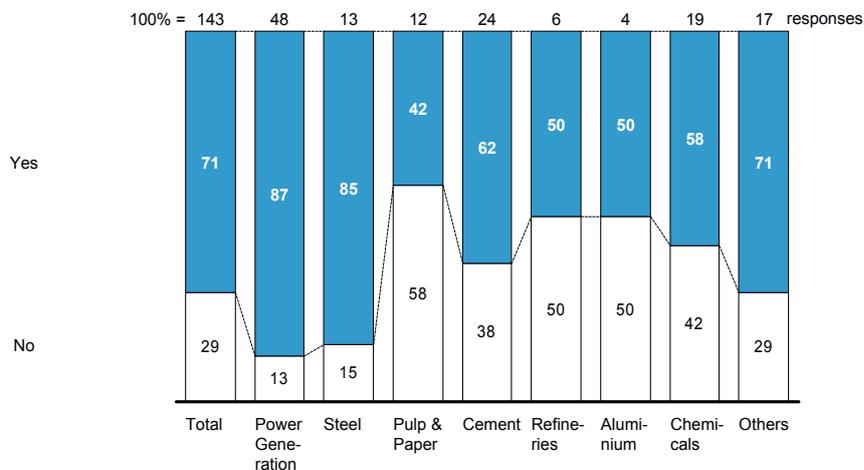


Figure 2-7: Declared Future Pricing Behaviour within EU ETS

The results of the survey about the EU ETS support this assumption. About half the companies that responded are already "pricing-in" the value of $CO_2$ in their daily operating decisions and three-quarters intend to do so in the future.

## 2.4.3  Pass Through Capabilities by Sector

We assumed the following pass through capabilities of the total cost increase on average across Europe:

**Power sector:**
On average across Europe, the price of electric power will increase by around 10 Euro per MWh when $CO_2$ is priced at 20 Euro ton, assuming the full cost pass through[4] of $CO_2$ opportunity costs into operational decisions. Taking this 10 Euro per MWh electricity price increase and dividing it by the total production cost of each type of electricity generation technology results in different percentages per technology, which are shown in detail in the section on the electricity sector.

Empirical studies[5] show that, the lower the competitiveness in an electricity market is, the lower the pass through of $CO_2$ costs into electricity prices. The fundamental explanation is that, in competitive markets, the value of $CO_2$ will automatically be fully reflected in each player's operating decisions, whereas, in monopolistic or oligopolistic markets, price setting is not fully determined by fundamental economics. Furthermore, there is a time delay for an unexpected change in electricity spot prices to impact the profitability of an industrial consumer, as positions are typically hedged in one to two year contracts. Last not least some Member States had delays in implementing the EU ETS. For these reasons, figures are exemplary presented for a lower pass through of 50% in the aluminium section in chapter 3.6.8 on page 53.

**Steel:**
• BOF: 6% of the additional cost can be passed through to customers
• EAF: 66% of the additional cost can be passed through to customers

**Pulp & paper production:**
• 50% of the additional costs can be passed through to customers in chemical pulping
• 0 to 20% for paper from integrated processes can be passed through to customers

**Cement from dry process:**
• 0 to 15% of the additional cost can be passed through to customers

**Refining:**
• 25 to 75% of the additional cost can be passed through to customers

**Aluminium:**
• 0% of the additional cost can be passed through to customers

The details on the estimated cost pass through are explained in the individual chapters for each sector.

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4    Please see definition of "full pass through" in chapter 1.2.1 on page 4
5    Dr Felix Christian Matthes, Öko-Institut, "Emissions Market: Historical and future impact on European power prices." European Energy Day 2006 Königswinter, 27 April 2006

## 2.4.4   Internal CO$_2$ Reduction Measures in Industry

The purpose of emissions trading is to incentivise emission reduction where it can be done for less than the market price of CO$_2$. A company operating under the EU ETS and implementing internal reduction measures that cost less than allowances can create a profit. Therefore, the compliance cost for that company within the EU ETS is lower than the cost of buying all required allowances in the market.

Although internal reduction measures are important overall, they change the assessment of the average impact of the EU ETS on the competitiveness of industries only marginally. If, for example, an integrated steel production (BOF) has the potential to reduce emissions internally by 2% for costs in the order of 50% of the CO$_2$ market price, the gain on profitability would be equal to getting 1 percentage point more free allowances. This would, for the steel industry example, reduce the negative short-term impact from 1.7% to 1.6% of costs for a CO$_2$ price level of 20 Euro/ton. This 0.1% change in margin is below the accuracy of the estimations in the calculation and thus not relevant for the assessment of the impact on industry competitiveness.

It is, however, meaningful for the individual steel player, because even 0.1% of the cost base is large enough to be worth pursuing. That is why the steel player will probably implement the internal measures to the extent that they make economic sense.

While this methodological approach leads to a certain over-estimation of competitiveness effects, it is considered not to change the conclusions in any major way, as the IEA also stated in their 2005 report (see Reinaud, Julia, *Industrial Competitiveness under the European Union Emission Trading Scheme*, IEA, 2005).

## 2.4.5   Auto-generation

Some industrial companies produce a share of the electricity they need in-house, a process sometimes referred to as auto-generation. On average across the affected industries, the consumption-weighted share is around 16%, with particularly low shares in non-ferrous metals and minerals, and higher shares in oil refineries and pulp & paper.

The average share of auto-generation across all industries varies widely by country, ranging from 3% in Belgium to 26% in Portugal. On an individual industry basis, the spread is even higher. For example, the share of auto-generation in the pulp & paper industry is 9% in Belgium and more than 80% in Portugal.

The view on auto-generation confirms the point that the impact on individual companies differs widely from the average impact.

For our analysis of the average competitiveness impact, we did not take auto-generation into account apart from the pulp & paper industry. In chemical pulp & paper production, the auto-generation of electricity is fully integrated in the calculation of the competitiveness impact, as pulp & paper and electricity production are integrated processes, in which the electricity production could not be performed without the pulp & paper production.

Accounting for auto-generation only in the pulp & paper industry means that cost increases in other sectors may be over-estimated from a total company perspective, in particular for sectors with a high share, since, from a company point of view, auto-generation protects competitiveness.

**SHARE OF AUTOGENERATION**
Percent of consumption

Average    Standard deviation

| Sector | Outside-in estimate of auto-generation share | Sub-sector | Survey results: Share of autogeneration of respondents | |
|---|---|---|---|---|
| Steel | 14 | BOF | 41 | 41 (n = 10) |
| | | EAF | 0 | (n = 9) |
| Pulp & Paper | 30 | Chemical pulp | 37 | 42 (n = 6) |
| | | Mechanical pulp | 14 | 28 (n = 4) |
| | | Thermo-mechanical pulp | 14 | 28 (n = 4) |
| | | Waste paper recycling | 0 | (n = 3) |
| | | Paper making | 42 | 20 (n = 8) |
| Cement | 6 | Dry process | 4 | 14 (n = 16) |
| | | Semi-dry process | 2 | 8 (n = 10) |
| | | Wet process | 0 | (n = 11) |
| Refineries | 57 | Refining process | 83 | 14 (n = 3) |
| Aluminium | 3 | Primary production | 0 | (n = 3) |
| | | Secondary production | 0 | (n = 3) |
| Chemicals | 23 | Basic chemicals** | 27 | 33 (n = 7) |
| | | Specialty chemicals | 0 | (n = 3) |
| | | Polymers | 4 | 6 (n = 3) |
| **Total** | **16** | | | |

\* Rough estimates by sector based on IEA data; see back-ups for definitions and calculations
\*\* Petrochemicals/Basic organic chemicals, basic inorganic chemicals, fertilizers
Source:  IEA Electricity Information; Survey EU ETS Review

Figure 2-8: Auto-generation Share of Different Industries in Europe

However, from the perspective of production operations competing in the market, auto-generation should not be taken into account apart from the pulp & paper production. Firstly, while the share of auto-generation is in some industries considerable, the variation across countries, industries and within each sector is considerable and the average share of auto-generation, at 16% (or 14% without pulp & paper), is not that high. Secondly, in most instances, an industrial company would have the opportunity to sell its auto-generated electricity on the wholesale market. Therefore, the internal transfer price, that has to be applied is the wholesale market price.

In the sections for the individual industries, a subchapter provides a specific perspective of auto-generation per sector.

## 2.4.6   Other Assumptions

The level of free allowances is an important driver of the impact of the EU ETS on industry competitiveness. The results given are for the short- and mid-term scenario in which industry gets 95% of the required allowances for free. The results for other allowance levels can be extrapolated from the results shown.

A $CO_2$ price of 20 Euro/ton translates on average across Europe into an electricity price increase of 10 Euro/MWh. This average figure is the result of an analysis with the McKinsey wholesale market model, which simulates the dispatch of the European power plants assuming a fully competitive market in which every power plant optimises its contribution margin on an hourly basis. In countries with a large share of coal, the real impact on electricity prices is higher, while it is lower in countries with a lower share of coal. The competitiveness analysis does not consider these regional specificities.

The analysis is based on today's cost structures and technologies. Average cost structures

representative for industry (sub-sectors) have been used without taking into account the specificities of a location or an individual player.

Finally, in order to illustrate the total emissions of a process – direct $CO_2$ emissions and indirect emissions from electricity production – average emissions of 0.41 tons of $CO_2$ per MWhel are assumed for electricity production in Europe.

## 2.5 METHODOLOGY

The bottom-line impact on margins for a given industry – expressed as percentage of total costs – was determined using the following steps:

- Add the cost increases for input factors, e.g., electricity, to the cost of direct emissions, the allowances. We use 100% of the direct costs here, regardless of the level of free allocation, because the allowances can be sold if not used internally.
- Estimate the potential to pass through the cost increase to customers on the basis of the competitive situation in the industry.
- Calculate the value of free allowances.
- Determine the overall net impact on cost.

# 3  OBSERVATIONS BY SECTOR

## 3.1  POWER GENERATION

### 3.1.1  Sector Summary

The electricity sector in the liberalised market in Europe has gone through a phase of low wholesale market prices, which did not allow for new power plant investments. Triggered by reduced capacity reserve margins, increasing gas and coal prices and the $CO_2$ prices, electricity prices have again reached the level required to support investment in new power plants.

In the short to mid term, the impact of $CO_2$ prices on electricity prices should be in the order of 10 Euro/MWh for a 20 Euro/ton $CO_2$ price on average across Europe assuming a full pass through[6] of the value of allowances to power prices.

In the short- and medium-term, $CO_2$ emissions trading will make electricity generation more profitable on average, especially for existing nuclear power plants. The profitability of other plants depends largely on the level of free allowances.

### 3.1.2  Processes and Products

Nuclear power is the most important source of electricity generation in Europe accounting for nearly one-third of production. Gas and hard coal account for nearly 20% each, hydro and other renewables for 17%, lignite for 11% and oil for 4%. $CO_2$ emission reduction via the EU ETS is expected to mainly affect the balance between hard coal and gas.

### 3.1.3  Carbon Intensity

Electricity generation accounts for over 50% of the direct emissions covered by the EU ETS. The average carbon intensity of electricity generation in Europe is 0.41 tons of $CO_2$ per MWh of electricity. The carbon intensity depends on the fuel and the efficiency of the power plants.

**CARBON INTENSITY IN POWER GENERATION**
Tons of $CO_2$ per MWh

| Industry | Indirect $CO_2$ emissions | Direct $CO_2$ emissions | Total $CO_2$ emissions |
|---|---|---|---|
| • New CCGT | 0.00 | 0.35 | 0.35 |
| • New hard coal | 0.00 | 0.75 | 0.75 |
| • New lignite | 0.00 | 0.91 | 0.91 |
| • New nuclear | 0.00 | 0.00 | 0.00 |
| • Gas ST old | 0.00 | 0.63 | 0.63 |
| • GT | 0.00 | 0.65 | 0.65 |
| • Hard coal old | 0.00 | 0.91 | 0.91 |
| • Lignite old | 0.00 | 1.11 | 1.11 |
| • Nuclear old | 0.00 | 0.00 | 0.00 |

Source: McKinsey estimate

Table 3-1: Carbon Intensity in Power Generation

6    Please see definition of "full pass through" in chapter 1.2.1 on page 4

While old lignite power plants emit more than one ton of $CO_2$ per MWh of electricity produced, modern combined cycle gas turbines (CCGT) emit less than one-third of a ton. At the same time, the data in Table 3-1 above show that a replacement of an old power plant with a new one for the same fuel usually increases $CO_2$ efficiency by about 20%.

### 3.1.4   Industry Trends

Given the age of the generation park and the increase in demand for electricity in Europe up to 2020, around 260 to 300 GW of new capacity will be needed. Within that total range, 130 to 170 GW will be needed to replace old capacity that will be shut down. Another 130 GW will be needed to satisfy higher demand. The investment cost will be in the order of 130 to 200 billion Euro depending on technological choices.

After liberalisation, the electricity sector in the European Union has gone through a phase of low wholesale market prices that did not allow for significant new investments. Triggered by reduced reserve margins, increasing gas and coal prices and the $CO_2$ prices, electricity prices have again reached the level required to support investment in new power plants.

### 3.1.5   Players in the Industry

The five largest players in the European electricity generation market – EdF, E.ON, Enel, RWE and Vattenfall – hold 43% of the total capacity.

**OVERVIEW OF GENERATION COMPANIES IN EUROPE**

| | Company | Country | Capacity 2003 [MW] | [%] | | Company | Country | Capacity 2003 [MW] | [%] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | EdF | France | 101.2 | 15.1% | 14 | Edison+Sondel | Italy | 7.0 | 1.0% |
| 2 | E.On | Germany | 61.8 | 9.2% | 15 | Scottish&Southern Energy | UK | 5.7 | 0.9% |
| 3 | Enel | Italy | 45.7 | 6.8% | 16 | Scottish Power | UK | 5.4 | 0.8% |
| 4 | RWE | Germany | 45.1 | 6.7% | 17 | Unión Fenosa | Spain | 5.4 | 0.8% |
| 5 | Vattenfall Group | Sweden | 30.8 | 4.6% | 18 | PVO | Finland | 4.7 | 0.7% |
| 6 | Electrabel | Belgium | 28.8 | 4.3% | 19 | Nuon | Netherlands | 3.7 | 0.6% |
| 7 | Endesa Group | Spain | 28.5 | 4.3% | 20 | Essent | Netherlands | 3.1 | 0.5% |
| 8 | Iberdrola | Spain | 20.3 | 3.0% | 21 | Hidrocantábrico | Spain | 2.6 | 0.4% |
| 9 | EnBW | Germany | 15.2 | 2.3% | 22 | TVO | Finland | 1.7 | 0.3% |
| 10 | Statkraft | Norway | 12.2 | 1.8% | 23 | BKK | Norway | 1.6 | 0.2% |
| 11 | British Energy | UK | 11.6 | 1.7% | 24 | Centrica | UK | 1.6 | 0.2% |
| 12 | Fortum | Finland | 11.3 | 1.7% | | OTHERS | | 207.6 | 31.0% |
| 13 | Edipower | Italy | 7.4 | 1.1% | | **TOTAL** | | **670.0** | **100%** |

Source: Annual reports; McKinsey estimate

Table 3-2: Overview of Generation Companies in Europe

### 3.1.6   Trade Flows

European electricity markets are fairly integrated, at least within regional submarkets. Germany, France, and Austria can be seen as a well-connected submarket. The Netherlands, together with Belgium, represent another, Iberia is one, and Italy is one, Scandinavia another and the new EU Member States can roughly be seen as one market as well.

Within the regional submarkets, transmission capacity is sufficient to keep electricity wholesale market prices uniform in most hours of the year. There are transmission flows

**PRODUCTION, IMPORTS, EXPORTS BY COUNTRY 2003**

| | Production | Imports | Export | | Production | Imports | Export |
|---|---|---|---|---|---|---|---|
| | TWh | TWh | TWh | | TWh | TWh | TWh |
| **Austria** | 58 | 19 | 13 | **Latvia** | 4 | n.a. | n.a. |
| **Belgium** | 82 | 15 | 8 | **Lithuania** | 18 | n.a. | n.a. |
| **Cyprus** | 4 | n.a. | n.a. | **Luxembourg** | 4 | 7 | 3 |
| **Czech Republic** | 77 | 10 | 26 | **Malta** | 2 | n.a. | n.a. |
| **Denmark** | 44 | 7 | 16 | **Netherlands** | 93 | 21 | 4 |
| **Estonia** | 9 | n.a. | n.a. | **Poland** | 151 | 5 | 15 |
| **Finland** | 80 | 12 | 7 | **Portugal** | 44 | 6 | 3 |
| **France** | 541 | 6 | 72 | **Slovakia** | 29 | 7 | 9 |
| **Germany** | 559 | 45 | 54 | **Slovenia** | 13 | n.a. | n.a. |
| **Greece** | 52 | 4 | 2 | **Spain** | 242 | 9 | 8 |
| **Hungary** | 31 | 14 | 7 | **Sweden** | 133 | 24 | 12 |
| **Ireland** | 25 | 1 | n.a. | **UK** | 354 | 5 | 3 |
| **Italy** | 280 | 52 | 1 | **SUM** | **1841** | **185** | **207** |

Source:   IEA, UCTE, Eurostat, Nordel, DTI

Table 3-3: Production, Imports, Exports by Country 2003

between regional submarkets, the biggest one being the flow from France towards Italy, which partly flows through Germany and Switzerland.

### 3.1.7   Cost Structure

The cost structure of different power plants can be broken down into three main elements, fuel costs, operating and maintenance (O&M) costs and capital costs. Fuel costs are a main element in the dispatch decision, i.e., deciding which plant to run in the next hours.

O&M costs are relevant for long-term decisions, such as potential plant closures. Capital costs are sunk costs for existing power plants.

The lifetime of a power plant is typically 45 years. After 20 years, a plant is usually depreciated and bears no more capital costs. For decisions on investment in new power plants, the capital costs are relevant.

**INDICATIVE COST STRUCTURE OF POWER PLANTS**
Euro/MWh

| Industry | Fuel* | O&M | Capital** | Total costs |
|---|---|---|---|---|
| **Power** | | | | |
| • New CCGT | 22.1 | 4.7 | 8.3 | 35.1 |
| • New hard coal | 15.2 | 6.3 | 17.4 | 38.9 |
| • New lignite | 8.9 | 6.5 | 15.3 | 30.7 |
| • New nuclear | 14.1 | 7.1 | 19.5 | 40.7 |
| • Gas ST old | 39.4 | 12.9 | 0.0 | 52.3 |
| • GT | 40.6 | 42.0 | 0.0 | 82.6 |
| • Hard coal old | 18.3 | 21.0 | 0.0 | 39.3 |
| • Lignite old | 10.8 | 13.1 | 0.0 | 23.9 |
| • Nuclear old | 14.5 | 8.3 | 0.0 | 22.8 |

\*    Assumed fuel prices of 56 Euro/t for hard coal, 31 Euro/t of hard coal equivalent for lignite, 12.6 Euro/MWh for gas
\*\*   On an annuity basis over 20 years at an 8% interest rate; old plants assumed to be depreciated

Table 3-4: Indicative Cost Structure of Power Plants

Gas plants typically have higher fuel costs and lower capital costs, while the opposite is true for coal plants.

Power plant dispatch decisions are based on the short-term marginal costs. Those are mainly fuel costs, with some consideration of the current status of the plant (cold, warm reserve, online), start-up costs and times, and expected future electricity prices. $CO_2$ costs will have to be included in the short-term marginal costs for the dispatch decision. $CO_2$ costs have the tendency to shift production from more carbon-intensive fuels to less carbon-intensive fuels.

Lignite power plants have short-term variable costs of only about 10% of their fuel costs, because the lignite mine belongs typically to the power plant owner, the costs in the mines are mostly fixed costs and lignite can not be sold elsewhere, because it holds too little energy to justify transport over distances. Thus, even with high $CO_2$ costs added on top of the short-term variable costs, lignite plants will continue being dispatched nearly all the time.

The short-term variable costs of hard coal power plants and gas power plants are more or less identical with their fuel costs. With the $CO_2$ costs on top, the balance between coal and gas can shift easily towards gas and that is one of the main levers of emission reduction in the EU ETS.

## 3.1.8    Short- and Mid-term Impact of the EU ETS on Competitiveness

In the short and mid term, $CO_2$ emissions trading will make electricity generation more profitable on average, especially for existing nuclear power plants. The fossil-fuel power plants will incur a huge increase in direct costs of between 20% and 90% from the EU ETS before taking into account the value of free allocation. New CCGT plants incur a lower increase; old lignite plants a higher increase.

Electricity generators will adapt their dispatch behaviour in order to reflect $CO_2$ costs. According to McKinsey's electricity wholesale market model for the European power sector under fully competitive assumptions, the resulting average increase of electricity prices across Europe would be in the order of 10 Euro/MWh for a 20 Euro/MWh $CO_2$ price, assuming a full pass through[7] of the value of allowances to power prices. Some research institutes[8] use a more generic approach based on conceptual power plants, a gas power plant and a coal power plant. Their results in terms of observed pass through rates are not comparable with the McKinsey approach. A 75% cost pass through rate in one of the research institute's conceptual approaches is equivalent to a 100% pass through in the McKinsey model of the full European power plant fleet.

Taking the 10 Euro per MWh electricity price increase and dividing it by the total production cost of each electricity generation technology results in different percentages per technology. The electricity price increase compensates the cost increase that new CCGT incur due to $CO_2$. It represents about two-thirds of the cost increase for new hard coal plants and half of the cost increase for old coal and lignite plants.

The coverage of costs via free allowances compensates for another significant part of the cost increase. The resulting net increase in costs is about -25% for new power plants, meaning that costs net of all effects decrease.

The net cost effect for existing power plants is negative on average as well, between around -10% for GT and -40% for existing nuclear power plants.

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7    Please see definition of "full pass through" in chapter 1.2.1 on page 4
8    E.g. ECN

**Overview of Short- and Mid-term Findings in Power Generation**
Percent of total costs

| Industry | Indirect cost increase | Direct cost increase | Total cost increase | Offset by product price increase | Offset by allowance endowment at 95% free allowances | Net cost increase |
|---|---|---|---|---|---|---|
| • New CCGT | 0.0 | 20.1 | 20.1 | 28.5 | 19.1 | <0 |
| • New hard coal | 0.0 | 38.6 | 38.6 | 25.7 | 36.7 | <0 |
| • New lignite | 0.0 | 59.3 | 59.3 | 32.6 | 56.4 | <0 |
| • New nuclear | 0.0 | 0.0 | 0.0 | 24.6 | 0.0 | <0 |
| • Gas ST old | 0.0 | 24.1 | 24.1 | 19.1 | 22.9 | <0 |
| • GT | 0.0 | 15.7 | 15.7 | 12.1 | 15.0 | <0 |
| • Hard coal old | 0.0 | 46.1 | 46.1 | 25.5 | 43.8 | <0 |
| • Lignite old | 0.0 | 92.7 | 92.7 | 41.9 | 88.0 | <0 |
| • Nuclear old | 0.0 | 0.0 | 0.0 | 43.8 | 0.0 | <0 |

Table 3-5: Overview of Short- and Mid-term Findings in Power Generation

The impact on fossil-fuel power plants depends largely on the level of free allowances.

In the table above, the results are given for 95% of free allowances. However, the impact on new power plants, as well as on new assets in other industries, depends on the new entrant provisions, which can vary considerably among Member States. In particular, new coal plants would not receive 95% of their need in Member States with a fuel-blind new entrant benchmark such as Denmark and the UK.

## 3.2   STEEL

### 3.2.1   Sector Summary

Assessing the impact of the EU ETS on the competitiveness of steel requires distinguishing between two main processes for steel making: Basic Oxygen Furnace (BOF) in integrated mills, producing mainly flat products, and Electric Arc Furnace (EAF) in minimills, producing mainly long products from scrap steel.

With total emissions of 2.0 tons of $CO_2$ per ton of steel, the BOF process is more exposed to carbon reduction than EAF, which has total emissions of around 0.4 tons of $CO_2$ per ton of steel. Nearly 100% of emissions in EAF are indirect emissions in the form of electricity, while only 10% are indirect in BOF.

At a $CO_2$ price of 20 Euro/ton, the total short- and mid-term cost increase is around 17.3% for BOF and 2.9% for EAF. Of the total, the indirect cost increase is around 2.0% for BOF and 2.5% for EAF. The direct cost increase is 15.3% and 0.4% respectively.

Given the product mix and types of markets, it is expected that around 6% of the total cost increase in BOF and 66% in EAF can be passed through to customers on average, because long products – mostly produced in the EAF process – tend to compete in more local markets, while flat products from BOF go into more global markets. Individual players, particularly in the high-quality segment, could, however, be more affected given their product mix.

Under carbon constraints, slag increases in value by 20 Euro/ton. This additional revenue

potential equals 0.5% of the total costs in BOF, if BOF can capture 50% of the value increase.

Assuming 95% free allowances[9] on direct emissions and a typical industry EBIT[10] in the order of 5%, 1.7 percentage points of EBIT might be lost due to $CO_2$ regulation for BOF and 0.6 of a percentage point for EAF. Typical long-term industry margins before Chinese demand picked up were in the order of 5%. A 1.7% increase would therefore decrease the value of the industry by one-third. Over the last two to three years, margins have been better, but as China is likely to turn into a steel exporter in the near future, margins might come under further pressure.

For BOF, continued debottlenecking is an important factor over the medium term. Achieving a continuous increase in production capacity while the allowance allocation remains constant might decrease the implicit share of free allowances. A decrease of free allowances to 80% would imply a reduction of EBIT by 4.0 percentage points for BOF. Given the additional costs of about 17% on the marginal production of primary steel (BOF), there is an incentive to stop debottlenecking in Europe and to shift marginal production into areas without the additional $CO_2$ costs.

### 3.2.2    Value Chain

Two main production process routes characterise the steel industry along the steel value chain: the integrated mill route (often referred to as "BOF") and the mini-mill route (often referred to as "EAF").
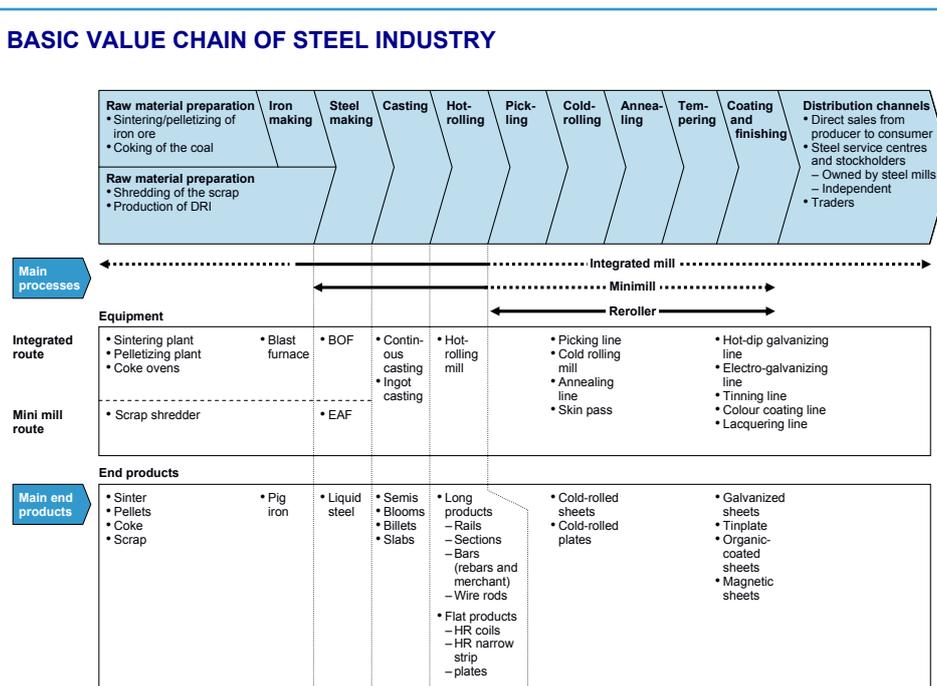


Figure 3-1: Steel Value Chain

### 3.2.3    Processes and Products

In the **integrated mill route**, two "subroutes" are eventually combined in the blast furnace: the "iron route" and the "coal route".

---

9    95% of required allowances
10   Earnings Before Interests and Taxes

**DETAILS OF PROCESSES – STEEL**                                    <u>SIMPLIFIED</u>

**Integrated mill**

```
                    Sinter
           Iron ore  plant
           fines
Raw                                Blast      Hot metal    BOF steel-    Secondary    Continuous
materials                          furnace    pre-         making        metallurgy   casting
• Iron ore          Coke                      treatment
• Coking coal       ovens
• Scraps   Coking
           coal
                                                                                      Production
                                                                                      of flat or
           Iron ore lumps and/or pellets                                              long
                                                                                      products
        Scrap shredder*
```

**Minimill**

```
                Scrap shredder*

Raw                                EAF          Secondary    Continuous
materials       DRI plant**        steel-       metallurgy   casting
• Scraps                           making
• Iron ore   Iron ore
                                                              Production
                                                              of flat or
                                                              long
                                                              products
```

\*   Depending on the quality of the scrap collected, a shredder is required or not
\*\* EAF can use scraps, DRI or a mix of the two depending on the quality of the end product (in Europe DRI is rarely used for cost reasons)
Source:  McKinsey

Figure 3-2: Details of Steel Process

In the iron route, iron ore from iron ore mines goes as iron ore fines into a sinter plant. In the sintering process, iron ore fines are transformed into sinter. The sintering process makes iron ore fines resistant and strong enough for processing in the blast furnace.

In the coal route, coking coal from coal mines goes into a coke oven in order to transform it into coke. This process is likewise needed in order to use the coke as an input in the blast furnace. In most cases, a coking plant and a sintering plant are situated on the same site because coke dust from the coking plant is used in the sintering plant.

Coke and sinter are fed into the blast furnace where the iron ore is reduced and melted by burning the coke. The process is initiated and accelerated by blowing hot air through the blast furnace. Output of the blast furnace is liquid iron called "pig iron" at a temperature of approx. 1,400 degrees Celsius. Often the pig iron is then physically transported by torpedo wagons to the basic oxygen furnace. Pig iron still contains significant carbon. In order to get rid of the carbon, pig iron goes into the basic oxygen furnace (BOF). Note that $CO_2$ emissions at integrated sites are process intrinsic in the sense that the $CO_2$ is a product of the reaction. It is for this reason that it is difficult to reduce $CO_2$ emissions in this route. The industry is examining potential breakthrough concepts based on the recycling of blast furnace top gas after decarbonisation, potentially with added $CO_2$ capture and storage, electrolysis, use of hydrogen, use of carbon and natural gas with $CO_2$ capture and sequestration in reactors different from the blast furnace, utilization of biomass etc. However, these are long-term efforts requiring at least five years to deliver a concept and another five years to confirm technical and economical viability.

The output of the basic oxygen furnace is liquid steel. The steel properties of liquid steel are then improved by adding metals in the process called "second metallurgy". Then the steel is moved to the continuous caster and solidified into semi-finished products: slab for flat products, and billet or bloom for long products.

In the **minimill route**, raw materials can be scrap and iron ore. The Electric Arc Furnace process (EAF) transforms these raw materials into liquid steel. Scrap usually is shredded in a scrap shredder, while iron ore is processed in a DRI (direct reduction iron) plant. EAF can

use scrap, DRI or a mix, depending on quality. In Europe, DRI is hardly used for cost reasons because, in the DRI process, natural gas is used for the reduction process instead of coke and natural gas is rather expensive in Europe in comparison with other regions, e.g. the Middle East.

As in the integrated mill route, the steel properties of liquid steel are improved in the "second metallurgy. "Then the steel is cast and solidified into semi-finished products: slab for flat products, and billet or bloom for long products.

In the EU25, the total 2003 steel production capacity was around 215 million tons annually and the total actual production around 184 million tons.

The **integrated mill route** produces **mainly flat products.** Around 75% of the total production of integrated mills of approx. 114 million tons annually consists of flat products and the remaining 25% is long products.

The **minimill route** produces **mainly long products.** Around 85% of the total production of minimills of approx. 70 million tons annually consists of long products and the remaining 15% is flat products.

## 3.2.4   Carbon Intensity

The integrated route emits about five times more $CO_2$ per ton of produced steel than the minimill route (around 2 tons of $CO_2$ per ton of produced steel versus around 0.4 tons of $CO_2$ per ton of produced steel respectively).

**CARBON INTENSITY IN STEEL PRODUCTION**
Tons of $CO_2$ per ton of steel

| Industry | Indirect $CO_2$ emissions | Direct $CO_2$ emissions | Total $CO_2$ emissions |
|---|---|---|---|
| • BOF (mainly flat) | 0.20 | 1.80 | 2.00 |
| • EAF (mainly long) | 0.35 | 0.05 | 0.40 |

Table 3-6: Carbon Intensity in Steel Production

Most of the emissions in the integrated route are direct process emissions, i.e., around 1.8 tons of $CO_2$ per ton of produced steel out of a total of 2 tons of $CO_2$ per ton of produced steel, and around 0.2 tons of $CO_2$ per ton of produced steel are indirect $CO_2$ emissions.

Most of the emissions in the minimill route are indirect emissions from electricity generation because the EAF process uses a substantial amount of electricity (0.35 tons of $CO_2$ per ton of produced steel). The remainder is $CO_2$ emissions from direct emissions caused by the anode in the Electric Arc Furnace (0.05 tons of $CO_2$ per ton of produced steel).

## 3.2.5   Industry Trends

### 3.2.5.1   Industry Structure

The **demand side** of the carbon steel[11] industry in the EU25 is characterised by several factors. Firstly, demand is stable, although the market is highly volatile and cyclical. Secondly, long products are mostly commodities while flat products are more often specialties. Thirdly, aluminium competes with flat products, but only marginally, while concrete competes significantly with long products.

The **supply side** of the carbon steel industry in the EU25 is characterised by a modest concentration for flat products and a high fragmentation for long products. Flat products are subject to strong import pressure. Long products experience less import pressure than flat products, since the market for long products has a more local nature given the size, weight and limited value of those products. When compared with minimills, integrated mills usually have relatively high fixed costs and a high capacity utilization. Minimills have relatively lower fixed costs (approx. 15% of total costs) and a more heterogeneous capacity utilization. In some European countries the steel industry has been substantially restructured, while others still have to go through this process. Capacity shutdowns are expected in countries that have not yet restructured their steel industry.

The steel industry has high barriers to both exit and entry. High exit barriers exist mainly because integrated players face high potential social costs and minimills are often family businesses. High entry barriers exist because the industry is capital intensive and potential new entrants often compete with depreciated assets.

Perhaps the most important feature on the supply side of the steel industry is continuous "debottlenecking. "The step in the production route of steel that is the bottleneck for the capacity flow through the process is the focus of constant improvement. While in theory debottlenecking can happen in each industry, it is particularly relevant for the steel industry, which has delivered debottlenecking rates of approximately 1% per year between 1989 and 2003 in the EU15. We do not see any limits to the debottlenecking potential in the steel industry. This implies that ongoing incremental debottlenecking over the years to come could have significant impact on steel-making capacity in the European Union. Moreover, incremental debottlenecking of some individual players has more impact than the European average of approximately 1 % per year. This characteristic of the steel industry is important for allowance allocation. With a grandfathering principle (in effect allocating allowances on the basis of historical emissions) players could, ceteris paribus, as a consequence of continuous debottlenecking, face increasing shortages over the years with a constant allocation.

### 3.2.5.2   Industry Conduct

The "volume rather than margin" logic in **marketing and sales** is slowly changing to less volume and higher margins. Customers expect new products but they are reluctant to pay any extra cost. **Distribution** is highly heterogeneous, depending on the country and product. On the environmental side, sustainability is promoted in joint campaigns with a focus on recycling ("easy to recycle").

**Capacity** reduction is partly compensated by the expansion of some players and continuous debottlenecking. The market for flat products was consolidated through the mergers of Arcelor, ThyssenKrupp and Corus. In the market for long products, consolidation is still in a very early stage.

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11   Carbon steel is the most basic steel as opposed to stainless steel

The steel industry has very limited **integration** upstream but increasing presence downstream. Long-term contracts are seen only in the automotive industry (flat products). Some players and/or end-customer markets focus on "one-stop-shopping".

The steel sector is characterised by a strong pressure on cost control. Just-in-time logistics and a reduction of working capital are common. Research and development efforts focus mainly on flat products.

### 3.2.5.3  Industry Performance

In terms of **financial results**, the carbon steel industry in the EU25 is historically characterised by poor average profitability except for a few niche players. Moreover, there has been value destruction – not earning the cost of capital – over the past two decades except for a few exceptional years (e.g., 2004 and 2005).

In terms of **technological progress**, no technological revolution has been observed over the past two decades. There has been a strong development of coated flat steel versus uncoated steel (corrosion).

In terms of **employment objectives**, there is a recurrent decline of employment linked to productivity gains required by the price-cost squeeze and international competition.

### 3.2.6  Players in the Industry

**TOP 10 EU25 STEEL PRODUCERS**



Source: Eurofer; McKinsey

Figure 3-3: Top 10 EU25 Steel Producers

The top 10 steel producers in the EU25 and their market shares are listed in figure 3-3: "Top 10 EU25 Steel Producers". Of a total EU25 production of 184 million tons of steel, the top five players hold 53% of the overall EU25 market while the top 10 players hold 68%. The top 10

players cover a substantial part of the EU25 countries: they are present in most of the larger countries.

## 3.2.7  Trade Flows

Within the EU25, about 90 million tons of long end-products[12] are produced and about 94 million tons of flat end-products[13]. Around 4.2 million tons of long products are imported into the EU25 (approx. 5% of long product production) and around 5.9 million tons are exported

**TRADE FLOWS IN STEEL INDUSTRY**

| Product | Production | Imports | Exports |
|---|---|---|---|
| | [M tons] | [M tons] | [M tons] |
| **Long end-products** | 90 | 4.2 | 5.9 |
| Billets, blooms (SEMI) | | 2.4 | 1.4 |
| **Flat end-products** | 94 | 10.1 | 11.9 |
| Slabs (SEMI) | | 3.2 | 1.5 |
| **TOTAL** | **184** | **19.9** | **20.7** |

Source:  ISSB; McKinsey estimate

Table 3-7: Trade Flows in Steel Industry

(approx. 7% of long product production). Around 10.1 million tons of flat products are imported into the EU25 (approx. 11% of flat product production) and around 11.9 million tons are exported (approx. 13% of flat product production).

## 3.2.8  Cost Structure



Figure 3-4: Potential Mid- and Short-term Cost Impact of ETS on Steel Industry – BOF

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12   25% of the 114 million tons from the integrated mill route (BOF) plus 85% of the 70 million tons from the minimill route (EAF) are long end-products

13   75% of the 114 million tons from the integrated mill route (BOF) plus 15% of the 70 million tons from the minimill route (EAF) are flat end-products

**POTENTIAL COST IMPACT OF ETS ON EU STEEL INDUSTRY
(SLAB, EAF PROCESS)**
Euro/ton

$\overline{CO_2 @ 20€/TON}$
■ Indirect $CO_2$ costs
□ Direct $CO_2$ costs
% Cost increase

An indirect $CO_2$ effect might be the increase in scrap demand and thus price

Direct $CO_2$ at anode

Increase in electricity price

High volatility, especially in 2004

139
1
138

13

29
6
23

30

13

11

235
7

228

(Range: 190-260)

+2.9%

Raw materials, alloys | Refrac-tories | Electricity | Services, overhead | Labor | Capital | Total cost with $CO_2$ impact

Source:  MEPS Steel Review; McKinsey Metals & Mining Practice; Iron making and Steel making 2000; ECOFYS; McKinsey analysis

Figure 3-5: Potential Short- and Mid-term Cost Impact of ETS on Steel Industry – EAF

Of an overall cost increase for BOF steel of 40 Euro/ton steel, 36 Euro is the short- and mid-term direct cost increase and 4 Euro is the indirect cost increase (2 Euro in refractories and 2 Euro in electricity price increase).

EAF faces an overall cost increase of 7 Euro/ton steel in the short- and mid-term, of which 6 Euro/ton of steel is caused by higher electricity prices.

### 3.2.9   Impact of the EU ETS on Competitiveness

At a $CO_2$ price of 20 Euro/t, the total cost increase for BOF is around 17.3% and for EAF 2.9%. Of the total, the indirect cost increase is around 2.0% for BOF and 2.5% for EAF. The direct cost increase is 15.3% and 0.4%, respectively.

**OVERVIEW OF SHORT- AND MID-TERM FINDINGS IN STEEL INDUSTRY**
Percent of total costs

| Industry | Indirect cost increase | Direct cost increase | Total cost increase | Offset by product price increase | Offset by allowance endowment at 95% free allowances | Net cost increase |
|---|---|---|---|---|---|---|
| • BOF (mainly flat) | 2.0 | 15.3 | 17.3 | 1.1 | 14.5 | 1.7 |
| • EAF (mainly long) | 2.5 | 0.4 | 2.9 | 1.9 | 0.4 | 0.6 |

Table 3-8: Overview of Short- and Mid-term Findings in Steel Industry

Given the product mix and types of markets, it is expected that around 6% of the total cost increase in BOF and 66% in EAF can be passed through to customers. Products with a more local nature can pass through their costs more easily than products that compete on the global market. European quality products are expected to be able to pass costs through at least as long as the global supply-demand balance is characterised by a high demand for import into China.

Slag is a waste product in steel-making that is – if used in the cement sector – a way to cut emissions from cement-making. A carbon constraint makes slag more valuable. Under carbon constraints, slag increases in value by 20 Euro/ton. This additional revenue potential equals 0.5% of the total costs in BOF, if BOF can capture 50% of the value increase.[14]

Assuming 95% free allowances[15] on direct emissions and a typical industry EBIT for the BOF and EAF routes in the order of 5%, 1.7 percentage points of EBIT might vanish in the short- and mid-term due to $CO_2$ regulation for BOF and 0.6 of a percentage point for EAF.

For BOF particularly, continued debottlenecking is an important factor over the medium-term. A decrease of free allowances to 80% would mean a reduction of EBIT by 4.0 percentage points instead of 2.4 percentage points at 90% free allowances for BOF. Because of the additional costs of about 17% on the marginal production of primary steel (BOF), there is an incentive to stop or reduce debottlenecking in Europe and to shift marginal production into areas without these costs.

One could conclude that EAF would be the favourable choice over BOF and that BOF could be substituted by EAF. However, a further replacement of BOF by EAF is not a viable solution at this stage due to the current scarcity of scrap, mainly caused by Chinese demand, which is expected to continue.

### 3.2.10    The Importance of Auto-generation

On average across Europe, according to IEA figures 14% of the electricity for steel production is produced by the steel companies themselves (Figure 2-8: Auto-generation Share of Different Industries in Europe on page 15). According to the results of the survey on the EU ETS, the non-weighted average auto-generation share is zero for the EAF route and 41% for the BOF route for the respondents. Assuming the 0% for the EAF route is correct, we can calculate from the IEA average of 14% using the production figures of 114 million tons p.a. for the BOF route and 70 million tons p.a. for the EAF route that the correct number for the production-weighted share of auto-generation in the BOF route should be around 23%.

For the EAF route, the competitiveness impact would not change at all, as there is no auto-generation. For the BOF route, we have to distinguish between the total company perspective and the perspective of the BOF operation. From a total company perspective, the company would have to bear only 77% of the electricity price increase. Therefore the short- and mid-term indirect cost increase from electricity would go to 1.5% instead of 2.0% (relative to the total production costs). From the perspective of the BOF operations and potential relocation decisions for the relevant production, the picture does not change at all with auto-generation, as the electricity plant operator can sell its electricity to the grid, if it is not used internally. Therefore, the market price of electricity has to be applied.

### 3.3    PULP & PAPER

### 3.3.1    Sector Summary

Half of the pulp for paper production in Europe is produced from recovered fibre, while the other half is based on wood. The latter, called "primary pulp", is produced in mainly three processes: chemical pulping, mechanical pulping and thermo-mechanical pulping.

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14    Given the uncertainty about how much of the additional value can be captured by the steel industry, we have not included it into the base case in the table above.
15    95% of required allowances

Chemical pulp, which accounts for over 30% of total European pulp production, is traded as a quasi-commodity on a world market. Thermo-mechanical pulp accounts for about 12% of production, mechanical pulp for 6%. In chemical pulp, one needs to differentiate long-fibre pulp (made from softwood) and short-fibre pulp (made from hardwood). Mechanical pulp, thermo-mechanical pulp and recovered fibre are used mainly in integrated pulp and paper mills.

The short- and mid-term effect of the EU ETS on competitiveness in the pulp & paper sector is on average across the industry compensated only partially by free allowances – even assuming 95% free allocation – since most of the cost increase comes from indirect sources. The remaining net cost increase is in the order of 0.3 to 1.0% in processes with chemical pulp and up to 1.9% in pulp and paper production based on recovered fibre. Mechanical pulping (6% of total pulp) and thermo-mechanical pulping (12% of total pulp) are affected by a 3 to 4% and 5 to 6% net cost increase.

In chemical pulping, most of the energy consumed originates from burning carbon compounds in the process of recovering the pulping chemicals. Thus, the external energy demand and the overall $CO_2$ intensity are significantly lower than in other pulping processes (mechanical pulping and thermo-mechanical pulping). As a consequence, the cost increase in chemical pulping is only around 0.7%. Even though the market is global, we expect that the direct cost increase from $CO_2$ (0.2% of the chemical pulp costs before free allowances) can be passed through to customers, while electricity prices increases cannot. About 0.2% of the cost increase will be covered by free allowances, so that the overall net cost increase is in the order of 0.3% for chemical pulp production.

Mechanical and thermo-mechanical pulp production exists only in integrated pulp & paper plants. Including paper production, they have to bear a total cost increase in the order of 6% to 8%. The free allocation of allowances covers only slightly more than 1 percentage point of those costs. The potential cost pass through covers between zero and 1 percentage point, so that the remaining net cost increase will still be very significant with 3 to 4 percentage points in the mechanical pulp & paper process and 5 to 6 percentage points in the thermo-mechanical process.

Integrated pulp & paper production based on recovered fibre will see a cost increase of around 3%, of which 1 percentage point will be covered by free allocation, between zero and 1 percentage point can be passed through to customers, so the remaining net cost increase will be between 1% and 2%.

Paper making based on chemical pulp will see a cost increase of 2%, out of which 1 percentage point will be covered by free allocation. Some of the remainder can be passed through to the customers, so that the remaining net cost increase will be below 1%.

One could conclude from this that in a carbon-constrained environment primary pulp production would see a trend towards more chemical pulping at the expense of mechanical and thermo-mechanical pulping. However, this is not the case, as chemical pulp production is already rather expensive (Figure 3-9: Short- and Mid-Term Impact of ETS on Cost in Pulp & Paper). Furthermore, chemical pulp production in Europe has come under increasing competition from cheaper chemical pulp from abroad, especially Brazil.

### 3.3.2  Value Chain

Five main processes can be characterised along the pulp and paper value chain: chemical pulping, mechanical pulping, thermo-mechanical pulping, waste paper recovery and paper making. The first four are all inputs into the paper making process.

**BASIC VALUE CHAIN OF PULP & PAPER INDUSTRY**

| Raw material preparation<br>• Harvesting trees<br>• Collecting saw milling waste wood | Chemical pulping<br>Mechanical pulping<br>Thermo-mechanical pulping | Paper making | Coating | Converting | Distribution channels<br>• Direct sales from producer to large consumers (publishing houses, retail chains, pack-aging industry)<br>• Trade |
|---|---|---|---|---|---|
| Raw material preparation<br>• Collecting waste paper from industry and households | Waste paper recovery | | | | |

← Market pulp mill →

← Integrated pulp and paper mill →

← Paper mill →

**Equipment**

| • Chemical pulping<br><br><br><br>• (Thermo-) Mechanical pulping<br><br>• Waste paper recovery | • Chipper<br>• Digester<br>• Washing/bleaching<br>• Pulp dryer<br><br>• Chipper + Refiner or<br>• Grinder<br><br>• Pulper (dissolver)<br>• De-inking equipment | • Paper machine with<br>  – Wet section<br>  – Press section<br>  – Dryer<br>  – Winder | • On- or offline coating machine | • Rewinder for transformation of reels<br>• Available machines for production of sheets | |

**End products**

| | • Packages of market pulp (air dry) or<br>• Fibre suspension (integrated mills) | • Paper "mother" reels in full machine width (2m to 10m) | | • Paper reels in printable width<br>• Paper sheets in various sizes<br>• Tissue products | |

Source: McKinsey

Figure 3-6: Value Chain Pulp & Paper Industry

The first three are sometimes called primary pulp while wastepaper recovery is called secondary pulp (also known as "de-inked pulp" or "DIP").

### 3.3.3 Processes and Products

Wastepaper recovery accounts for half of the EU15 pulp production (51%), followed by

**DETAILS ON PRODUCTS PER PROCESS**    EU15
Percent of tons; 2003

| | Product | Key characteristics | Share of EU production |
|---|---|---|---|
| **Chemical pulping** | • Sulphate pulp, Sulphite pulp | • High fibre quality; Sulphate pulp provides strength, Sulphite pulp smoothness and good printability; bleached or unbleached<br>• Most expensive fibrous raw material for paper production but inevitable for bright (woodfree) writing and printing paper | 31 |
| **Mechanical pulping** | • Ground wood | • Poor fibre quality; strength of fibres limited due to mechanical treatment; paper tends to yellow as fibres are not woodfree<br>• Used as bulk material for paper and board manufacturing as far as paper/board properties allow that; is substituted by DIP | 6 |
| **Thermo-mechanical pulping** | • TM Pulp<br>• CTM Pulp | • Medium fibre quality; paper tends to yellow as fibres are not woodfree<br>• Used for most paper and board grades, where brightness is not important | 12 |
| **Wastepaper recovery** | • De-inked pulp (DIP) | • Poor fibre quality (varies between different grades of waste paper); provides hardly strength for the paper; tends to yellow<br>• Cheapest fibrous raw material; used as bulk material for paper and board manufacturing as far as paper/board properties allow | 51 |
| | | | **100\*** |
| **Paper making** | • Newsprint | • Limited strength, tends to yellow, cheap bulk paper, 40-50 g/m² | 12 |
| | • Magazine | • Limited strength, often calandered or coated for better printability, 50-70 g/m² | 17 |
| | • Writing | • Good strength, bright (usually woodfree), 80-100 g/m² | 12 |
| | • Printing | • Good strength, bright (usually woodfree), often coated, 80-120 g/m² | 11 |
| | • Sanitary | • Good strength, somewhat wet stable, sometimes in layers, 40-80 g/m² | 7 |
| | • Case materials | • High strength, often unbleached, 50-80 g/m² | 31 |
| | • Board | • High grammage, often low strength (in relation to grammage), sometimes coated, 200-500 g/m² | 12 |
| | | | **100** |

\*   Calculated from capacity, utilization and recovery rate
Source: NLK Mill database; McKinsey

Figure 3-7: Details on Products in Pulp & Paper

chemical pulping (31%). Thermo-mechanical pulping and mechanical pulping are processes that are much less common in the EU15 at 12% and 6% respectively.

### 3.3.4  Carbon Intensity

Except for paper making, indirect emissions make up the bulk of total emissions in the pulp & paper industry. Mechanical pulping, thermo-mechanical pulping and wastepaper recovery need little or no heat originating from burning fuels. The heat demand for chemical pulping is mainly covered by burning biomass carbon compounds, which is treated as carbon-neutral under the EU ETS. Some $CO_2$ emissions from make-up chemicals are rather minor.

Only paper production has a significant demand for fossil-produced heat.

**CARBON INTENSITY IN PULP & PAPER PRODUCTION**
Tons of $CO_2$ per ton of pulp/paper

| Industry | Indirect $CO_2$ emissions | Direct $CO_2$ emissions | Total $CO_2$ emissions |
|---|---|---|---|
| • Chemical pulp | 0.07 | 0.04 | 0.12 |
| • Chemical P&P* | 0.62 | 0.00 | 0.62 |
| • Mechanical P&P* | 1.03 | 0.00 | 1.03 |
| • Thermo-mech. P&P* | 0.12 | 0.02 | 0.14 |
| • Recovered fibre P&P* | 0.27 | 0.34 | 0.61 |

Table 3-9: Carbon Intensity in Pulp & Paper Production

In chemical pulping, 0.12 ton of $CO_2$ is emitted on average per ton of pulp, of which 0.07 ton is in indirect emissions and 0.04 tons in direct emissions.

In mechanical pulping, thermo-mechanical pulping and wastepaper recovery, nearly all emissions are indirect emissions. Mechanical pulping emits 0.62 ton of $CO_2$ per ton of pulp, thermo-mechanical pulping 1.03 tons per ton of pulp and wastepaper recovery 0.14 ton per ton of pulp.

In paper making, 0.61 ton of $CO_2$ is emitted on average per ton of paper, of which 0.27 ton is in indirect emissions and 0.34 ton in direct emissions.

### 3.3.5  Industry Trends

### 3.3.5.1  Industry Structure

In 2002, EU15 countries[16] produced 39 million tons of pulp (excluding wastepaper recovery) and 91 million tons of paper (28% of world production), accounting for a turnover of 73 billion Euro. Market growth within the EU15 from 1992-2004 has been 3% per year in terms of physical volume.

The pulp market is more cyclical than the paper market. Sometimes even integrated pulp &

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16   Pulp & paper figures for the new EU Member States are difficult to collect. However, McKinsey experts from the plup & paper sector estimate that the new Member States account for only 10% of the total market.

paper mills produce market pulp. In paper, the cyclical nature of prices differs significantly by product.

Leading companies active in Europe are domiciled in Scandinavia, the United States and South Africa. The top 10 companies within the EU15 account for 56% of EU capacity. Large players are often integrated pulp and paper producers.

Import competition is rather moderate. Wastepaper is becoming scarce on the world market. The market has high entry barriers because of the high investment cost for a new pulp mill or paper machine.

### 3.3.5.2  Industry Conduct

As industry concentration is rather low, pricing is competitive (especially for major products, such as newsprint, case materials and office paper).

Some product categories are sold to industrial customers (newsprint, case materials, board), while others (office and printing paper) are sold mainly to merchants. Tissue is distributed via retail chains (often as a trade brand).

Much of Western European capacity is aged 20 years or more and slowly being replaced. Eastern European mills face a faster replacement as large multinational players are investing heavily. Integration of multinational players comprises pulp manufacturing, wastepaper recovery and paper making. Some Scandinavian companies also own and operate forests.

### 3.3.5.3  Industry Performance

EBITDA[17] margins for 2004 for selected players are: Stora Enso 12.2%; UPM-Kymmene 14.9%; SCA 15.2%

Operating margins for 2004 for these players are: Stora Enso 2.7%; UPM-Kymmene 6.5%; SCA 6.0%

ROCE[18] for 2004 for these players is: Stora Enso 3.1%; UPM-Kymmene 4.9%; SCA 7.0%

### 3.3.5.4  Important External Factors

Wood prices could rise as a consequence of public support schemes for generating green electricity from (co-) burning fresh round wood or wood chips. A further increase in electricity prices might cause a decrease in the international competitiveness of the European pulp and paper industry, if other competitors are not exposed to parallel electricity price trends.

### 3.3.6  Players in the Industry

The top 10 pulp and paper producers in the EU15 and their market shares are listed in Figure 3-8 (Top 10 EU 15 Pulp & Paper Producers).

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17   EBITDA: Earnings Before Interests, Taxes, Depreciation and Amortisation = Revenue - Expenses (excluding tax, interest, depreciation and amortization)
18   ROCE: Return On Capital Employed = EBIT / (total assets – current liabilities)

**TOP 10 EU15 PULP & PAPER PRODUCERS**

**Top 10 EU15 pulp & paper producers, 2003**
100% = 139.1 million metric tons of pulp & paper*

**Country coverage top 10 EU15 producers pulp & paper**
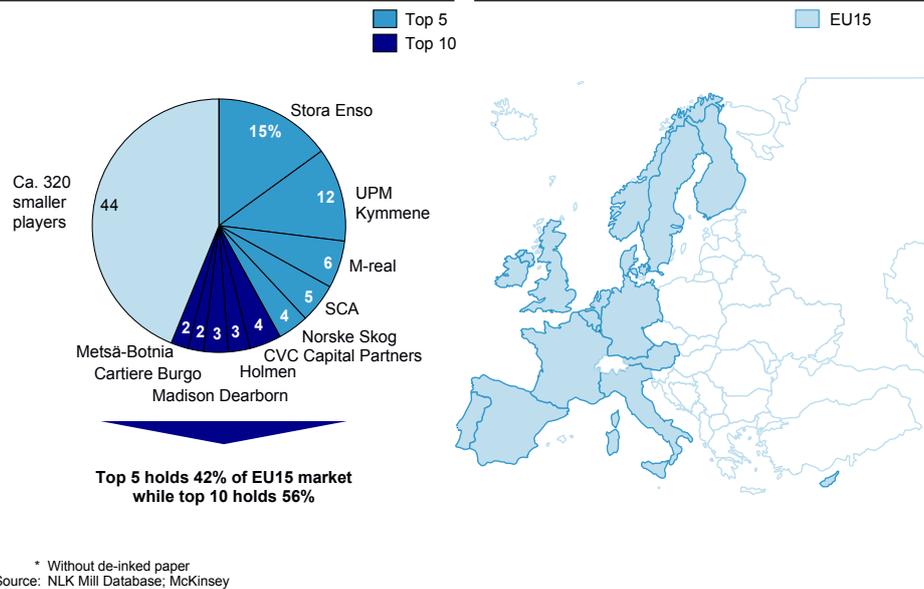
Figure 3-8: Top 10 EU 15 Pulp & Paper Producers

The European pulp & paper market is rather fragmented. Of a total EU15 pulp and paper production capacity of 139.1 million metric tons (excluding waste paper recovery), the top five players hold 42% of the overall EU15 market while the top 10 players hold 56%.

## 3.3.7  Trade Flows

Within the EU25, the total production of primary pulp is around 38 million tons. The access to recovered fibre as secondary pulp is around 39 million tons as 46 million tons are collected (utilized) and on average slightly above 80% of this can be recovered as usable fibre. The total production of paper is 91.7 million tons.

**TRADE FLOWS PULP & PAPER**

| Product | Production | Imports | Exports |
|---|---|---|---|
| | [M tons] | [M tons] | [M tons] |
| Chemical pulp | 25.5 | | |
| Mechanical & semi-chemical pulp | 12.2 | | |
| Other pulp | 0.5 | | |
| **Total pulp** | **38.2** | **7.8** | **2.2** |
| **Total recovered fibre** | **46.3** | **1.0** | **4.0** |
| Packaging paper & board | 38.2 | | |
| Printing & writing paper | 34.2 | | |
| Newsprint | 9.7 | | |
| Tissue paper | 5.7 | | |
| Other paper | 3.8 | | |
| **Total paper** | **91.6** | **4.2** | **12.7** |

Source:   Paperloop, CEPI, RISI, FAO, McKinsey estimates

Table 3-10: Trade Flows Pulp & Paper

Around 7.8 million tons of pulp is imported into the EU25 which is approx. 20% of the EU25 production of pulp while 2.2 million tons are exported (approx. 6% of the EU25 production of pulp). A breakdown into imports and exports of chemical pulp, mechanical & semi-mechanical pulp and other pulp is not available.

Paper and recovered fibre are exported more than imported. Of recovered fibre, approx. 1.0 million tons is imported and 4.0 million tons is exported (2% and 9% of total EU25 production respectively). Of paper, approx. 4.2 million tons is imported and 12.7 million tons is exported (5% and 14% of total EU25 production respectively).

### 3.3.8   Short- and Mid-term Impact on Cost Structure

For the analysis, we looked into six typical processes in the pulp & paper industry: 1) production of chemical pulp for the market, 2) paper production based on chemical pulp from the market, 3) paper production in integrated processes based on chemical pulp, 4) paper production in integrated processes based on mechanical pulp, 5) paper production in integrated processes based on thermo-mechanical pulp, and 6) paper production in integrated processes based on recovered fibre.

To simplify the discussion, we show the integrated plants as if they produced all pulp internally. In reality, integrated mechanical and thermo-mechanical pulp & paper plants tend to purchase a share of chemical pulp from the market in addition to their own production. This share varies but could be in the order of 20%.
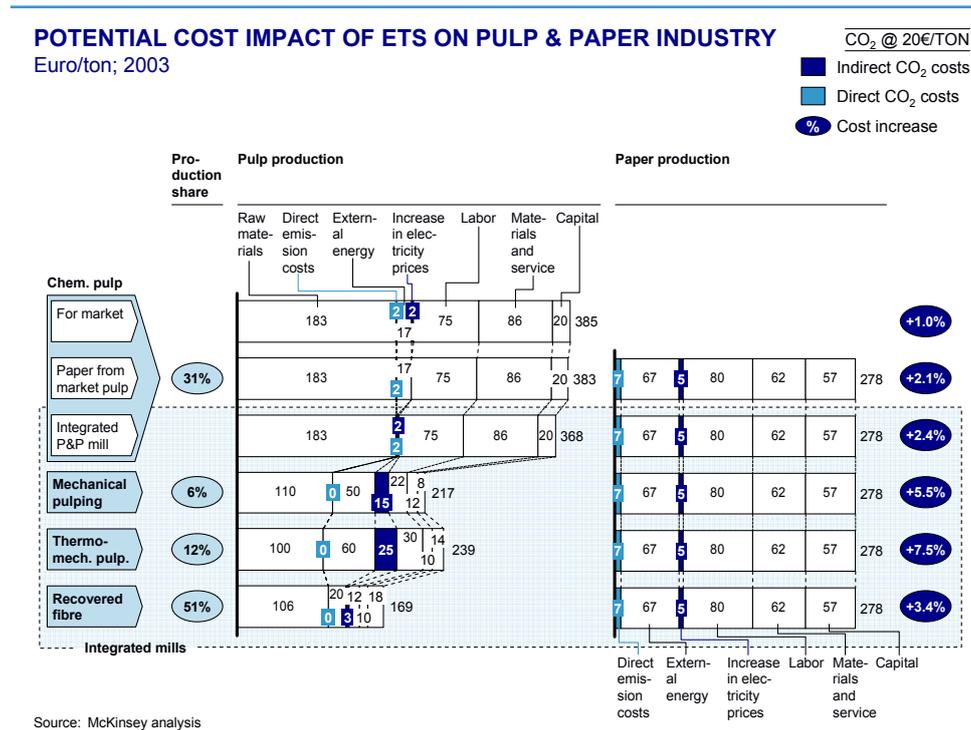


Figure 3-9: Short- and Mid-Term Impact of ETS on Cost in Pulp & Paper

The short- and mid-term total cost increase in chemical pulping is 4 Euro/ton (1.0% of total costs), of which 2 Euro is the indirect cost increase due to higher electricity prices and 2 Euro is the direct cost increase. We assume that 20% of the electricity is bought from the grid. In chemical pulping as well as throughout the section on pulp & paper, the auto-generation of electricity is fully integrated in the calculation, as pulp & paper and electricity production are

truly integrated processes, in which the electricity production would not be possible without the pulp & paper production.

Paper-making based on chemical pulp will see a cost increase of 2.2%.

Integrated pulp & paper production in an integrated process based on chemical pulp has a slightly more favourable cost structure than the sum of the costs of the two processes, because the pulp does not have to be dried in an intermediate stage.

Integrated pulp & paper production based on mechanical and thermo-mechanical pulp has to bear a total cost increase in the order of 5.5% and 7.5%, respectively. Around 75% to 80% of this increase results from higher electricity prices.

Integrated pulp & paper production based on recovered fibre will see a cost increase of around 3.4%. Half of this increase is caused by direct emissions; half by an electricity price increase.

### 3.3.9   Short- and Mid-term Impact of the EU ETS on Competitiveness

On average across the industry, the short- and mid-term effect of the EU ETS on competitiveness in the pulp & paper sector is compensated partially by free allowances – assuming 95% free allocation[19]. The remaining cost increase is in the order of up to 1.1% in processes with chemical pulp and up to 1.9% in pulp and paper production based on recovered fibre.

Even though the market is global, we expect that, in the production of chemical pulp for the market, 50% of the additional costs can be passed through to customers, while electricity prices increases cannot be passed through. About 0.5% of the cost increase will be covered by free allowances, so that the overall impact is neutral.

**OVERVIEW OF FINDINGS IN PULP & PAPER INDUSTRY – SHORT- AND MID-TERM VIEW**
Percent of total costs

| Industry | Indirect cost increase | Direct cost increase | Total cost increase | Offset by product price increase | Offset by allowance endowment at 95% free allowances | Net cost increase |
|---|---|---|---|---|---|---|
| • Chemical pulp for market | 0.5 | 0.5 | 1.0 | 0.5 | 0.5 | 0.0 |
| • Paper from chem. pulp | 1.0 | 1.1 | 2.1 | 0 to 0.4 | 1.0 | 0.7 to 1.1 |
| • Chemical P&P* | 1.0 | 1.4 | 2.4 | 0 to 0.5 | 1.3 | 0.6 to 1.1 |
| • Mechanical P&P* | 4.1 | 1.4 | 5.5 | 0 to 1.1 | 1.3 | 3.1 to 4.2 |
| • Thermo-mech. P&P* | 6.1 | 1.4 | 7.5 | 0 to 1.5 | 1.3 | 4.7 to 6.2 |
| • Recovered fibre P&P* | 1.8 | 1.6 | 3.4 | 0 to 0.7 | 1.5 | 1.2 to 1.9 |

  * Numbers for whole value chain of pulp and paper production

Table 3-11: Overview of Findings in Pulp & Paper Industry – Short- and Mid-term View

For paper production, we assume a range of 0% to 20% pass through capability of the total cost increase. For paper production based on chemical pulp from the market, and pulp & paper production based on chemical pulp in integrated processes, this implies a 0.6% to 1.1% net cost increase.

Mechanical pulping (6% of total pulp production) and thermo-mechanical pulping (12% of total pulp production) are affected by a net cost increase of 3.1 to 4.2% and 4.7 to 6.2%

19  5% of required allowances

respectively. As most of the cost increase for these processes is indirect (electricity prices), even full coverage with free allowances cannot compensate for it.

We estimate the potential to pass costs through to the market in integrated pulp & paper production based on recovered fibre to be in the order of 0 to 0.7%, so the remaining net cost increase will be between 1.2% and 1.9%.

### 3.3.10  The Importance of Auto-generation

Throughout this section on pulp & paper, the auto-generation of electricity is fully integrated in the calculation, as the pulp & paper and electricity production are truly integrated processes, in which the electricity production would not be possible without the pulp & paper production.

## 3.4  CEMENT

### 3.4.1  Sector Summary

Cement can be produced in three processes: dry, semi-dry and wet. Because of higher energy efficiency and much better overall economics, the dry process has become dominant in Europe with a 95% market share.

In the dry process $CO_2$ emissions range from 0.4 to 1.0 ton of $CO_2$ per ton of cement with an average of around 0.7 ton of $CO_2$.

More than 50% of the European market is accounted for by five major players that are very significant on a global scale as well and have increased their global positions over the past year.

The cost for a typical European cement production process will increase by 36.5% due to $CO_2$ emissions trading. The biggest part of the increase (~93% ) is from direct emissions. The indirect impact from higher electricity prices is only a small share of the overall cost increase (7%).

Depending on the level of potential cost pass through, the cement industry on average across Europe might face a cost increase or come out neutral. The likelihood of a cost increase is highest in areas close to seaports or outside EU borders, such as Greece, Italy, southern France and Spain, where the possibility of substitution by imports is highest. The level of free allowances is crucial for the competitiveness impact of the EU ETS on the cement industry.

The impact on the cost of the marginal unit of production in the cement industry is very significant at over 36% or 12 Euro per ton of cement, which is roughly equal to freight costs from northern Africa or the eastern European countries outside the EU to Antwerp. Therefore, under an allocation method based on historic emissions – which is the current preferred method in the EU ETS – the possibility of production shifts and $CO_2$ leakage is real.

### 3.4.2  Value Chain

The two main steps within the cement value chain are clinker production and cement production. The bulk of the $CO_2$ emissions come from clinker production.

### 3.4.3  Processes and Products

Cement can be produced in three different processes: the dry process, the semi-dry process and the wet process. In the dry process, dry raw materials are mixed together without moisture and are then heated directly in the kiln.

**BASIC VALUE CHAIN OF CEMENT INDUSTRY**

| | Raw materials procurement | Clinker production | Cement production | Distribution | End users |
|---|---|---|---|---|---|
| **Main steps** | • "Mining" for limestone, clay, sand<br>• Storage<br>• Grinding and setting the right proportions for the mixture | • Carefully proportioned raw materials mixture is processed in a rotary kiln<br>• It follows several stages: heating, dehydration, calcification and cooling | • Clinker mixed with 3-8% gypsum<br>• Grinding and storage (in bulk or in bags) | • By train, ship or truck<br>• Bags or bulk | • From retail chain (DIY chains) to large direct contractors |
| **Key issues** | • Availability of raw materials can act as a strong constraint (raw material deposits must be close to the cement factory) | • Highly energy-intensive process | • Some players just produce clinker, which is shipped to cement mills to produce cement | • Highly dependent on the distance and type of clients/end usage | |

Figure 3-10: Value Chain of Cement Industry

In the semi-dry process, raw materials are mixed in the form of a slurry and are then deposited into a dryer before being heated in a kiln.

In the wet process, raw materials are mixed in a slurry, which is either fed directly into a kiln or treated in a filtration unit before burning.

Many companies are currently investing in the shift towards dry or semi-dry processes. The wet process is older and less energy-efficient than the semi-dry or dry processes. Dry cement plants are also generally more productive and require less manpower and maintenance.

It is estimated that, within the EU25, total cement production capacity is around 283 million tons annually, 95% of which is accounted for by dry processes and only 5% by wet processes. Since most EU cement production capacity is already using the dry process, there are no significant variances in technological exposure within Europe, except for the UK where wet processes still account for some 40% of the UK production capacity.

### 3.4.4  Carbon Intensity

$CO_2$ emissions from the dry process range from 0.4 to 1.0 ton of $CO_2$ per ton of cement with an average of 0.7 ton. Direct emissions make-up the bulk of $CO_2$ emissions with 0.6 ton of $CO_2$ per ton of cement. Indirect emissions through electricity consumption account for 0.1 ton of $CO_2$ per ton of cement.

**CARBON INTENSITY IN CEMENT PRODUCTION**
Tons of $CO_2$ per ton of cement

| Industry | Indirect $CO_2$ emissions | Direct $CO_2$ emissions | Total $CO_2$ emissions |
|---|---|---|---|
| • Dry process | 0.08 | 0.6 | 0.7 |

Table 3-12: Carbon Intensity in Cement Production

## 3.4.5  Industry Trends

### 3.4.5.1  Industry Structure

Demand growth in the EU25 cement industry is closely related to both GDP and new construction growth.

Large players often integrate downstream into concrete "manufacturing" and "admixture/ aggregate" business. The cement industry has seen consolidation in recent years; five large multinationals now have a market share of 58% in the EU25 market.

The cement industry is characterised by high entry barriers, including large capital start-up costs (120 million Euro for a 1 million ton plant) and by access to privileged assets. This is especially relevant for areas at seaports or waterways, which are often characterised by stronger competition.

### 3.4.5.2  Industry Performance

Operating margins in Europe are relatively low (between 11 and 15%) compared to emerging markets (between 15 and 20%). Compared to other regions of the world, Europe has low prices and high production costs. European prices are around 50-70 Euro/ton, whereas Latin America and the United States have prices of around 100 Euro/ton. This is due to the fact that the US has a very high demand and low supply in cement. The US is the world's biggest import market, while building up additional production capacity is a very long and difficult process due to strict regulation. The production costs in Asia are low compared to the production costs in Europe.

## 3.4.6  Players in the Industry

Of a total production capacity of 283 million metric tons of cement, the top five players hold 58% of the market while the top 10 players hold 76%. A typical characteristic of the cement market is that the top five players also hold a large share in the global cement market with an estimated market share of around 30%.

**TOP 10 EU25 CEMENT PRODUCERS**                                    <u>WORK IN PROGRESS</u>

**Top 10 EU25 cement producers, 2003**                    **Country coverage top 10 EU25 cement producers**
100% = 288 million metric tons of installed capacity
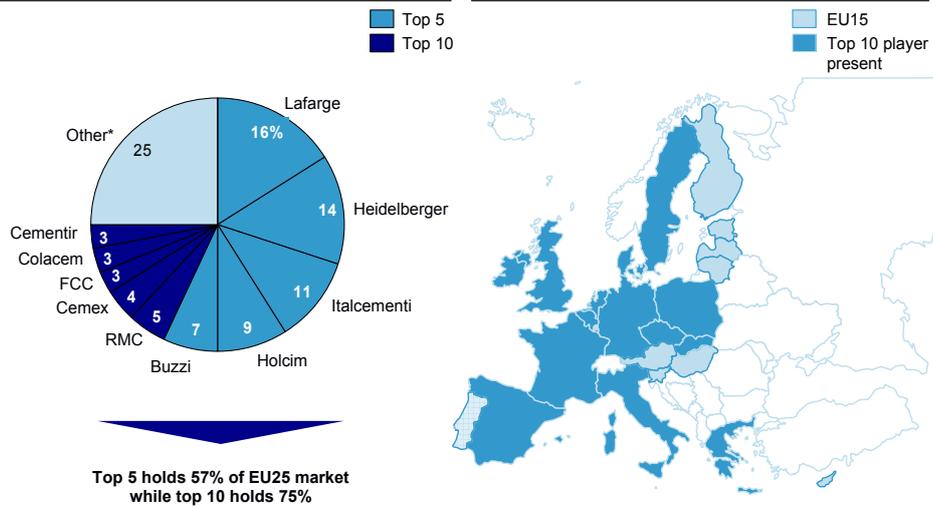


Top 5 holds 57% of EU25 market
while top 10 holds 75%

\* Specify also "Other category"
Source: Credit Suisse First Boston; McKinsey analysis

Figure 3-11: Top 10 EU25 Cement Producers

## 3.4.7  Cost Structure

Of an overall cost increase for cement of 12.4 Euro/ton, the short- and mid-term direct cost increase is 11.7 Euro and the indirect cost increase is 0.7 Euro from higher electricity prices.

The 11.7 Euro direct cost increase splits into 7.5 Euro/ton of cement for inputs in clinker production, and 4.2 Euro for direct process emissions from clinker production.

**POTENTIAL COST IMPACT OF ETS ON EU CEMENT INDUSTRY**         $\overline{CO_2 @ 20€/TON}$
Euro/ton cement
                                                               Indirect $CO_2$ costs
                                                               Direct $CO_2$ costs
                                                               % Cost increase
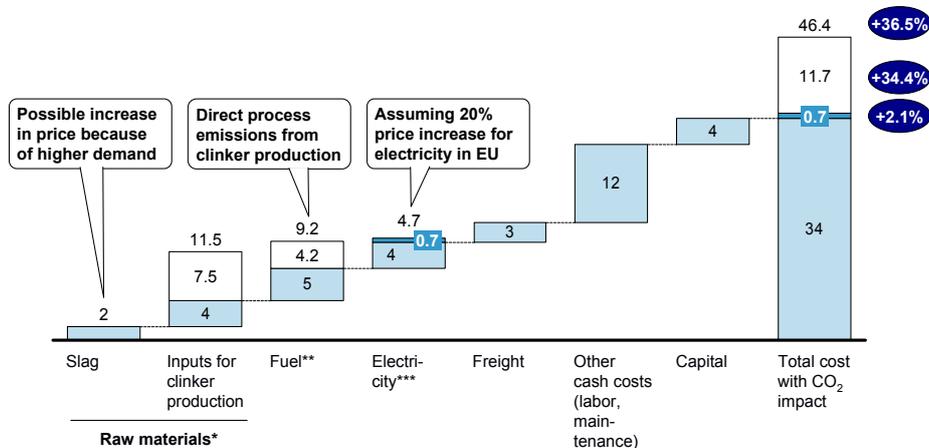


\*   Assume dry clinker production process at 75% clinker per ton cement
\*\*  Fuel emissions assuming use of coke from coal
\*\*\* Assuming no autoproduction in which case the impact is direct (and higher if coal is used)
Source: Ecofys; McKinsey analysis

Figure 3-12: Potential Cost Impact of ETS on Cement Industry

### 3.4.8   Impact of the EU ETS on Competitiveness

The cost for a typical European cement production process will increase by 36.5% due to $CO_2$ emissions trading in the short- and mid-term. By far the largest share of the cost increase is from direct emissions (~93%).

Depending on the level of potential cost pass through, the cement industry on average across Europe might face a cost increase come out neutral or experience a net benefit. The likelihood of a cost increase is particularly high in areas close to seaports or outside EU borders, such as Greece, Italy, southern France and Spain, where the possibility for substitution by imports is highest. The level of free allowances is crucial for the impact of the EU ETS on the cement industry's competitiveness.

**OVERVIEW OF FINDINGS IN CEMENT INDUSTRY – SHORT- AND MID-TERM VIEW**
Percent of total costs

| Industry | Indirect cost increase | Direct cost increase | Total cost increase | Offset by product price increase | Offset by allowance endowment at 95% free allowances | Net cost increase |
|---|---|---|---|---|---|---|
| • Dry process | 2.1 | 34.4 | 36.5 | 0 to 5.5 | 32.7 | <0 to 3.8 |

Table 3-13: Overview of Findings in Cement Industry – Short- and Mid-term View

The impact on average costs of the additional 12.4 Euro per ton of cement is a real cost increase for the marginal production unit. As 12 Euro per ton is roughly equal to freight costs from northern Africa, Russia, Ukraine or Turkey to Antwerp under an allocation method based on historic emissions – the currently preferred method in the EU ETS – the possibility of production shifts and $CO_2$ leakage is real.

### 3.4.9   The Importance of Auto-generation

Auto-generation in the cement industry accounts for 6% of consumption according to a McKinsey outside-in analysis across all processes. The respondents to the survey on the EU ETS stated a 4% auto-generation share in the dry process, which is the most relevant process across Europe. Therefore, taking auto-generation into account reduced the overall impact on competitiveness at the company level by only 0.1%. This is below the accuracy of the analysis.

## 3.5   REFINING

### 3.5.1   Sector Summary

The refining industry produces a range of products from asphalt to fuel gas based on various crude oil grades. A refinery can consist of many different units of varied sizes, such as a distillation tower, vacuum flasher, catalytic cracker, coker etc. Depending on the market prices of products, the optimal ratio of products is determined with linear programming considering the technical boundary conditions of the site.

With the combination of different units in a refinery and different combinations of processes to get to any given product, it seems difficult to determine the typical $CO_2$ emissions in a

refinery. However, $CO_2$ emissions correlate strongly with refinery capacity and the typical emissions are 15.0 tons of $CO_2$ per 1000 barrels of crude oil in direct emissions and 1.4 tons of $CO_2$ per 1000 barrels in indirect emissions.

The overall cost for refining one barrel is between 1.0 and 2.5 Euro/ton depending on refining complexity. At a $CO_2$ price of 20 Euro/ton, these costs will increase by about 32 cents or 20.5%. However, this increase represents only about 1 percent of the final product price to end customers and is, in our perspective, likely to be passed through to a large extent to customers. Product prices are related to the spot market and are usually set by the marginal production capacity in any region, but with differentials usually set by local logistics costs.

Refinery margins are estimated to at least stay constant on average, assuming 95% of the $CO_2$ costs can be covered by free allowance and around 25 to 75% can be passed through to customers.

## 3.5.2   Value Chain

The process of refining can be split into three parts. First, the crude oil is broken up into its components, for example, via distillation.

**REFINERY PROCESSING STEPS**



| | Separation | Conversion | Finishing |
|---|---|---|---|
| Crude oil → | | | |
| **Objective** | • Breaking up a mixture into its components | • Fundamentally changing the chemical structure of a product by:<br>– Breaking down molecules<br>– Combining molecules<br>– Rearranging structure | • Improving the qualities of products by:<br>– Blending products of different qualities to get an optimal mix<br>– Treating products (typically with hydrogen) to remove impurities |
| **Examples** | • Distillation/fractionation<br>• Extraction | • Coking<br>• Cracking<br>• Alkylation (combining)<br>• Isomerization (rearranging) | • Gasoline blending<br>• Hydrotreating |

Figure 3-13: Refinery Processing Steps

Second, depending on the end products required, several intermediate streams can be converted, typically by further breaking up molecules.

Third, in the finishing process, different intermediate streams are blended to achieve the desired qualities, and impurities are removed.

### 3.5.3  Processes and Products

The refining industry produces a range of products from asphalt to fuel gas based on various crude oil grades.



**DETAILS OF PROCESSES - REFINING**
Complex refinery (U.S.)

ILLUSTRATIVE
■ Optional

*  Fluid catalytic cracker unit Catalytic cracking unit, also called an FCC or fluid catalytic cracker
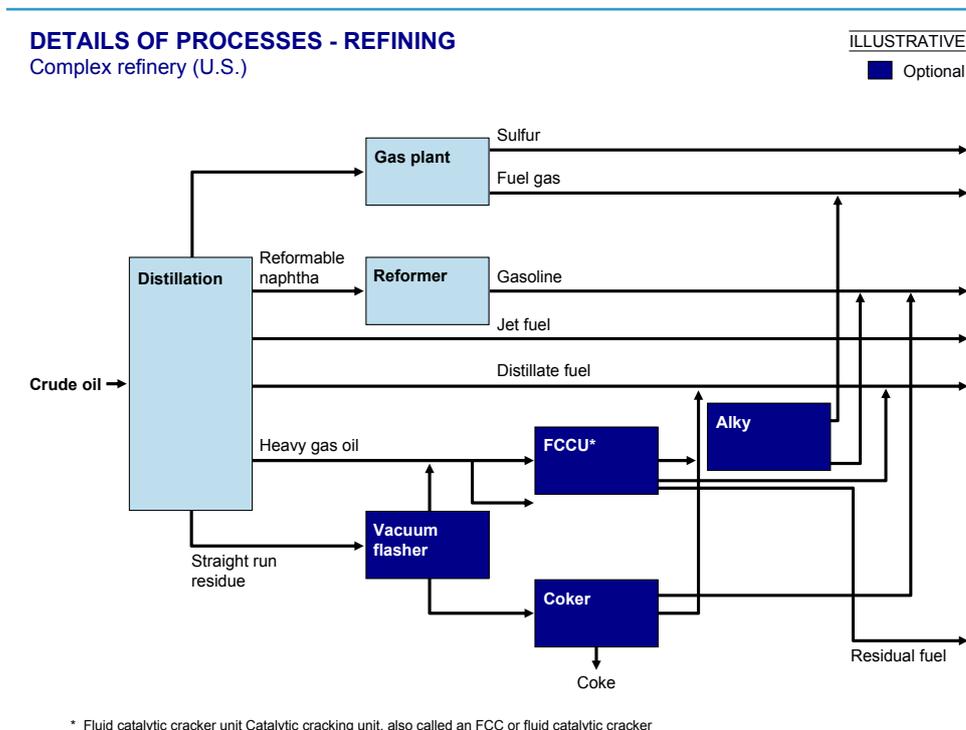
Figure 3-14: Typical Refinery Layout

Basic elements such as the distillation tower and the reformer can be found in most refineries. Other elements, such as a vacuum flasher, catalytic cracker, and coker, can be added on top of the process and increase the complexity of the refinery. In a complex refinery, a mix of output can be produced with a combination of different processes. The optimal operational mode at any point in time is calculated based on crude and product prices using linear programming.

### 3.5.4  Carbon Intensity

With the combination of different units in a refinery and different combinations of processes to get to any given product, it seems difficult to determine the typical $CO_2$ emissions in a refinery.

**CARBON INTENSITY IN REFINING INDUSTRY**
Tons of $CO_2$ per 1000 bbl of oil

| Industry | Indirect $CO_2$ emissions | Direct $CO_2$ emissions | Total $CO_2$ emissions |
|---|---|---|---|
| • "Average process" | 1.40 | 15.0 | 16.4 |

Table 3-14: Carbon Intensity in Refining Industry

However, $CO_2$ emissions appear to correlate strongly with refinery capacity, and the typical emissions are 15.0 tons of $CO_2$ per 1000 barrels of crude oil in direct emissions and 1.4 tons of $CO_2$ per 1000 barrels in indirect emissions.

### 3.5.5  Industry Trends

The refining industry in Europe can be characterized as a relatively fragmented industry with a number of big multinational companies owning capacity in many countries. During the late 1990s, a wave of mergers increased industry concentration across some European markets. The significant liquidity in crude and products trading has narrowed the value of vertical integration to some specific regions.

Complex configurations of refineries with many conversion process options and potential product mixes result in limited transparency concerning performance metrics.

The overall demand for refined products is static in many key European countries.  A switching away from gasoline towards diesel can be observed as well as tightening product specifications. The push towards 10 ppm sulphur is occurring at different rates across EU countries and requires significant investment in desulphurisation capacity.

The industry has a strong tendency to over-invest during positive years of the refining margin cycles, which have therefore been highly cyclical with a bias towards the lower periods of the cycle. The cyclical margins in the industry is further enhanced because economies of scale make new unit additions very lumpy in comparison with demand growth.

Historically, the financial performance of the industry has therefore been rather low, and many refiners have struggled to achieve returns to cover their cost of capital. More recently, returns have been higher due to US and Chinese demand growth, tighter product specifications and environmental permit constraints.

As far as cost optimization is concerned, most refiners focus heavily on cost control and unit availability.

### 3.5.6  Players in the Industry

**TOP 10 EU25 REFINING PLAYERS**
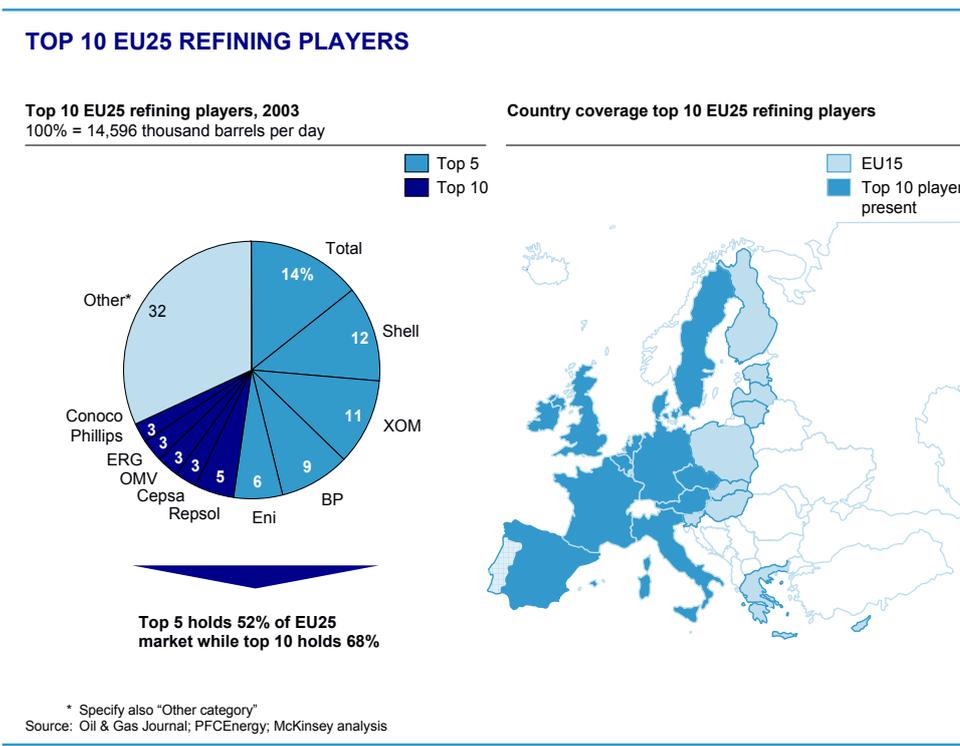


Figure 3-15: Top 10 EU25 Refining Players, 2003

The top five EU refining companies hold over fifty percent of the market share, while the top 10 companies hold nearly 70%. Total, Shell, Exxon Mobil, BP and ENI are the biggest players in the market.

## 3.5.7  Trade Flows

Refined products are traded in and outside of the European Union to a fair extent. There is a clear pattern that the EU is short on some products and long on others, and those positions are traded.

**EXTRA COMMUNITY TRADE FLOWS OF REFINED PRODUCTS 2003**

| Product | Production | Imports | Exports |
|---|---|---|---|
| | million metric tons | | |
| Liquified petroleum gas | 20 | 33% | 16% |
| Naptha | 41 | 32% | 8% |
| Motor gasoline | 147 | 5% | 17% |
| Kerosene type jet fuel | 36 | 25% | 7% |
| Gas/Diesel oil | 252 | 14% | 6% |
| Residual fuel oil | 106 | 24% | 15% |
| Other petroleum products | 95 | 18% | 7% |
| **TOTAL** | **698** | **16%** | **10%** |

Source:   IEA, McKinsey estimate

Table 3-15: Extra Community Trade Flows of Refined Products 2003

However, transport costs and logistics keep refining markets rather local, apart from the structural imports and exports described above. Usually it is cheaper and easier to transport the crude oil than the product, because a single barrel of crude creates many products in small volumes, each with its own higher-cost logistics requirements.

## 3.5.8  Cost Structure

The total cost of refining one barrel of crude is in the order of 1 to 2.5 Euro, depending on the complexity of the refinery and the higher energy consumption in the more complex facilities. Even the higher range represents less than 5% of the current crude price. These costs will incur an increase of above 20% long-term due to the EU ETS, which represents less than 1% of the total costs including the crude costs.

Nearly all of the cost increase is a direct cost increase due to the burning of fuel; only a small fraction is an indirect cost increase due to increased electricity costs.

**POTENTIAL IMPACT OF CO₂ REGULATION ON EU REFINING INDUSTRY COST STRUCTURE**
Euro cents per bbl

$\overline{CO_2 @ 20€/TON}$

▢ Indirect CO₂ costs (filled)
☐ Direct CO₂ costs
◖%◗ Cost increase

• Total refinery costs represent below 5% of the product costs
• CO₂ cost increase is around 1% of product costs

Increase in electricity price

42.5    33 (30 / 3)    12 (2 / 10)    10    55    20    20    192 (30 / 2 / 160)

+19.0%
+1.5%

(Range: 100-200)

Pur-chased | Consu-med fuel | Electri-city** | Chemicals and catalyst | Labor, maint-enance | Materials, other | Depre-ciation (capital) | Total Opex plus increase

\*    Assume 5% of throughput consumed at average hydrocracking refinery, 85% utilization, Brent crude
\*\*  Assume 50% of electricity is purchased and other 50% autogenerated – based on rough EU average
Source:  Disguised client examples; McKinsey analysis

Figure 3-16: Potential Short- and Mid-Term Impact of EU ETS

## 3.5.9    Impact of the EU ETS on Competitiveness

On average, refinery margins are likely to benefit from the CO₂ emissions trading, if 95% of the CO₂ costs can be covered by free allowances and at least a quarter of the cost increase can be passed through to customers. Given the relatively high cost for transport and logistics, the potential to pass costs through might even be significantly higher.

**OVERVIEW OF FINDINGS IN REFINING INDUSTRY – SHORT- AND MID-TERM VIEW**
Percent of total costs

| Industry | Indirect cost increase | Direct cost increase | Total cost increase | Offset by product price increase | Offset by allowance endowment at 95% free allowances | Net cost increase |
|---|---|---|---|---|---|---|
| • "Average process" | 1.5 | 19.0 | 20.5 | 5 to 15 | 18.1 | <0 |

Table 3-16: Overview of Findings in Refining Industry – Short- and Mid-term View

At significantly lower levels of free allowances (i.e. below 80%), refinery margins might come under pressure.

## 3.5.10  The Importance of Auto-generation

From a top down perspective, the share of auto-generation does not influence the competitiveness impact of the EU ETS on refineries: the increased in electricity cost accounts for only a very small fraction of the total cost increase for refineries as a result of the EU ETS. Refineries should be able to pass through a significant share of the overall cost increase, so that, on average, higher electricity wholesale market prices would not harm their competitive position in the market, what ever their auto-generation share is.

A more detailed look at refinery auto-generation shows that refineries in Europe produce a significant share of the electricity they require by themselves. On average across Europe according to outside-in analysis, this share is in the order of 57%. (Figure 2 8: Auto-generation Share of Different Industries in Europe on page 12). As far as the impact of this auto-generation on the estimation of the competitiveness impact is concerned, we have to distinguish between the total company perspective and the perspective of the refining operation. From a total company perspective, the company would bear only 43% of the electricity price increase. Therefore, the short- and mid-term indirect cost increase from electricity would go to 0.6% instead of 1.5% (relative to the total production costs). The net effect on the margins would be smaller, because a higher costs would be compensated by higher cost pass through. From the perspective of the refining operations, the picture on competitiveness does not change at all with auto-generation, as the electricity can be sold to the grid, if it is not used internally. Therefore, the market price of electricity has to be applied.

## 3.6  ALUMINIUM

### 3.6.1  Sector Summary

About 50% of the aluminium in Europe is produced by primary smelting; 50% by secondary smelting (recycling). Primary smelting consumes about 20 times more electricity than secondary smelting (15 MWh per ton versus 0.7 MWh per ton).

As the aluminium industry is currently not included in the EU Emission Trading Scheme, the industry does not yet have to bear direct $CO_2$ costs.

At a $CO_2$ price of 20 Euro per ton and a corresponding short- and mid-term electricity price increase of 10 Euro per MWh on average across Europe, the cost of primary aluminium production will increase by 11.4%, the cost of secondary aluminium production by 0.5%. This cost increase is not covered by any free allocation of allowances. Furthermore, due to competitive intensity, none of the cost increase can be passed through to customers. Competition and trade flows in the aluminium market are highly international. A new smelter in Iceland or China could deliver aluminium to Europe or the US at a cost 10% lower than for European production, including the transport costs, even before an EU ETS driven increase in electricity prices.

All of the impact on aluminium smelting comes from increased power prices resulting from increasing $CO_2$ cost. Most of the primary smelting capacity in Europe and the United States is likely to be shut down over the next 20 years due to increased power prices and the search for cheaper, stranded energy.[20] In many ways, $CO_2$ is not the determining factor but a contributing/accelerating one. That is, the shut-down of primary smelting in Europe would most likely happen irrespective of $CO_2$ costs because of the general development in energy prices.

Secondary aluminium smelting will not be much affected by the electricity price increase.

### 3.6.2  Value Chain

Two main processes characterise the aluminium industry along the aluminium value chain: primary aluminium production and secondary aluminium production (recycling).

---

20  From 2002 to 2005 the numbers for primary aluminium production stayed flat in the US and Canada and were still growing by 10% in Europe.

Each process accounts for about half of the aluminium produced in Europe. Aluminium is traded on the London Metals Exchange (LME).

**DETAILS OF PROCESSES WITHIN THE ALUMINIUM VALUE CHAIN**
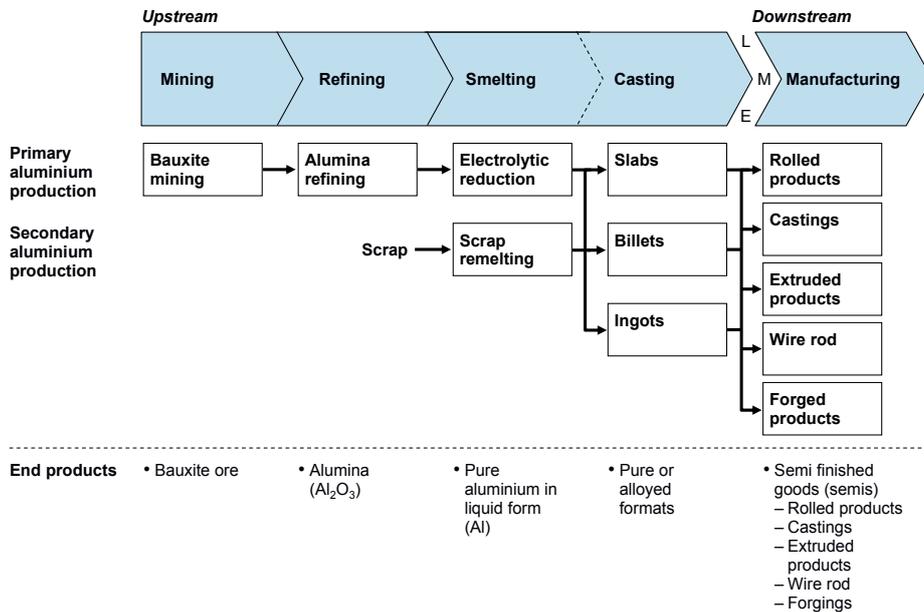


Figure 3-17: Value Chain of Aluminium Industry

### 3.6.3   Processes and Products

The main steps in primary aluminium production are mining of bauxite, refining of alumina and smelting/casting.  In secondary aluminium production, scrap is smelted/casted. Smelting is the most important process from a $CO_2$ perspective. Input in the smelting process is alumina for primary aluminium production and scrap for secondary aluminium production. Output is pure aluminium in liquid form.

### 3.6.4   Carbon Intensity

The aluminium industry is not a "trading sector" within the EU ETS. As a consequence, direct emissions are currently not within the EU ETS. However, the aluminium sector is nevertheless exposed because of its electricity consumption. Primary aluminium production consumes about 20 times more electricity than secondary aluminium production (15 MWh per ton vs. 0.7 MWh per ton).

**CARBON INTENSITY IN ALUMINIUM PRODUCTION**
Tons of $CO_2$ per ton of Aluminium Production

| Industry | Indirect $CO_2$ emissions | Direct $CO_2$ emissions | Total $CO_2$ emissions |
|---|---|---|---|
| • Primary prod. | 4.8 | 3.8 | 8.6 |
| • Secondary prod. | 0.3 | 0.0 | 0.3 |

\* CO2 and CO2 equivalents

Table 3-17: Carbon Intensity in Aluminium Production

In primary aluminium production, total $CO_2$ emissions are 8.6 tons of $CO_2$ per ton of aluminium, of which 4.8 tons are indirect emissions and 3.8 tons are direct emissions.[21] In secondary aluminium production, total $CO_2$ emissions are 0.3 ton of $CO_2$ per ton of aluminium, all in indirect emissions. Primary aluminium production thus causes almost 30 times more total $CO_2$ emissions per ton of aluminium.

### 3.6.5  Industry Trends

### 3.6.5.1  Industry Structure

Upstream aluminium is a global business (from mining to casting in the value chain) while downstream aluminium (manufacturing in the value chain) is for the most part a regional or local business. From a $CO_2$ perspective, smelting is the most important part and is a global business. Global **demand** in aluminium is dependent on economic cycles and has grown with a compounded annual growth rate of 1.7% in the last 10 years. China is the key demand region going forward. Aluminium is traded on the London Metals Exchange (LME).

On the **supply** side, a few players have large shares of the global market. For example, Alcan accounts for about 27% of production, Alcoa about 16% and Norsk Hydro about 10%. As the market is global, European market shares are not very meaningful. Energy prices determine the location for smelters, resulting in long-distance alumina shipping. Alumina resources are in the hands of four to five players.

### 3.6.5.2  Industry Conduct

In terms of **capacity changes**, significant smelter expansion in low-cost regions[22] is reducing traditional high-cost US/Europe production. Most of the smelting capacity in Europe and the United States is likely to be shut down over the next 20 years in response to increased power prices and the search for cheaper, stranded energy. In many ways, $CO_2$ is not the determining factor but a contributing/accelerating one. That is, the shut-down of smelting in Europe would most likely happen irrespective of $CO_2$ costs because of the general development in energy prices.

In terms of **pricing**, the industry has cyclical prices with strong fluctuations due to suboptimal investment decisions. Increased low-cost capacity will prevent large price peaks.

In terms of **vertical integration**, about 70% of smelting is owned by players that are also active in the bauxite/alumina part of the value chain.

### 3.6.5.3  Industry performance

The traditionally strong financial performance of the aluminium industry has been driven by one to two players. Profitability decreased in the past 10 years at a rate of around 1.8% per year as a result of substantial cost pressure on smelters, concentration of customers and increased LME volatility, which created price instability.

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21  This has to be seen in the light of 4.4 million tons of primary aluminium production in Western Europe and 4.2 million tons in Eastern Europe including Russia.
22  Africa +27% over last 3 years because of cheap gas; Asia +37% in 3 years for cheap coal and overall cost level

## 3.6.6  Cost Structure

**POTENTIAL COST IMPACT OF ETS ON EU15 ALUMINIUM
INDUSTRY (PRIMARY SMELTING)**
Euro/ton aluminium; 2002

$\overline{CO_2 \text{ @ } 20€/TON}$
■ Indirect $CO_2$ costs
□ Direct $CO_2$ costs
● % Cost increase

**Direct emissions\* from alumina
smelting and carbon anode baking;
includes PFC and $CO_2$; not relevant,
as long as not included in EU ETS**

**Electricity price
increase,
assuming no
auto generation**

+17.0%
+5.6%
+11.4%

**To be compared
with industry
average EBIT of
10%**

1,587
75
182
492
182
130
110
220
635
75
310
560
1,330
(Range:
1,100-
1,600)

Raw
materials
(alumina,
carbon)    Power    Labor    Other    Capital    Total cost
with $CO_2$
impact

**Power is ⅔ of the plant-specific
costs, hence key source of
competitive advantage**

\* Includes 1.6 tons $CO_2$ and 0.33 kg PFC per ton metal; 1 kg PFC is equivalent to 6,500 kg $CO_2$
Source:  CRU; McKinsey metals and mining practice; James F. King; McKinsey analysis

Figure 3-18: Potential Short- and Mid-term Cost Impact of ETS on Aluminium
Industry (Primary Smelting)

For primary aluminium smelting, the short- and mid-term total cost increase is projected to be
182 Euro/ton of aluminium or 11.4% caused by indirect costs in the form of electricity prices. If
direct emissions were also within the ETS, the total costs would increase by an additional 75
Euro/ton.

**POTENTIAL COST IMPACT OF ETS ON EU15 ALUMINIUM
INDUSTRY (SECONDARY SMELTING)**
Euro/ton aluminium

$\overline{CO_2 \text{ @ } 20€/TON}$
■ Indirect $CO_2$ costs
□ Direct $CO_2$ costs
● % Cost increase

**No direct
emissions**

**Price increase
of electricity**

+0.5%

**To be compared with
assume industry
average EBIT of 10%**

1,542
7
57
7
145
110
1,230
50
1,535
(Range:
1,300-
1,800)

Scrap    Energy    Labor/
overhead    Capital    Total cost
with $CO_2$
impact

Source:  James F. King; McKinsey metals and mining practice; McKinsey analysis
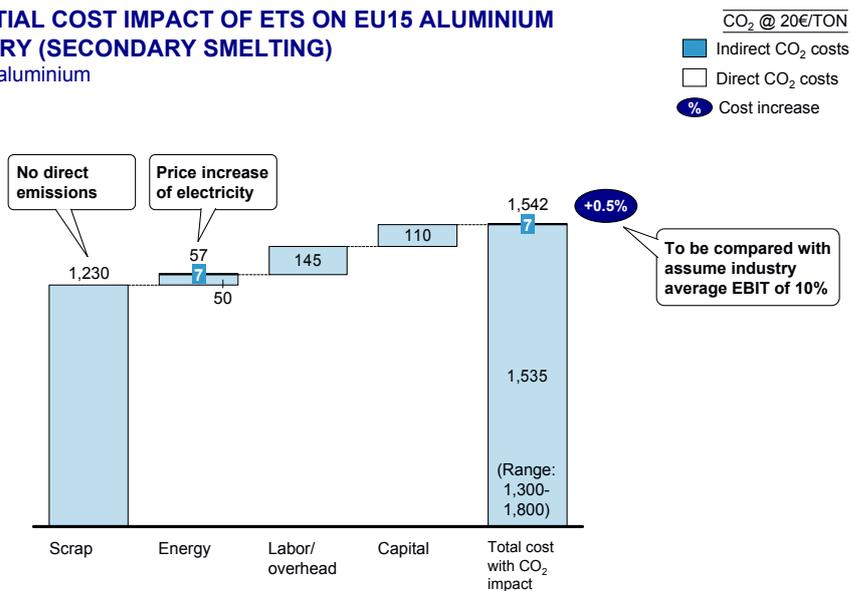
Figure 3-19: Potential Short- and Mid-term Cost Impact of ETS on Aluminium
Industry (Secondary Smelting)

Secondary aluminium smelting is projected to experience a total short- and mid-term cost increase of 7 Euro/ton of aluminium caused by indirect costs from higher electricity prices.

### 3.6.7   Impact of the EU ETS on Competitiveness

With a $CO_2$ price of 20 Euro/ton and a corresponding electricity price increase of 10 Euro/MWh on average across Europe, the short- and mid-term cost for primary aluminium production is projected to increase by 11.4% and the cost for secondary aluminium production by 0.5%. Secondary aluminium smelting will not be affected much by the electricity price increase.

**OVERVIEW OF FINDINGS IN ALUMINIUM INDUSTRY – SHORT- AND MID-TERM**
Percent of total costs

| Industry | Indirect cost increase | Direct cost increase | Total cost increase | Offset by product price increase | Offset by allowance endowment at 95% free allowances | Net cost increase |
|---|---|---|---|---|---|---|
| • Primary prod. | 11.4 | 0.0 | 11.4 | 0.0 | 0.0 | 11.4 |
| • Secondary prod. | 0.5 | 0.0 | 0.5 | 0.0 | 0.0 | 0.5 |

Table 3-18: Overview of Findings in Aluminium Industry – Short- and Mid-term View

As mentioned, most of the primary smelting capacity in Europe and the United Status is likely to be shut down over the next 20 years in response to increased power prices and the search for cheaper, stranded energy. In many ways, $CO_2$ is not the determining factor but a contributing/accelerating one. That is, the shut-down of smelting in Europe would most likely happen irrespective of $CO_2$ costs because of the general development in energy prices.

Due to the industry's competitive intensity, none of the cost increase can be passed on to customers.

### 3.6.8   Impact of the EU ETS on Competitiveness Assuming 50% Pass Through of $CO_2$ Costs in Power Sector

If all electricity players only price the value of $CO_2$ into electricity prices by 50% (a figure arbitrarily selected for the sake of argument), the impact on costs and ultimately on the competitiveness of the aluminium industry would only be half as high as the figures mentioned in the chapter above. On average across Europe, primary aluminium production would see a cost increase and margin decrease of 5.7 percentage points, while secondary aluminium production would see a cost increase and margin decrease of 0.3 percentage points.

### 3.6.9   The Importance of Auto-generation

Auto-generation in aluminium production is only marginal with a 3% share on average across Europe according to outside-in figures. As aluminium production requires electricity and not heat or steam, there is no reason why an aluminium production site would be better suited for electricity production than any other location. Nor is an aluminium producer better qualified to enter into electricity generation than any other company.

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