



# CLIMATE POLICY AND CARBON LEAKAGE

## *Impacts of the European Emissions Trading Scheme on Aluminium*

IEA INFORMATION PAPER

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## EXECUTIVE SUMMARY

The implementation of the Kyoto Protocol - or other regimes that exclude major players in important industrial activities - creates competitiveness concerns for CO<sub>2</sub>-intensive products that are traded internationally and face uneven greenhouse gas constraints.

Since 2005, the European Union has created an emissions trading scheme (ETS) that caps GHG emissions of power generation, but also of industrial activities whose products, in some cases, are traded internationally. The primary aluminium sector in Europe, whose direct emissions are not capped, stands to lose profit margins and, possibly, market shares, as electricity prices are bound to increase as the constraint on CO<sub>2</sub> emissions in power generation results in the pass-through CO<sub>2</sub> prices onto electricity prices.

This report explores the possible effect of climate policy on the competitiveness of the European primary aluminium sector, a first step towards a more robust method of quantification of this issue. A clear assessment of this question is increasingly important at a time where the European Commission considers measures to limit competitiveness losses driven by climate policy.

“[The European Commission] will base its analysis on the assessment of the inability to pass through the cost of required allowances in product prices without significant loss of market share to installations outside the EU not taking comparable action to reduce emissions” (EC 2008). In the case of the aluminium sector, the price is set globally at the London Metals Exchange and the Shanghai Futures Exchange. European producers are therefore unable to unilaterally increase prices to account for cost that they, alone, face. Could, then, the ETS have triggered carbon leakage?

### **Carbon leakage: scope of the analysis**

Carbon leakage is defined as the increase in emissions outside a region as a direct result of the policy to cap emission in this region. Carbon leakage means that the domestic climate mitigation policy is less effective and more costly in containing emission levels, a legitimate concern for policy-makers.

This report focuses on the competitiveness leakage channel for manufacturing sectors: immediate loss of market share for carbon-constrained industrial products, to the benefit of non carbon constrained countries (*i.e.* decreases of exports and increases of imports); and relocation of energy-intensive industries to countries with a more favourable climate policy. Changes in trade patterns as a result of uneven carbon constraints are the main indicator of this competitiveness-driven carbon leakage.

## **Competitiveness - loss of competitiveness: definitions**

In theory, the competitiveness of a sector or company is defined as its ability to maintain profits and market share. A substantial increase in costs for a sector in one region (entailing loss in profits compared to international competitors) would affect an industry's competitiveness (its ability to retain market shares) in different ways: enhanced competition from cheaper competitors on domestic and overseas markets and lower profits leading to lower capacity to invest and expand activities.

With or without the CO<sub>2</sub> cost component, the European primary smelting industry has *de facto* lost its position: demand is increasingly met by imports as domestic production is saturated and no investments in additional capacity are in the pipeline. Although there may be loss in market share, there will not necessarily be a loss in profits as the volume sold remains constant and prices are at high levels.

This report considers two indicators of competitiveness for a sector in a given region: the estimated profit margins of primary aluminium smelters and trade flows.

## **Europe's competitive situation since 1999**

About 85% of Europe's primary aluminium imports originate from eight countries: Norway, Russia, Mozambique, Brazil, Iceland, United Arab Emirates, Canada and South Africa. At present, it costs more to produce a tonne of primary aluminium in Europe than in many other regions. However, this was already the situation in 1999, prior to the introduction of a carbon cost in the EU. The carbon constraint is obviously only one element in this picture, as higher electricity prices prevailed before the introduction of the ETS (with the exception of China and India). Differences in labour and power costs are the main reasons for this competitive situation.

### **1. Changes in costs**

Monitoring the impact of the EU ETS on the European production cost levels requires looking at electricity cost increases since the start of the EU ETS in 2005, and assessing whether Europe's cost increase is higher than for the rest of the world - and then determining whether carbon policy is the main cause of such difference. We rely on 1999 and 2006 data to test this hypothesis.

The cost increase in Europe between 1999 and 2006 was below the global average over the same period. As for electricity prices, estimated prices paid by smelters increased in Europe at a rate that is slightly above the global average

(EUR6.9/MWh for Europe compared to EUR5.6/MWh for the world average).<sup>1</sup> How much of the increase was linked to CO<sub>2</sub> versus the interruption of long-term contracts is difficult to determine. Indeed, in 2006, 82% of the European primary smelting capacity was still under long-term electricity contracts.

If maintaining profits and expanding capacity are the industry's objective, European smelters have benefited from high profit margins as a result of high aluminium prices - which apply to the rest of the world as well. Average prices for 2005-2006 were 62% higher than 1998-1999, which means a doubling of profit margins in Europe. Any effect of higher electricity prices in Europe would be partly blurred by this situation.

## **2. Trade flows: is there evidence of carbon leakage?**

Has the price of CO<sub>2</sub> triggered additional imports into the EU 27? Statistical analysis of 1999-2006 trade data does not confirm that CO<sub>2</sub> prices affected EU primary aluminium trade flows. At the same time, growing demand in Europe has not triggered investment in local primary smelting capacity. The region is obviously less attractive for new capacity than regions that guarantee lower energy costs.

Since the beginning of the EU ETS in 2005, three smelters have closed in Germany, Hungary and France (representing 6.5% of European production in 2006). Two more smelters in Norway also closed over the same period, and while Norway was not covered by the EU ETS, it had its own trading scheme that capped emissions from its electricity sector. Is this a sign of possible relocation caused by the CO<sub>2</sub> cap? At this stage of the analysis, it is not possible to conclude. The study of the impacts of the EU ETS on competitiveness is, and will remain plagued by the difficulty to establish the counterfactual, *i.e.*, what would have happened in the absence of a CO<sub>2</sub> cost: how does one detect, in the rapid industrial production growth outside the EU, the actual effect of an ambitious climate policy in the EU? While decisions to close and re-open an existing smelter may be relatively quick, investment in new capacity takes years to finalise. Any impact on locating new capacity outside the EU, at the expense of existing EU capacity, may require more time to materialise. A constant monitoring of trade flows is necessary to watch how the situation evolves.

### **Conclusions at this stage**

Much of the EU primary smelter capacity is still under long-term electricity contracts and the specifics of these contracts are unknown. Hence, it is difficult to assess the exact impact of the ETS. By 2010, power supply contracts will have expired for 65% of European capacity. The reaction of smelters to this new environment will be an indication of the seriousness of climate policy

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<sup>1</sup> These estimates were calculated using CRU cost data on electricity, and EAA or IAI data on electricity consumption per smelter on an average country or regional basis.

competitiveness impacts on this activity. Whether or not the additional CO<sub>2</sub> cost in electricity prices is what would trigger a closure remains unclear. Unless companies develop new electricity purchasing strategies that will mitigate the effect of the carbon cost on power prices, construction of new smelters is more likely to occur in regions where smelters can secure cheap, long-term supply of electricity.

Will smelters close and production relocate once long-term contracts expire? This also depends on the aluminium market cycle. In any case, European producers would incur higher production costs than unconstrained competitors. The inclusion of their direct emissions in the ETS, if allowances were fully auctioned, could only worsen the picture. Indeed, the proposed revised Directive that extends the EU ETS would be broadened to include primary and secondary aluminium and would cover its emissions of CO<sub>2</sub> and perfluorocarbons (PFCs) from 2013 onward.

### **Policy questions**

The proposed revision of the current EU-ETS Directive lists several measures aimed to mitigate carbon leakage. The first is continued free allocation. For those sectors or sub-sectors where there is a risk of carbon leakage, and where electricity constitutes a high proportion of production costs, the level of free allocation “may take into account the electricity consumption in the production process”, hence compensating electricity-intensive sectors from CO<sub>2</sub>-driven electricity cost increases. Having a clear idea of the role CO<sub>2</sub> prices play in electricity contracts will be critical before considering compensating for increases in indirect CO<sub>2</sub> costs.

The second is a “carbon equalisation system” for imports: “imported products would be included into the EU in the Community Scheme” (EC, 2008). To the extent these trade measures are put forward for to restore a sector’s competitiveness to its level without a carbon constraint, the extent to which they are still conducive to GHG emissions reductions world-wide will be critical. Provided that such measures would be compatible with the WTO, many technical questions remain; What products will be included (semi-finished and/or finished)? How would import-related emissions be measured and verified? Would the supply of allowances for such carbon adjustment come from the EU allowance market, or from a separate pool of allowances, or other Kyoto mechanisms?

To conclude, if sectoral carbon leakage is deemed politically relevant, robust indicators (not just simulations) are needed. This report shows that primary aluminium has not suffered from carbon leakage to date. More ambitious climate policy goals may nonetheless alter this picture.

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## INTRODUCTION

Currently, governments around the world rely on various policy tools to mitigate climate change (e.g. cap-and-trade, voluntary agreements, taxes, subsidies, etc.). The Heiligendamm G8 summit declaration explicitly mentions that “*market mechanisms, such as emissions-trading within and between countries (...) can provide pricing signals and have the potential to deliver economic incentives to the private sector. Fostering the use of clean technologies, setting up emissions-trading systems and, as many of us are doing, linking them are complementary and mutually reinforcing approaches.*”

However, not all countries are proceeding at equal speed. Concerns about the loss of industrial competitiveness remain one of the major barriers to setting more robust CO<sub>2</sub> mitigation obligations on industrial sectors around the world. Country-level commitments do not necessarily imply an identical price of carbon across activities within an individual country. Some countries have taken very limited steps, yet they cannot be held entirely responsible, as the UNFCCC draws distinctions between countries.

Carbon leakage is defined as the increase in emissions outside a region as a direct result of the policy to cap emission in this region. Carbon leakage means that the domestic climate mitigation policy is less effective and more costly in containing emission levels, a legitimate concern for policy-makers.

Since 2005, the European Union has created an emissions trading scheme (ETS) that caps GHG emissions for certain sectors. The EU-ETS is embedded in the broader regime created by the Kyoto Protocol, but applies only to European countries and its industrial activities whose products, in some cases, face competition from countries without emission constraints. Since its implementation, industry has been actively debating how much the EU-ETS would affect their competitiveness vis-à-vis the rest of the world, and how much carbon leakage would follow. The impact of the EU-ETS on competitiveness is twofold: direct costs associated with the cap on direct emissions; indirect impact through increases in electricity prices. Indeed, in a competitive market, the pass-through of CO<sub>2</sub> prices in electricity prices is inevitable as each free allowances has an opportunity cost associated with it (Reinaud, 2007).

Competitiveness, in the context of climate policy, is a notion that applies best to some sectors, tied to the qualitative and cost parameters of a product. The activities that are most prone to such competitiveness problems are trade-exposed, energy-intensive activities (primarily heavy industry). Although the primary aluminium sector is not directly covered by the ETS, the impacts of the CO<sub>2</sub> price are felt through increases in electricity prices. Working on the basis of EU averages for manufacturing plants and the power generation mix, the IEA found that the implementation of the EU-ETS (*i.e.* including free allocation of emission allowances) would only have modest impacts on the cost structure of most of energy-intensive industries (Reinaud 2005).<sup>2</sup> Nonetheless, primary aluminium could face increased electricity costs provided that electricity prices reflect the full opportunity cost

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<sup>2</sup> Local circumstances related to power markets and prices, and openness to foreign competitors could of course change these conclusions.

of CO<sub>2</sub> allowances and that electricity is purchased through the wholesale market. Reinaud analysis shows that foreign imports could increase their competitiveness in European markets for primary aluminium, in spite of freight costs and border tariffs.

This paper explores the ex-post impacts of the EU-ETS on the competitiveness of the primary aluminium sector, looking at the 3 years of functioning of the scheme. It indicates the magnitude of the competitiveness-driven carbon leakage issue for the primary aluminium sector as some IEA member countries are considering more binding measures to combat climate change. The competitiveness-driven channels of carbon leakage for manufacturing sectors are: immediate loss of market share for carbon-constrained industrial products, to the benefit of non carbon constrained countries (*i.e.* decreases of exports and increases of imports); and location of energy-intensive industries to countries with a more favourable climate policy.

The purpose of this paper is also to clarify the debate and bring evidence that can be drawn to date, without sidestepping remaining uncertainties. As we will see, much of the EU primary smelter capacity is still under long term electricity contracts and the specifics of these contracts are unknown. At this stage, it is difficult to assess the exact impact of the ETS.

The paper begins by setting the context: how important is European primary aluminium production compared to the rest of the world? How important is the European market for non-EU producers, and who are the main competitors on the domestic market? It looks into the cost situation of European producers and assesses whether change in costs have been more important in Europe than on a global average. The focus is on estimates of power prices paid by smelters, a first indication of the EU-ETS effects on competitiveness. Tests on trade flows then verify whether the EU-ETS has had an impact on Europe's net imports - if net imports increased, this would be evidence of sectoral carbon leakage.<sup>3</sup> These tests verify whether net trade flows have structurally changed since 2005 (*i.e.* a flood in non-EU imports and/or a decrease in EU exports). The report concludes on the ex-post effects of the EU-ETS on the primary aluminium sector, and provides initial thoughts on some cost mitigation measures various governments have suggested as a means for reducing potential carbon leakage.

This paper focuses only on the primary aluminium industry. It does not look into other parts of the production chain.

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<sup>3</sup> "If competitive distortions are significantly different between constrained regions and unconstrained regions, carbon leakage should be apparent in the trade flows to and from the constrained region. In the short term, an indicator of carbon leakage is a change in international trade flows of carbon constrained products. In the case where the CO<sub>2</sub> price triggers cost differentiation and companies do not pass-through the additional cost, differences in cost levels could trigger changes in trade flows as companies shift to the sourcing of emissions-intensive products from abroad. Over the long run, the main indicators of carbon leakage are changes in investments patterns" (Reinaud 2008).

# 1. Setting the context: aluminium production and trade flows

## 1.1 Sector boundary: which production processes?

The aluminium industry features mining and alumina production, primary and secondary smelting and metal processing into semi-finished products (e.g. bars, profiles, wires, sheets, foils, tubes, pipes) or speciality products (e.g. powders, special alloys). From a technical standpoint, there is no difficulty in producing a new aluminium product from the same used product. Further, there are no differences in quality between a product entirely made of primary metal and a product made of recycled metal.

- The production of primary aluminium consists of three steps: bauxite mining, alumina production and electrolysis. 100 tonnes of bauxite produces 40 - 50 tonnes of alumina (aluminium oxide), which then produces 20 - 25 tonnes of primary aluminium.<sup>4,5</sup>
- In the secondary aluminium sector (*i.e.* recycling), there is a distinction made between: remelters which work from the cleaner scrap and sell final products to rolling mills and extruders; and refineries who buy all qualities of scrap and sell alloys to foundries as well as the steel sector.

In the aluminium sector, integrated companies such as Rio Tinto, UC Rusal, BHP Billiton, Chalco, VALE, Alcoa, etc, produce everything differ from those that are specialised. The specialised companies can be alumina focused (e.g. Alumina company (Australia) produces only alumina), smelter specialised (e.g. the Gulf countries, which are focusing on transforming alumina into metal), or finished product oriented (e.g. India, where some companies have become owners of European rolling mills).

Figure 1 illustrates the production chain for the aluminium sector. Once the primary aluminium sector (or the recycling industry) produces molten aluminium, it is then transported to the cast house where it is alloyed in holding furnaces by the addition of other metals, cleaned of oxides and gases, and then cast into ingots of various forms (EAA). Other finishing processes are applied based on consumers' needs. This report focuses solely on the impact of the EU-ETS on primary smelters.

In the whole aluminium industry, most of the electricity is consumed in primary ingot production (*i.e.* the primary aluminium segment). Primary aluminium production is about twenty times as energy intensive as recycling (IEA, 2007). Indeed, electrolysis is the most energy intensive step in the production of aluminium.<sup>6</sup> Location of primary smelters is, therefore, extremely sensitive to the levels of electricity costs.

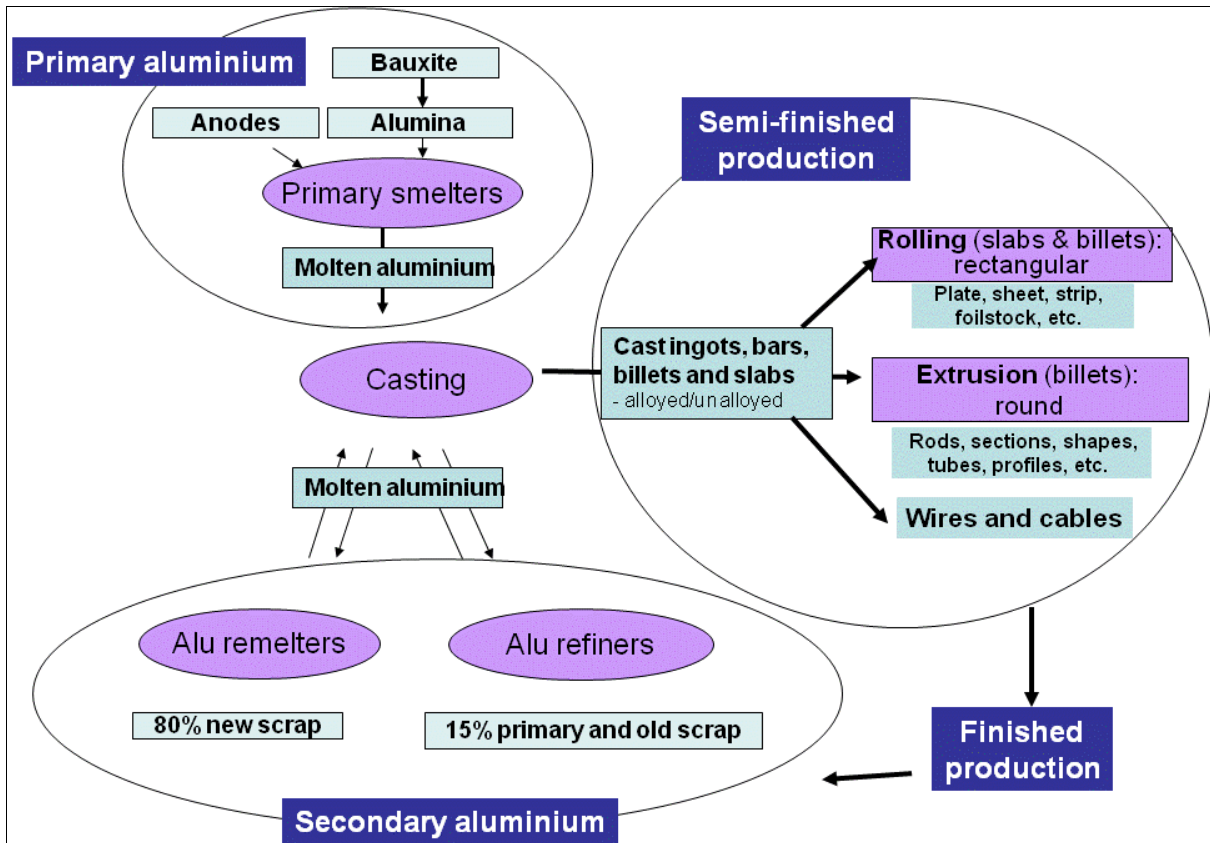
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<sup>4</sup> The alumina yield difference comes from the chemical composition of bauxite.

<sup>5</sup> Primary aluminium is extracted from alumina in reduction plants (smelters) through electrolysis. Two main types of smelters are used for the electrolysis: the Hall-Héroult system and the Söderberg cell. The majority of global primary aluminium production uses the former, and in Europe, Söderberg units account for some 10% of the total capacity (EAA). By 2010, the share of the latter technology should decrease to 6% of total EU capacity as it is less efficient in its electricity use than the Hall-Héroult system.

<sup>6</sup> Primary aluminium smelting consumes large quantities of electricity: the electrolysis uses 15.3 MWh per ton (MWh/t) on average globally; the EU-27 average is lower, at 14.8 MWh/t.

Figure 1: Boundaries of the primary aluminium sector



Source: author

Further, if we go down the production chain, the production of semi finished products is also by far less electricity intensive (4.5% of the electricity consumption for primary metal production) as well as producing metals from recycling. Table 1 provides the average electricity consumption for primary aluminium production in the EU 27 in 2005 compared to that of rolling or extruding products.

Table 1: Average electricity consumption in the primary aluminium sector for Europe in 2005

	Primary	Rolling	Extrusion
Average European electricity consumption (kWh/tAl)	14 810	624	667

Source: EAA

Our analysis focuses on the primary aluminium smelting, where one would expect to see the effects of the EU-ETS, via electricity prices. In the initial phase of the EU-ETS, the impacts of the CO<sub>2</sub> price are only felt through increases in electricity prices. Indeed, before 2013, the greenhouse gas (GHG) emissions of this sector are not capped by the EU-ETS Directive.

## 1.2 Production levels and projected additional capacity

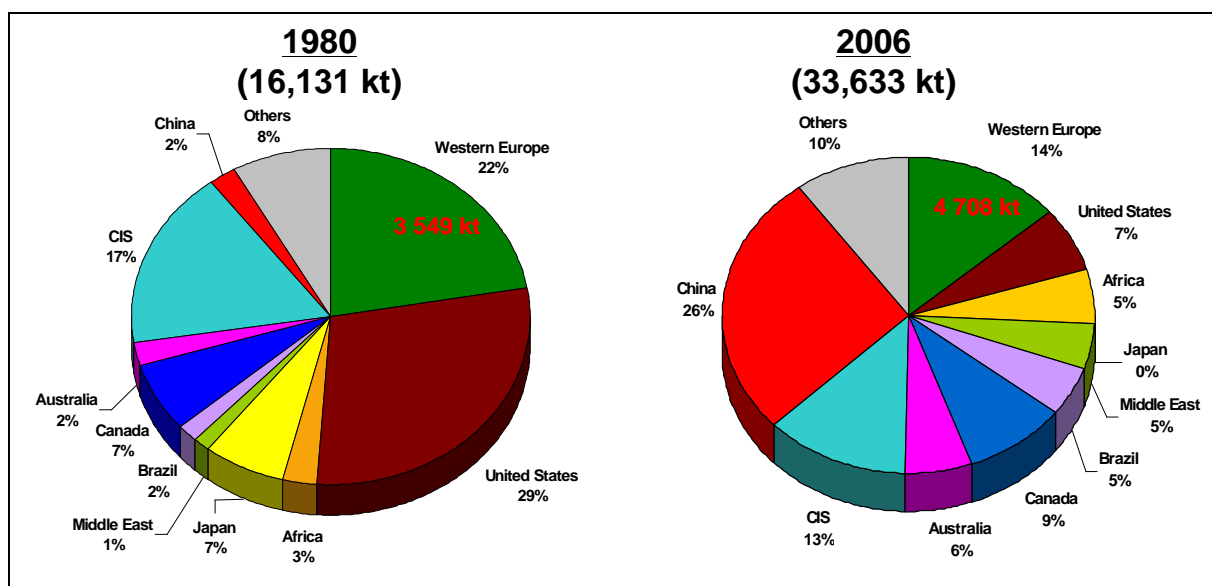
### 1.2.1 Production levels

Between 1980 and 2006, the world total production of primary aluminium increased by 108%. This growth was mainly driven by the emergence of Chinese demand and its exponential supply growth. In 2006, it was reported that China increased its production to 9.349 million tonnes, or 26% of the world production that year, and in 2007, it further increased its production capacity by 38% (ENAM, 2007).

In 2006, the largest producing smelters were in Russia (two smelters over 950kt), Bahrain (one smelter over 850kt), Dubai (one smelter over 780kt), South Africa (one smelter over 700kt), Canada (one smelter over 570kt) and Mozambique (one smelter over 560kt) (CRU).

Figure 2 provides the change in regions' share of world production of primary aluminium. Since 1980, Chinese production has increased by close to 3000%, and its share in world production has grown by 24 percentage points. The share in world production has also increased for Australia and the Middle East, while in the United States primary production has decreased from 4678kt to 2354kt (*i.e.* by almost 50%). Western Europe's share in total production has also declined, but in absolute terms, production levels have increased.<sup>7</sup>

Figure 2: Primary aluminium production by region: 1980 - 2006



Source: EAA

### 1.2.2 Projected additional capacity

Aluminium production is essentially a manufacturing process. It is about locating smelters in regions offering favourable power prices (ideally stranded or captive power to the smelters) and ready transport access to alumina feedstock.

<sup>7</sup> Western Europe regroups France, Germany, Greece, Iceland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and United Kingdom.

Currently, with the exception of China, new aluminium smelters are built in areas where electricity prices are cheap compared to Europe. There are a high level of committed projects (ca. 5Mt excluding China - of which 4.2 Mt Greenfield projects and ca. 3.2 Mt for China alone) and planned (or mooted) projects (ca. 8Mt) in new aluminium production areas, with the intended electricity supply spanning from hydro, nuclear, natural gas and coal. The projected additional or extension of existing capacity is in United Arab Emirates (UAE), Argentina, Brazil, Canada, Dubai, Iceland, India, Iran, Kazakh, Oman, Qatar and Russia.<sup>8</sup>

The amount of new capacity (China excluded) that will come on line by 2011 is equivalent to 166% of Europe's 2006 primary aluminium production, 15% of the world production for the same year. Further capacity is planned in China - the equivalent to 107% of Europe's 2006 capacity should come on-line by 2010. Nonetheless, the Chinese government is trying to regulate production and limit primary aluminium exports, which they consider as indirect electricity exports.

### **1.3 Evolution of primary aluminium prices**

The profitability of the European primary aluminium industry strongly depends on which price is used as a benchmark. Increases in costs associated with increases in prices can maintain a company's margins. Today, the aluminium industry uses the London Metals Exchange (LME) and the Shanghai Futures Exchange (SFE) in almost all phases of the aluminium cycle.<sup>9</sup> LME and SFE are a world price. Aluminium sales are determined by the market price and are only for a relatively small share driven by product and location premiums. Hence, one single company cannot influence its levels. The iron and steel or cement sectors are different in this regard as there no world price for their products, conferring producers possible pass-through opportunities (see Box 1).<sup>10</sup>

LME-based pricing extends from raw materials to semi-fabricated products such as sheets and extrusions, and finished products such as cans, foil and even recycled material. Indeed, in project and trade finance, banks insist that clients remain hedged via LME or OTC products.

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<sup>8</sup> It is important to note that these committed projects are firm: they have political as well as electricity supply contracts. Nonetheless, there have been signs that long term gas supply contracts for additional supply in Oman may be renegotiated and may not benefit from advantageous conditions. Indeed, these are dependant on the supply from Qatar, and Qatar could renegotiate these supply contracts. Further, Qatar has a moratorium on new LNG projects. Hence, this new capacity may not benefit from low gas prices unless they find solutions with Iran.

<sup>9</sup> The Shanghai Futures Exchange (SFE) is also used as a benchmark for aluminium prices.

<sup>10</sup> For a full review of elements influencing pass-through rates in a sector see Reinaud (2008)

## Box 1: Pricing environment for aluminium, cement and steel

### Aluminium:

**Pricing environment:** Aluminium-related prices are set globally at the London Metals Exchange (LME) and the Shanghai Futures Exchange (SFE).<sup>11</sup> LME price is applicable to one specified grade of pure aluminium. The price of all other types of aluminium is composed of the same LME base price plus premiums, which include transport and tariffs, and the specific price for shape and alloy of the semi-finished product.<sup>12,13</sup> As a result, producers cannot pass-through cost increases on the LME price unless their competitors join them in such price move - which they have no interest in doing. Both the geographic market and the pricing environment distinguish primary aluminium from other energy-intensive activities such as iron and steel and cement.

### Cement:

**Pricing environment in Europe:** Contract prices between producers and their major customers (concrete producers and builder merchants) are generally negotiated on a bilateral basis. Nevertheless, an analysis of Eurostat production data reveals substantial and persistent differences in average market prices between adjacent countries (see Ponsard and Walker 2008). This confirms that the price of cementitious products is determined at a regional or national level depending on the cement type.<sup>14</sup> Further, there may also be a difference in prices between coastal installations versus inland producers. Inland producers could in theory tend to impose higher prices as they are more protected from foreign competitors.

### Iron and steel:

**Pricing environment:** Steel prices are mainly set on a bilateral basis over a region, if not more globally.<sup>15</sup> There is no common price indicator for steel, nor a central market place for steel products. However, there is a growing trend for benchmark price discovery of long products on a regional basis. Steel futures are developing on the London Metals Exchange, the New York Metals Exchange and the Dubai Gold and Commodities Exchange (SBB Insight Issue 48).

Source: Reinaud, 2008

<sup>11</sup> In the EU case decision on the merger between Rio Tinto and Alcan (Case No COMP/M.4827), “geographic markets for primary aluminium should be defined as global”. “The final price of aluminium is determined to an overwhelming extent by the LME price and, only to a negligible extent, by the regional premiums.”

[http://ec.europa.eu/comm/competition/mergers/cases/decisions/m4827\\_20071002\\_20310\\_en.pdf](http://ec.europa.eu/comm/competition/mergers/cases/decisions/m4827_20071002_20310_en.pdf)

<sup>12</sup> Note that primary and secondary aluminium cannot be distinguished (although certain applications require only the use of primary).

<sup>13</sup> 97.5% of global aluminium volume is traded on the LME (in 2007) and trade is about 30 times higher than real production. However, only 1% of physical aluminium is traded on the LME.

<sup>14</sup> In the EU case decision on the merger between Cemex and RMC (Case No COMP/M.3572), the European Commission notes “there are two main types of cement: grey cement and white cement”. “Regarding the relevant geographic markets, for white cement it has been defined as at least EEA whereas for grey cement it has been considered as national or EEA, leaving the final definition open” (see Case No COMP/M.3713 for the merger between Holcim and Aggregate Industries).

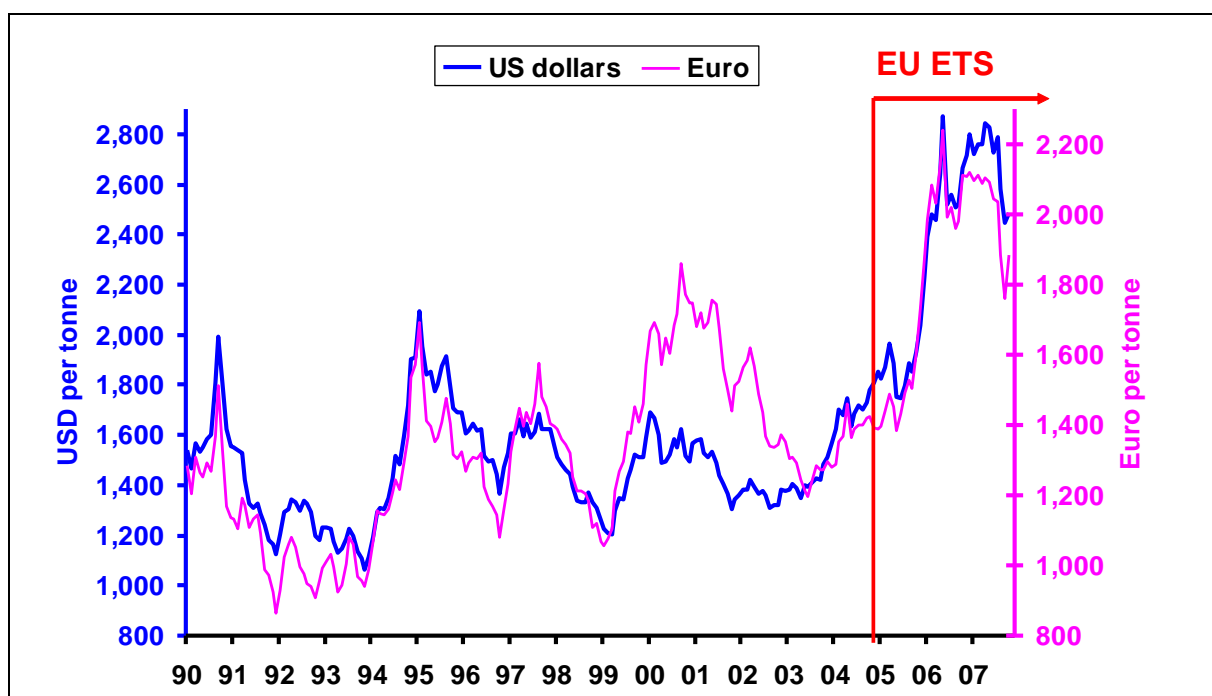
<sup>15</sup> See EU case decision on the merger between Mittal and Arcelor (COMP/M.4137) “The market for the production and direct sale of carbon steel flat and long products are at least EEA-wide.” (*i.e.* European Economic Agreement)



In Europe, aluminium is priced in dollars (USD) whereas most costs incurred are in Euros (EUR), meaning European producers are exposed to the volatility of the exchange rate. However, in 2005 and 2006 LME prices in dollars and Euro followed more or less same price movements resulting in the exchange rate having very little impact (EAA, 2006). This was not the case in 2007 (or between 1999 and 2004). A competitive disadvantage occurred for European based semi-fabricators as the prices in dollars increased less than the prices in Euro.

Figure 3 provides the evolution of primary aluminium prices for delivery 3 months-ahead between 1990 and 2007 in both EUR and USD. The 3 month-ahead delivery prices are used as a benchmark for most aluminium supply contracts.

Figure 3: Primary aluminium 3 month-ahead price (1990-2007) in EUR and USD



Source: EAA

LME prices have been volatile between USD1200/tonne and USD 2100/tonne (see figure above). Since 2005 aluminium saw a run up in price, briefly hitting USD 2800/tonne but have subsequently fallen back to around US\$ 2400/tonne. If we include the EUR/USD effect, LME prices are not above their 2000 levels in EUR.

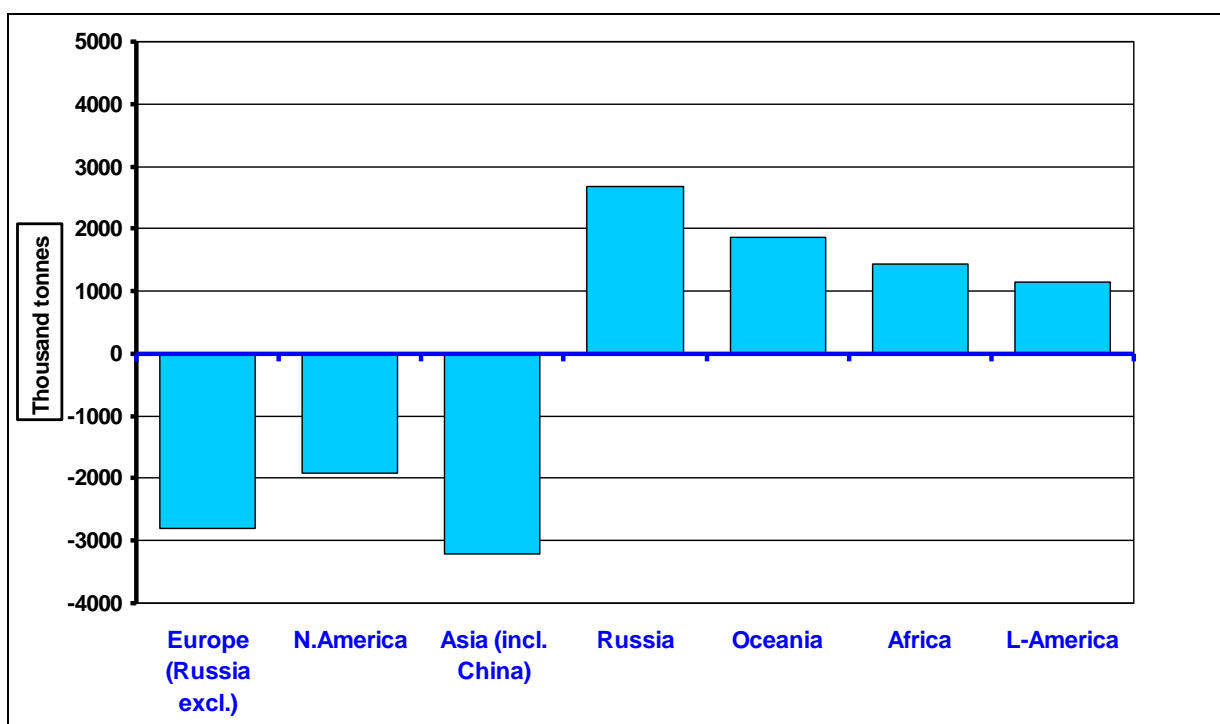
What explains this rise in prices? Is the EU-ETS playing a role in its evolution as the inception of the EU-ETS corresponds to the high escalation in price levels? The supply-demand dynamics as well as the high prices of raw materials (*i.e.* alumina, electricity) and freight costs (see Annex 2) are the main drivers. Chinese smelters are the main driving force in the aluminium and alumina market. According to market analysts, Chinese demand represents approximately 33% of the global demand, and in 2007, its aluminium consumption grew by 37%, (ENAM 2007), matched by a corresponding increase in production.

## 1.4 Trends in EU trade flows of primary aluminium

### 1.4.1 Trends in EU trade flows

Global demand in aluminium is dependent on economic cycles and has grown with a compounded annual growth rate of 4.8% in the last 10 years (1997-2006) (IAI). China is the key demand region going forward because of absolute volume and growth rate. In 2006, Russia, Oceania (*i.e.* Australia and NZ), Africa, and Latin America were net exporters. On the contrary, in that same year, the consumption level in Asia (including China) was closely followed by the United States as well as Western Europe and these three regions had a growing primary aluminium deficit (EAA, 2006). As illustrated in Figure 4, they were net importing regions of primary aluminium. In 2007, however, China's production had exceeded demand, and the country became a net exporter for the first time.

Figure 4: Primary aluminium regional balance 2006



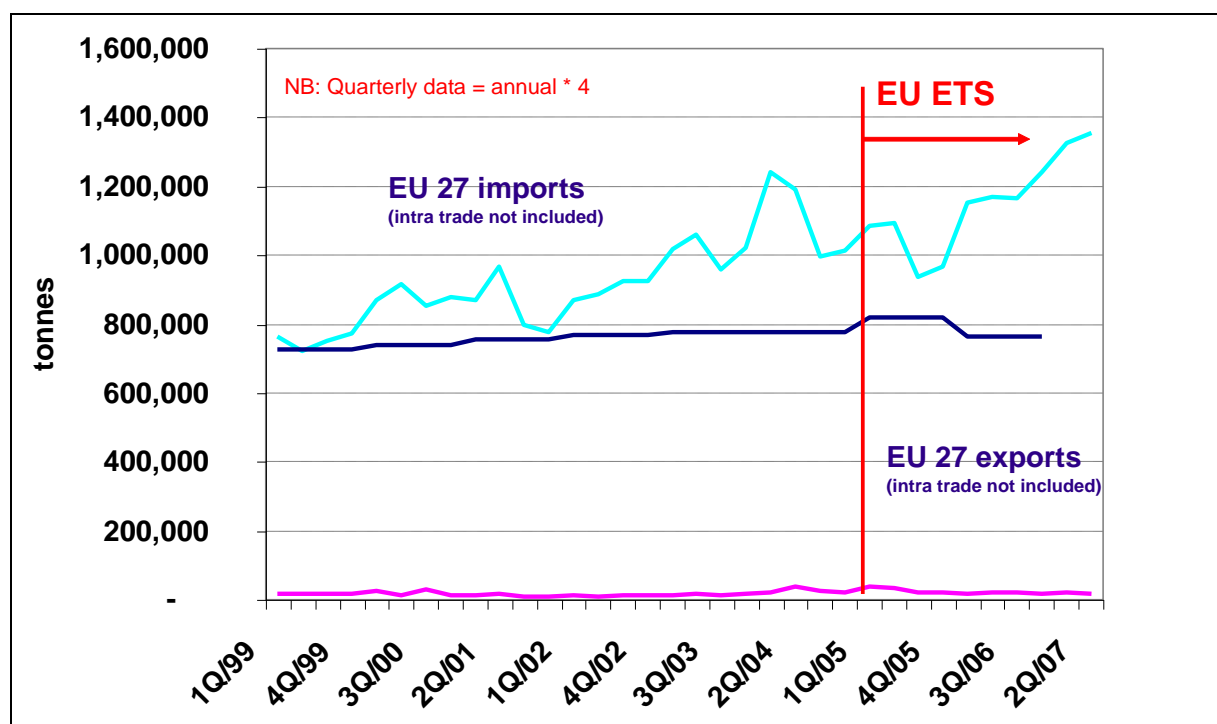
Source: EAA

Aluminium is heavily traded: its high value per ton means that transport costs weigh little in the final price; further, production is traditionally located near low-cost electricity capacity. The latter is a major element in the choice of location, proximity to markets much less so, in opposition with commodities like cement. As a result, 77% of total output is traded internationally (Baron, Reinaud, Genasci and Philibert, 2007). Western Europe and the USA, while accounting for only 22% of global production, account for 44% of global consumption (each consumes roughly a quarter).

Imports in the EU 27 have increased following a rise in total consumption and stagnation in production. Between 1999 and 2006, consumption of primary aluminium grew by 40%. Over the same time period, production increased only by 5%. Today, European smelters are

running at full capacity and no construction or extension of smelters is currently planned in Europe. Any rise in demand will be met by imports. Figure 5 illustrates this trend over the same period. It shows how non EU imports have soared to meet demand. This figure also points to the official starting date of the European ETS January 1, 2005.

Figure 5: EU 27 Primary aluminium trade and production (1st quarter 1999 to 2nd quarter 2007)



Source: EAA

In volume, imports from non-EU countries are largely above EU exports (intra-trade is not included). Export volumes represent only 2% of the import volume (intra EU trade excluded). The paper will not look at EU 27 exports as these are insignificant compared to production and import levels, and rather focus on European smelters' competitors on the domestic market.

Have there been significant changes in the import/export pattern in Europe since the beginning of the EU-ETS? Table 2 shows the relative change in volumes on an annual basis between 2004 and 2006. It shows that between 2005 and 2006, there was a decrease in the total level of production.<sup>16</sup>

<sup>16</sup> Section 3 also analyses European primary aluminium trade flows in light of the CO<sub>2</sub> price and test if there is evidence of a structural change in trade flows with the implementation of the EU-ETS in 2005.

Table 2: Changes in EU 27 primary aluminium production and trade (2004-2006)

	2004-2005	2005-2006
<b>EU 27 Production</b>	<b>1%</b>	<b>-7%</b>
<b>Non EU Imports</b>	<b>-3%</b>	<b>15%</b>
<b>EU 27 Exports (extra EU)</b>	<b>0%</b>	<b>7%</b>

Based on EAA data

The decrease in European aluminium production in 2006 (-7% or 200kt) corresponds in part to closures of some smelters, or the slowing down production before closure in 2007. Since the beginning of the EU-ETS in 2005, four smelters have closed in Germany, Hungary and France (representing 6.5% of European production in 2006), although one reopened in 2007 in light of high LME price.<sup>17,18</sup> In 2005, the owner of the smelter reported that the closure was motivated by the company's inability to secure power contracts (i.e. the power contract for this smelters expired at the end of 2005). Others also invoked rising electric energy prices in the region and the weak dollar. Two more smelters in Norway closed over the same period, and while Norway was not covered by the EU-ETS, it had its own trading scheme since 2005 that capped emissions from its electricity sector.

Is this carbon leakage (i.e. defined as the ratio of increased emissions in one region as the result of an emissions constraint introduced in another)? In the short term, the indicator of competitiveness-driven carbon leakage is a change in international trade flows of carbon constrained products. These trade flows should then be matched with other economic parameters to evaluate whether the EU-ETS (i.e. the carbon policy) played a role.<sup>19</sup>

At this stage of the analysis, it is not possible to conclude (see Section 3). The study of the impacts of the EU-ETS on competitiveness is, and will remain for long, plagued by the difficulty to establish a proper counterfactual scenario (i.e. what would have happened otherwise): how does one detect, in the rapid industrial production growth outside the EU, the actual effect of Europe's ambitious climate policy and resulting relocation? Decisions to shut down and reopen an existing smelter may not take a lot of time compared to decisions to invest in new capacity, which take years to finalise in the heavy industry sector. Although the Directive had been "in the works" for some time, any impact on locating new capacity outside the EU, at the expense of existing EU capacity, may require more time to materialise.

<sup>17</sup> It is interesting to note that in Hungary, the aluminium company announced it would maintain the production of semi-finished products (and even increase it by 50% until 2010) on the basis of purchased primary aluminium and aluminium scrap.

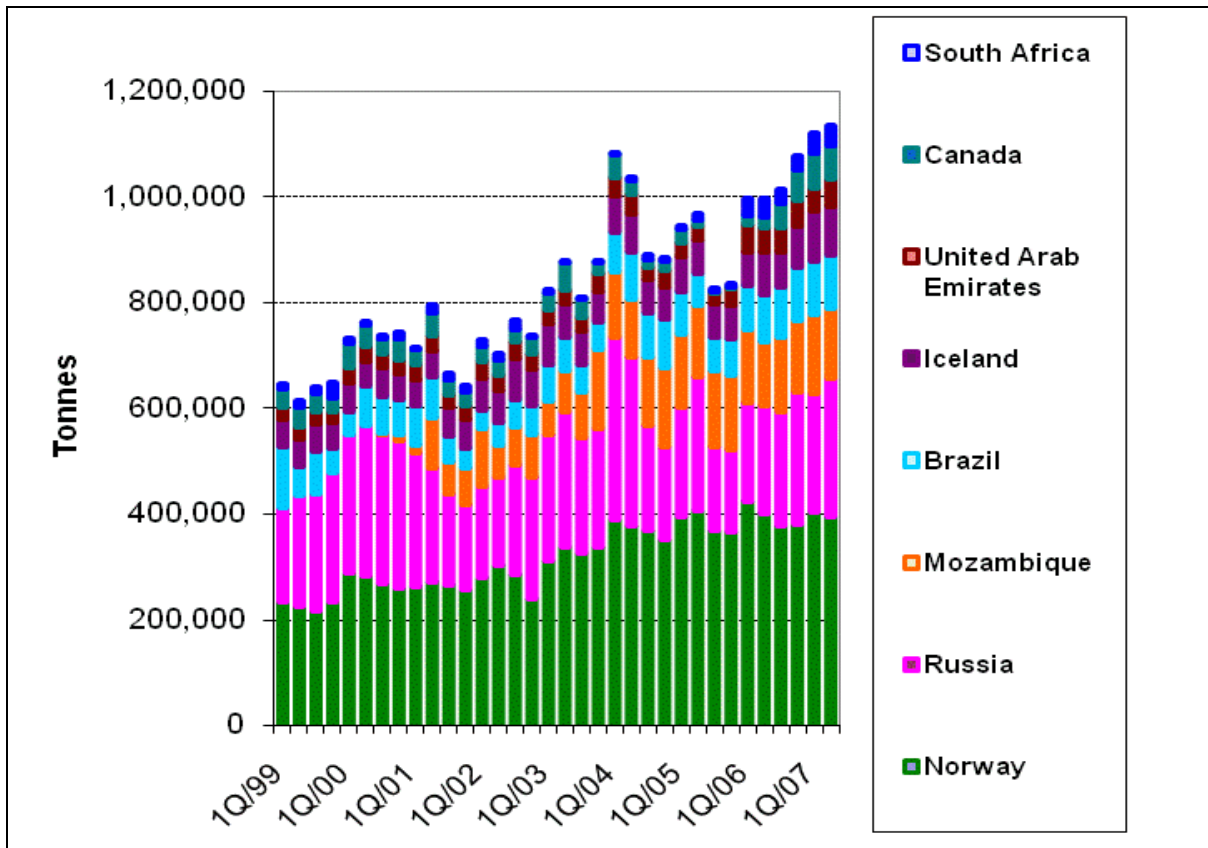
<sup>18</sup> It should also be noted, however, that the smelter that reopened was written-down in the books (i.e. fully depreciated) of the previous owner (a global aluminium operator) and then sold to local investors who re-opened it on the back of high aluminium prices, a short-term electricity position (including the decline in the ETS permit price), government assistance to maintain employment, and almost zero capital exposure - the combination of factors providing the opportunity for strong positive cash flow for the new owners.

<sup>19</sup> Indeed, In the case where the CO<sub>2</sub> price triggers cost differentiation and companies do not pass-through the additional cost, differences in cost levels could trigger changes in trade flows as companies shift to the sourcing of emissions-intensive products from abroad

### 1.4.2 A Focus on imports in Europe from non EU producers

The bulk of primary aluminium imports into the EU originate from non EU countries. In 2006, the volume of intra EU trade was only 60% of the imports from non-EU countries. If we look at the historical trend of non EU imports of primary aluminium, eight countries account for 85% of total EU 27 imports (Figure 6). The largest importers into Europe: Norway, Russia, Mozambique, Brazil, Iceland, the Middle East and South Africa.

Figure 6: EU-27 Imports of primary aluminium by country of origin (intra EU 27 excluded)



Source: EAA

At this stage, China is not one of Europe’s main competitors on the European market. Imports from China represented only 0.05% of the total non EU imports over 1999-2007. Further, China has decided to limit export of primary aluminium, mainly through a tax scheme. It is mostly importing downstream finished products into Europe. Nonetheless, market analysts expect that primary metal over-capacity in China could be a looming problem that serves to depress global prices and flood the export market.

Further, it is interesting to note that since 2005 Norway has implemented its own emissions trading scheme, which similar to the EU and initially only covers the electricity generation sector. Since its implementation, imports from Norway have increased. Further, Norway and Iceland have agreed to implement the EU-ETS (although in January 2008, it was still not clear whether Iceland would have any installations covered by the emissions trading scheme until 2012). In October 2007, the joint Committee of the European Economic Area agreed to

incorporate the EU Directive in their legislation. This means that these schemes could also potentially expand their scope to cap the aluminium industry's direct emissions post 2012.

#### Preliminary conclusion:

*Trends since 1999 show a growing share of non-EU imports and a relatively constant (low) level of EU exports. European producers are de facto losing market share, but this is the result of a particular situation: production levels in Europe are saturated and no new smelters are planned.*

*Nonetheless, we can wonder if the lack in new production or the closures of smelters is the result of a loss in European competitiveness. If yes, what are the driving forces: exchange rates, higher growth in electricity costs compared to other regions, CO<sub>2</sub> pass-through in electricity prices? If so, how much of the electricity cost increase was linked to CO<sub>2</sub> versus the interruption of long-term contracts will be difficult to determine.*

## **2. Competitiveness of European producers: definition, status and evolution**

In this section, the definition of competitiveness of a sector (or an industry facility) is focused on its ability to produce at a lower cost than competitors, while maintaining profits. Trade patterns of a region or country (and the share of European primary aluminium in the international market) and their evolution are also a relevant indicator for the international competitiveness of a sector, but will be treated in Section 3.

The aim of this section is to trace whether the EU-ETS has caused a loss in competitiveness of the primary aluminium sector in Europe vis-à-vis the rest of the world, which in turn could translate into carbon leakage. If carbon leakage occurred, this means that the domestic climate mitigation policy is less effective and more costly in containing emission levels.

Note that there may be a discrepancy between how policy-makers look at competitiveness (iron and steel in Japan or the European Union versus China) and how companies themselves see it (*i.e.* a multinational company with assets in both China and Europe may well see growth in investment in China as a winner from a competitiveness perspective, even though on paper, it could be construed as a loss of competitiveness from a European perspective).

### **2.1 Potential impacts the EU-ETS on the European primary aluminium sector**

GHG emission trading schemes may cause an increase in production costs, whether the cost elements are variable (*e.g.* raw materials, energy, maintenance) or fixed (*e.g.* labour, financing of the capital cost or depreciation). The effect of the first phase of the EU-ETS on the primary aluminium may be indirect or from a rebound effect of this indirect effect.

- Increases in costs of certain raw materials following an increase in demand of those products as their consumption triggers less emissions than if others were consumed (*e.g.*, natural gas compared to coal, scrap), or because these products are also covered by the same policy instrument (*e.g.*, electricity).

- Increase in financial costs as a result of a higher required return on investment or higher interest rates if the investment risk is perceived as higher by investors.

The high electricity intensity of aluminium makes it vulnerable to electricity price hikes triggered by CO<sub>2</sub> costs in power generation. Studies have shown that the cost of the EU-ETS can be high at the margin for aluminium (Reinaud, 2005; McKinsey and Ecofys, 2006). These marginal costs could have a pronounced effect on decisions to increase output in the region, or import. Reinaud (2005) studies the impacts of the EU-ETS on the competitiveness of the primary aluminium industry through the increase in cost of electricity. Reinaud assumes that electricity pricing would lead to a full pass-through of the carbon opportunity cost in power prices. A EUR20 per tonne of CO<sub>2</sub> would result in a 21% price increase in Continental Europe (or an increase of EUR10/MWh). McKinsey and Ecofys (2006) follow the same methodology and also estimate that a EUR20/tCO<sub>2</sub> price will increase in electricity prices by EUR10/MWh. Table 3 shows cost increases estimates for European primary smelters under a full pass-through of electricity price scenario. Results are slightly higher in the McKinsey and Ecofys report as they consider a slightly higher electricity-intensity for European primary smelters.

Table 3: Cost increase estimates at EUR20/tCO<sub>2</sub> price

% of total cost increase	Reinaud 2005	McKinsey and Ecofys 2006
Cost increase	8	11.4

Source: author

## 2.2 Evolution of production costs

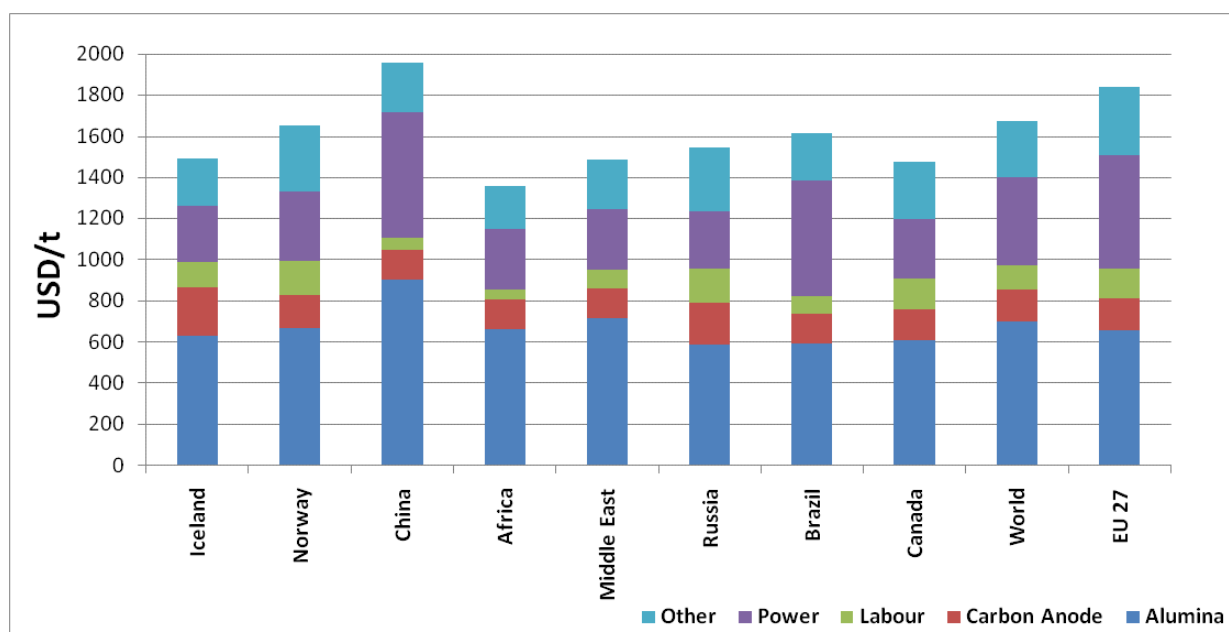
Sectoral characteristics matter when we consider the impacts of environmental regulations on cost competitiveness (Cosbey and Tarasofsky, R., 2007). Access to raw materials, human capital, energy costs, the ability to transport semi-finished products and re-treat them, etc. are all elements to bear in mind when we consider companies' adaptive strategies following the implementation of binding GHG constraints.

In this paper, the operational costs for a primary aluminium smelter costs are defined as those incurred at the specific production site. These are raw material costs (alumina based on LME prices and carbon anode) and conversion costs (*i.e.* all labour-related costs, fuel and power, other consumables, maintenance materials and supplies and purchased services of all kinds). Costs related to capital expenditure, or accounting concepts like depreciation, amortisation, depletion or sinking fund payments are not included, but maintenance is considered to be part of conversion costs (CRU).

If we focus on Europe's main competitors identified in Figure 6, in absolute terms, the European Union (27) was the least competitive in 2006 (see Figure 7).<sup>20</sup> Figure 7 provides the operational cost breakdown for 2006. China is included in this graph as market analysts still foresee Chinese producers as a potential threat to European producers in the next few years.

<sup>20</sup> According to CRU, the most competitive smelters are in India, Canada, Mozambique, Russia, Norway, and France.

Figure 7: Operational cost estimates (2006)



Source: CRU [www.crugroup.com](http://www.crugroup.com)

The Euro/US dollar exchange rates used are: 1999 = 1.067 and 2006 = 1.241

If we look at the share of each cost element in the total cost structure, a significant part of the production costs are determined by power and alumina costs. Alumina and electricity inputs are rather stable in the primary aluminium production (although as the next section will describe, the average electricity intensity for European smelters has decreased by 4% between 1999 and 2006). Hence, any movements in total costs per tonne are chiefly driven by price movements. The high share of alumina costs in total operational costs is function of the high LME prices during 2006 and the negotiated alumina/aluminium ratio. While there are no market prices for alumina, when signing supply contracts, contracts refer to a price that is a percentage of the LME price (ratio).<sup>21</sup>

Monitoring the impact of the EU ETS of the European production cost levels requires looking at electricity cost increases since the start of the EU ETS in 2005, and assessing whether Europe's cost increase is higher than for the rest of the world - and then whether carbon policy is the main cause of such difference. We rely on 1999 and 2006 data to test this hypothesis.

<sup>21</sup> In 2007, while the LME price was constant, contracted alumina prices plunged and recovered on a spot basis over the same period. The result was a decrease in the alumina/aluminium ratio. A domestic dispute in China is sought to have caused this situation as independent producers of alumina fought for market shares.



Table 4: Variation in production costs since 1999

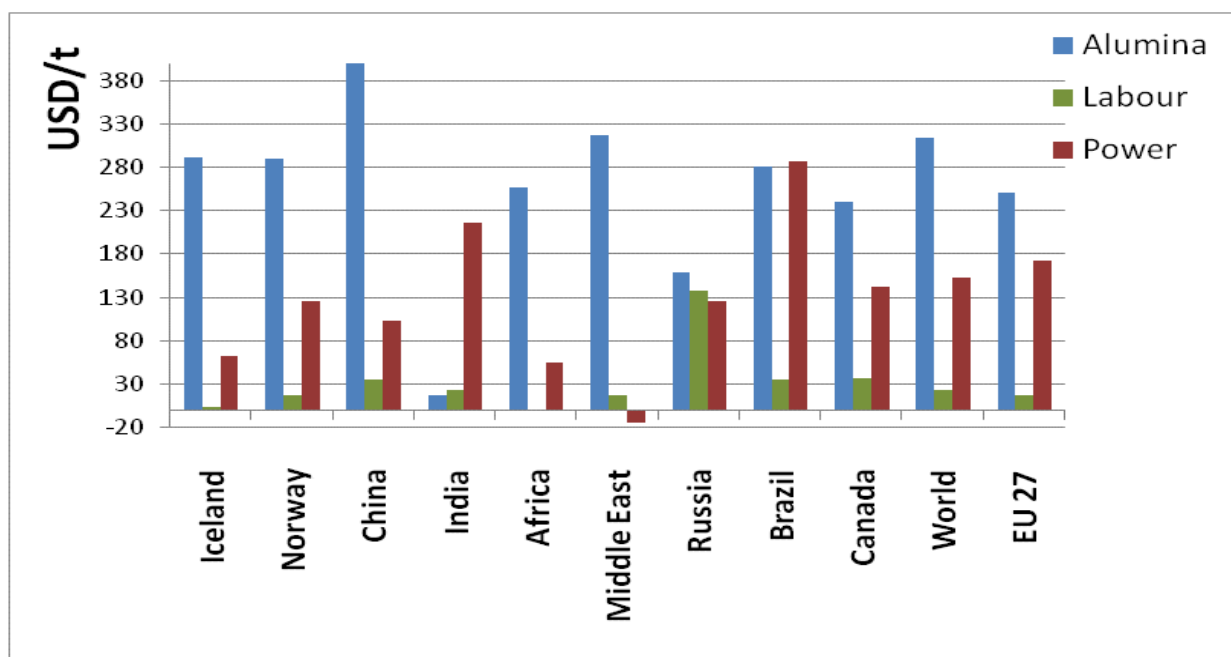
	Percentage Growth	Increase in USD/t
Iceland	31%	350
Norway	44%	504
China	40%	558
India	26%	308
Africa	29%	306
Middle East	26%	308
Russia	50%	518
Brazil	66%	644
Canada	48%	477
World	44%	514
EU 27	33%	449

Source: CRU [www.crugroup.com](http://www.crugroup.com)

The Euro/US dollar exchange rates used are: 1999 = 1.067 and 2006 = 1.241

First, if we take into account the total operational costs, between 1999 and 2006, increase in total operational costs for the Europe was also below the global average (approximately 449USD/t compared to 514 USD/t) (Table 4). This was also the case for the Middle East, India, Africa, Iceland and China. Cost increases were higher for Brazil (USD187/t), China (USD101/t), Russia (USD62/t) and Norway (USD48/t) if Europe's growth is used as a reference.

Figure 8: Increase in alumina, labour and power costs per tonne of aluminium (1999 - 2006)



Source: CRU [www.crugroup.com](http://www.crugroup.com)

The Euro/US dollar exchange rates used are: 1999 = 1.067 and 2006 = 1.241

Second, if we look into detail, only labour costs grew more in Europe compared to the global average (although in absolute terms, the difference is not very significant). Figure 8 provides variation in costs (USD) per tonne for alumina, labour and power.

On a regional basis, raw material costs increased for all countries, and market analysts predict that prices could grow even higher following a 3% tariff removal on Chinese alumina imports. They predict that this could spur increases in imports, and push international alumina prices to higher levels.

Power costs have increased all around the world except in the Middle East (CRU). Electricity costs in Europe increased slightly more than the world average both in absolute terms and in percentage. Only India and Brazil's increase in power costs were higher (Brazil's increase being close to double the world average due to the strong Real re-evaluation to the USD (see Table 5 for details on the increase in estimated power prices paid by smelters).

The next chapter focuses on estimated power prices paid by the primary smelters.

### **2.3 Estimated power prices paid in primary smelting: evolution since 1999**

Electricity consumption has declined in most regions as new capacity is constructed and old capacity is retrofitted with new cells (IEA, 2006). This average has declined about 0.4% per year over the last twenty-five years (see annex I). The range across regions is relatively narrow, compared to the differences in energy efficiency that have been observed in other manufacturing industries. New smelters tend to be based on the latest technology and energy efficiency is a key consideration in smelter development. For example, Africa has the most energy efficient smelters in the world as it benefits from the relatively young age of its smelters (IAI).

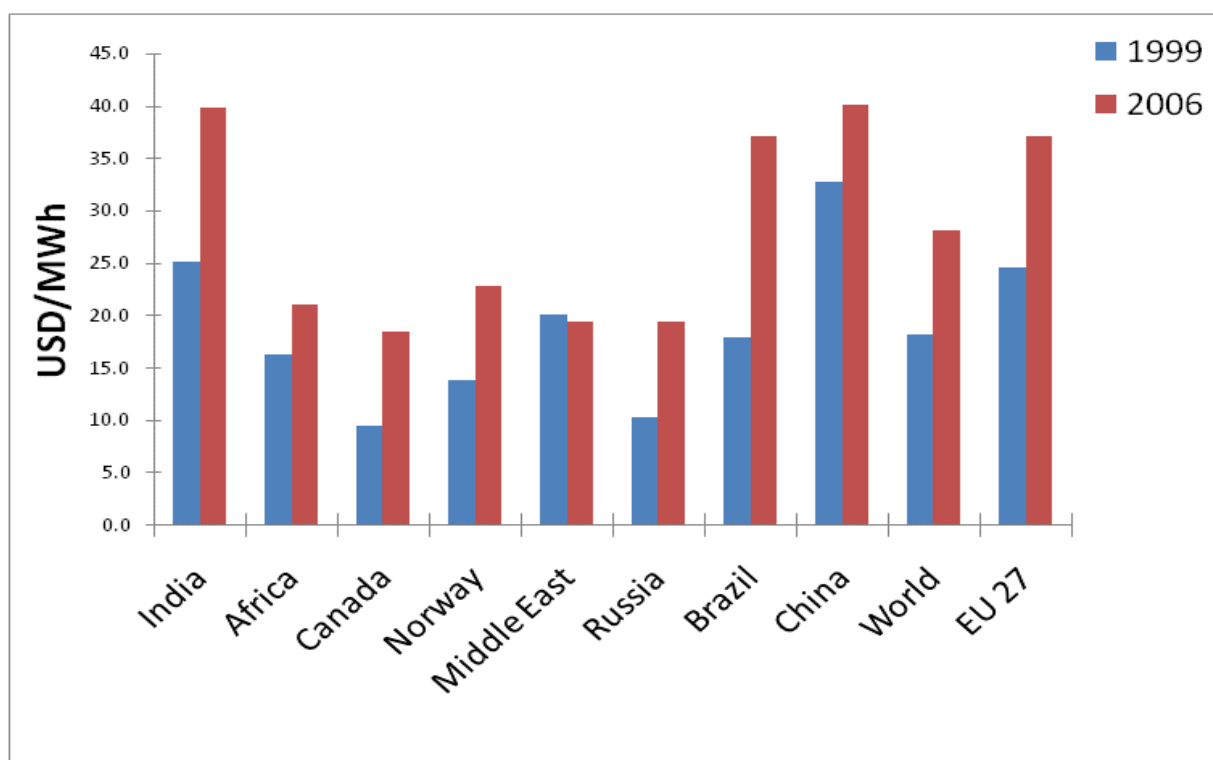
#### **2.3.1 World average**

Figure 9 presents estimates for the power prices paid by aluminium smelters in 1999 and 2006 for the main countries/regions competing with the EU. These prices were calculated based on CRU power cost estimates and IAI and EAA regional electricity consumption by smelter (see Annex I for details on the regional specific power consumption in aluminium smelting).

In 2006, Indian and Chinese smelters were paying the highest price for electricity on a MWh basis (USD40/MWh), followed by Brazil (USD37/MWh) and the EU 27 average (USD34/MWh or EUR28/MWh). These regions were above the global average of around USD 28/MWh (or about 23 EUR/MWh: 1 EUR = 1.48759 USD)

Monitoring the impact of the EU-ETS of the European smelters requires looking at electricity cost increases since the start of the EU-ETS in 2005. If we look through the prism of the estimated price of electricity contracts for smelters, Europe has experienced a higher rise than its competitors. Table 5 shows the increase in the estimated power prices for smelters in absolute terms both in Euros and in USD.

Figure 9: Power price estimates (selected regions 1999 - 2006)



Estimates based on CRU, EAA and IAI data; [www.crugroup.com](http://www.crugroup.com)

The average electricity price European smelters pay has increased more than the global average since 1999 including the effect of exchange rates (USD11/MWh for Europe compared to 10USD/MWh for the world average). Only Brazil and India's electricity price increases were higher.

Table 5: Increase in estimated contracted power prices (1999 - 2006)

	USD/MWh	EUR/MWh
Africa	4.8	1.7
Canada	9.0	6.0
Iceland	4.7	2.0
Norway	9.0	5.5
Middle East	-0.7	-3.2
Russia	9.2	6.0
Brazil	19.2	13.1
China	7.3	1.6
India	14.7	8.5
World	10.0	5.6
EU 25 w/o NL & G	8.5	3.8
EU 27	11.3	6.9

Estimates based on CRU, EAA and IAI data

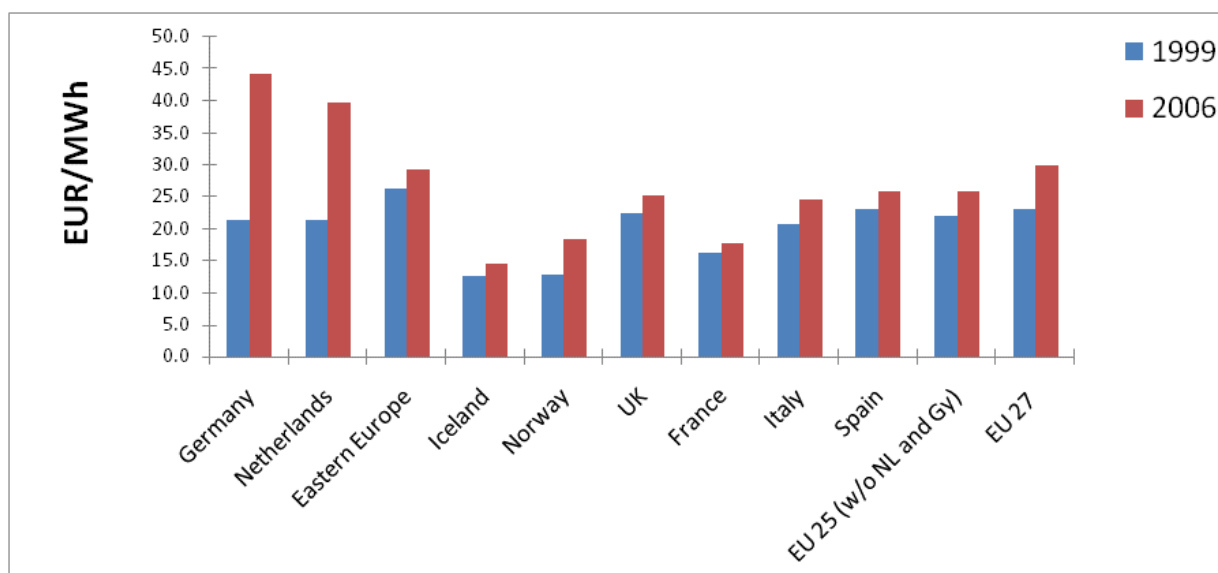
The Euro/US dollar exchange rates used are: 1999 = 1.067 and 2006 = 1.241

The Russian smelters were strongly impacted by the Rouble re-evaluation during the period. The same applied for the Brazilian smelters with the Real re-evaluation.

### 2.3.2 Focus on Europe

There are large disparities within Europe as Figure 10 shows. This figure provides the same power price estimates that smelters paid in 1999 and 2006 in EUR with a focus on several European countries. These estimates are based on CRU cost data and EAA's electricity consumption estimates.

Figure 10: European power price estimates (1999 - 2006)



Estimates based on CRU, EAA and IAI data [www.crugroup.com](http://www.crugroup.com)

In 2006, smelters in Italy, Spain and France paid lower electricity prices than the European average due to the on-going long term contracts concluded prior to the liberalisation movement in Europe. Contract prices in Iceland and Norway were also well below the EU average. In contrast, smelters in Germany (EUR44/MWh), the Netherlands (EUR40/MWh) and Eastern Europe (EUR36/MWh) had electricity prices that were higher than European average (EUR35/MWh). Nonetheless, these prices were below the wholesale market price. In April 2006, baseload prices for supply in calendar year 2007 were around EUR 57/MWh in Germany (European Commission).<sup>22</sup>

The situation was different in 1999. The highest electricity prices were in Eastern Europe followed by the UK and Spain. Compared to 1999, the estimated prices in power contracts increased the most in Germany and the Netherlands, while Italy, France, Spain and the UK, the increase was below the EU average. Estimated increased reach EUR23/MWh in Germany and EUR19/MWh in the Netherlands (compared with the 6.9 EUR/MWh for EU 27). Germany and the Netherlands excluded, prices estimates for EU 25 only increased by EUR3.8/MWh.

Beyond a disparity between European countries, there are also strong disparities in prices that each smelter pays within a country. In 2006, for example, in the Netherlands, the difference between the highest and the lowest power contract price reached approximately EUR23/MWh. In Germany, the range reached EUR22/MWh, in the UK EUR21/MWh, and in Eastern Europe EUR25/MWh. The disparities were much lower in 1999 (respectively

<sup>22</sup> [http://ec.europa.eu/energy/electricity/publications/doc/review/2006\\_04\\_qr07.pdf](http://ec.europa.eu/energy/electricity/publications/doc/review/2006_04_qr07.pdf)

EUR2/MWh, EUR3/MWh, EUR16/MWh, and EUR17/MWh). These are signs that smelters that pay the highest cost may no longer benefit from long term contracts (see Table 6). Indeed, in the Netherlands and in some smelters in Germany, it is reported that some plants are no longer running under long term prices. Another explanation could be that for some smelters, a part of their electricity price is pegged to LME prices as LME prices were also at high levels in 2006. Nonetheless, the first hypothesis is more realistic than the latter according to industry sources.

In 2006, 18% of Europe's primary smelting capacity was buying electricity on the wholesale market (Table 6), meaning that the majority of smelters was protected from price increases following the introduction of the EU-ETS. This picture could be worse in the next few years as currently, most European smelters are still under long term electricity supply contracts. Table 6 provides the status of the electricity contracts for primary aluminium smelters, and their expiry date.

**Table 6: Status of primary aluminium electricity contracts in 2007**

Capacity with contracts ending in	kt	% of EU 27 2006 production
2008	626	20%
2009	145	5%
2010	346	11%
2011	0	
2012	271	9%
2013	159	5%
2014	0	
2015	91	3%
2016	256	8%
Capacity running with wholesale prices as long term contracts ended without replacement		
	542	18%
Capacity running on self-generation of electricity		
	210	7%
Capacity in former Eastern European countries in private hands endangered by local unsecurity of supply		
	260	9%
Capacity owned by state-owned companies in former Eastern European countries		
	137	4%
Capacity having probably found a solution with Russia		
	103	3%
<b>Total EU 27 based capacity</b>		<b>103%</b>
	<b>3146</b>	

Source: EAA

In the short term (*i.e.* before 2010), 65% of the European capacity is vulnerable to changes in electricity market prices and by 2016, 79% of the European aluminium smelters will no longer be covered by long term electricity contracts. Hence, unless they develop new electricity purchasing strategies or build their own power generation facility, they could be highly exposed to electricity market price volatility (under the condition that there are no more regulated prices in Europe). Further, under the proposed revision of the EU-ETS

Directive, CO<sub>2</sub> allowances could be fully auctioned to the power sector. Will this increase power prices even more? Although in theory the opportunity costs of free allowances holds the same economic value than auctioned permits, estimates of pass-through rates of the free CO<sub>2</sub> allowances in 2005 ranged between 39 and 70% in Germany and the Netherlands (Sijm et al, 2006).

There is no single EU electricity market, but several markets and regulatory frameworks across the EU (Reinaud, 2007). Further, if companies' are not bound by long term electricity contracts, end-user prices can be a mix of various market prices. Thus, the impact of CO<sub>2</sub> on end-user electricity prices is even less well known than the impact on generation prices. How does the electricity cost faced by industrial energy users relate to the prices observed on electricity markets (whether they are organised through an exchange or not)? Obviously, the relationship hinges on industrials' power purchasing strategies. As a result, changes in electricity costs for energy-intensive industries cannot be estimated from day-ahead or forward electricity prices variations - although supply contracts are sometimes indexed to exchange prices (Reinaud, 2007).

In Europe, industry has access to various electricity pricing mechanisms, depending on the country or region of operation. Not all of these purchasing methods entail the same exposure to CO<sub>2</sub> prices. Further, not all supply contracts are based on the electricity market's fundamentals such as fuel or CO<sub>2</sub> prices if the electricity market is supplied by fossil fuel generation. As mentioned above, the contracting parties may agree that the benchmark price for contracts is the final price of the product (e.g. LME) and in which case, the CO<sub>2</sub> price does not affect the electricity cost for industry.<sup>23</sup> The main categories are identified in Box 2 .

#### Box 2: Broad categories for industry's electricity purchases in Europe

Market prices set by the marginal generator or bidder In Scandinavia, hourly prices formed on the Nord Pool exchange, representing the hourly marginal cost of the marginal generation plant, are the dominant element of electricity supply contracts.

"Screen prices" with trading of blocks for baseload needs: Prices paid by industrial facilities can be set on broker or market electronic platforms (i.e., "screen pricing") through the trading of blocks (daily, monthly, trimester). Costs of intra-day adjustment are added to obtain the final supply cost. This is the common practice in the UK and in Continental Europe

Annual contracts: Electricity prices are based on the negotiation between the supplier and the consumer on an annual basis via tenders. The prices can be fixed during the period or indexed to the forward market. This is the case in Italy and also in Continental Europe.

Regulated tariffs: "regulated" tariffs may be a chosen option in some countries such as Spain and Italy

Source: Reinaud 2007

<sup>23</sup> This is one type of electricity purchasing practice in South Africa for example.

Whatever the form of electricity contract European smelters will sign, if the power costs increase while LME prices remain stable, the European aluminium sector could lose its profit margins. Indeed, changes in electricity costs are not translated into changes of the aluminium LME price.<sup>24</sup>

## 2.4 Evolution of operational margins

Has the profitability of the primary aluminium sector been hit since the EU-ETS? The competitiveness impacts of the European aluminium industry strongly depend on which aluminium price is used as a benchmark. From 2003, international aluminium price have skyrocketed, blurring partly any effect of higher power prices on European smelters' operational margins (see section 101 for LME price variations). An illustration of this is the closure of a German smelter in 2005 that reopened in 2007 in light of high LME prices.<sup>25</sup>

High LME prices have allowed European primary aluminium smelters to benefit from operational margins in the order of 49%, compared to 20% on average in 1999. These estimates are based on CRU data and LME 3 month-ahead 1998-1999 (USD 1380/t) and 2005-2006 (2 250 USD/t).<sup>26</sup> In comparison, the operational margin on a global level reached 40% in 2006 (29% in 1999), mostly driven down by China's relatively low margins (18%). Indeed, in the countries that import into Europe, these levels were above European profit margins (e.g. 54% in Russia, 53% in the Middle East, 65% in Norway and 71% in Iceland).

There are also strong disparities in Europe. In France, Italy and Spain, business operating margins were higher than the European average (67%, 63% and 61% respectively). Smelters in Germany and the Netherlands whose long term contracts may have expired reported profits margins below the EU average (20% and 31% respectively). Expiration of long-term contracts would have led to a sudden surge in power prices. Yet how much of the increase is linked to CO<sub>2</sub> price versus the interruption of long-term contracts? Further, whether or not it is the CO<sub>2</sub> in these electricity prices is what would trigger a closure is another unanswered question.

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<sup>24</sup> Nonetheless, while LME price cannot be influenced or negotiated, the regional premium is open to strategic behaviour for operators and is partly negotiable. Some portion of costs increases may be passed-on to regional premiums. Nonetheless, if European producers were to increase their regional premium price as a result of high electricity prices, the aluminium market in Europe could become more exposed to competition from non-EU countries in low electricity priced regions. Further, in 2007, there was a factor 8 difference between premiums and LME prices. So the overall pass-through capacity of a European producer is low compared to the benchmark price (LME 3 months ahead).

<sup>25</sup> It should be noted, however, that the smelter that reopened was written-down in the books (*i.e.* fully depreciated) of the previous owner (a global aluminium operator) and then sold to local investors who re-opened it on the back of high aluminium prices, a short-term electricity position (including the decline in the ETS permit price), German Government assistance to maintain employment, and almost zero capital exposure - the combination of factors providing the opportunity for strong positive cash flow for the new owners.

<sup>26</sup> These estimates are based on CRU's definition of "Business Operating Costs". They do not take into account the costs of capital. They include all costs incurred at the specific production site and additional costs associated with the transportation, sales, marketing of the commodity, interest on working capital and sustaining capital investment costs. According to CRU, they yield an estimate of free cash flow when deducted from the benchmark price.

### Preliminary conclusion:

*In this paper, one dimension of competitiveness is a sector's ability to produce at a lower cost than its competitors, while maintaining profits. Although profits levels have been sustained following the strong increase in LME prices since 2005, operational costs increased on a global level. The playing field remained approximately the same around the world, and even worked in favour of Europe as a whole, as costs increased less than the global average. Nonetheless, it costs more to produce the tonne of primary aluminium in Europe than it does in many competing countries. This is true today, but it was also the situation in 1999, prior to the introduction of a carbon cost in the EU.*

*Were the effects of the EU-ETS visible in Europe's cost increase since 1999? Focusing on the electricity price component where any effect of the EU-ETS could have been felt, estimates of electricity prices paid by smelters in Europe increased slightly more in absolute terms than the global average both in EUR and in USD over the same period (EUR 6.9/MWh for Europe compared to EUR 5.6/MWh for the world average). Further, much of the EU primary smelter capacity is still under long term electricity contracts. Those smelters whose long term contracts are reported to have expired (e.g. in the Netherlands and in Germany) suffered from a surge in power prices. Nonetheless, with or without the CO<sub>2</sub>, these smelters would have been hit with (too) high electricity prices. Whether or not the additional CO<sub>2</sub> cost in wholesale electricity prices is what would trigger a closure is unclear.*

## **3. Impact of the EU-ETS on European trade flows**

For policy-makers, the main concern behind uneven carbon constraints is the issue of carbon leakage (*i.e.* an increase in emissions outside the region as a direct result of the policy to cap emission in the EU). If carbon leakage took place, this means that the domestic climate mitigation policy is less effective in containing emission levels.

Changes in trade patterns as a result of uneven carbon constraints are the main short term indicator of this leakage. The aim of this section is to analyse European primary aluminium trade flows in light of the CO<sub>2</sub> price and test if there is evidence of a structural change in trade flows with the implementation of the EU-ETS in 2005.

### **3.1 Statistical tests and analysis on trade flows**

The data gathered for this exercise are in the form of historical time series. Quarterly data from the first quarter 1999 to the second quarter 2007 (*i.e.* from January 1999 to June 2007) was available.

We attempted to explain the net trade flows (*i.e.* imports minus exports) in Europe as a function of several variables:

- *EU 27 consumption volumes.* The expected correlation is that of a positive impact on trade flows: the higher the consumption volume in Europe, the higher level of imports.
- *Aluminium prices (LME 3 month-ahead delivery quoted in USD).* The expected effect is not clear: higher prices could reduce global consumption levels, both reducing imports and exports.



- *Price premiums for delivery in Europe (i.e. Rotterdam CIF 3 month ahead delivery).* While LME prices are a global price, for delivery into Europe, suppliers add a price premium that in this case includes the impact of freight costs. The expected correlation is that of a negative impact on trade flows: the higher the premium for imports into Europe, the lower the level of imports.
- *The US/EUR exchange rate.* The expected correlation is that of a positive impact on trade flows: the higher the US/EURO exchange rate, the higher level of imports paid in dollars and the lower the level of European exports.
- *The CO<sub>2</sub> price.* The assumption is that the CO<sub>2</sub> allowance price would be passed through to electricity prices, and the CO<sub>2</sub> price used as a reference is the year-ahead price (e.g. 2005 prices are the prices quoted for delivery in 2006). In continental Europe, if smelters are no longer under long term supply contracts, the general practice is to sign electricity contracts one year ahead (Box 2). The electricity suppliers hedge their position by buying CO<sub>2</sub> allowances on the forward market. For this reason, the fall in CO<sub>2</sub> prices end-2006 did not coincide with a fall in electricity prices in Europe. Contracts signed in 2006 used 2007 CO<sub>2</sub> prices and those signed in 2007, used 2008 prices. In 2007, the 2008 CO<sub>2</sub> price had no relation with the 2007 CO<sub>2</sub> spot price.

Two elements were tested:

1/ Can the net trade flows be explained by the variables chosen?

(See [Annex 3](#) for detailed results of the regression and explanations of the model)

2/ Was there a structural change in the trade flows following implementation of the EU-ETS? (See [Annex 3](#) for details on the model used and the caveats for the usage of this method)

## 3.2 Statistical results

### 3.2.1 Regression analysis

USD/EUR exchange rate as well as price premiums for Europe do not explain changes in trade flows (*i.e.* statistically insignificant variables).

In order of importance, the variables that explain Europe's net trade flows (*i.e.* significant variables) are: world LME aluminium prices, EU 27 primary aluminium consumption volumes, and CO<sub>2</sub> prices (starting 2Q 2004). The coefficient for LME prices and consumption volumes are positive, respectively 0.23 and 0.4. While this positive correlation makes sense for the consumption variable (*i.e.* the higher the consumption level, the higher the import rate), it is not possible to conclude regarding the LME factor.

What is surprising is the negative correlation between CO<sub>2</sub> and net imports. This invalidates our model's assumption that CO<sub>2</sub> prices should lead to higher imports.

### 3.2.2 Testing structural changes

The test determined if the net trade flows were statistically significant from the time before the EU-ETS to the period after the EU-ETS. The structural change in trade flows cannot be confirmed. There has not been a structural change in trade flows between 1999 and 2006.

#### Preliminary conclusion

*Statistical analysis of 1999-2006 data does not confirm the assumption that CO<sub>2</sub> prices, through their impact on electricity prices, affected EU primary aluminium trade flows.*

## 4. Conclusions on the impacts of the first phase of the EU-ETS

We looked ex-post at the impacts of the first phase of the EU-ETS (2005-2007), often regarded as a testing phase before the Kyoto Protocol compliance period (2008-2012), on the primary aluminium sector. While operational costs have increased, there is no statistical evidence that the EU-ETS has increased imports of primary aluminium from non-carbon constrained countries. All this said, there has been no rise in capacity in Europe. This underlines that investors associate Europe with a higher risk than greenfield investments in other regions. But this is not a new phenomenon.

The effects of the EU-ETS could be different with caps on the primary sectors' direct GHG emissions. Investors say that the costs of any future cap are already included in investment decisions, even though this possibility is only under discussion at this stage. Indeed, as indicated in the proposed revisions to the EU-ETS Directive to improve and extend the EU greenhouse gas emission allowance trading system, the EU-ETS could be extended starting January 2013 to include primary and secondary aluminium. It would cover these sectors CO<sub>2</sub> emissions and well perfluorocarbons.

Table 7 provides the key features of the proposal.

**Table 7: Summary comparison of the proposed revision of the EU-ETS and the current Directive<sup>27</sup> (see next page)**

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<sup>27</sup> "Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system"

FEATURES	DESCRIPTION/REQUIREMENTS	
	<u>Proposed Revision of the EU emissions trading directive</u> 2008/0013 (COD)	<u>EU Emissions Trading Scheme</u> Directive 2003/87EC
<b>Type of target</b>	Absolute target, e.g. X tCO <sub>2</sub> e. Overall cap reduces greenhouse gas emissions by 21% from 2005 in 2020. One allowance in the EU-ETS allows the owner to emit one tonne of CO <sub>2</sub> e.	Absolute target, e.g. X tCO <sub>2</sub> e. One allowance in the EU-ETS allows the owner to emit one tonne of CO <sub>2</sub> e; its validity is limited to a specific period.
<b>Allocation mode</b>	<p>The Comitology (committee decision) will be used to elaborate the harmonised allocation rules to apply to all installations within given sectors regardless of country. This would mean no more individual national action plans after 2012.</p> <p><i>Power generation:</i> Full auctioning should be the rule from 2013 onwards for sectors not subject to non-EU competition.</p> <p><i>Other sectors:</i> Other sectors initially receive a free allocation based on Community-wide harmonised allocation rules that are to promote carbon-efficient technologies (e.g. benchmarks). Free allocation will be phased out progressively resulting in full auctioning by 2020. However, an exception may be made for sectors that are exposed to a significant risk of carbon leakage.</p>	<p>Allocation defined by Member States through their National Allocation Plans, and approved by the Commission.</p> <p>During 2005-2007, mostly free allocation by Member states following common criteria</p> <p>Up to 5% auctioning allowed during 2005-2007</p> <p>Up to 10% auctioning allowed for 2008-2012</p>
<b>Commitment period</b>	8 years (2013-2020) and a stated intention to continue to allocate fewer allowances out to 2050	2005-2007: first trading period. 2008-2012: second trading period
<b>Sectors included</b>	<p>The EU-ETS will be extended to include: (i) additional sectors such as aviation, chemicals, petrochemicals and primary and secondary aluminium; (ii) the capture, transport and geological storage of all GHG emissions; and (iii) new plants covered by the scheme as a result of a harmonised definition of combustion installation.</p> <p>The scheme could exclude small installations of thermal output below 25MW and emissions of less than 10,000 tCO<sub>2</sub>eq in each of the preceding 3 years.</p>	CO <sub>2</sub> emissions from large combustion installations (>20MWth rated input) from all sectors (i.e. including power generation), plus emissions from oil refineries, coke ovens, iron and steel, cement, lime, glass, ceramics, and pulp and paper (coverage of these sectors is subject to certain size criteria)
<b>Coverage</b>	CO <sub>2</sub> and additional gases, such as nitrous dioxide emissions from the production of nitric, adipic and glyoxalid acid production and perfluorocarbons from the aluminium sector.	Initially CO <sub>2</sub> only. After 2008, other gases may be included, provided adequate monitoring and reporting systems are available and provided there is no damage to environmental integrity or distortion to competition.
<b>Banking</b>	The proposed Directive foresees unlimited banking of phase 2 allowances into phase 3. This means that every allowance not surrendered or retired in the second trading period can be used at face value in phase 3.	No banking from phase 1 to phase 2.

<b>New entrants</b>	5% of the total allocation will be set aside for new entrants carrying out industrial activities, to be distributed in accordance with the above mentioned harmonised allocation rules. The reserve is likely to be set EU-wide (according to the Explanatory Memorandum) or per sector.  Installations that have closed shall no longer receive any allowances.	Member States shall take into account the need to provide access to allowances for new entrants; how and how much is to be decided by each Member State.
<b>Links with Kyoto units</b>	Restrictions on credits from CDM and JI projects are foreseen, which are particularly stringent in the absence of an international post-2012 agreement: only the use of (remaining) 2008-2012 credits will be allowed from 2013 onward. Exemptions may be possible for projects in least developed countries or so-called high-quality projects through bilateral or multilateral agreements with third countries.  An increased use of credits is envisaged only once a “satisfactory international agreement” has been concluded (up to 50% of the extra effort required from ETS sectors to reach the -30% EU-wide goal).  Domestic offset projects may be allowed to issue allowances provided they comply with certain conditions necessary to safeguard the proper functioning of the EU-ETS (e.g. take place in accordance with harmonised rules, avoid double-counting and impede other policy measures to reduce emissions not covered by EU-ETS).	The council of ministers and the European Parliament agreed (April 2004) on a text for the EU “Linking Directive” that will allow entities covered by the EU-ETS to use emission units from the Kyoto Protocol’s project-based mechanisms ( <i>i.e.</i> Joint Implementation and the Clean Development Mechanism) towards meeting their emissions targets. The use of the mechanisms is to be “supplemental” to domestic action, in accordance with the relevant provisions of the Kyoto Protocol and the Marrakech Accords. The EU Directive does not include recognition of assigned amount units ( <i>i.e.</i> governments’ overall emissions allocation under the Kyoto Protocol).
<b>Links with other countries’ schemes</b>	The proposal suggests allowing for linking the EU-ETS with any country or administrative entity ( <i>i.e.</i> , state or group of states under a federal scheme, sub-federal or regional entities) which has established a cap-and-trade system provided that its design elements would not undermine the environmental integrity of the EU-ETS.	The Directive includes the possibility of linking with third Parties with Kyoto commitments and that have ratified the Kyoto Protocol, based on agreements that provide for the mutual recognition of allowances between the EU-ETS and other domestic GHG trading schemes.  NB: the linking Directive says that it may the Commission may consider linking with Parties that have yet to ratify the Kyoto Protocol.
<b>Penalties</b>	The excess emissions penalty relating to allowances issued from 1 January 2013 onwards shall increase (from the non-compliance penalty tax of €100 in the second period) in accordance with the European Index of Consumer Prices, plus restoration of the GHG emitted without having surrendered allowances.	A non-compliance penalty tax of €40 per tonne of excess CO2 emissions in the first compliance period and of €100 in the second period, plus restoration of the GHG emitted without having surrendered allowances.

*Based on European Commission, 2008/0013 (COD)*

The largest source of both direct and indirect GHG in the production of aluminium comes from the primary smelting operations (IAI). Direct emissions from smelting are: CO<sub>2</sub> emitted during the electrolysis which uses carbon anodes and two perfluorinated carbon compounds (PFCs), CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> when the process is out of balance. In Europe, direct emissions from primary aluminium production are estimated at 2.4-2.8 tCO<sub>2</sub> equivalent per ton of aluminium (Table 8). If the future EU-ETS covered the aluminium sector's total emissions, conclusions on the potential impacts on an emissions trading scheme should not be taken at this step.

Table 8: Direct emissions from primary aluminium production

	Primary		Rolling	Extrusion	Remelting
	Anode produced on site	Purchased carbon anode			
Average 2005 emissions (tCO <sub>2</sub> /t primary aluminium)	2.79	2.39	0.135	0.155	0.184

Source: EAA

If the CO<sub>2</sub> price reached approximately EUR 20/tCO<sub>2</sub> and the sector needed to pay for all its GHG emissions, in theory, the cost increase could be much higher.<sup>28</sup> Table 9 assumes all things equal to the 2006 cost structure.

Table 9: Increase in costs following the account of direct and indirect CO<sub>2</sub> costs at EUR20/tCO<sub>2</sub>

	Increase in costs (%)	
	With anode production	Without anode production
Average Europe	46%	45%

Source: Using Reinaud 2005 method and data from EAA and CRU [www.crugroup.com](http://www.crugroup.com)

This said, the final effect will depend both on the allocation method (*i.e.* free versus auctioned) and the potential for mitigation in that sector. Decoupling between aluminium production and PFC emissions has been going for many years - PFC emissions have gone down by 74% on a global level relative to a 1990.

The key question for the future competitiveness and sustainability of the European primary aluminium industry is the producers' ability to secure baseload, possibly low-CO<sub>2</sub> electricity contracts. Unless new business models develop to secure such contracts, it seems unlikely that their competitive situation will improve.

## 5. Initial thoughts on border adjustments within the context of an emissions trading scheme

As we know, the EU-ETS is embedded in the broader regime created by the Kyoto Protocol, but applies only to a subset of countries and industrial activities whose products, in some cases, face competition from countries without emission constraints. Industry has

<sup>28</sup> Note that in August 2008, prices for EU allowances were traded between EUR24-29/tCO<sub>2</sub>, depending on the vintage of the allowances.

been actively debating how much the EU-ETS would affect their competitiveness vis-à-vis the rest of the world.

In January 2008, the European Commission released a proposal for revision of its emissions trading scheme.<sup>29</sup> It is part of a broader energy and environment package to deliver ambitious GHG emission reductions in the EU. If enacted as proposed, Article 10b “Measures to support certain energy intensive industries in the event of carbon leakage” states that in the event that other developed countries and other major emitters of GHG do not participate in an international agreement, the Commission recognises that European companies could be put at a competitive disadvantage. This loss in competitiveness could result in carbon leakage, whereby reduced emissions in the EU lead to an increase in third countries”.

By June 30, 2010 the Commission will decide which energy-intensive industrial sectors are likely to be subject to carbon leakage. “The basis of the analysis will be on companies’ ability to pass-through the cost of required allowances in product prices without significant loss of market share to installations outside the EU not taking comparable action to reduce emissions.” In the case of the aluminium sector, European producers are unable to unilaterally increase prices to account for cost that they, alone, face. But in the case of other heavy-industries, the question is, how do you measure the level of pass-through? Further, as explained in Reinaud (2008), a domestic sector’s ability to pass-through additional costs that foreign competitors do not bear is dynamic as elements driving competition change with time (e.g. transport costs, production costs, production availability, product specifications, etc.).

Beyond the question of determining pass-through capabilities for a sector, for those sectors or sub-sectors where there is a risk of carbon leakage, and where electricity constitutes a high proportion of production costs, the level of free allocation “may take into account the electricity consumption in the production process”, hence compensating electricity-intensive sectors from CO<sub>2</sub>-driven electricity cost increases. Such a measure could prove difficult to implement as long-term contracts on electricity prices are confidential. It may be difficult to pinpoint the role of CO<sub>2</sub> in the electricity prices actually delivered to smelters

Mitigating measures for these industries include a continued free allocation of allowances, or some carbon equalisation system that would “seek to put EU and non-EU producers on a comparable footing”, and should be in conformity with European Community, WTO and UNFCCC principles. The carbon equalisation system would be done by “applying to importers of goods requirements similar to those applicable to installations within the EU, by requiring the surrender of allowances.”<sup>30</sup> Yet, this does not imply rebating carbon costs for exported products. Only under this condition would the CO<sub>2</sub> playing field for trade

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<sup>29</sup> “Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system”

<sup>30</sup> Concerns about the loss of industrial competitiveness and potential carbon leakage have also triggered thoughts in the US on adjustment measures in some countries where cap-and-trade schemes are proposed (See Reinaud 2008 for an overview of with legislative proposals include these provisions).

exposed sectors be levelled and the effectiveness of the carbon equalisation system (also called border adjustment for some) ensured.

Further, many technical questions remain unanswered at this stage. For example, on what products should one set the border adjustment (BA)? Ideally, the BA would cover all goods from a given emission-intensive trade exposed sector. However, as noted in Reinaud (2008), there is an inherent tension between full coverage on the one hand, and administrative feasibility on the other. Second, even if an accurate determination of the amount of carbon emitted in the production of a finished good could be made, assigning a price for emissions through a BA would have a negligible effect on its overall cost. Targeting the BA to the most emissions-intensive traded products in a sector could be one solution to addressing carbon leakage for a sector. Yet if only semi-finished emission-intensive products were covered, such a BA could worsen the competitiveness situation for the downstream industry. Moreover, how would import-related emissions be measured and verified? Would the supply of allowances for such carbon adjustment come from the EU allowance market, or from a separate pool of allowances, or other Kyoto mechanisms?

Finally, to the extent these trade measures are put forward for to restore a sector's competitiveness to its level without a carbon constraint, the extent to which they are still conducive to GHG emissions reductions world-wide will be critical. This is the subject of another Reinaud (2008) publication.

## CONCLUSION

The purpose of this paper was to explore the issue of carbon leakage for a sector with a view to elaborate a robust method of quantification of this issue. We tested this in the case of primary aluminium the EU-ETS. This report shows that the European primary aluminium on average has not suffered from carbon leakage to date. The absence of statistical evidence of a direct effect of CO<sub>2</sub> prices on aluminium trade flows is not surprising. There is a number of reasons as to why the impacts during the period under review would have been difficult to observe: the prevalence of long-term electricity contracts; a high cycle for demand of aluminium and correspondingly high LME prices, which should alleviate concomitant increases in cost, including related to CO<sub>2</sub>; high levels of imports following an increase in consumption and no additional production capacity coming on-line in Europe; and finally, aluminium smelter direct emissions were not covered by the EU-ETS in this period.

Yet even if the impacts of the EU-ETS are not yet observable, this should not be taken as definitive evidence that increased in electricity prices triggered by the EU-ETS have had no impact on aluminium smelting in Europe. Some smelters have definitely suffered from increases in electricity prices following the end of their long term contracts. What remains unclear, however, is how quickly such phenomenon will develop and lead to an additional increase in aluminium imports, from what would have happened in the absence of the EU-ETS. Indeed, the study of the impacts of the EU-ETS on competitiveness is, and will remain for long, plagued by the difficulty to establish a proper counterfactual scenario (*i.e.*, what would have happened in the absence of a CO<sub>2</sub> cost).

Growing demand in Europe has not triggered investment in local primary smelting capacity. The region is obviously less attractive for new capacity than regions that guarantee lower energy costs. The carbon constraint is, nonetheless, only one element in this European picture, as higher electricity prices prevailed before the introduction of the ETS (with the exception of China and India) (CRU cost estimates). The key question for the future competitiveness and sustainability of the European primary aluminium industry is the producers' ability to secure baseload, possibly low-CO<sub>2</sub> electricity contracts. Unless new business models develop to secure such contracts, it seems likely that their competitive situation will deteriorate.

To conclude, the assessment tools developed in this paper are important in light of mitigation measures the EU (and other governments) may exercise to limit competitiveness losses driven by climate policy in specific industries. A clear and objective assessment will be needed, identifying clearly what results from the carbon policy. Appropriate compensation will not be completed without a full view on some critical issues.



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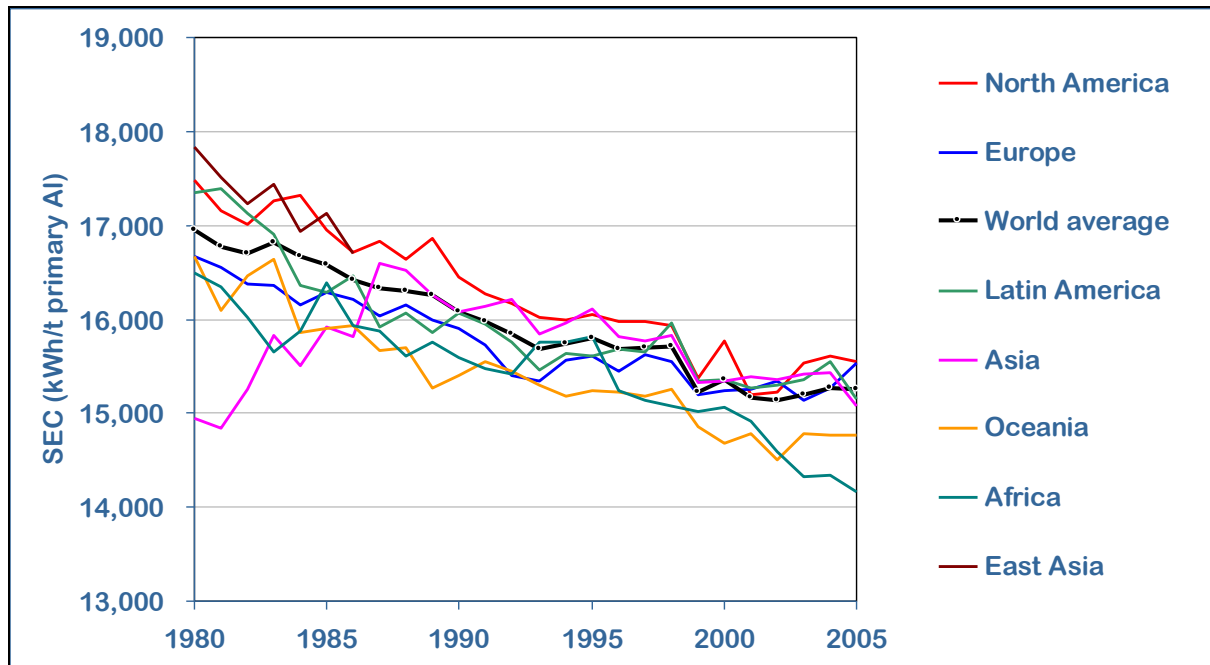
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### Annex 1: Regional specific power consumption in aluminium smelting

This figure depicts the specific power consumption for primary aluminium production for various regions.



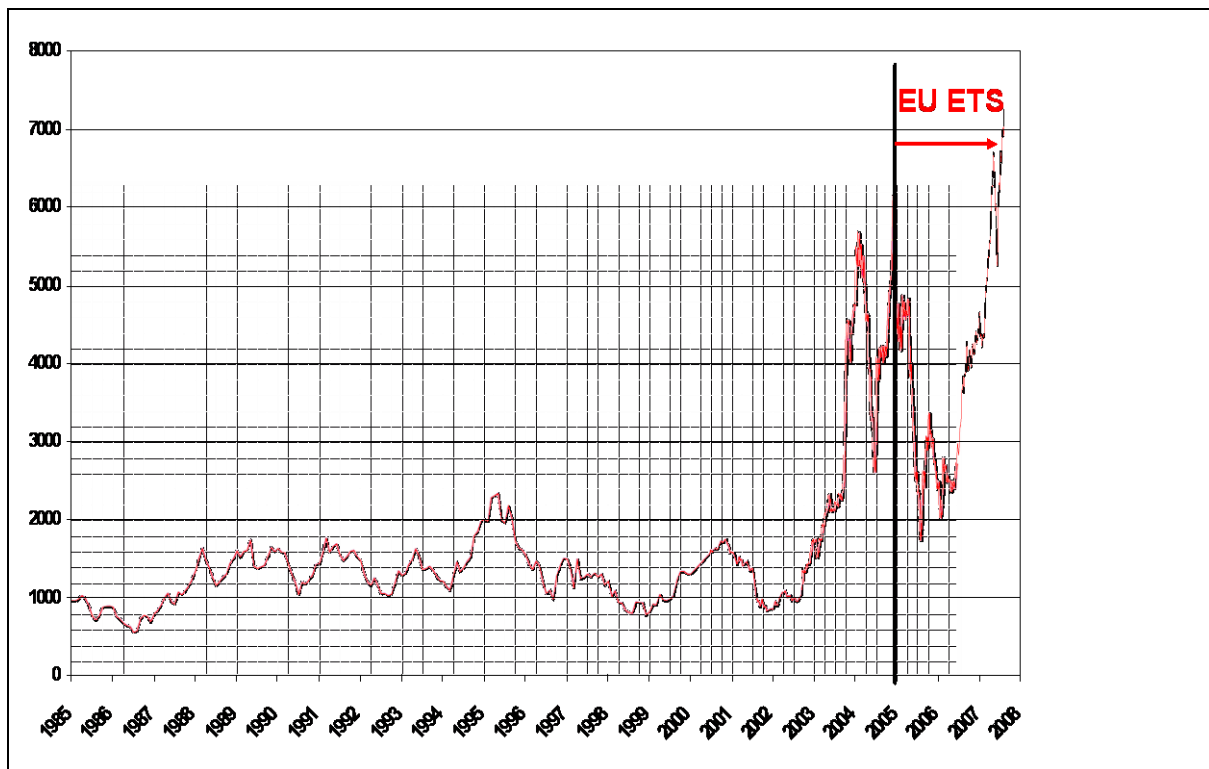
Source: IEA (2007)

## Annex 2: Evolution of freight rates

Aluminium is a heavily traded sector. Of all production, 77% is traded across borders (Baron et al, 2007). Any movement in the freight costs should also participate in determining the world price of this commodity.

This chart illustrates this recent volatility in freight rates. The Baltic Dry Index is an index covering dry bulk shipping rates and managed by the Baltic Exchange in London.

**Figure 11: Freight price index (1985 - 2007)**



Freight costs are influenced more by demand for non-energy commodities such as iron ore, grain, steel, wood and cement, than by international coal trade. Capesize freight rates had been relatively low and stable in the 1990s, at about US\$10/tonne, but have increased and become more volatile since the end of 2003 due to:

- massive demands for iron ore imports into China which caused loading and unloading port congestion and queuing of up to six weeks, reducing the availability of holds by approximately 20 percent;
- higher demand for steel, coal and iron ore as a result of increased European car production;
- upward pressure on prices from increases in harbour expenses, movements in the \$US exchange rates and oil prices;
- weather factors including very hot summers or particularly rigorous winters, which increase electricity requirements and steam coal imports, and the disruptive effects of coastal hurricanes in the USA and Australia; and
- longer transportation distances, as more supplies to the Atlantic basin are sourced from the Pacific basin, reduce the number of journeys possible from a given vessel fleet.

In recent years, a shipping capacity shortage has left charter rates for all classes of vessel at historic highs. Ship developments should increase the supply of available holds and ease freight market prices. However, the success of the Chinese government in moderating infrastructure investment and the growth of its steel production, together with the potential requirements of a growing market in India for raw material imports, remain significant uncertainties for the global freight market.

## Annex 3: Statistical tests

### 1. Regression analysis

We used a Prais-Winsten transformation as it was impossible to conclude on the autocorrelation of the residues in our time series. Prais-Winsten is an improvement to the original Cochrane-Orcutt algorithm for estimating time series regressions in the presence of autocorrelated errors. Prais uses the generalized least-squares method to estimate the parameters in a linear regression model in which the errors are serially correlated. Specifically, the errors are assumed to follow a first-order autoregressive process.

#### Results of the Prais-Winsten regression (AR1)

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nettrade <sub>fl-s</sub>	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]		
-----+							
lme3montha-d	.2311311	.0481866	4.80	0.000	.1327208	.3295413	
consumptio-s	.4070241	.1308632	3.11	0.004	.1397659	.6742824	
co21yearah-d	-.007125	.0023403	-3.04	0.005	-.0119045	-.0023456	
cons	-.3705494	.1910127	-1.94	0.062	-.7606493	.0195505	
-----+							
rho	.3008438						
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### 2. Testing structural change in trade flows

The test for structural change is an econometric test to determine whether the coefficients in a regression model are the same in separate sub samples - here, different groups of years, before and after the introduction of the EU-ETS. The breakpoint used is the period of initial quotation of CO<sub>2</sub> price (*i.e.* before and after Q2 2004).

The Chow test is most commonly used in time series analysis to test for the presence of a structural break. The test statistic follows the F distribution with  $k$  and  $N_1 + N_2 - 2k$  degrees of freedom. The results of a Chow test confirm whether or not coefficients in regression equations are statistically significant from each other. The F-statistic found (0.25) is well below a critical F-value of 2.69 ( $F_{7, 20}$ ). Therefore, the Chow test indicates that the change in the coefficients of the variables was not statistically significant at the 95% level.

Nonetheless, there are caveats to keep in mind when interpreting the result of the Chow test. The Chow test can be used if the time series' residuals are not correlated, and if they follow a Normal distribution. While the second rule was met, we tested the first rule by using the Durbin-Watson statistic, a test statistic used to detect the presence of autocorrelation in the residuals from a regression analysis. The results of the Durbin-Watson test were inconclusive.