Methodology for the free allocation of emission allowances in the EU ETS post 2012

Sector report for the aluminium industry

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Ecofys (project leader)
Fraunhofer Institute for Systems and Innovation Research
Öko-Institut

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Disclaimer and acknowledgements

Disclaimer

The views expressed in this study represent only the views of the authors and not those of the European Commission. The focus of this study is on preparing a first blueprint of an allocation methodology for free allocation of emission allowances under the EU Emission Trading Scheme for the period 2013 – 2020 for installations in the aluminium industry. The report should be read in conjunction with the report on the project approach and general issues. This sector report has been written by the Fraunhofer Institute for Systems and Innovation Research.

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1 Introduction

The aluminium industry produces aluminium via two routes. In the primary production process alumina (aluminium oxide) is produced from bauxite and further processed to aluminium via electrolysis. Secondary aluminium is refined or remelted from scrap. Further processing of aluminium includes casting, rolling and extrusion operations.

Cogeneration facilities can be found in three out of eight alumina producing installations (of which five are in operation). There are two aluminium plants with own electricity production in the UK. In addition, electricity production may also be outsourced.

In order to acquire information and data on the aluminium sector, the Fraunhofer Institute for Systems and Innovations Research (ISI) is in contact with Eurométaux and the European Aluminium Association (EAA).

In Annex I to the amended Directive on the EU ETS[1], aluminium production is divided into primary and secondary production. Further processing of aluminium such as alloy production, refining, foundry casting, etc. are considered with a common NACE code together with further processing of other non-ferrous metals. Table 1 gives an overview of the classification of these Annex I activities.

Table 1 Division of the aluminium industry according to Annex I to the amended Directive and corresponding activities in NACE Rev. 1.1 classification

Annex I category of activities	NACE code (Rev. 1.1)	Description (NACE Rev. 1.1)
Production of primary aluminium	27.42	Aluminium production
Production of secondary aluminium where combustion units with a total rated thermal input exceeding 20 MW are operated	27.42	Aluminium production
Production and processing of non-ferrous metals, including production of alloys, refining, foundry casting etc., where combustion units with a total rated thermal input (including fuels used as reducing agents) exceeding 20 MW are operated.	27.53	Casting of light metals

Information on the number of aluminium production installations included in the ETS has been provided by the European Aluminium Association[2]. An overview is given in Table 2. From the data given in Table 2 it is obvious that all primary smelters have a cast house attached.

[1] Non-ferrous metals were not specified in Annex I to the original Directive.
[2] Personal communication, EAA via e-mail, 15th of May 2009

Table 2 Overview of installations included in the EU ETS; including installations in Norway and Iceland (EAA, 2009)

Activity	Number of ETS installations	Notes
Bauxite mining	2	Not included in the ETS. Energy consumption is low.
Alumina refining	8	6 large and 2 smaller installations[1].
Anode production	18	
Primary smelting operations	31	
Primary aluminium casting	31	
Secondary remelting operations	20	More than 30 installations, out of which 20 above the 20MW limit.
Secondary refining operations	10 (6)	About 130 installations, out of which 6 above the 35 MW and 10 above the 20 MW limit[2].
Rolling operations	14	Rolling installations included in ETS mainly due to the fact that they have remelting operations on-site[3].
Extrusion operations	0	About 300 installations that are, according to current knowledge, all not included in the ETS.

[1] The two smaller installations (since last year) and one of the large installations (since February 2009) are currently shut down. It is unclear for the moment whether the two small operations will be opened again.
[2] The number of secondary refining installations within the EU ETS is small compared to the overall number of refiners. In terms of production volume (t) the fraction within EU ETS could be 40-50% according to the Organisation of European Aluminium Refiners and Remelters (OEA).
[3] Double counting of remelting and rolling installations.

Exact emissions data for the years 2005 – 2007 are not available as non-ferrous metals activities were not included in the EU ETS. An approximate estimation has however been provided by the EAA[3]. The approximate GHG emissions given in Table 3 are calculated using a weighted average of the range of direct emission factors for the European installations and shall provide a first impression of the GHG emissions for lack of the exact values that may be derived from benchmarking curves.

Table 3 Approximate GHG emissions 2007 from aluminium production in the EU27; including emissions from installations not included in the EU ETS; excluding emissions from installations in Norway and Iceland (EEA, 2009)

Activity	Production vol. EU27 (Mt)	Range of direct emissions (kg CO_2/t product)	Approx. GHG emissions (Mt CO_2-eq.)
Alumina refining	6.8	400 - 830	4.18
Pre-bake anode production	2.3	320 - 575[1]	0.84

[3] Personal communication – EAA via e-mail, 6th of July 2009

Continuation Table 3

Activity	Production vol. EU27 (Mt)	Range of direct emissions (kg CO_2/t product)	Approx. GHG emissions (Mt CO_2-eq.)
Primary smelting	3.054	1500 - 2550	5.6
(Emissions from anodes[2])			(4.8)
(PFC emissions)			(0.8)
Primary casting	3.65	70 - 200	0.40
Secondary remelting	4.9	150 - 350	0.88
Secondary refining	3.0	250 - 390[3]	0.96
Rolling operations	4.8	20 - 235	0.35
Extrusion operations	3.3	50 - 250	0.30
Total			**13.51[4]**

[1] About half of this amount is due to material consumption during prebaking (peat), the other half from fuel combustion for the provision of heat.
[2] According to EAA (2008), p. 27 in 2005 there was a net consumption of ca. 428 kg carbon-anodes/paste per t prim. aluminium
[3] The data is collected from 9 EU27 refining plants of which some are part of the ETS and some not.
[3] A cross-check with the fuel consumption of non-ferrous metals in the EU27 from NEA data (2008) shows that these should emit around 14 Mt CO_2 (excluding PFC Emissions from primary smelting and anode consumption)

Since exact data on electricity consumption are also not available, an approximate estimation has been provided by the EAA as well (see footnote 3). The approximate power consumptions given in Table 4 (see next page) are calculated using the weighted average of the range of specific electricity consumption of European installations and shall give an idea of the magnitude of electricity use. It must be underlined that the main focus of this report is on direct emissions from the aluminium chain within the EU ETS. However, as primary aluminium production is one of the large electricity consumers and hence possibly concerned by compensation mechanisms for indirect effects of the ETS via the inclusion of allowance prices into the electricity prices, the relevant data are also collected here to allow for a discussion of electricity benchmarks.

Table 4 Approximate electricity consumption 2007 from the aluminium production chain in the EU27, calculated from data on production volume and specific electricity consumption; including activities not included in the EU ETS; excluding installations in Norway and Iceland (EEA, 2009)

Activity	**Production volume (Mt)**	**Range of specific power consumption (kWh/t product)**	**Approximate power consumption (GWh)**
Alumina refining	6.8	225 - 260	1649
Pre-bake anode production	2.3	120 - 190	357
Primary smelting	3.054	14000 - 16000[1]	45352
Primary casting	3.658	50 - 200	685
Secondary remelting	4.9	120 - 340	1127
Secondary refining	2.7	?	?
Rolling operations	4.8	70 - 900	2740
Extrusion operations	3.3	300 - 1200	2475
Total			**54385** [2]

[1] AC consumption including total plant electricity consumption apart from anode baking and cast house.
[2] A cross-check with electricity consumption of non-ferrous metals in the EU27 from NEA data (2008) shows that these consumed around 78.9 TWh of electricity in 2006.

2 Production process and GHG emissions

2.1 Description of the production process

Primary aluminium production is conducted in basically two process steps, namely the production of the intermediate product aluminium oxide or alumina (Al_2O_3) in the Bayer chemical process and the following conversion to aluminium by electrolysis.

The common raw material for alumina production is bauxite, composed primarily of one or more aluminium hydroxide compounds and a variety of impurities. In refineries the aluminium oxide contained in bauxite is selectively leached from the other substances at high temperatures in autoclaves filled with an alkaline solution (Bayer Process). The solution is then filtered to remove the so-called red mud. On cooling, alumina is precipitated from the soda solution, washed and dried and then calcined at about 1100°C. The end-product, alumina, is a fine grained white powder.

The following reduction of pure alumina into aluminium is done via the Hall-Héroult process in electrolysis plants or primary smelters. In electrolytic cells alumina is reduced in a fluorinated bath of cryolite under high intensity electrical current. Carbon cathodes form the bottom of the cells while carbon anodes are held at the top. The anodes are consumed during the process when reacting with the oxygen released from the alumina input. Electricity consumption during the electrolysis step constitutes the major part of energy consumption in aluminium primary production. Molten aluminium tapped from the electrolysis cells is transported to the cast house where it may be alloyed, cleaned of oxides and gases and then cast into ingots.

Electrolysis cells differ in the types of anodes used. Most of the European installations use prebake anodes, manufactured from a mixture of petroleum coke, returned anodes and coal tar pitch and then pre-baked in separate anode plants. Few installations use Söderberg anodes instead, that are fed directly into the top part of the electrolysis cell and self-baked through the heat released during the electrolytic process. Installations using Söderberg anodes generally show higher CO_2 emissions and higher electricity consumption.

All primary aluminium smelters have a cast house attached. It has to be stressed, however, that cast houses are not only doing ingot casting. In addition, there is also a varying degree of remelting done at primary smelter cast houses which can account for up to 50% of the total hot metal production. Some cast houses also have integrated homogenisation units.

In secondary aluminium production new and old aluminium scrap[4] are converted into new ingots, deoxidiser for the steel industry or delivered as molten metal. Recycling of aluminium and its alloys can be done without any loss of quality and requires much less energy than primary aluminium production; however the presence of alloys alters the material quality.

[4] New scrap stems directly from the production processes, while old scrap comes with products at the end of their lifecycle.

Both, new and old scrap with a large variety of quality is processed by the secondary industry. Stakeholders are on the one hand remelters using primarily reverbatory furnaces for the production of new wrought aluminium alloys out of scrap of known quality and alloy and on the other hand refiners melting both old and new scrap into casting alloys in rotary furnaces as well as reverbatory furnaces and very rarely by the use of induction technology. Old scrap often needs to be collected, sorted, prepared, decoated and shredded before being fed to the secondary furnaces.

For further processing of aluminium semi-fabricates leaving the cast house one can distinguish between sheet production, foil production and extrusion. Ingots for sheet production pass through a hot rolling and a cold rolling mill. The following finishing operations include sizing, annealing according to alloy grades and final surface preparation (excluding coating and painting). Foil production can either be carried out via the classical foil production route that is similar to the sheet production described above or it can be directly produced via the strip casting process, casting the molten aluminium directly into a strip, which is then cold rolled into a foil. The extrusion process finally is applied for the production of aluminium profiles by pushing a hot cylindrical billet of aluminium through a shaped die.

2.2 Direct emissions and steam use

In the alumina production process, direct CO_2 emissions occur from both the leaching and the calcination process. In addition to that, three out of eight European alumina refineries have cogeneration facilities, the steam of which is used in the Bayer process.

During the electrolysis process CO_2 emissions occur due to the carbon anode consumption and further direct PFC emissions resulting from anode effects.

Remelting and refining of secondary aluminium lead to direct CO_2 emissions from the fuel used for the furnaces.

In the pre-baking process of anodes, about 50% of direct CO_2 emissions result from fuel used for the baking process and the other half from process emissions due to the combustion of pitch volatiles from the anode and packing coke.

The production of semi-finished and foundry products as well as the hot rolling, cold rolling and extrusion processes lead to direct CO_2 emission from the fuel used in these installations.

3 Benchmarking methodology

3.1 Background

The products of the aluminium sector are covered by the following 15 PRODCOM codes.

Table 5 PRODCOM codes of aluminium products in Annex I to the amended Directive

Product	PRODCOM Code
Unwrought non-alloy aluminium (excluding powders and flakes)	27.42.11.30
Unwrought aluminium alloys in primary form (excluding aluminium powders and flakes)	27.42.11.53
Unwrought aluminium alloys in secondary form (excluding aluminium powders and flakes)	27.42.11.55
Aluminium oxide (excluding artificial corundum)	27.42.12.00
Aluminium powders and flakes (excluding prepared powders or flakes for use as colours, paints or the like)	27.42.21.00
Aluminium bars, rods and profiles (excluding rods and profiles prepared for use in structures)	27.42.22.30
Aluminium alloy bars, rods, profiles and hollow profiles (excluding rods and profiles prepared for use in structures)	27.42.22.50
Non-alloy aluminium wire (excluding insulated electric wire and cable, twine and cordage reinforced with aluminium wire, stranded wire and cables)	27.42.23.30
Aluminium alloy wire (excluding insulated electric wire and cable, twine and cordage reinforced with aluminium wire, stranded wire and cables)	27.42.23.50
Aluminium plates, sheets and strips > 0.2 mm thick	27.42.24.30
Aluminium alloy plates, sheets and strips > 0.2 mm thick	27.42.24.50
Aluminium foil of a thickness (excluding any backing) ≤ 0.2 mm	27.42.25.00
Aluminium tubes and pipes (excluding hollow profiles, tube or pipe fittings, flexible tubing, tubes and pipes prepared for use in structures, machinery or vehicle parts, or the like)	27.42.26.30
Aluminium alloy tubes and pipes (excluding hollow profiles, tubes or pipe fittings, flexible tubing, tubes and pipes prepared for use in structures, machinery or vehicle parts, or the like)	27.42.26.50
Aluminium tube or pipe fittings (including couplings, elbows and sleeves) (excluding fittings with taps, cocks and valves, tube supports, bolts and nuts, clamps)	27.42.26.70

Alumina is a traded intermediate product and should in accordance with the principles as outlined in Chapter 4 of the report on the project approach and general issues receive a separate benchmark in order to allow allocation to installations selling this intermediate product. Since there are only a few alumina producing installations with a relatively high share of carbon emissions (see Table 2 and Table 3) and since the spread in the benchmarking curve is more than a factor 2 (Table 7), one could argue that a benchmark on alumina production based on the most carbon efficient plant (which the EAA considers an outlier) could create carbon costs that some of the installations could not afford. The EAA therefore proposes to exclude the outlier from the curve, by reason of its different process technology and differences in raw material. We are however not in favour of this suggestion, since it contradicts the principle that no benchmark corrections should be made due to different technology and raw material quality.

An alternative proposition is to divide the Bayer process into two steps, leaching and calcination. Hydrate aluminium is the output of the leaching process and also a traded intermediate product. Most of the differences in energy consumption between installations arise from the hydrate production step due to differences in raw material (gibbsite, …) and technology. The alternative benchmark approach would set a benchmark for the calcination process only, combined with a fall-back approach for hydrate production (which accounts for 60-65% of the energy consumption in alumina production) (see Chapter 5 of the report on the project approach and general issues). We do however not recommend this approach, since a large coverage of the aluminium chain mainly with a benchmark-based approach would not be feasible anymore, given the large share of emissions from alumina production in the overall emissions from the aluminium production chain. (In case that only the calcinations step in the alumina production would be benchmarked, the sector coverage with benchmarks would fall to 76 - 78%.)

Although the majority of pre-bake anode production facilities are situated onsite with primary aluminium production, there is a significant share of non-integrated plants as well and pre-baked anodes should as traded intermediate products receive their own benchmark.

Primary and secondary aluminium production routes are clearly distinguishable. Not all products can be made via both routes justifying one benchmark for primary and one for secondary aluminium. We advise that a primary aluminium benchmark should include the following casting step because all primary installations have a cast house attached and liquid molten aluminium is immediately casted into ingots after being tapped from electrolysis cells. The inclusion of primary casting in the benchmark has the advantage that it increases the number of process steps covered by the benchmark approach. It is however still to be investigated in how far the share of secondary remelting processes in the primary cast house will complicate the measurement of direct emissions from the primary casting activity[5]. Homogenisation activities carried out in the cast house should, however, be treated with a fall-back approach (see Chapter 5 of the report on the project approach and general issues).

In the electrolysis process for primary aluminium production direct CO_2 emissions occur due to the reaction between oxygen and carbon anodes and the number of anode effects resulting in PFC emissions. Direct emissions strongly vary with the kind of electrolysis cell used. There are three plants using Söderberg instead of pre-baked anodes[6] registering higher electricity consumption and higher emissions from anode burning during the electrolysis step.

[5] Benchmark curves provided by the EAA to the present do not allow for differentiation between primary casting and secondary remelting activities in the cast house.

[6] According to the *Environmental Profile Report for the European Aluminium Industry 2008* (EAA, 2008), the European anode production mix was 90% of prebake technology compared to 10% of Söderberg technology in 2005.

Nevertheless, we recommend one single benchmark for primary aluminium production according to the rule one benchmark for the same product.

One could, however, suggest to allocate to Söderberg installations the amount of allowances corresponding to the benchmarks for both primary production and anode pre-baking. The allowances for pre-bake anode production can however not be fully allocated to Söderberg installations, since Söderberg anodes are burnt by the use of electricity during electrolysis and allocations can only be made for direct emissions. Söderberg installations should therefore only receive the share of process emissions in the pre-bake anode benchmark.

Stakeholders from the secondary aluminium industry argue that secondary production of low-quality scrap is not comparable to production of high-quality scrap, since it is much more energy intensive. Environmental policy prescribes, however, that scraps of all different qualities are to be recycled and forces secondary producers to also apply more energy intensive processes. Data provided by the EAA Recycling Division presented in Table 3 show that emissions from remelting installations on the one hand and refining installations on the other hand are significantly different[7]. (Remelting is a process which basically melts fabrication scrap, e.g. cuts off pieces and casts them into solid ingot to be put back to the fabrication process. In the refining process, however, scrap needs to be 'cleaned' by using salt to remove contaminants. The higher the share of contaminants in the scrap, the more salt is to be added and the more energy requested.) EEA argues that a distinction between refiner and remelter products should here be considered given the environmental importance of recycling processes covering large fractions of wastes with different quality. This would however increase the number of benchmarks for a relatively small sector and also contradicts the principle that benchmark corrections should not be applied for raw material quality. Another issue is that the products from remelting and refining cannot be distinguished based on relevant PRODCOM codes making a clear distinction between the two difficult. Since furthermore the data on refining installations given in Table 3 are collected on a weak data basis (9 EU27 refining plants, of which some are part of the ETS and some are not)[8], we propose a single benchmark for the two processes.

Another concern of the EAA Recycling Division is about turnings, i.e. process scraps from semi or final product fabrication. If turnings are used as input to the refining furnace, additional energy is needed for their pre-treatment in form of drying, whose energy consumption should be similar to that of secondary aluminium refining itself[9]. No data has however been provided on the question in how far the energy consumption of pre-drying of tunings is higher in comparison to other pre-treatment processes of secondary raw material. In the case that pre-drying of turnings reveals not comparable to other pre-treatment of secondary raw material, we propose a fall-back approach for this preparation step (see Chapter 5 of the report on the project approach and general issues).

[7] In energy terms the difference between remelting and refining is less important due to the fact that about 15% additional energy is provided by contaminants, mainly plastics, which contribute, however, to the CO_2 emissions, see EAA (2008), p.55/56 (remelting) and p. 60/62 (refining).

[8] The EAA judges the data nevertheless representative for the whole industry. The range of energy consumption given has been confirmed by all ETS plants.

[9] Data from the Reference Document on Best Available Techniques in the non-ferrous metals industry (BREF non-ferrous-draft, 2008) show that energy consumption for drying of turnings is in the range of 3.5 – 5.2 GJ/t of turning, corresponding to 196 – 292 kg CO_2/t of turning.

Because of the variety of products from hot rolling, cold rolling and extrusion plants, having distinctly different characteristics such as product form, alloy, coating and field of application, we advise treating those products by a fall-back approach (see Chapter 5 of the report on the project approach and general issues).

3.2 Final proposal for products to be distinguished

As a result of the presented arguments, we propose to determine benchmarks for the following four products:

Table 6 Overview of the benchmark products of the aluminium sector and their corresponding PRODCOM codes

Product	**Corresponding PRODCOM codes**	**PRODCOM description**
Alumina	27.42.12.00	Aluminium oxide (excluding artificial corundum)
Pre-baked anodes[1]	?	?
Primary aluminium including casting	27.42.11.30	Unwrought non-alloy aluminium (excluding powders and flakes)
	27.42.11.53	Unwrought aluminium alloys in primary form (excluding aluminium powders and flakes)
	27.42.22.30	Aluminium bars, rods and profiles (excluding rods and profiles prepared for use in structures)
	27.42.22.50	Aluminium alloy bars, rods, profiles and hollow profiles (excluding rods and profiles prepared for use in structures)
Secondary aluminium	27.42.11.30	Unwrought non-alloy aluminium (excluding powders and flakes)
	27.42.11.55	Unwrought aluminium alloys in secondary form (excluding aluminium powders and flakes)

[1] No PRODCOM code for pre-baked anodes nor any other industry standard or classification number for the product could be found.

These four products would cover about 96% of the emissions from the aluminium sector as calculated in Table 3. We recommend treating the remaining products, i.e. products from rolling plants, extrusion plants and foil plants by a fall-back approach, as far as covered at all by the ETS (see Chapter 5 of the report on the project approach and general issues).

4 Benchmark values

4.1 Background and source of data

Emission intensity of alumina production depends amongst others on bauxite quality. Heavy oil and natural gas are used as fuel input. According to EAA (2008) (p.25) for alumina production in 2005, a larger part of the fuel used in Europe (EAA members) was natural gas. In some cases, heavy oil was used instead.

For the primary casting either fossil fuel, electricity or a varying degree of one or the other may be used, depending on the equipment installed. According to EAA (2008) (p. 29) in 2005 a larger part of the fuel used in Europe (EEA) was natural gas.

The energy consumption of secondary refiners might significantly depend on the form in which aluminium alloys are sold to foundries, i.e. in liquid form or as ingots. According to the EAA, selling liquid aluminium occurs mainly in Austria and Germany, where it makes up about 30% of the total refining production. In case of transportation in liquid form more energy is required to heat the liquid to a higher temperature enabling customer delivery within a certain distance. From an overall point of view transportation of liquid aluminium should be encouraged according to EEA, since the additional energy expenses of the melting installations are claimed to be overcompensated by the energy gain of the foundries, economising fuel costs as well as the investment in melting facilities. Secondary installations selling liquid aluminium will probably be situated at the upper end of the benchmark curve (on average 15% higher than the middle of the curve) and would therefore be penalised. As long as the allocation would be based on the 10% best installations any compensation for this difference seems, however, difficult to argue. Also the difference induced by the transport of liquid aluminium might be in the range of what is induced by other factors causing variations in the benchmarking curves. A more solid data basis covering further installations is, however, required for an in-depth discussion of this issue.

Most of the European secondary aluminium plants are fuel based (using to the larger degree natural gas), but there are also some electricity based installations. Since electricity based plants apply induction furnaces and only feed clean scrap input, their direct emissions are significantly lower than those of fuel based plants[10]. The same holds for cast houses. Benchmark curves on direct emissions could therefore be dominated by the most electricity intensive instead of the most carbon efficient installations. Two solutions are possible for this problem (see Section 6.3 in the report on the project approach and general issues).

- Establishing a primary emissions benchmark curve that takes both direct emissions as well as the indirect emissions from electricity use in the furnace into account, using a uniform emission factor for electricity. In the allocation procedure, the resulting 'primary' benchmark needs to be multiplied with the plant-specific share of direct

[10] Those plants are however only part of the ETS if they are included in a larger site, e.g. a rolling plant. Stand-alone secondary installations using induction furnaces perform below the 20 MW limit.

emissions to the total primary emissions. In order to avoid free allocation for electricity production, allocation should be limited to the level of historic direct emissions (Art. 10a (1) of the amended Directive.)

- Automatically using a fall-back option for products where this problem occurs (see Chapter 5 of the report on the project approach and general issues).

There is still a lack of data on the number of concerned electric furnaces in the secondary aluminium industry and the casting industry. We would in principle recommend the primary emissions benchmark as the preferred choice. Alternatively (e.g. if the amount of emissions from electric furnaces is marginal), electric furnaces could be excluded from the benchmark curves and be covered by a fall-back approach (see Chapter 5 of the report on the project approach and general issues). Due to lack of data a decision on this issue could not yet be taken.

The EAA has collected data on direct emissions as well as electricity consumption among its members. Benchmark curves for alumina, anode, primary and secondary production have been provided to the project team (see Figure 1 - Figure 8). In addition, the values of highest and lowest emissions are given in Table 7, together with the spread factor for the benchmarking curves of the different aluminium production steps, i.e. the factor describing the distance from the lowest to the highest emitter in the curve[11].

Table 7 Overview of the factors reflecting the spread in the benchmarking curves for different aluminium production steps[12] (EAA, 2009)

Activity	**Range of direct emissions (kg CO_2/t of product)**	**Spread factor[1]**
Alumina refining	400 - 830	2.1
Anode production	320 - 575	1.8
Primary smelting	1500 - 2550	1.7
Primary casting[2]	70 - 200	2.9
Secondary remelting[2]	150 - 350	2.3
Secondary refining[2]	250 - 390	1.6
Rolling operations	20 - 235	11.8
Extrusion operations	50 - 170	3.4

[1] Ratio between the highest and the lowest value in the curve
[2] Only direct emissions

[11] Personal communication – EAA via e-mail, 6th of July 2009
[12] Data from Norwegian and Icelandic installations are not included.

4.2 Final proposed benchmark values

The following graphs give an overview of the benchmarking curves provided by the EAA[11]. Since only the graphs have been delivered to the consortium and no information is available on the figures behind the data points, benchmark values representing the 10% most carbon efficient installations can only be read from the diagrams. It has to be emphasised, however, that the graphs must be regarded as preliminary and not eligible for the determination of final benchmark values. Installations are still reporting corrections and additions to the EAA, due to a more careful check of the data according to a clearer definition of the boundary conditions of the different process steps. Installations form Norway and Iceland were not included. The benchmark values shown in Table 8, as read from the diagrams, provide therefore only a rough estimation of the actual final benchmark values.

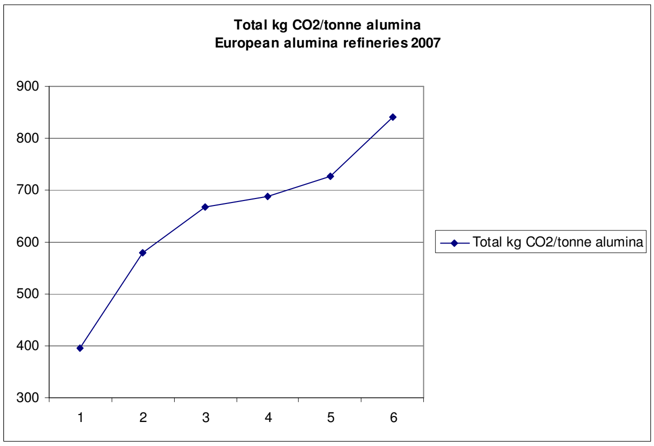

Figure 1 Preliminary benchmark curve on alumina production, 2007 (EAA, 2009)

For alumina, one installation determines the benchmark value based on the 10% most carbon efficient installations. We read from the diagram that the benchmark value is about 390 kg CO_2/t of alumina[13]. This value is in accordance with literature values on Best Available Techniques. In the Reference Document on Best Available Techniques in the non-ferrous metals industry (BREF non-ferrous-draft, 2009), a value of 392 kg CO_2/ t of alumina is given.

[13] The EAA requests treating this installation as an outlier, due to different process technology for hydrate production and differences in raw material quality.

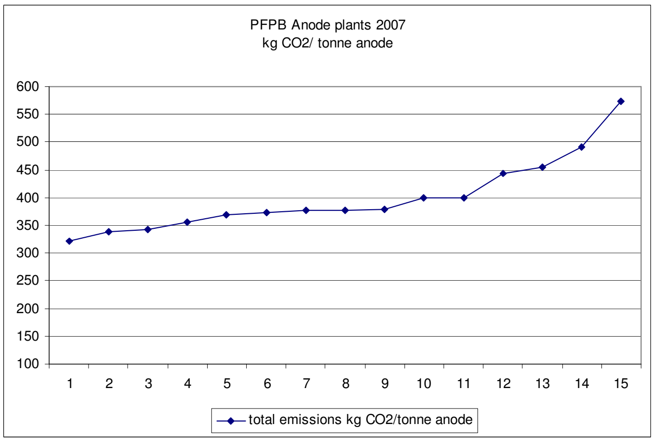

Figure 2 Preliminary benchmark curve on pre-bake anode production, 2007 (EAA, 2009)

For pre-bake anodes, two installations determine the benchmark value based on the 10% most carbon efficient installations. We read from the diagram that the benchmark value is about 330 kg CO_2/t of pre-bake anode.

We recommend including the primary casting process in the primary aluminium benchmark, since liquid molten aluminium is immediately casted into ingots after being tapped from the electrolysis cells. The EAA has provided three curves to the project team, one for primary aluminium production without casting, one curve for casting only and one curve including both processes, primary smelting and casting.

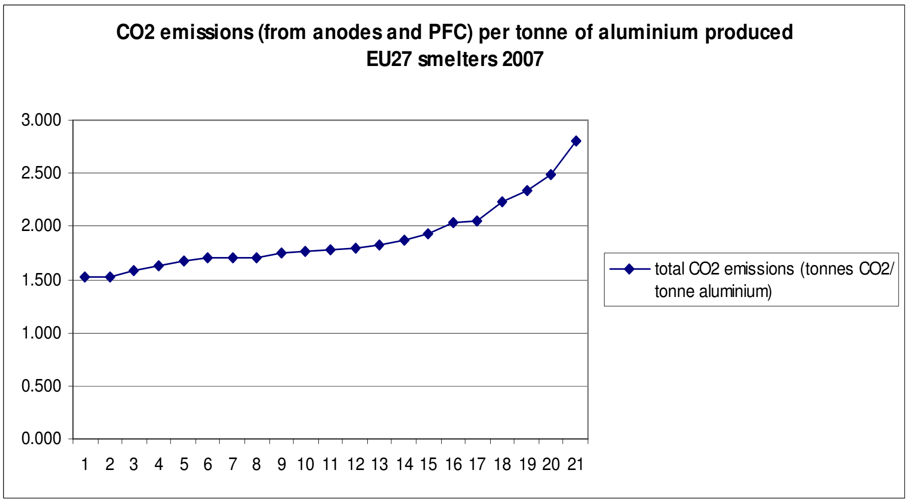

Figure 3 Preliminary benchmark curve on primary smelting without casting, 2007 (EAA,2009)

In case of a primary aluminium benchmark without casting, two installations would determine the benchmark value based on the 10 % most carbon efficient installations. We read from the diagram that the benchmark value would be about 1600 kg CO_2/t of primary aluminium.

The benchmark curve on the casting process only, which has been provided to the consortium, contains emissions from primary casting as well as from remelting activities carried out in the cast house. It is a primary benchmark curve, including both, direct and indirect emissions as recommended in section 4.1 of this report. It has to be emphasized, however, that the conversion factor that has been used for the indirect emissions is too high. The indirect emissions were included by the EAA, using a conversion factor of 0.75 kg CO_2/kWh. We insist, however, that a factor of 0.465 kg CO_2/kWh must be used in accordance with the carbon leakage analysis. The actual benchmark values will therefore be lower.

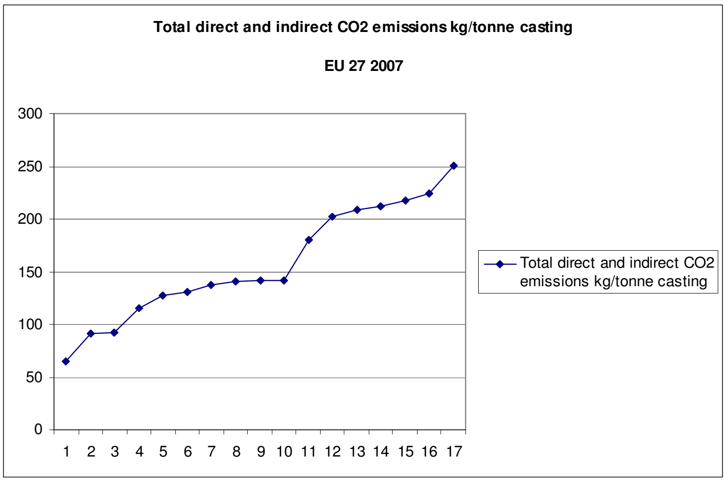

Figure 4 Preliminary benchmark curve on primary casting without remelting, including indirect emissions, 2007[14] (EAA, 2009)

For primary casting only, two installations determine the benchmark value based on the 10 % most carbon efficient installations. A benchmark value of about 80 kg CO_2/t of casted aluminium can be read. The actual benchmark value will, however, be lower, since the correct conversion factor for electricity will have to be used.

The benchmark curve on primary smelting including casting, provided by the EAA, is on direct emissions only. In addition to primary casting, remelting activities carried out in the cast house are also part the curve.

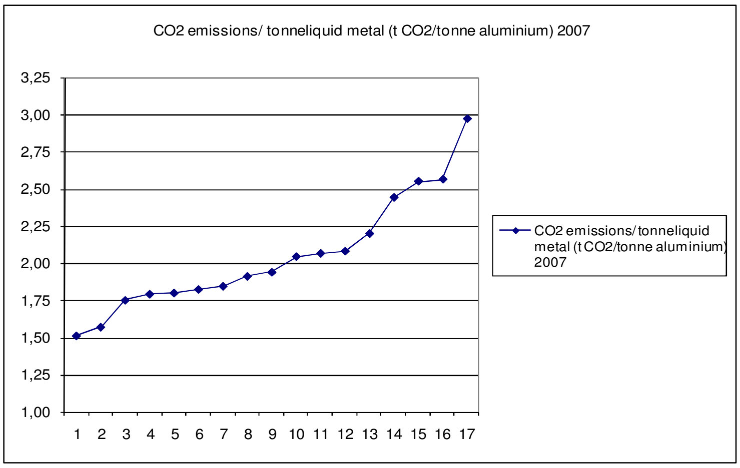

Figure 5 Preliminary benchmark curve on primary smelting including casting, 2007 (EAA, 2009)

[14] The indirect emissions were included by the EAA, using a conversion factor of 0.75 kg CO_2/kWh. We insist, however, that a factor of 0.465 kg CO_2/kWh must be used in accordance with the carbon leakage analysis.

For primary smelting including casting, two installations determine the benchmark value based on the 10 % most carbon efficient installations. We read from the diagram that the benchmark value is about 1570 kg CO_2/t of primary aluminium in casted form.[15]

The EAA has provided two benchmark curves on secondary aluminium, one for remelting and one for refining. Both curves are primary benchmark curves, including direct and indirect emissions as recommended in section 4.1 of this report. It has to be emphasized, however, that the conversion factor that has been used for the indirect emissions is too high (see footnote 14). The actual benchmark values will therefore be lower.

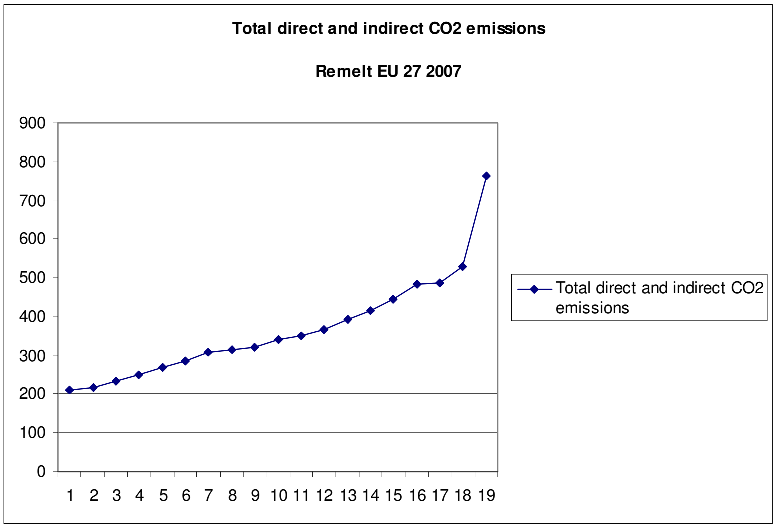

Figure 6 Preliminary benchmark curve on secondary aluminium (remelting) including indirect emissions, 2007[14] (EAA, 2009)

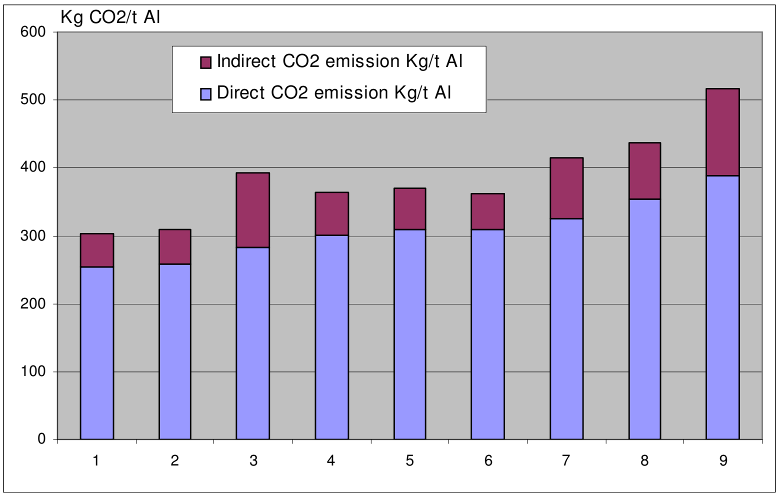

Figure 7 Preliminary benchmark curve on secondary aluminium (refining) including indirect emissions, 2007[14] (EAA, 2009)

[15] We are surprised that the lowest data point of primary smelting including casting is below the lowest data point of primary smelting without casting. The EAA comments on this that the metal flows involved are not the same for the two approaches.

It is obvious from Figure 6 and Figure 7 that the range of emission intensities of remelting and refining are of comparable magnitudes, which further supports our approach of grouping remelting and refining together in one benchmark for secondary aluminium. Three remelting installations determine the benchmark value based on the 10% most carbon efficient installations. A benchmark value of about 220 kg CO_2/t of secondary aluminium can be read. The actual benchmark value will, however, be lower, since the correct conversion factor for electricity will have to be used.

An overview of the preliminary benchmark values for the aluminium sector, read them from the benchmark curves provided by the EAA, is given in Table 8.

Table 8 Preliminary benchmark values for the aluminium sector, 2007 data (Values taken from the benchmark curves, Figure 1 - Figure 7)

Product category	Benchmark value (kg CO_2/t of product)[1]
Alumina	390
Pre-bake anodes	330
Primary aluminium without casting[2]	1600
Aluminium casting[3]	80
Primary aluminium including casting[2]	1570
Secondary aluminium[2]	220

[1] Benchmarks do not include installations from Norway and Iceland.
[2] We are surprised that the benchmark curves provided by the EAA result in a lower benchmark value for primary aluminium including casting than for primary aluminium without casting.
[3] This primary benchmark value (including direct and indirect emissions) is too high because the share of electricity was taken into account with a conversion factor of 0.75 kg CO_2/kWh instead of 0.465 kg CO_2/kWh.

In addition to the benchmark curves on direct greenhouse gas emissions in the aluminium industry, a benchmark curve on electricity consumption has been provided for the primary smelting process (electrolysis) and is presented in Figure 8.

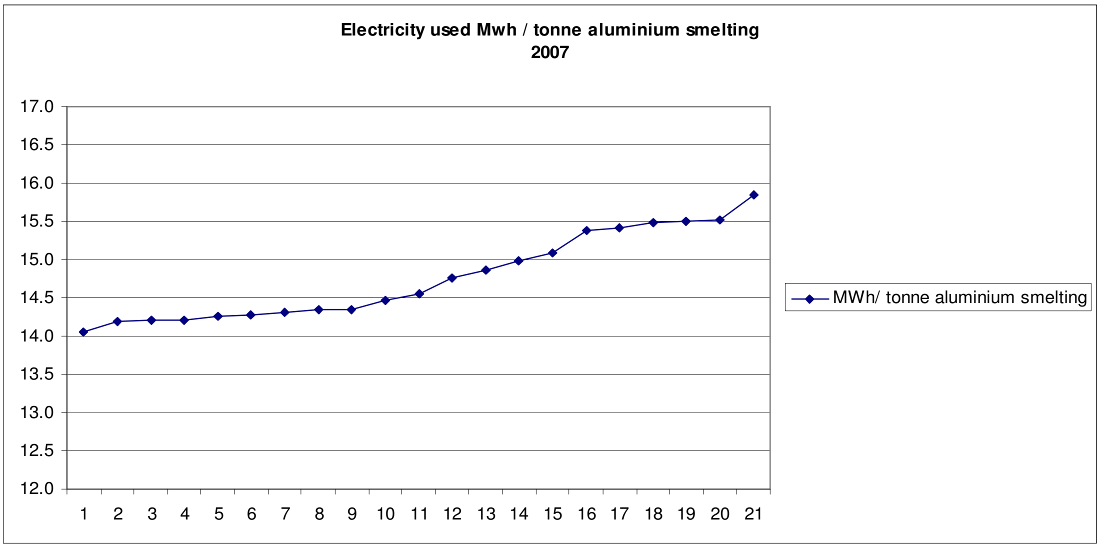

Figure 8 Preliminary electricity benchmark curve on primary smelting, 2007 (EAA, 2009)

5 Additional steps required

Several open issues have been mentioned in the sections 3.1, 4.1 and 4.2, on which a more solid data basis is required to allow for further decisions. Particularly for the secondary aluminium refiners the data basis is still very weak.

1. An exact product definition for pre-baked anodes is still missing. Since pre-bake anodes are not listed in the PRODCOM classification, other internal industry standard or classification will be required.

2. For further work on the determination of final benchmark values based on the average of the 10% most carbon efficient installations, benchmark curves based on a reliable data collection and including installations from Norway and Iceland are required. It is essential that system boundaries will be made clear to all installations participating in the data collection, in order ensure high quality of the data provided.

3. Indirect emissions included in the benchmark curves for secondary aluminium production and casting must be calculated with a conversion factor of 0.465 kg CO_2/kWh, which is the factor used in the carbon leakage analysis.

4. It is still not clear for cast houses whether emissions from primary smelting and emissions from secondary remelting activities can be separated in the data collection. This would be essential in order to allow for the inclusion of primary casting in the primary aluminium benchmark.

5. Data on the number of electric furnaces as well as the shares of electricity versus fossil fuel used for secondary aluminium production and casting is necessary to allow for a decision on the treatment of electric furnaces in these activities. A decision, if either a primary emissions benchmark or a fall-back option (see Chapter 5 of the report on the project approach and general issues) for electric furnaces shall be applied, can only then be taken.

6 Stakeholder comments

Comments on the interim report have been made by the EAA on the following issues[16].

Alumina plants:
It is difficult to come up with one benchmark for the alumina plants due to the small number of plants and the large spread between the plants. The situation is that the lowest emitting plant uses a completely different process technology for hydrate production from the other plants and this can not be adopted by the other plants without a complete demolition and rebuilding of most of the plant. There are also some differences due to different raw materials, since alumina plants are to a large extent built to process a certain type of raw material. The emissions of the lowest plant are around 400 kg CO_2/t alumina. The average for all plants is 685 kg CO_2 t. If all the other plants get an allocation according to the benchmark set by the lowest emitter, this is a total cost of 56 millions of € for the other plants, using a CO_2 cost of 30€. This would put all these plants out of business, so it is necessary to find an alternative approach. The alternative approach would be: Consider the lowest emitter as an outlier (different technology) and set a benchmark based on the remaining plants.

Söderberg vs. prebake:
In order to establish a benchmark for primary aluminium electrolysis, the EAA considers it necessary to compare:

- Prebake: Anode baking + electrolysis emissions
- Söderberg: electrolysis emissions

For the allocation of free allowances, in the case of prebaked, they are distributed to the anode baking plants and electrolysis installations according to benchmark. In the case of Söderberg they are distributed to the electrolysis installations according to the anode + prebake electrolysis benchmarks.

Primary smelter cast houses:
The consortium proposes to include the primary smelter cast house in the total primary smelter benchmark. EAA has a problem with the inclusion of the casting step in the primary aluminium benchmark for the following reasons:
1. How to get credit for recycling activities. Primary smelter cast houses often remelt considerable quantities of clean scrap, up to 50% of the hot metal production, which increases energy consumption compared to smelters, not doing any remelting. In order to avoid disincentives for metal remelting, this activity has to be included in the benchmark.
2. How to consider electrical vs. fossil fuel fired furnaces. There can be use of either form of energy in a cast house depending on the furnaces and other equipment.
3. In addition some smelters have homogenisation units for finishing purposes, usually using about 200 kWh/t electricity or equivalent fuel consumption. This can also be the case for remelting plants.

[16] Personal communication – EAA via e-mail, 17th of August 2009

Due to this the EAA proposes a separate benchmark for primary smelter cast houses, where there is a basic cast house benchmark, an addition for the remelting based on the quantity remelted and the remelting benchmark and an addition for any homogenisation unit. The proposed benchmark would look as follows:

Benchmark = CMP * A + RMP * B + HMP * C

Where
CMP = Cast metal production
RMP = Remelt metal production
HMP = Homogenisation metal production
A = Basic cast house benchmark
B = Remelt benchmark
C = Homogenisation benchmark

Use of fossil fuel or electricity:
In some of the installations like primary smelter cast houses, remelting plants, rolling mill and extrusion plants there may be used either electricity or fossil fuel for the same functions, depending on the equipment installed, or varying degree of one or the other. This means that one or the other form of energy is used, not that it is possible to switch between the two. This presents a problem for the benchmarking as the plant with some electricity and some fossil fuel would have lower direct emissions than the other comparable plants. The solution could be as already indicated to construct a new benchmarking curve, where the indirect emissions are added to the direct emissions with a specific factor for CO_2 /kWh. In the benchmarking curves for primary smelter cast house and remelting, we have included such curves in the graphs enclosed with this note, using a factor of 0.75 kg CO_2 / kWh.

Remelting plants:
As proposed for plants with either fossil fuel or electricity or a combination of these a benchmarking curve which includes both needs to be developed in order to determine a realistic benchmark. In addition, an extra allocation needs to be added for homogenisation for plants which have this installed.

7 References

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EAA (2009b) EAA *comments to zero-order draft report,* 17th of August 2009

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