Aluminium Carbon Footprint

Technical Support Document

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This guidance is prepared by International Aluminium Institute on behalf of its member companies.

Contents

1 Introduction

This guidance addresses the single environmental impact category of climate change. It specifies the principles, requirements and guidelines for quantifying and communicating greenhouse gas (GHG) emissions from primary aluminium production processes. It enables aluminium producers to assess and communicate full or partial carbon footprints of their products by following a simplified approach, as compared to ISO standards.

2 Normative references

ISO 14044:2006, Environmental management -- Life cycle assessment -- Requirements and guidelines

http://www.iso.org/iso/catalogue_detail?csnumber=38498

ISO 14064-1:2006, Greenhouse gases -- Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals

http://www.iso.org/iso/catalogue_detail?csnumber=38381

ISO/NP 19694-4, Stationary source emissions -- Determination of greenhouse gas (GHG) emissions in energy-intensive industries -- Part 4: Aluminium industry

https://www.iso.org/standard/73182.html

ISO/TS 14067: 2013, Greenhouse gases -- Carbon footprint of products -- Requirements and guidelines for quantification and communication

https://www.iso.org/standard/59521.html

Global Advisory Group (GAG) Guidance Document 001: Terms and Definitions (3rd Edition – 2011-01)

http://www.aluminum.org/sites/default/files/GAG_001_Terms_and_Definitions_3rd_Edition_2011_01_August_21_2011_JW.pdf

Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard (2011)

http://www.wri.org/publication/greenhouse-gas-protocol-product-life-cycle-accounting-and-reporting-standard

Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (2013)

http://www.ghgprotocol.org/standards/scope-3-standard

Greenhouse Gas Protocol Technical Guidance for Calculation Scope 3 Emissions (2013)

http://ghgprotocol.org/feature/scope-3-calculation-guidance

Greenhouse Gas Protocol Calculation tools:

The Aluminium Sector Greenhouse Gas Protocol (2006)

- Guidance: www.ghgprotocol.org/sites/default/files/ghgp/aluminium_1.pdf
- Worksheet: http://www.ghgprotocol.org/sites/default/files/ghgp/Aluminium%20Sector%20GHG%20Workbook%20-%20version%202_1_0.xls

GHG Emissions from Stationary Combustion (2005)

- Guidance: http://www.ghgprotocol.org/sites/default/files/ghgp/Stationary_Combustion_Guidance_final_1.pdf
- Worksheet: http://www.ghgprotocol.org/sites/default/files/ghgp/Stationary_combustion_tool_%28Version4-1%29.xlsx

GHG Emissions from Purchased Electricity (2015)

- Worksheet: http://www.ghgprotocol.org/sites/default/files/ghgp/Purchased_Electricity_Tool_Version-4_8_0.xlsx

GHG Emissions from Transport or Mobile Sources (2015)

- Worksheet: http://ghgprotocol.org/sites/default/files/ghgp/Transport_Tool_v2_6.xlsx

3 Terms and definitions

Aluminium related terms and definitions follow “Global Advisory Group (GAG)– GAG Guidance Document 001 - Terms and Definitions (3rd Edition – 2011-01)” and “ISO/NP 19694-4, Stationary source emissions -- Determination of greenhouse gas (GHG) emissions in energy-intensive industries -- Part 4: Aluminium industry (3. Terms & Definitions)”.

4 Methodology for carbon footprint qualification

4.1 Goal and scope

The goal of this guidance is to calculate the potential contribution to global warming of the production of one (1) tonne of cast primary aluminium metal from aluminium containing ore(s). Its climate change impact, expressed as carbon dioxide equivalents (CO_2e), is the summation of all significant GHG emissions and removals over the product's partial life cycle.

A cradle-to-gate system of primary (or electrolytic) aluminium production is shown in Annex B. It includes bauxite mining, alumina production, carbon anode production, aluminium electrolysis, ingot casting, raw materials transport, electricity generation, and aluminium dross processing. It also includes the production of ancillary materials and fuels required for primary aluminium production.

4.2 Sources of GHG

The greenhouse gas predominantly emitted in the production of primary aluminium is carbon dioxide (CO_2), although other, high global warming potential (GWP) gases are also – or have the potential to be – released. These emissions can be categorised as:

- Direct emissions from electrolysis (CO_2, CF_4 and C_2F_6) and fuel combustion (CO_2, CH_4 and N_2O) unit processes.
- Emissions (CO_2, CH_4 and N_2O) from the production of electricity, including fuel combustion, consumed by unit processes.
    - Emissions associated with electricity production for activities not related to aluminium production shall be excluded.
- Non-electricity generation related indirect emissions, such as transport-related activities and waste disposal, as well as cradle-to-gate emissions associated with fuels destined for combustion in electricity generation.

4.3 Life cycle impact assessment

The latest value of 100-year global warming potential (GWP) from the Intergovernmental Panel on Climate Change (IPCC) should be used. At time of writing, GWPs published in the Fifth Assessment Report (IPCC, 2014) are the most recent.

When comparing data across different years, GWPs must be consistent. When comparing current data with inventory calculations and reports that use GWPs from previous IPCC Assessment Reports, these should be recalculated using latest GWPs.

4.3.1 Calculation of direct emissions from unit processes and fuel combustion

Required data from the following unit processes is summarised in Annex A.

4.3.1.1 Bauxite mining

Most of the emissions from this unit process are from the combustion of fossil fuels, and the calculation follows the GHG Protocol calculation tool “GHG Emissions from Stationary Combustion (2005)”.

4.3.1.2 Alumina refining

Most of the emissions associated with alumina refining are from the combustion of fossil fuels, and the calculation follows the GHG Protocol calculation tool “GHG Emissions from Stationary Combustion (2005)”.

4.3.1.3 Aluminium electrolysis

Calculation of emissions from the electrolysis process is according to the following sections of “The Aluminium Sector Greenhouse Gas Protocol (2006)”:

1.3 calculation of carbon dioxide emissions from prebake processes

1.4 calculation of carbon dioxide emissions from Søderberg processes

2 calculating perfluorocarbon emissions

4.3.1.4 Anode production

Calculation follows “The Aluminium Sector Greenhouse Gas Protocol (2006)":

1.3.2 Baking furnace carbon dioxide emissions

4.3.1.5 Aluminium ingot casting

Calculation of CO_2e emissions from fuels used in the cast-house follows the calculation tool “GHG Emissions from Stationary Combustion (2005)”.

4.3.2 Calculation of emissions from electricity & heat production

4.3.2.1 Purchased electricity & heat

The operator shall obtain the relevant physical[1] emission factor for purchased electricity and heat from the supplier. If the operator has a contract with a supplier with a defined power generation facility, the emissions factor for the contractual amount of power from the specific generation facility, and the energy mix and emissions factor for the residual purchased power shall be calculated separately, with a principle of transparency and avoidance of double counting. If relevant data are not available from the supplier, the operator shall use factors from recognized national sources for the national power grid or for the regional part of the grid. In the absence of other sources, the operator may use the latest emission factors for the country published by the International Energy Agency (IEA): http://www.iea.org/statistics/topics/co2emissions/.

A record shall be maintained of the reference factors and their source in the supporting evidence.

The GHG Protocol also provides a calculation tool, "GHG Emissions from Purchased Electricity (2015)", which offers country-level emission factors from the IEA for years up to 2012.

4.3.2.2 Self-generated electricity & heat

Self-generators of electricity & heat are expected to disclose emission factors for their direct emissions.

The following table of fuel combustion CO_2 emissions (IEA, 2017) is an example of data expected to be communicated at disclosure.

[1] Exclude the use of virtual green certificates/guarantees of origin as a basis for calculating emission factors

Implied carbon emission factors from electricity generation (CO_2 / kWh) for selected products

Average implied carbon emission factors from electricity generation by product are presented below, for selected products. Those values are given as a complement of the CO_2 emissions per kWh from electricity generation by country presented in the Summary tables. The values below represent the average amount of CO_2 per kWh of electricity produced in OECD member countries between 2011 and 2015. As they are very sensitive to the quality of underlying data, including net calorific values, and of reported input/output efficiencies, they should be taken as indicative; actual values may vary considerably.

Product	gCO_2 / kWh
Anthracite*	860
Coking coal*	845
Other bituminous coal	870
Sub-bituminous coal	940
Lignite	1020
Gas works gas*	330
Coke oven gas*	390
Blast furnace gas*	2430
Other recovered gases*	1585
Oil shale*	1195
Peat*	765
Natural gas	400
Crude oil*	600
Refinery gas*	460
Liquefied petroleum gases*	540
Kerosene*	655
Gas/diesel oil*	700
Fuel oil	675
Petroleum coke*	940
Municipal waste (non-renew.)*	1195

* The electricity output from these products represents less than 1% of electricity output in the average of OECD member countries for the years 2011-2015. Values will be less reliable and should be used with caution.

(IEA, 2017)

4.3.3 Calculation of other emissions

A number of guidance documents are available to assist with collection and calculation of emissions under this category, which is mainly non-electricity related indirect emissions for the aluminium industry.

“The Aluminium Sector Greenhouse Gas Protocol (2006)" includes a section (1.6) on ‘Additional Sources of Process Carbon Dioxide’.

The Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (2013) offers an internationally accepted method to enable GHG management of companies’ value chains. It allows user to address the emissions outside of one’s organisational walls -- from the goods it purchases to the disposal of the products it sells.

The “Greenhouse Gas Protocol Technical Guidance for Calculation Scope 3 Emissions (2013)” serves as a companion to the aforementioned GHG Protocol Scope 3 Standard to offer companies practical guidance on calculating their scope 3 emissions. It provides information not contained in the Scope 3 Standard, such as methods for calculating GHG emissions for each of the fifteen Scope 3 categories, data sources, and worked examples. Calculation methods are summarised in Appendix D of this Technical Guidance.

The Greenhouse Gas Protocol also provides the calculation tool “GHG Emissions from Transport or Mobile Sources (2015)”. These sources are indirect emissions and are considered Scope 3 for reporting purposes.

In order to simplify data collection and calculation for aluminium producers, instead of following “Greenhouse Gas Protocol Technical Guidance for Calculation Scope 3 Emissions (2013)”, the International Aluminium Institute (IAI) suggests including indirect GHG emissions from the following sources:

- Bauxite transport;
- Alumina transport;
- Production of calcined lime;
- Production of sodium hydroxide;
- Production of cathode carbon;
- Production of aluminium fluoride;
- Production of coke;
- Production of pitch.

This simplified solution is based on an impact analysis of historical aluminium industry cradle-to-gate life cycle inventory data. The chart in Annex B locates each of the above processes, which cover over 90% of non-electricity generation related indirect emissions in the aluminium production chain.

4.4 Modelling parameters and assumptions, allocation issues

4.4.1 General

Inputs and outputs shall be allocated to different products according to a clearly stated and justified allocation procedure.

The sum of allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation.

Whenever several alternative allocation procedures seem applicable, a sensitivity analysis shall be conducted to illustrate the consequences of the departure from the selected approach.

4.4.2 Allocation procedure

4.4.2.1 Ingot casting

It is assumed that the cast-house of a smelter only transforms liquid metal from the electrolytic process and run-around scrap from the sawing of ingots into different forms of primary aluminium cast products.

All cast-houses are requested to report additional solid metal inputs, i.e. remelt ingots, scrap (excluding cast-house run-around scrap) and alloy additives. If a cast-house reports additional solid metal input, the furnace operation is considered as a joint process consisting of

- *process A*: transformation of liquid primary aluminium and run-around scrap into ingots
- *process B*: transformation of purchased solid scrap and alloying ingots into ingots

It is proposed to apply mass allocation, which means that the data of the cast-house should be reduced by the data for the remelting of x tonnes of additional solid aluminium scrap and alloying elements, as reported by data providers (if not directly available). It is assumed that the run-around scrap helps to cool down the liquid primary aluminium coming from the smelter, whereas additional purchased solid metal needs additional energy and creates additional emissions and dross.

4.4.2.2 Alumina production

An allocation issue occurs for alumina refineries which sell both calcined metallurgical alumina to aluminium smelters and non-calcined hydrate, as co-products, to other users. It is proposed to solve this allocation issue as follows:

1. The refinery shall report the mass P_1 of annually produced calcined metallurgical alumina and the mass P_2 of the annually produced non-calcined hydrate as separate figures
2. The refinery shall report the GHG emissions E_c of the calcination and the GHG emissions E_r of all the other operations in the refinery as separate figures

3. The mass $P_{1.0}$ of metallurgical alumina before calcination shall be determined by using the relevant stoichiometric formulas
4. Allocation by mass is applied to the GHG emissions E_r of all the other operations in the refinery according to the ratio of the mass $P_{1.0}$ of metallurgical alumina before calcination and the mass P_2 of the annually produced non-calcined hydrate.

4.4.2.3 Reuse and recycling

The allocation principles and procedures in 4.4.1 and 4.4.2 also apply to reuse and recycling situations.

Changes in the inherent properties of materials shall be considered. In addition, particularly for the recovery processes between the original and subsequent product system, the system boundary shall be identified and explained, ensuring that the allocation principles are observed.

However, in these situations, additional elaboration is needed for the following reasons:

— reuse and recycling (as well as composting, energy recovery and other processes that can be assimilated to reuse/recycling) may imply that the inputs and outputs associated with unit processes for extraction and processing of raw materials or final disposal of products are to be shared by more than one product system;
— reuse and recycling may change the inherent properties of materials in subsequent use.

Specific care should be taken when defining system boundary with regards to recovery processes.

4.5 Level of disclosure

Three levels of disclosure of carbon footprints are proposed to reduce the workload of data collection and calculation, while maintaining consistency and transparency:

- Level 1: Emissions from aluminium electrolysis, aluminium ingot casting, anode/paste production, as well as emissions from electricity generation & heat production associate with these processes.
- Level 2: In addition to Level 1 emissions, direct emissions from bauxite mining and alumina refining, plus emissions from electricity & heat production and fuel combustion at these two production unit processes.
- Level 3: A complete cradle-to-gate carbon footprint of aluminium ingot. This includes all GHG emissions from bauxite mining, alumina production, carbon anode production, aluminium electrolysis and ingot casting processes, raw materials transport, electricity & heat generation, and aluminium dross processing. It also includes the production of ancillary materials and fuels required for primary aluminium production.

Preference should be given to site-specific data from suppliers. If such data is not available, regional averages from the IAI's 2015 life cycle inventory dataset should be used.

A schematic of included process emissions by level of disclosure is included as Annex C.

4.6 Communication of carbon footprint result

Section 6.6 of "ISO/TS 14067: 2013" and chapter 11 of the "Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard (2011)" are the general guidelines.

At the communication stage, along with the carbon footprint result, the following information should be provided:

1) Extra inventory elements, if there is divergence from the data collection requirements outlined in Annex A.
2) The percentage of climate change impact that is derived from secondary data, if any.

Primary data are defined as quantified values of a process or an activity obtained from a direct measurement or a calculation based on direct measurements. Data from databases or other sources which fulfil the criteria of primary data are also primary data. Secondary data are defined as data from sources other than primary data.

Table 1 summarises the components, as well as required data quality when calculating a carbon footprint by following the approach articulated in this guidance.

Category	Required Data	Note
4.3.1 Direct emissions	Primary	a) Unit processes to be included in calculation are listed in Annex B; b) Data sources must be specified at communication.
4.3.2 Emissions from electricity & heat production	Primary or secondary	
4.3.3 Other emissions	Primary or secondary	

4.7 Bibliography

IAI (2017). 2015 Life Cycle Inventory Data and Environmental Metrics.

http://www.world-aluminium.org/publications/tagged/life%20cycle/

IEA (2017). CO_2 Emissions from Fuel Combustion: Highlights.

https://www.iea.org/publications/freepublications/publication/CO2EmissionsfromFuelCombustionHighlights2017.pdf

IPCC (2014). Fifth Assessment Report: Climate Change 2014.

https://www.ipcc.ch/report/ar5/

IPCC (2006). Guidelines for National Greenhouse Gas Inventories.

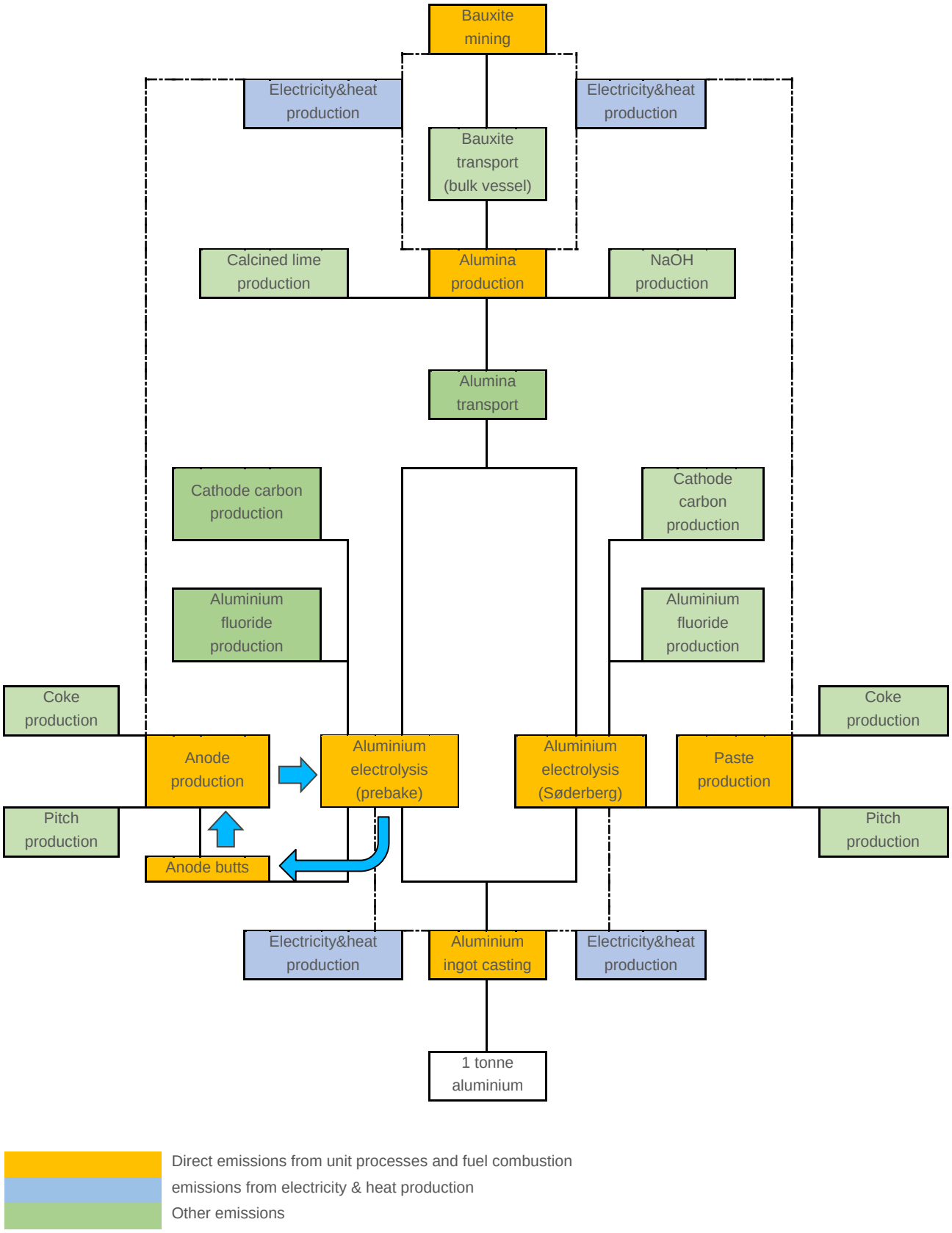
https://www.ipcc-nggip.iges.or.jp/public/2006gl/

Annex A: Data collection items (required items are marked with "Y")

INPUTS							OUTPUTS						
Process	**Bauxite Mining**	**Alumina Production**	**Anode Production**	**Electrolysis**	**Cast-house**	**Units**	**Process**	**Bauxite Mining**	**Alumina Production**	**Anode Production**	**Electrolysis**	**Cast-house**	**Units**
Raw materials							**Air emissions**						
							Gaseous Fluoride (as F)						kg
Bauxite		Y				kg	Particulate Fluoride (as F)						kg
Caustic Soda		Y				kg	Particulates						kg
Calcined Lime		Y				kg	NOx (as N_2O)		Y	Y	Y	Y	kg
Alumina input				Y		*kg*	SO_2						kg
							Total PAH						kg
Petrol Coke			Y			kg	BaP (Benzo-a-Pyrene)						g
Pitch			Y			kg	CF_4				Y		kg
Anode				Y		*kg*	C_2F_6				Y		kg
							HCl (Hydrogen chloride)						kg
Aluminium fluoride				Y		kg	Mercury						g
Cathode carbon				Y		kg							
Aluminium (liquid						*kg*	**Water emissions**						
							Fresh Water discharge						m^3
Alloy additives						kg	Sea Water discharge						m^3
Chlorine						kg	Fluorides (as F)						kg
Cast ingot						*kg*	PAH (6 Borneff components)						g
							Oil and grease/hydrocarbons						kg
Other raw material							Suspended Solids						kg

INPUTS							OUTPUTS						
Process	**Bauxite Mining**	**Alumina Production**	**Anode Production**	**Electrolysis**	**Cast-house**	**Units**	**Process**	**Bauxite Mining**	**Alumina Production**	**Anode Production**	**Electrolysis**	**Cast-house**	**Units**
Fresh Water input						m^3	Mercury						g
Sea Water input						m^3	**By-products for external recycling**						
Refractory material						kg	Bauxite Residue						kg
Steel						kg	Dross						kg
							Filter dust						kg
Fuels and electricity							Refractory material (excluding SPL)						kg
Coal	Y	Y	Y		Y	kg	SPL – carbon						kg
Diesel Oil	Y	Y	Y		Y	kg	SPL – refractory						kg
Heavy Oil	Y	Y	Y		Y	kg	Steel						kg
Natural Gas	Y	Y	Y		Y	m^3	Other by-products						kg
Electricity	Y	Y	Y	Y	Y	kWh							
							Solid waste						
Transport							Bauxite residue						kg
Sea transport		Y		Y		km	Alumina waste						kg
Road transport		Y		Y		km	Carbon waste			Y	Y		kg
Rail transport		Y		Y		km	Dross - landfill						kg
							Filter dust - landfill						kg
							Refractory (excl. SPL) - landfill						kg
							SPL - landfill						kg
							Scrubber sludges						kg
							Other solid waste						kg
							Total SPL output						kg

Annex B: Life cycle flow chart (Cradle to Gate)



Annex C: Level of disclosure