ENVIRONMENTAL METRICS REPORT

YEAR 2010 DATA

FINAL v1.1

NOVEMBER 2014

Amendments in v1.1

- Expansion of Goal and Scope chapters
- Addition of Process Flow Diagram
- Inclusion of reviewer's comments

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Contents

1 Introduction

This report, an adjunct to the 2013 publication “Global Life Cycle Inventory Data for the Primary Aluminium Industry”, delivers Life Cycle Impact Assessment (LCIA) results for the worldwide aluminium industry, using 2010 data.

The LCIA phase of a Life Cycle Assessment (LCA) is the evaluation of potential environmental and human impacts of environmental resource uses and releases by an industrial process or processes, identified during the Life Cycle Inventory.

Key Steps of an LCIA:

1. Selection and definition of relevant environmental (or health) impact categories - e.g. global warming, acidification, terrestrial toxicity.
2. Classification of LCI results according to selected impact categories (e.g. classifying tetrafluoromethane, methane and carbon dioxide emissions as having global warming potential).
3. Characterization of LCI results within impact categories by multiplying them with science-based factors and adding them up to category indicator results.
4. Normalization: the calculation of the magnitude of the category indicator results relative to some reference information, e. g. category indicator results of other materials.
5. Grouping: sorting and ranking of the impact categories.
6. Weighting: converting and possibly aggregating indicator results across impact categories using numerical factors based on value-choices; data prior to weighting should remain available. Weighting is not permitted for studies containing comparative assertions intended to be published.
7. Data quality analysis: better understanding the reliability of the collection of indicator results, the LCIA profile.

The ISO 14040 series states that the first three steps – impact category selection, classification, and characterization – are mandatory steps for an LCIA. The remaining steps are optional, depending on the goal and scope of the study.

In line with the ISO standard and the goal and scope, this report addresses impact category selection, classification, and characterization only.

1.1 Goal of the study

The purpose of the 2013 publication *Global Life Cycle Inventory Data for the Primary Aluminium Industry* was to characterize accurately and at the global level resource inputs and significant environmental releases directly associated with the production of primary aluminium, for the reference year 2010.

The objective of the current report is to evaluate the significance of potential environmental impacts based on the LCI flow results, against a defined set of impact categories, which can be tracked over time. The system boundary has been expanded from the 2013 publication, to include the environmental impacts of background processes, such as electricity and ancillary materials production. The intended target audience comprises aluminium industry participants, customers and non-industry stakeholders.

The results of this study are not intended to be used in comparative assertions disclosed to the public. However, the LCI data on which this report is based can be used in studies where comparative assertions are made and where a separate review of that study will be carried out. Such data is available from website of the International Aluminium Institute (www.world-aluminium.org/publications/tagged/life%20cycle/) as well as from latest releases of the Ecoinvent (http://www.ecoinvent.ch/) and GaBi (http://www.gabi-software.com) databases.

1.2 Scope of the study

The scope of an LCA study is defined in ISO 14044:2006 section 4.2.3, outlining, among other things, the functions, functional unit and system boundary of the study. These are summarised in the following sections.

1.2.1 Functional Unit

Within the scope of this study, the functional unit is 1kg of primary aluminium ingot at the factory gate; thus all results are provided per kg Al.

1.2.2 System Boundary

In addition to the unit processes contained within the 2013 report, all upstream (background) processes are included here; the results are thus known as cradle-to-gate (see Appendix A). GaBi software and background datasets (version 6, 2013) were used to model the cradle-to-gate impacts.

Aluminium is used in many different products and applications and as a consequence, downstream manufacturing, the use phase, recycling and end-of-life processes need to be included, as well as upstream processes, in the modelling of a cradle-to-cradle or cradle-to-grave product LCA.

As the system boundary of study does not encompass such downstream, use phase, recycling and end-of-life processes, it cannot and should not be used for comparative assertions.

1.2.3 Geography

Two distinct primary aluminium datasets were modelled in GaBi, one Global and Rest of World (Global minus China), the reasons for which are discussed in section 2.3.1. The LCIA results for both models are presented in this report.

2 Methodology

This section describes the various methodologies used to produce LCIA results for the global aluminium industry.

2.1 Selection & Definition of Impact Categories

In accordance with the 2014 *PE International* publication "Harmonization of LCA methodologies for Metals (v1.01)" the LCIA methodology followed in this assessment is CML, with the following impact categories selected:

- Acidification potential
- Depletion of fossil energy resources
- Eutrophication potential
- Global warming potential
- Ozone depletion potential
- Photo-oxidant creation potential
- Water scarcity footprint

In addition, a breakdown of the relative contribution to global warming potential of industrial processes in the primary aluminium value chain is included, along with a breakdown of total primary energy transformed. For a complete description of the selected impact categories see Appendix B.

Land use is not included as an impact category here, as its complexity and the limited availability of data from aluminium industry (and background) processes makes its quantification difficult and results highly uncertain. It is hoped that future data collection and further developments in calculation methodologies will enable reporting of a land use impact category in subsequent reports.

Human toxicity and ecotoxicity are not included as impact categories here as the (complex) methodologies for their quantification, with respect to metals production, are not felt to be robust enough at this time (PE International 2014), with high uncertainties. However, the aluminium industry, through the International Aluminium Institute, has funded and undertaken research to develop better such methodologies and to test them using aluminium industry data (Li et al, 2014; Kounina et al, forthcoming; Gandhi, forthcoming) and it is hoped that future reports will be able to report against such impact categories.

Category Indicator Results	Unit (per kg Al)	Methodology
Acidification Potential (AP)	kg SO_2 e	CML2001-Nov 2010
Depletion of fossil energy resources	MJ	net cal. value
Eutrophication Potential (EP)	kg PO_4 e	CML2001-Nov 2010
Global Warming Potential (GWP 100 years)	kg CO_2 e	CML2001-Nov 2010
Ozone Depletion Potential (ODP, steady state)	kg CCl_3F e	CML2001-Nov 2010
Photo-Oxidant Creation Potential (POCP)	kg C_2H_4 e	CML2001-Nov 2010
Water scarcity footprint (WSFP)	m^3 H_2O e	ISO 14046:2014

Table 1 - Pre-defined set of CML mid-point impact categories per kg of aluminium ingot

2.2 Classification & Characterisation

As described in ISO 14044, the assessment of potential environmental impacts is divided into two steps which must be performed as a minimum:

- Assigning life cycle inventory results to life cycle impact categories (classification).
- Characterization of LCI results within impact categories by multiplying them with science-based factors and adding them up to category indicator results

The two steps can be completed simultaneously using software tools to produce LCIA results.

Both the LCI datasets and LCIA results were modelled in GaBi version 6. The data used in the GaBi database for classification are published by:

- *International Organization for Standardization* (ISO);
- *Society of Environmental Toxicology and Chemistry* (SETAC);
- *World Meteorological Organisation* (WMO); and
- *Intergovernmental Panel on Climate Change* (IPCC).

2.3 LCI Data Modelling in GaBi Version 6

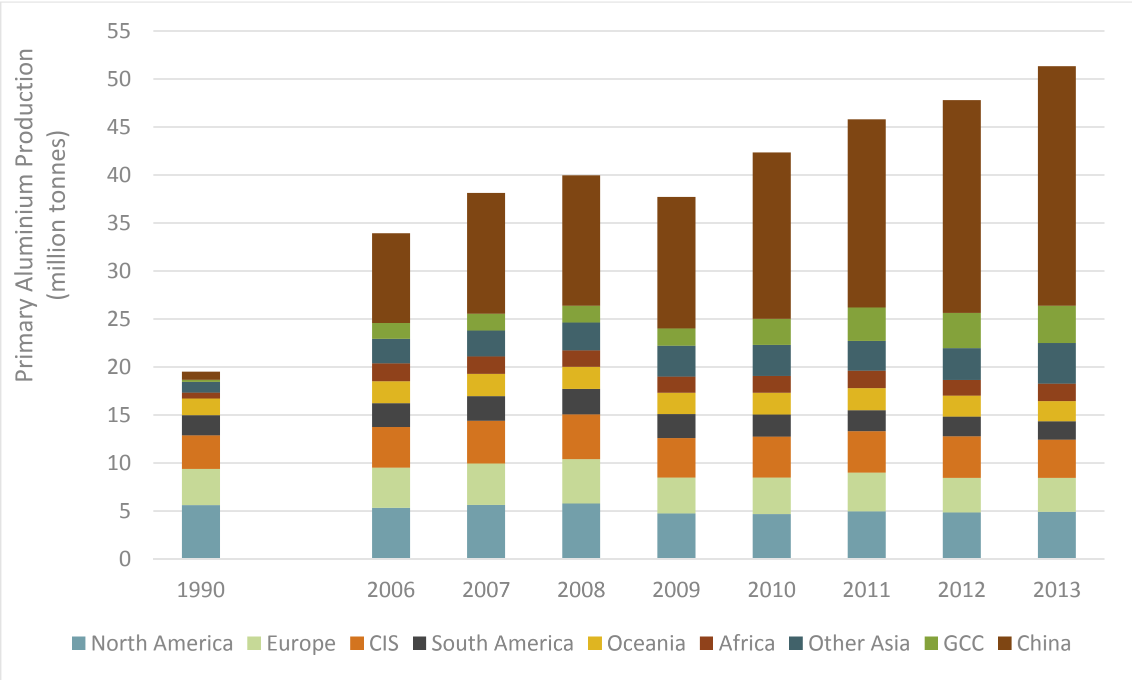


Figure 1 - Location of primary aluminium production, 1990 & 2006-2013 (SOURCE: IAI & CRU)

LCI foreground and background datasets related to year 2010 were supplemented with data collected in IAI annual surveys of energy use (http://www.world-aluminium.org/statistics/primary-aluminium-smelting-energy-intensity/, http://www.world-aluminium.org/statistics/primary-aluminium-smelting-power-consumption/) and perfluorocarbon (PFC) emissions (http://www.world-aluminium.org/statistics/perfluorocarbon-pfc-emissions/) to create the GaBi cradle-to-gate model.

Growth in primary aluminium production continues to be driven by China and the countries of the Gulf Co-operation Council (GCC) and, since the late 1990s, is based on latest point fed prebake technology. Global primary aluminium production in 2010 was 42 million tonnes (52 million tonnes in 2014).

At present, and for the past 5 years or more, China's primary aluminium demand been in balance with its production, meaning that (for primary aluminium at least), Chinese metal has not been available for consumption outside China. We therefore present here two datasets, one global (GLO), quantifying the impact of the entire sector, and one global minus China (RoW), which reflects the impact of primary metal that is available to the market outside of China.

The differences between the GLO and RoW datasets are in the foreground (alumina refining and aluminium smelting) energy and PFC emissions data (published per region at www.world-aluminium.org, in smelting technology mixes and in background datasets (which are highly dependent on electricity grid mixes). It should be noted that, while availability of Chinese foreground data (for aluminium industry processes) is limited, Chinese electricity consumption data is available and used herein and the greatest influence on impact category data is from background processes related to Chinese electricity production. Thus, while a weakness of the 2013 Lifecycle Inventory was the lack of Chinese foreground data, (coal fired) electricity production in China, for which robust data is available is the most material influence on environmental impact and is a strength of this report.

Figure 2 and Figure 3 (page 9) show how the primary aluminium data have been modelled in GaBi.

In addition to the inventory data related to the aluminium processes collected as part of the IAI surveys, additional inventory datasets (background data) related to supplementary processes have been used. These datasets are included in the GaBi database version 6. The most important are listed below, though it should be noted that the list is not exhaustive:

- Limestone production (DE*, 2010)
- Caustic soda production (DE, 2010)
- Aluminium fluoride production (RER, 2010)
- Petroleum coke production (EU27, 2008)
- Pitch production (DE, 2008)
- Electricity supply systems (GLO 2010)
- Fuel supply systems and fuel combustion (EU27 2009, GLO 2010)
- Transportation (GLO, 2010)

NB: Processing of residues (e. g. bauxite residue, dross and spent pot lining) is not included.

* GaBi geographical codes can be found at http://www.gabi-software.com/support/gabi/geographical-codes/

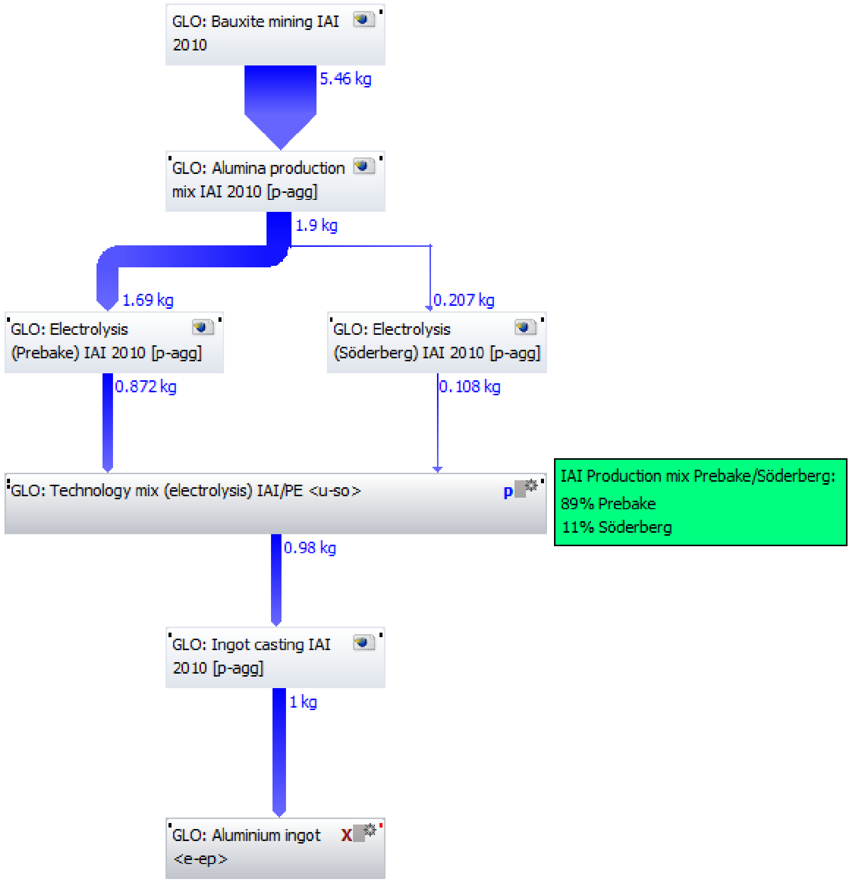


Figure 2 - Global (GLO) data model in GaBi version 6

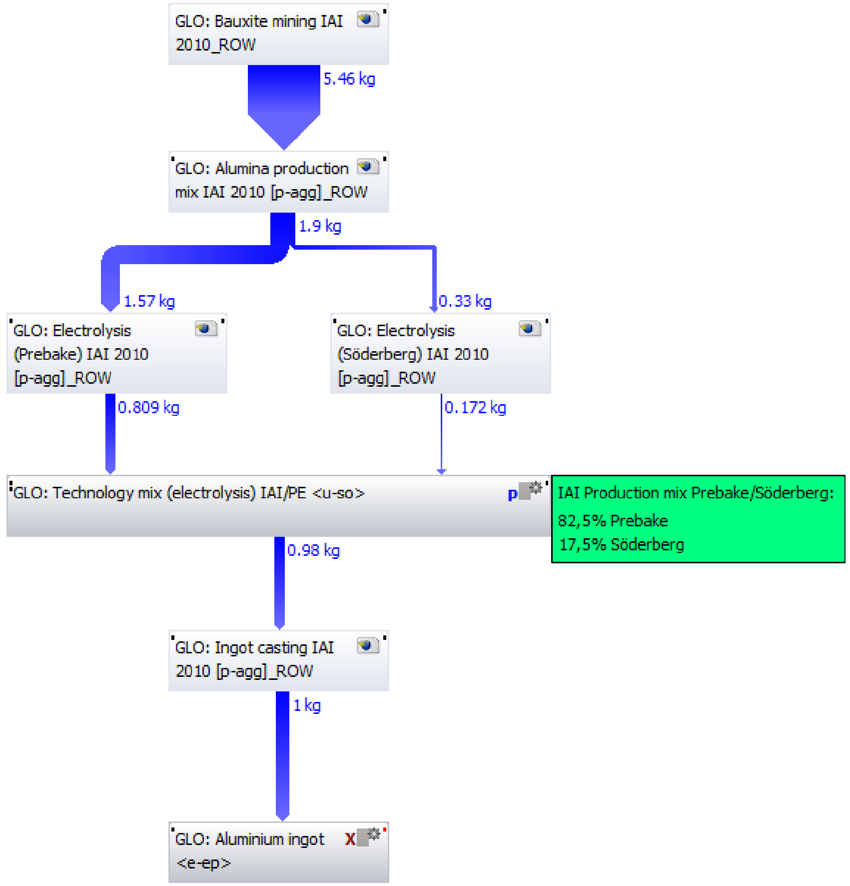


Figure 3 - Rest of World (RoW) data model in GaBi version 6

2.3.4 Electricity Modelling

Primary aluminium production is an energy intensive process; the largest percentage of electricity used is in the electrolysis process (>95%); it is therefore important to represent accurately the electricity consumption using detailed data collected by the IAI.

An industry specific model was built within the GaBi database for the electrolysis process (for both prebake and Søderberg technologies) based on IAI 2010 power consumption data (http://www.world-aluminium.org/statistics/primary-aluminium-smelting-power-consumption/). Such a model allows for the attribution of impacts, through the inclusion of background data, to an industry-specific electricity mix, rather than a regional or national grid mix (which for aluminium production is not always correct)

2010	Africa	North America	South America	Asia (ex China)	Europe	Oceani a	China	GLO (inc China)	RoW (ex China)
Reported Al Production ('000 tonnes)	1,441	4,440	2,210	1,855	7,981	1,542	16,194	35,664	19,469
POWER MIX (GWh)									
Hydro	9,181	50,355	29,145	4,817	97,271	5,211	22,638	218,618	195,980
Coal	11,844	16,095	0	8,171	13,856	17,932	203,745	271,643	67,898
Oil	0	7	0	138	238	6	0	389	389
Natural Gas	0	316	5,591	15,510	5,015	0	0	26,432	26,432
Nuclear	0	320	0	0	10,677	0	0	10,997	10,997
TOTAL	21,025	67,093	34,736	28,636	127,057	23,149	226,383	528,079	301,696

	GLO (GWh)	GLO %	RoW (GWh)	RoW %
Hydro	218,618	41%	195,980	65%
Coal	271,643	51%	67,898	23%
Oil	389	0%	389	0%
Natural Gas	26,432	5%	26,432	9%
Nuclear	10,997	2%	10,997	4%
TOTAL	528,079	100%	301,696	100%

Table 2a & b - Electricity sources for Global and Rest of World electrolysis datasets
(Any errors in total percentages are due to rounding)

Regional background datasets, corresponding to the aluminium producing regions in the published IAI statistics (Africa, Asia, China, N. America, S. America, Europe and Oceania), were developed from individual LCI data (in GaBi) against each energy carrier (using proxy data for regions with limited data – e.g. South Africa for Africa), based on the energy share reported in the 2010 IAI Energy Survey of aluminium smelters worldwide (http://www.world-aluminium.org/media/filer_public/2013/01/15/iai_form_es001.pdf). See Figure 4 for an example for the region "Africa".

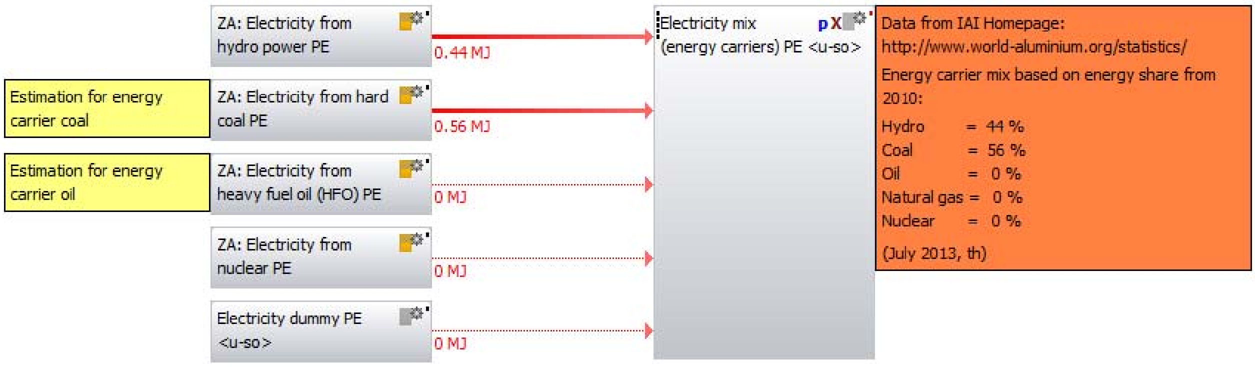


Figure 4 - Global Prebake Electrolysis: Africa Electricity Grid Mix (example)

The total impact of the global electricity mix was calculated as the production weighted average of all seven (or six in the case of RoW) regional electricity datasets, as in Figure 5.

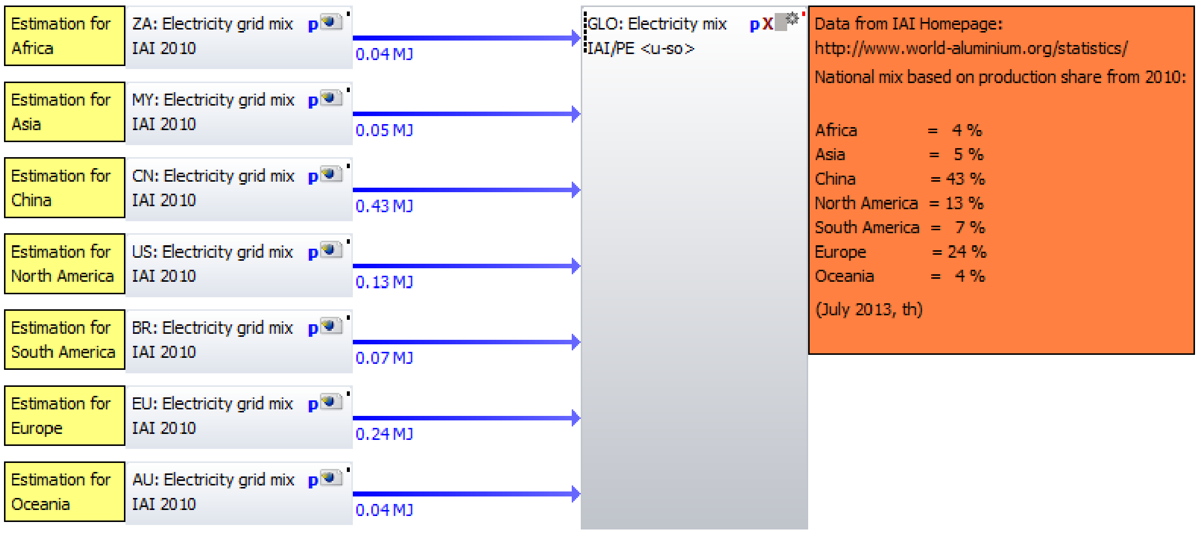


Figure 5 - Global Prebake Electrolysis: Global Electricity Mix

2.3.5 Thermal Energy Modelling

A similar methodology was used to model the impacts of thermal energy input to the following unit processes:

- Bauxite Mining;
- Alumina Refining (using data from http://www.world-aluminium.org/statistics/metallurgical-alumina-refining-fuel-consumption);
- Anode Production;
- Paste Production; and
- Ingot Casting.

A regional mix was constructed for each energy source (e.g. hard coal), with the percentage share of each region modelled on a relevant proxy LCI dataset (e.g. Brazil for South America) present within the GaBi database (see figure 6 for an example). The global mix is a production weighted average of the regional models, as for electricity.

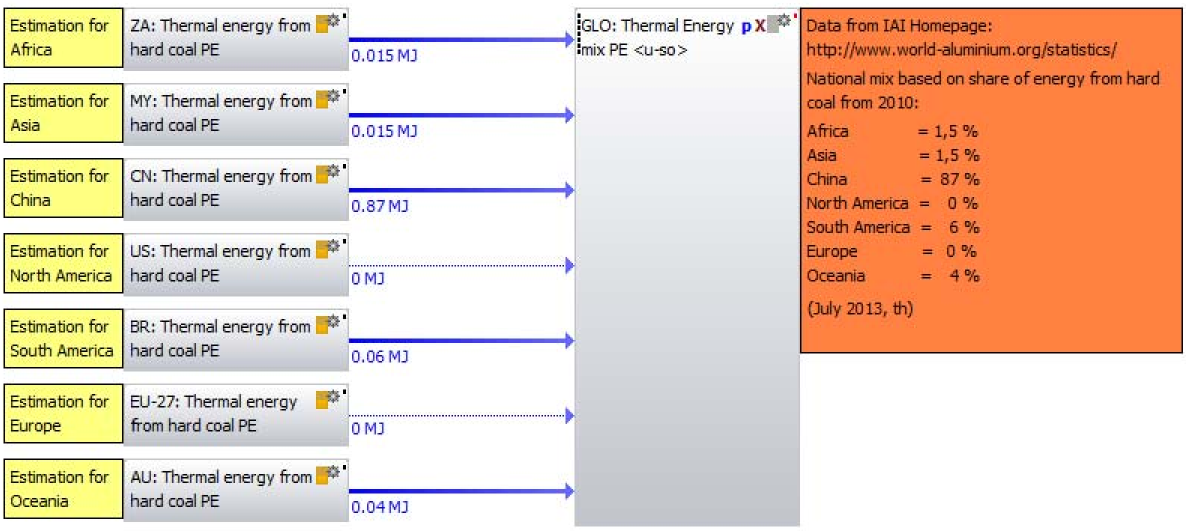


Figure 6 - Global Alumina: Thermal Energy Mix from Hard Coal

2.3.6 Classification of Processes and Material Inputs and Outputs

The processes (and material inputs/outputs) within the system boundary of the study were classified as one of four typologies: direct and auxiliary processes, transport, electricity and thermal energy. The LCI data (taken from the 2013 inventory report) were then assigned to each typology using the GaBi software, which allows the contribution of the relevant processes to each impact category to be displayed within the LCIA results.

These four categories are defined as follows:

- Direct & Auxiliary processes: Direct material consumption/use or direct emissions associated with the production of primary aluminium (bauxite mining, alumina production, anode/paste production, electrolysis, and casting) and the ancillary processes and materials used in the production of primary aluminium, which includes caustic soda, lime and aluminium fluoride.

- Electricity: The processes and materials needed to produce the electricity directly used in the production of primary aluminium, including fuel extraction and preparation.
- Thermal energy: The processes and materials needed to produce the thermal energy directly used in the production of primary aluminium, excluding the pitch and coke used for anode production.
- Transport: Ship, road and rail transport of input materials.

2.4 Water Scarcity Footprint methodology

The Water Scarcity Footprint (WSFP) for the production of primary aluminium was calculated using an approach in accordance with ISO 14046. The International Aluminium Institute is currently preparing a detailed report on the methodology and results of this analysis, for publication in poeer reviewed literature.

The water scarcity footprint (WSFP), cradle-to-gate, of primary aluminium has been determined for global aluminium including China (GLO) and global aluminium excluding China (RoW). It consists of

- the direct WSFP, which has been calculated based on the water consumption collected by the IAI within the LCI 2010 survey from global bauxite mines, alumina refiners and aluminium smelters, and
- the indirect WSFP which has been calculated from data supplied by PE International which is based on the water consumption of the different ancillary materials, fuel and electricity needed for the production of alumina, anodes and aluminium.

The WSFP of a plant quantifies to which extent the water consumption of this plant contributes to water scarcity in the region where it operates. For this purpose the WSFP of each plant was determined by multiplying the direct and indirect specific water consumption with a local Water Scarcity Index (WSI), freely available from http://www.ifu.ethz.ch/ESD/downloads/EI99plus. WSI values range from 0 to 1, with zero indicating water abundance and 1 indicating dry areas. The plant specific WSFP was then divided by 0.6, which is the average global WSI.

A generic water scarcity footprint per tonne of primary aluminium was then determined by summing up the WSFPs of the plants involved and normalizing it to the reference flow of 1 kg of primary aluminium.

3 Results & Evaluation

The impact category and additional indicator results (including GWP breakdown) were calculated using GaBi version 6 software and are reported per kg aluminium ingot. Water Scarcity Footprint results were calculated as part of a separate project in accordance with ISO 14046.

3.1 LCIA Results

IAI Impact Category indicator results (per kg primary ingot)	GLO 2010	RoW 2010
Acidification Potential (AP) [kg SO2-Equiv.]	0.13	0.090
Depletion of fossil energy resources (Depl. Fossil Energy) [MJ]	163	109
Eutrophication Potential (EP) [kg Phosphate-Equiv.]	0.011	0.0053
Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]	16	11
Ozone Layer Depletion Potential (ODP) [kg R11-Equiv.]	2.9E-10	2.8E-10
Photochemical Ozone Creation Potential (POCP) [kg Ethene-Equiv.]	0.0085	0.0047
Water Scarcity Footprint (WSFP) [m3 Water-Equiv.]	0.018	0.010

Table 3 - Global and RoW Impact Category indicator results (per kg Al)

3.2 Relative Contributions of Processes to Impact Category Indicator Results

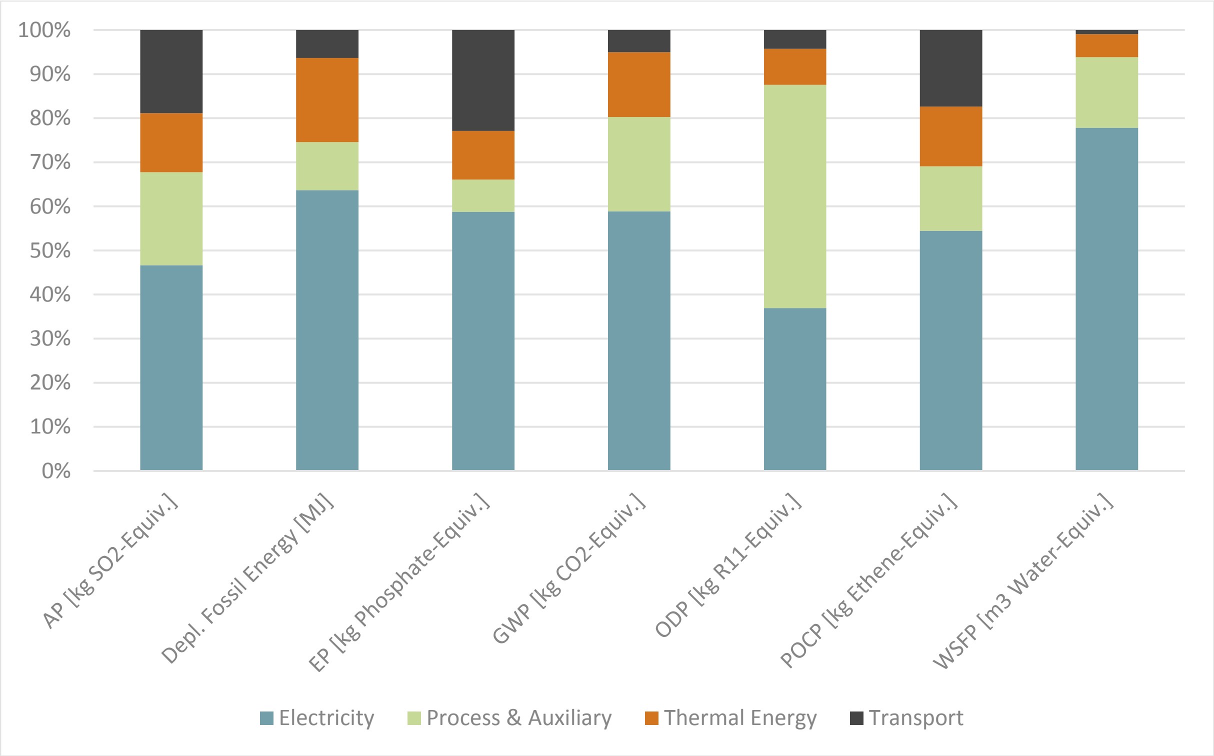


Figure 7 - GLO: Relative contributions to indicator results split by process type

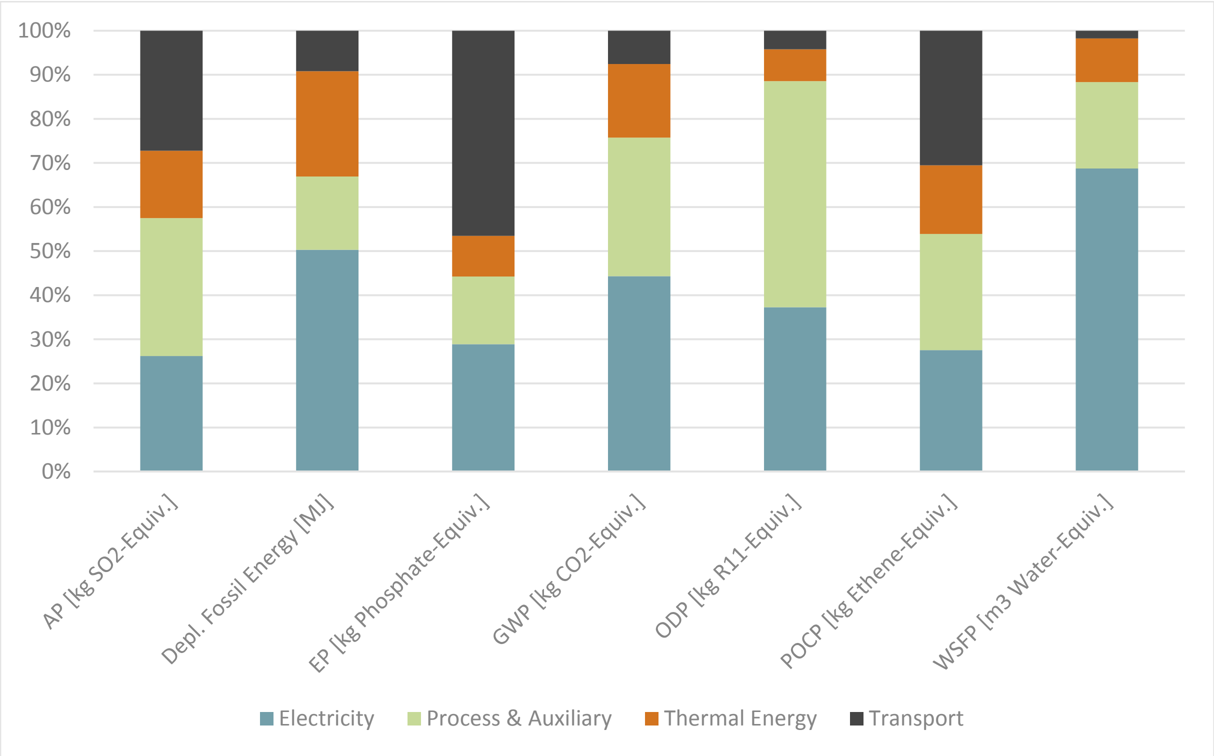


Figure 8 - RoW: Relative contributions to indicator results split by process type

3.3 Relative Greenhouse Gas Contribution of Aluminium Production Processes

The following charts and tables show the relative greenhouse gas (GHG) contributions of the aluminium production processes, along with the relative primary energy (from both renewable and non-renewable resources) transformed. All figures, unless otherwise indicated, are reported as kg CO2-Equiv./ kg Al.

GLO	Bauxite Mining	Alumina Refining	Anode/ Paste Production	Electrolysis	Ingot Casting	Total	Primary Energy (MJ)
Electricity	<0.1	0.4	<0.1	9.2	<0.1	9.7	131
Process & Auxiliary	<0.1	0.7	0.4	2.3	<0.1	3.5	19
Thermal Energy	<0.1	2.2	0.1	<0.1	0.1	2.4	31
Transport	0	0.5	<0.1	0.4	0	0.8	10
Total	<0.1	3.8	0.6	11.9	0.2	16.5	190

Table 4 - Global greenhouse gas emissions split by unit process and process type & primary energy input split by process type

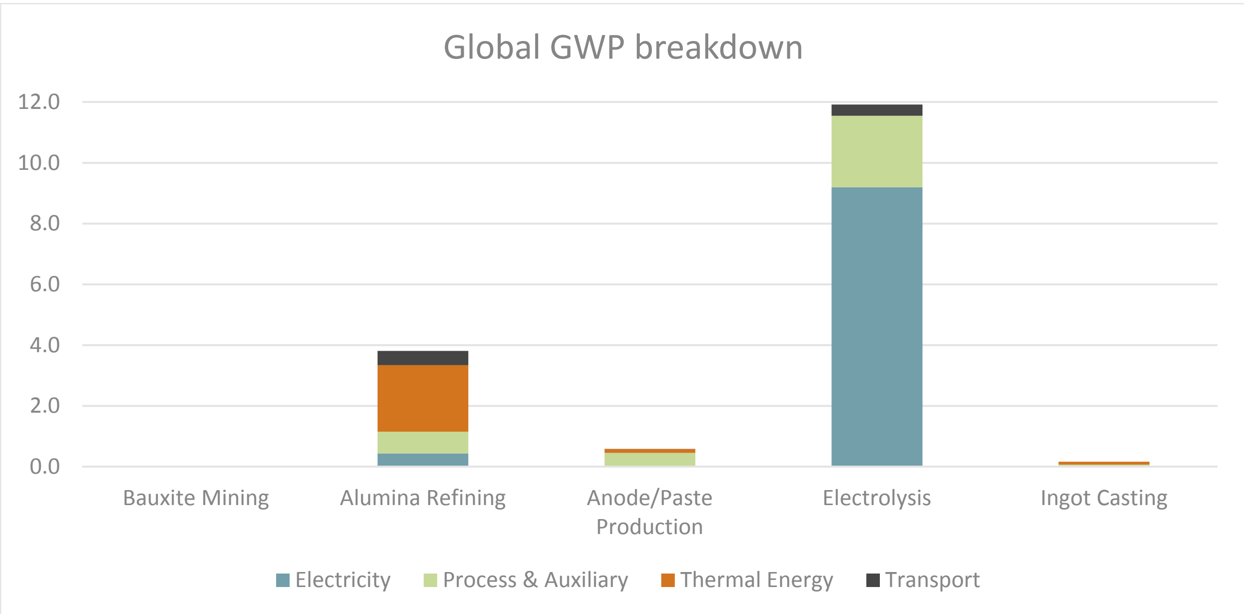


Figure 9 - GLO: Greenhouse gas emissions split by unit process and process type

RoW	Bauxite Mining	Alumina Refining	Anode/ Paste Production	Electrolysis	Ingot Casting	Total	Primary Energy (MJ)
Electricity	<0.1	0.1	<0.1	4.6	<0.1	4.8	98
Process & Auxiliary	<0.1	0.7	0.4	2.2	<0.1	3.4	19
Thermal Energy	<0.1	1.6	0.1	<0.1	0.1	1.8	26
Transport	0	0.5	<0.1	0.3	0	0.8	10
Total	<0.1	2.8	0.6	7.2	0.2	10.8	153

Table 5 - RoW greenhouse gas emissions split by unit process and process type & primary energy input split by process type

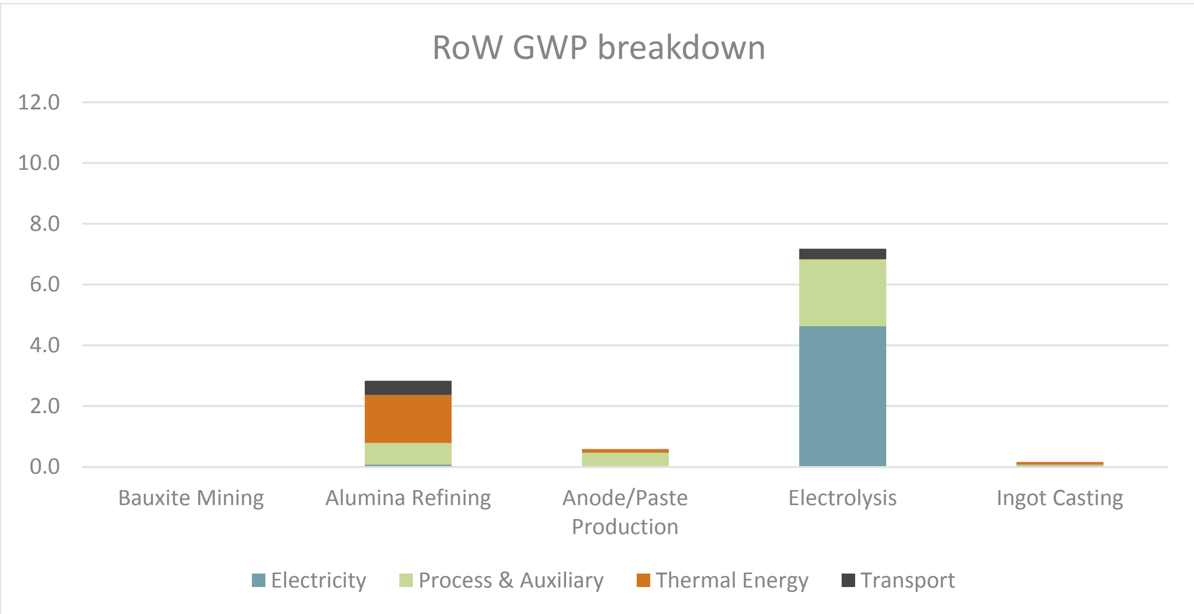


Figure 10 - RoW: Greenhouse gas emissions split by unit process and process type

The largest greenhouse gas contributions are attributed to the alumina refining and electrolysis unit processes in both datasets. Both the Global and Rest of World datasets have similar contributions for bauxite mining, anode production and ingot casting.

The most significant differences within the alumina refining and electrolysis processes are the values for electricity and thermal energy. For example GHG values for electricity in electrolysis are 9.2 kg CO2-Equiv./ kg Al for the GLO dataset and 4.6 kg CO2-Equiv./ kg Al for the RoW dataset. These differences are due to coal based energy production in China, which produces approximately 50% of global aluminium.

4 Interpretation

4.1 Significant issues

Aluminium production is an energy intensive process, and from the results presented above the production of this energy results in a significant contribution to the overall environmental impact.

- Electricity production contributes between 25 and 80% to all impact category results, with higher values in the global dataset due to the coal based electricity production in China.
- From the breakdown of greenhouse gas emissions (Tables 4 and 5), electricity production for electrolysis is the largest contributor for GWP (56% of total for GLO and 43% of total for RoW), with thermal energy production for direct use in alumina refining contributing 13% for GLO and 15% for RoW.

Apart from emissions relating to energy production, other significant influences on the GWP results (14% for GLO and 20% for RoW) are direct emissions from the electrolysis process. Perfluorocarbons (PFCs) are a group of potent greenhouse gases with long atmospheric lifetimes. Tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) are PFCs that are produced in the electrolytic process during events referred to as "anode effects" (for further information please see:
http://www.world-aluminium.org/media/filer_public/2013/01/15/fl0000441.pdf).

The IAI has collected and published annual data on energy consumption (alumina refining and electrolysis) and anode effects since the 1980s and 1990s respectively. The monitoring of data and sharing of best practices has driven significant reductions in both energy input and PFC emissions by improvements in technology and optimising production conditions.

- In 2010 PFC emissions per tonne were cut by almost 90% compared with 1990. With strong growth in aluminium production over the same period, total annual emissions of PFCs to the atmosphere by the aluminium industry were reduced by 73% despite a 111% increase in primary aluminium production.
- For refining, there was a 9% improvement in energy intensity between 2006 and 2010 and for electrolysis, the total electrical energy consumed per tonne of aluminium was cut by 10%, 1990-2010.

The industry recognises the significance of these issues and is committed to driving continual improvement through a set of voluntary objectives known as *Aluminium for Future Generations*.

4.2 Sensitivity and consistency

As reported in the LCI report, all reported data points were checked individually in a systematic approach. Significant variations (+/- 2STD) in reported data, when compared with 2005 data, were queried with reporters and either confirmed or amended as appropriate.

4.3 Limitations

Reporting rates for 2010 surveys are shown in figures 11 and 12. For further information on reporting rates, please see Section 2.1 of the LCI report (http://www.world-aluminium.org/publications/tagged/life%20cycle/).

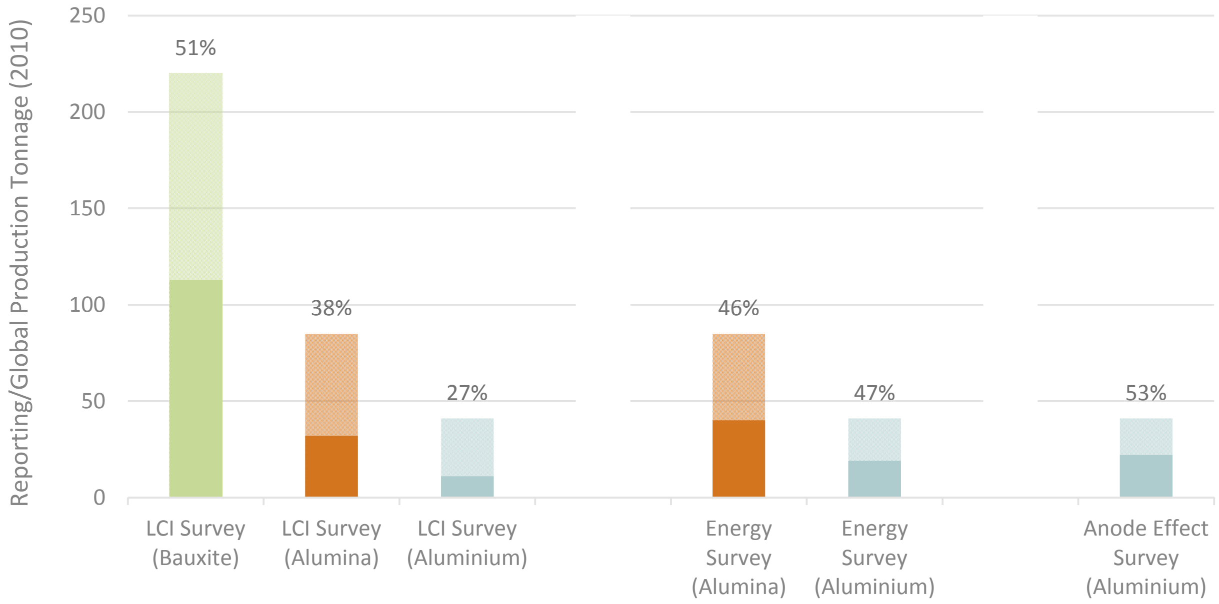


Figure 11 - GLO response rates and production figures for data year 2010

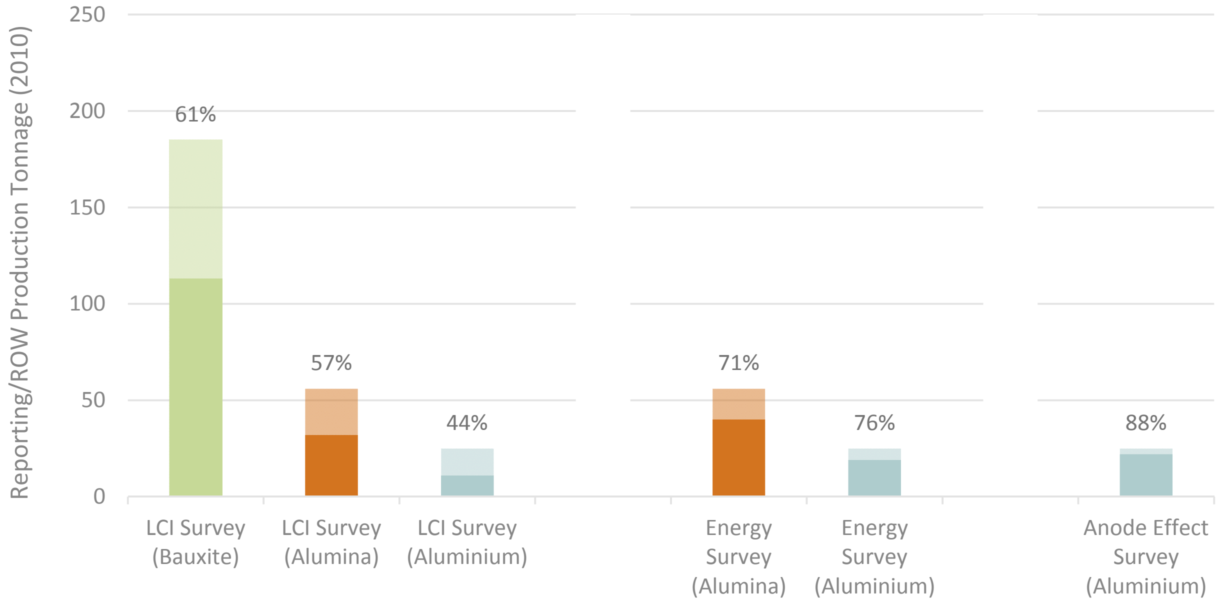


Figure 12 - RoW response rates and production figures for data year 2010

With regards to modelling in the GaBi v6 database, there are inevitably some limitations to the accuracy of the results given that the quality of background dataset can vary considerably. In addition, proxy datasets have been used when the required datasets were not available. However, the effects of this have been limited by the appropriate selection of the best available datasets, as advised by *PE International* consultants.

4.4 Conclusion

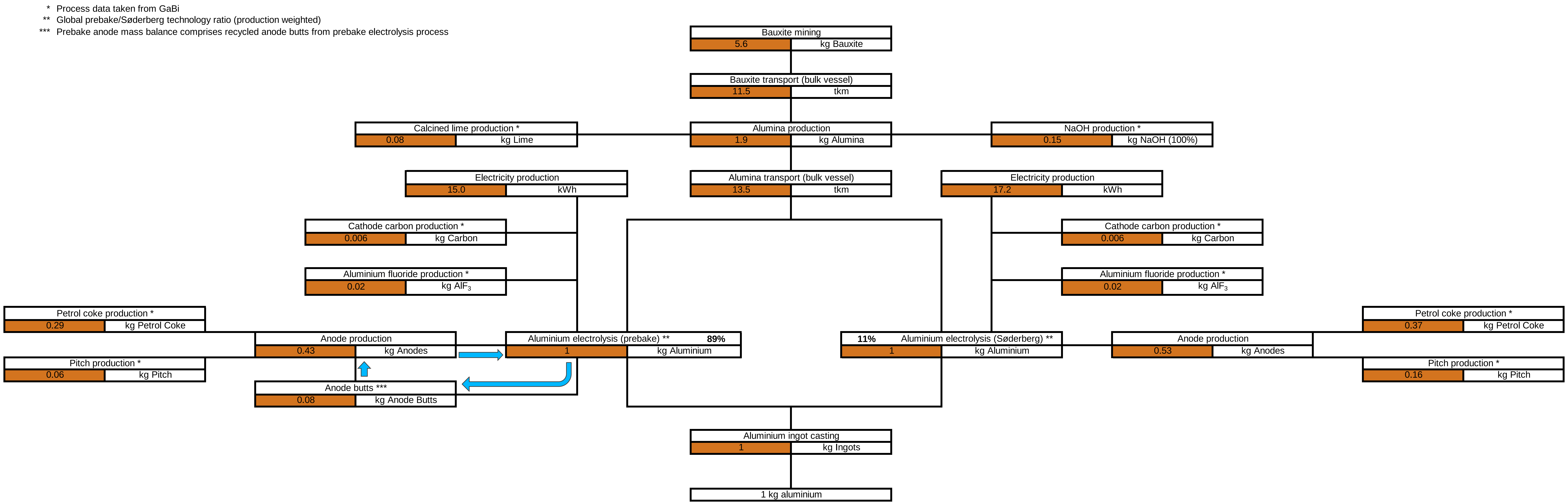
The publication of this, the first cradle to gate LCIA report published by the IAI, demonstrates the global aluminium industry’s dedication to report openly its environmental impacts and to publish regularly the latest and most representative data.

LCI data is collected on a five year cycle, and as such the next report will be published in 2017 using year 2015 data. During this time, the IAI will continue to monitor advances in LCA methodologies and in accordance with recommendations from future editions of the *Harmonization of LCA Methodologies for Metals* report, additional impact categories may be added.

In addition, the impact of annually collected IAI statistics on LCI and LCIA results will be evaluated using the GaBi database, and any significant variations will be reported.

Appendix A: Process Flow Diagram and LCI Data

Process Flow Diagram and LCI Data



Appendix B: Description of Impact Categories

Impact Category	Impact Category Description
Acidification Potential (AP)	This relates to the increase in quantity of acidifying substances in the low atmosphere, which cause a wide range of impacts on soil, groundwater, surface water, organisms, ecosystems and materials (buildings). Acidification potential is caused by direct outlets of acids or by outlets of gases that form acid in contact with air humidity and are deposited to soil and water. Examples are: SO2, NOx and Ammonia.
Depletion of fossil energy resources	This impact category quantifies the extraction of fossil fuels due to inputs into the system like coal, crude oil, natural gas or uranium.
Eutrophication Potential (EP)	Aqueous eutrophication (also known as nutrification) is characterized by the introduction of macro-nutrients (e.g. in the form of phosphatised and nitrogenous compounds), which leads to the proliferation of algae and the associated adverse biological effects. This phenomenon can lead to a reduction in the content of dissolved oxygen in the water which may result in the death of flora and fauna.
Greenhouse Gas emission (GWP 100 years)	Greenhouse gases (e.g. CO_2, CH_4 and C_2F_6) are components of the atmosphere that contribute to the greenhouse effect by absorbing, and subsequently re-emitting, outgoing long wave heat radiation, thus increasing the lower atmosphere temperature. The characterisation model as developed by the Intergovernmental Panel on Climate Change (IPCC) is selected for development of characterisation factors. Factors are expressed as Global Warming Potential for time horizon 100 years (GWP100), in kg carbon dioxide/kg emission.
Ozone Layer Depletion Potential (ODP, steady state)	Stratospheric ozone depletion (especially above poles) causes a larger fraction of UV-B radiation to reach the earth surface and results mainly from a catalytic destruction of ozone by atomic chlorine and bromine. The main source of these halogen atoms in the stratosphere is photodissociation of chlorofluorocarbon (CFC) compounds, commonly called freons, and of bromofluorocarbon compounds known as halons. These compounds are transported into the stratosphere after being emitted at the surface.
Photo-oxidant Creation Potential (POCP)	Photo-oxidant formation is the formation of reactive substances (mainly ozone), created by high concentrations of pollution and daylight UV rays at the earth's surface. There is a great deal of evidence to show that high concentrations (ppm) of these substances (mainly ozone) are injurious to human health and ecosystems and may also damage crops. The majority of tropospheric ozone formation occurs when nitrogen oxides (NOx), carbon monoxide (CO) and volatile organic compounds (VOCs), such as xylene, react in the atmosphere in the presence of sunlight. NOx and VOCs are called ozone precursors.
Water Scarcity	Water scarcity is the extent to which demand for water compares with the replenishment of water in an area (e.g. a drainage basin). This impact category quantifies the contribution of the water inputs and water outputs to water scarcity.

Appendix C: Reference Material

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