# Data Collation and Validation of Greenhouse Gas Emissions (GHGs) from ASI Members, as of July 2020

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Atmolite

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*Disclaimer*

# Executive Summary

This report summaries a review of published Greenhouse Gas (GHG) Emissions and energy use data from certified ASI Entities, and was conducted by *Atmolite Consulting Pty Ltd*. Where possible, totals and intensities (per unit product) were obtained for energy use and GHG emissions (Scope 1, 2 and where available Scope 3). The review covered 51 ASI Entities, from 34 ASI members. Of these, 15 Entities were engaged in aluminium smelting.

The findings here represent a snapshot of GHG data disclosures as of July 2020, with granularity at the regional, country and supply chain activity level. The data collected was from the most recent year for each Entity (2018 or 2019), and where available, up to 5 years' historical data to examine trends over time.

Note that this report uses generic labels (region and numeral) to refer to specific ASI Entities; for example, 'SA-1' refers to Entity #1 in South America.

**Data challenges**

All data acquired for this exercise were collected from publicly available sources. However, complete data sets – for both emissions and energy use – were not found for a large number of ASI Entities, despite reasonable efforts to source these. Challenges in obtaining data are described in the report, with a 'data quality rating' provided for each Entity. For example, no data were found for five out of 51 Entities, and data disclosure was rated 'poor' for 12 Entities. In light of these data challenges, it is recommended that ASI and its GHG Working Group consider the creation and adoption of standard data templates, or consistent reporting requirements, for Entities disclosing emissions and energy use.

Given the gaps in data completeness, absent emissions and/or energy values were calculated using other published data – for example, conversions of totals to intensities if production figures are known. This allowed for more meaningful comparisons across ASI's membership. Furthermore, where data specific to an ASI Entity was not available, data from their parent / corporate Entities (if applicable) was used to 'fill the gaps'. Data issues for specific Entities are described in the report's appendices.

Many ASI Entities report aggregated data across multiple supply chain activities, rather than individually. To facilitate comparison by activities, the aluminium supply chain was redefined into five categories: Bauxite, Alumina, Smelting, 'Remelt-to-Downstream' and Downstream. The resulting energy and emissions profiles (using intensity units, GJ and t $CO_2$e per t product) across the ASI membership were then examined by supply chain, region and country.

**Trends in energy intensity**

As expected, the Smelting supply chain activity exhibits the highest energy intensity, with a median of ~60 GJ/t product, compared to 5-7 GJ/t product for the Remelt and Downstream activities. Comparison with Bauxite and Alumina activities was not possible, given the lack of data. In Smelting, variability in energy intensity is noted in the Gulf Cooperation Council (GCC) region (different accounting basis) whilst Entities in West Europe exhibit the lowest energy intensity.

**Trends in GHG emissions intensity (Scope 1+2)**
Consistent with the energy profile, Smelting is responsible for the highest emissions across the supply chain activities within ASI's membership, with a median and average of 3.1 and 5.7 t $CO_2$e/t Al, respectively. Smelting also has the most significant variation compared to other supply chain activities, ranging from 1.6 to 17.8 t $CO_2$e/t Al. This is driven by the range of electricity sources – from renewable hydro to carbon-intensive coal. Nine of 11 reporting Smelting Entities meet the current ASI Performance Standard target of 8 t $CO_2$e/t Al. Seven Entities (mainly hydro powered) are at 4 t $CO_2$e/t Al or less, situated in West Europe, East/Central Europe, North America South America, or Oceania. GCC smelting Entities (mainly natural gas powered) are at or just above the 8 t $CO_2$e/t Al level. Despite representing >50% of global smelting capacity, China was only represented by a single ASI Entity with the 17.8 t $CO_2$e/t Al data point, due to coal being the energy source. Significant changes in the energy mix are needed if smelters in this region are to meet the 8 t $CO_2$e/t Al target over the next ten years. Some potential trends in China are discussed in this report.

ASI's Bauxite and Alumina supply chain activities exhibit lower GHG emissions, at below 0.1 t $CO_2$e/t bauxite and with a median of 0.7 t $CO_2$e/t alumina, respectively. The median value for Alumina is perhaps lower than might be expected from the International Aluminium Institute's (IAI) modelling of the emissions from the global alumina supply chain activity. The Remelt-to-Downstream and Downstream activities – representing over 50% of ASI Entities – reported median intensities of 0.8 and 0.5 t $CO_2$e/t Al, respectively.

In terms of trends in emissions or energy use over time, most Entities are reasonably stable or reducing, with some exceptions due to production increases or changes in investments/divestments.

**Impact of ASI membership**
An observed positive impact of ASI's membership has been the adoption of emissions, energy and general sustainability disclosures for companies and regions (particularly developing nations) that did not previously exhibit this practice.

Given the global Smelting activity's significant contribution to GHG emissions, it may be advantageous for ASI to provide alternative pathways for engagement and membership (if not certification) for smelting Entities that currently source their energy from coal (or other carbon-intensive sources). This could focus on Entities that cannot practically meet the 8 t $CO_2$e/t Al emissions target but can still demonstrate material reductions over time.

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## Figures



## Tables

# 1 Introduction

The following report on 'Data Collation and Validation of Greenhouse Gas Emissions from ASI members' was commissioned by the *Aluminium Stewardship Initiative* (ASI) and has been prepared by *Atmolite Consulting Pty Ltd (ATMOLITE)*.

The report summarises the findings of a data collection and review of published Greenhouse Gas (GHG) Emissions, emissions intensity and energy usage for all current ASI Performance Standard (PS) and Chain of Custody (CoC) certified Entities, and provides input into ASI's Monitoring and Evaluation (M&E) program.

## 1.1 Objectives

The main objectives of the data collection and validation exercise were to:

- Provide a 'snapshot' of the overall global GHG profile of all ASI Performance Standard Certified Entities, with granularity at the regional, country and supply chain activity level.
- Provide a total emissions baseline that can inform the development of any reduction in ASI's GHG emissions targets as part of its current 2020-21 Standards Revision process.
- Provide a segment analysis of the GHG profile of Chain of Custody (CoC) certified aluminium smelters.

## 1.2 ASI Performance Standard – Principle 5

Focused on Greenhouse Gas Emissions, Principle 5 of the ASI Performance Standard (PS) mandates for all ASI Entities:

- The reporting and disclosure of greenhouse gas emissions and energy use (PS 5.1)
- commitments to reducing GHG emissions over time through the setting of targets and implementation plans to reach these (PS 5.2)
- For Entities engaged in aluminium smelting, a further demonstration of goals, measures and performance in reducing 'Scope 1 and 2'* GHG emissions to below *8 tonnes $CO_2$-equivalent per metric tonne aluminium* (t $CO_2$e / t Al) by 2030 for existing smelters, or by 2020 for new smelters.

*The GHG Protocol standards (https://ghgprotocol.org/) defines:

- Scope 1 as *direct* greenhouse gas emissions from activities within the Entity's owned/controlled facilities, vehicles, etc.
- Scope 2 as *indirect* GHG emissions from the Entity's purchased electricity, steam and heating/cooling for its own activities, and
- Scope 3 as *indirect* GHG emissions from upstream and downstream activities outside the scope and control of the Entity (can include purchased goods, raw materials, transportation/distribution, product use and end-of-life treatment, etc.).

## 1.3 ASI Chain of Custody Standard – Criterion 9.3

ASI's Chain of Custody (CoC) standard 9.3 encourages Entities to issue chain of custody (CoC) documents along with shipments, which disclose the Entity's Scope 1 and 2 GHG emissions intensity – particularly those engaged in aluminium smelting, aluminium remelting/refining or cathouses or downstream processes.

*Table 1: Snapshot of ASI Entities reviewed by regions, countries and supply chain activities.*

| **51** ASI Entities (PS and CoC inclusive) | | | | | |
|---|---|---|---|---|---|
| **8** regions | | **23** countries | | **6** supply chain activities | |
| **Regions** [a] | | **Countries** | | **Supply Chain Activities** [b] | |
| North America | 3 Entities | Australia | 2 Entities | Bauxite Mining | 9 Entities |
| South America | 4 | Austria | 3 | Alumina Refining | 10 |
| West Europe | 21 | Bahrain | 1 | Aluminium Smelting | 15 |
| East & Central Europe | 1 | Belgium | 1 | Re-melting / Refining | 23 |
| China | 10 | Brazil | 4 | Casthouse | 32 |
| Asia (ex-China) | 2 | Canada | 2 | Downstream [d] | 13 |
| GCC | 2 | China | 10 | | |
| Oceania | 3 | France | 1 | | |
| *MULTIPLE* [c] | 5 | Germany | 5 | | |
| | | Iceland | 1 | | |
| | | Luxembourg | 1 | | |
| | | Netherlands | 1 | | |
| | | Norway | 1 | | |
| | | Russia | 1 | | |
| | | South Korea | 1 | | |
| | | Spain | 3 | | |
| | | Switzerland | 1 | | |
| | | Taiwan | 1 | | |
| | | UK | 1 | | |
| | | UAE | 1 | | |
| | | USA | 1 | | |
| | | *MULTIPLE* [c] | 9 | | |

[a] Regions are aligned with those defined by the International Aluminium Institute, IAI (http://www.world-aluminium.org/statistics/)
[b] The majority of ASI Entities are engaged in multiple *Supply Chain Activities* (see Appendix I)
[c] 'MULTIPLE' here refers to various regions or countries represented within a single ASI Entity, i.e. covering numerous sites or facilities.
[d] 'Downstream' here includes 'semi-fabrication, material conversion and other manufacturing or sale of products containing aluminium' supply chain activities, as defined by ASI.

# 2 Data Collection and Scope

## 2.1 ASI Members and Entities

The data collection and validation exercise was based upon ASI's list of certified Entities as reported at the end of June 2020. Including both PS and CoC certified Entities, data were reviewed for:

- **51** ASI Entities (single site facilities or corporate divisions/groups), representing
- **34** ASI member companies, and including
- **13** PS certified ASI Entities engaged in aluminium smelting.

Table 1 shows a summary of the ASI Entities reviewed and the regions, countries and supply chain activities represented. A full list of these Entities is provided in Appendix I.

Note that this report uses generic labels (regional code and numeral) to refer to specific ASI Entities. For example, the Entity label 'SA-1' refers to Entity #1 in South America. Regions are denoted as follows: North America (NA), South America (SA), West Europe (WE), East & Central Europe (EE), China (CH), Asia ex-China (A), GCC (GC), Oceania (OC) and Multiple regions (Multi).

## 2.2 Data Collection

### *2.2.1 Timing of Data Collection*

Collection of GHG emissions and energy use data was undertaken during July 2020. The findings reported here, therefore, represent a snapshot of GHG data disclosures as of July 2020, and do not consider more recent updates in data disclosures by ASI Entities.

The most recent year's data for each Entity was used in this exercise. Typically this meant 2018 or 2019, with either calendar year or fiscal year as the basis. Where available, up to 5 years' historical data was also collected to examine trends over time.

### *2.2.2 Data Sources*

All emissions and energy use data acquired for this analysis were collected from publicly available sources. These included:

- *Weblinks provided in ASI PS or CoC audit certificates* – these were accessed initially. For ASI's convenience, broken weblinks have been highlighted in Appendix II.
- *ASI Entity/Member websites* – in addition to providing access to reports, some Entities published GHG emissions and energy use in a dedicated sustainability webpage.
- *ASI Entity/Member sustainability reports or life cycle analysis (LCA) reports* – particularly in recent years, the majority of Entities publish annual sustainability reports.
- *ASI Entity/Member annual reports* –used to obtain production data (to estimate emissions and energy intensities, if not disclosed) which are often not reported in sustainability reports.

- *Carbon Disclosure Project (CDP) reports* – some Entities submit annual disclosures of emissions and energy data to CDP (https://www.cdp.net/en).
- *Emissions reporting to regional/national governmental bodies* – for some Entities, emissions data was available in compliance reporting to regional/national emissions inventories. These included – the Australian Government's National Greenhouse and Energy Reporting (NGER), New Zealand's Ministry for the Environment (MfE), Quebec's Atmospheric Emissions Inventory (IQEA), the Norwegian Environment Agency, and the Spanish Office for Climate Change (OECC).

However, complete data sets – for both emissions and energy use – did *not* appear to be available for a large number of ASI Entities, despite reasonable efforts* at sourcing these. Data quality issues are summarised in Section 4 of this report.

**Note that the data collection exercise should not be deemed an exhaustive search of all and every available public source; it is acknowledged that Entities may have published data in locations other than those reviewed above.*

### 2.2.3 Disclaimer on Data Collection and Validation

In-depth review or verification of data calculations from each ASI Entity was not undertaken, as this was outside the agreed scope of works. Where unusual data or numbers were observed, these have been highlighted in the Report.

Where Entities provided reports and data in a language other than English, reasonable attempts were made at translating these (using Google Translate) for compilation into a GHG database. However, as professional interpreters or native speakers have not verified these translations, errors in interpretation may be possible.

# 3 Development of a GHG Emissions Database

Publicly available GHG emissions data – Scope 1 and 2, and Scope 3 (where reported) – and energy use data were collected into a Microsoft® (MS) Excel-based database for ASI. Data fields developed include:

- *Entity details* – ASI Member, Entity Name, Supply Chain Activity, Region, Country
- *Year of data* – Year, Reporting Period, Markers for Latest Entry
- *Energy sources* – Energy Types (%), Electricity Types (%), Grid Connected, Power (Self-Generated/ Purchased)
- *Energy use* – Total Energy Use (TJ or GWh), Energy Intensity (GJ/t or kWh/t Product)
- *GHG emissions (t $CO_2e$)* – Scope 1, Scope 2, Scope 3, total Scope 1+2, total Scope 1+2+3
- *GHG emissions intensity (t $CO_2e$/t Product)* – Scope 1, Scope 2, Scope 3, total Scope 1+2, total Scope 1+2+3
- *Production* – Total Production (tonne Product) and units (tonne bauxite, alumina, aluminium, other)
- *Supply Chain Activity* – Bauxite Mining, Alumina Refining, Aluminium Smelting, Aluminium Re-melting/ Refining, Casthouse, Downstream.

For further details on the data fields described above, refer to the database files (provided separately).

## 3.1 'Filling the Gaps' for Data Completeness

Due to gaps and deficiencies identified in data completeness, attempts were made to estimate missing emissions data and/or energy variables using other published data. This allowed for a more meaningful comparison across the ASI membership. For example:

- Missing *intensity values* for emissions and energy use (e.g. t $CO_2e$/t Al) were calculated from emission and energy consumption totals (e.g. t $CO_2e$), provided matching production data (e.g. t Al) was available.

- Missing *total values* for emissions and energy use (e.g. GJ) were back-calculated from reported intensity data and production data (i.e. pro-rata), where available.

For some individual sites or facilities (i.e. Entities) within a large corporate company (i.e. the ASI Member), very little publicly available emissions and/or energy data were located. However, where the Member had disclosed relevant emissions and energy data, these were used to 'fill the gaps' for that specific ASI Entity or Entities.

## 3.2 Classifying Data for Entities with Multiple Supply Chains

Most ASI Entities are engaged in multiple supply chain activities as defined by ASI (see Appendix I), and have in turn reported aggregated data across multiple, rather than individual activities. Meaningful comparisons of energy use and emissions using ASI's categorisation of supply chain activities was therefore not possible.

The aluminium supply chain was redefined into five separate categories, to facilitate a level of comparison by supply chain activity, from 'Bauxite' to 'Downstream' as shown in Table 2. This definition was used to represent several activity combinations. For example, Entities engaged in aluminium smelting almost always reported aggregated emissions and energy data that included casthouse and/or remelting / refining activities; therefore these combinations were all categorised under the one label "Smelting".

Where data could not be split into the five categories, these were allocated a supply chain label, such as "Alumina-to-Downstream", where data encompassed 4 out of 5 activities.

For larger corporate Entities that disclosed separate emissions/energy datasets for different supply chains activities, multiple data entries were used for that ASI Entity in the GHG emissions database provided. For example, multinational Entity 'Multi-1' provided data for the entire production chain (Bauxite-to-Downstream), as well as discretised data for 'Smelting' and 'Alumina' activities; these are presented in the database as separate data entries.

*Table 2: Redefined supply chain labels employed here for data analysis and reporting.*

| | Modified 'Supply Chain' category used in this report | ASI Supply Chain Activities included |
|---|---|---|
| **01** | **Bauxite** | Bauxite Mining |
| **02** | **Alumina** | Alumina Refining<br>Bauxite Mining, Alumina Refining |
| **03** | **Smelting** | Aluminium Smelting, Casthouse<br>Aluminium Smelting, Remelting / Refining, Casthouse |
| **04** | **Remelt-to-Downstream** | Casthouse, Downstream<br>Remelting / Refining, Casthouse<br>Remelting / Refining, Casthouse, Downstream |
| **05** | **Downstream** | Casthouse, Downstream<br>Downstream |
| | | |
| **-** | **Bauxite-to-Downstream** | Bauxite Mining, Alumina Refining, Aluminium Smelting, Casthouse, Downstream<br>Bauxite Mining, Alumina Refining, Aluminium Smelting, Remelting / Refining, Casthouse<br>Bauxite Mining, Alumina Refining, Aluminium Smelting, Remelting / Refining, Casthouse, Downstream |
| **-** | **Alumina-to-Downstream** | Alumina Refining, Aluminium Smelting, Remelting / Refining, Casthouse, Downstream |
| **-** | **Smelting-to-Downstream** | Aluminium Smelting, Remelting / Refining, Casthouse, Downstream |

# 4 General Commentary on Data Quality

This section of the Report provides general commentary on the quality of published data (energy and emissions) for ASI Entities, based on this review.

## 4.1 Ranging Data Sources, Formats and Units

During the data collation exercise, it was found that there is no typical location or single format that ASI Entities use to publish GHG emissions and energy consumption. Most Entities publish these data in annual sustainability reports, however not in a standardised or consistent format. In other cases, further work and analysis were required to determine the data or convert it to a consistent and comparable unit.

For some Entities, the accessibility of published data was not straightforward. Examples include GHG emissions data for one Entity's (OC-3) ASI certified facilities. The data for the two certified aluminium smelting sites was split across two Governmental emission inventory sites and/or data were aggregated with other non-certified aluminium smelting sites. Another example was a Chinese Entity (CH-2) which published emissions data on company WeChat pages; whilst accessible to the Chinese market, these are not considered a common public source of information outside of China.

The format of the data was varied with some Entities publishing emissions and energy data in the form of charts or graphics, without providing numerical figures or values. In these cases, values were estimated from the visual representations presented in the charts.

Inconsistent or unusual data reporting units were another issue identified during the analysis. GHG emissions intensity was reported (or we estimated by calculation) by most Entities in units of 't $CO_2$e/t product'. However, several Entities reported this data in other more non-conventional units, which resulted in a reduction in transparency and comparability to others in the same supply chain activity. For example, Entity WE-8, a manufacturer of different packaging materials (plastic, aluminium, cardboard), publishes their intensities in 'company units', which is not convertible to weight. Similarly, Entity WE-11 publishes their emission intensities in 'kt $CO_2$-e/million $m^2$ foil products'; presumably this could be converted to 't $CO_2$e/t Al' units via the application of additional data and/or conversion factors. A multinational Entity (Multi-6) also reported their emissions intensity for two different regions in 't-$CO_2$e/t-Cu equivalents', alongside more conventional units.

Energy data were also published across a diverse range of units and at times, related to the energy source. These ranged from kWh, MWh, GJ or PJ for electricity, litres of diesel, tonnes of LPG/LNG, $m^3$ of natural gas, to tonnes of 'standard coal equivalent'. Where possible, all units were converted to kWh and GJ using conversion factors.

## 4.2 Challenges accessing Specific Data for each ASI Entity

In building an emissions and energy use database, one of the major challenges is that data is often aggregated and reported across an entire organisation. This can include multiple supply chain activities and/or multiple sites. In such cases, it is often difficult to find data that specifically relates to an ASI certified Entity. This problem was observed in 13 out of 51 Entities, mainly in the larger, multinational corporate organisations. However, it also can be seen in smaller organisations.

As an example, one multinational ASI Member (Multi-1) reports their energy consumption and GHG emissions for the entire organisation in their annual sustainability reports. The reported figures combine data from different supply chain activities as well as the Member's multiple ASI Entities – for the majority of these, complete sets of emissions and energy data are not explicitly reported, only in aggregated form within the corporate annual report. Some of Member's individual Entities do however publish their specific data separately on their own dedicated website. This issue appears in all large organisations assessed.

Aggregating an ASI Entity's data under a supply chain activity or group is also observed in other large corporates that publish comprehensive and very detailed datasets. In one good case study example, one multinational ASI Member published data according to country, type of emission and business units aligned with supply chain activities (e.g. Bauxite, Alumina, Smelting, and so on). However, data for one of the Member's specific Entities was not available and appears to have been aggregated within a business unit.

## 4.3 Limited Reporting of Energy Data

Disclosure of energy use figures (totals and intensity) was more limited compared to GHG emissions with no energy data identified for one-quarter of ASI Entities. While almost all Entities understand and comply with disclosing some GHG emissions information, many Entities appear less inclined to publish data on energy use and sources

## 4.4 Disclosing Emissions and Energy Use in Intensity Units

Both emissions intensities (i.e. t $CO_2$e/t product) and energy intensities (i.e. GJ/t product or kWh/t product) provide an ideal basis to benchmark the energy and emissions profile of different supply chain activities, and between different Entities. It was noted that over 50% of Entities preferred publishing data in total figures (GJ, kWh or t $CO_2$e) rather than per tonne of product. In such cases, intensity values were estimated using reported production figures, where available (see section 3.1). However, for almost 40% of Entities, production figures were not disclosed in either their sustainability or annual reports, which makes it challenging to estimate the energy and emissions intensity. The lack of intensity values (either reported or the means to calculate using production figures) reduces the level of transparency and ability to benchmark Entities within the same supply chain activity.

In other Entities, only energy and emission intensity values were published and not totals. Where production figures were available, these were used to convert intensities to totals.

## 4.5 Conflicting Data from Different Sources

Some Entities that report emissions in multiple locations – for example, in a sustainability report and a CDP report – appeared to have conflicting figures, with material differences (>10%). In one Entity (WE-12), the Scope 2 and Scope 3 GHG emissions reported to the CDP was two-times (in 2017, 2018) and eight-times higher (in 2017) than those reported in sustainability reports, respectively. In another Entity (Multi-3), energy consumption reported to the CDP differs by up to 80% (Scope 2) from figures published on their website; similarly, there are differences in GHGs reported in their 2018 sustainability report and their online Data Centre.

### 4.6 Recommendation - Standardised Reporting or Data Templates

The standardisation of data disclosures by ASI Members and Entities would significantly enhance transparency and provide an efficient means to profile or benchmark the membership's energy and emissions performance. These could then inform the work of ASI's Monitoring & Evaluation program and GHG Working Group regularly, and would, in turn, provide valuable input into the review of the ASI Performance and Chain of Custody standards.

Given the challenges reported above, it is recommended that ASI consider the creation and adoption of consistent data templates, standards and/or reporting requirements for ASI Entities in their disclosures of emissions and energy performance. This could include revised guidance to support the following:

- Reporting of data specific to each certified ASI Entity (as opposed to data being aggregated within a larger corporate, region or activity)
- Reporting of data for specific supply chain activities, if Entities are engaged in more than one
- Minimum reporting requirements for energy use – totals, intensities, and sources of energy % and electricity %
- Minimum reporting requirements for GHG emissions – totals, intensities, Scope included (e.g. 1+2 at a minimum); these could also include consistent definitions of Scope 3 emissions and global warming potential (GWP) values used for calculation (whether from the latest IPCC Assessment Report, or older)
- Consistent, standard units for all data reported – particularly for energy and intensity values.

Rather than imposing requirements on ASI Entities to tailor their sustainability reports strictly to ASI's guidelines, an alternative implementation pathway could be through the supply of standard data templates (e.g. a MS Excel template) to all ASI members, which then return annual data responses on emissions and energy performance in the standard format. If desired, ASI could annually update and publish energy and emissions profiles of its membership, for example, on an online dashboard. This could be in an anonymised form, e.g. profiles by region or supply chain activity.

### 4.7 Promising Uptake in Data Disclosures by New ASI Members

This review highlighted that there had been a recent uptake of energy, emissions and general sustainability disclosures by new ASI members, many of which did not have the practice of such disclosures prior to ASI certification. This trend was particularly noted in new members in developing regions/nations, such as in China. Whilst there is still room for improvement in the quality, standardisation and format of these data disclosures, this highlights ASI's impact in encouraging positive change by its members, through the ASI certification process.

It is hoped that ongoing transparency and the tracking of the energy and emissions profile of ASI Member organisations will help drive significant changes in the overall carbon footprint of global aluminium production.

# 5 GHG Emissions and Energy Profile of ASI Members

This section of the Report provides an overview of some of the general trends in GHG emissions and energy use for the ASI membership, particularly across the different supply chain activities, regions and countries. As comprehensive datasets were not available for the entire ASI member base, the emissions and energy profile presented here should not be considered as a comprehensive illustration of the ASI member base

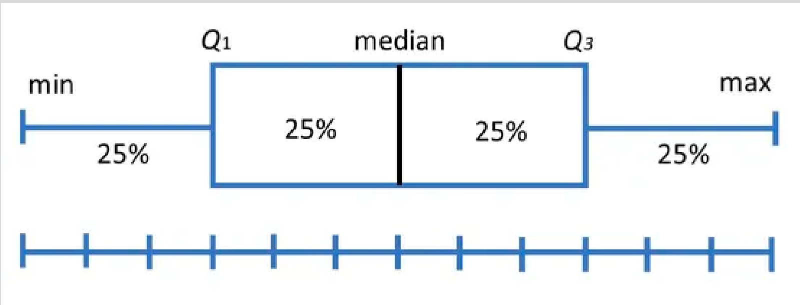
Energy and emissions intensities (GJ/t product and t $CO_2e$/t product respectively) are used for comparisons across supply chains, regions and countries. Whilst a comparison of totals is possible (see provided database and graphics), these mainly reflect any differences in production scale from one Entity to another.

For Greenhouse Gas Emissions, the focus in this report is on trends in Scope 1+2 emissions. Although the number of Entities reporting Scope 3 emissions is increasing (particularly in the Remelt-to-Downstream and Downstream activities), uptake is not widespread. Furthermore, some variation in how Entities interpret and define Scope 3 emissions was observed. Graphical illustrations for Scope 1+2+3 emissions are available in the provided database.

For comparison along the supply chain, energy and emissions data were analysed by activity (Bauxite, Alumina, Smelting, Remelt-to-Downstream, Downstream) and by region, and are depicted using *Boxplot* charts. Histograms are also used as an alternative means of data display.

**Introducing the Boxplot**

Also known as 'Box and Whisker Plots', these are a useful way to visualise differences amongst groups of samples (e.g. regions, supply chain activities, etc.) – particularly in the range and statistical distribution of data. As shown in the graphic below, the sides of the 'box' illustrate the position of the 25$^{th}$ and 75$^{th}$ percentiles (or 1$^{st}$ and 3$^{rd}$ quartiles), whereas the line inside the box denotes the median (50$^{th}$ percentile). The 'whiskers' indicate the minimum and maximum values, thereby showing the range of data. Statistical 'outliers' (if any) are denoted by stars (*).




A more in-depth explanation of boxplot charts can be found here (Source: McLeod, 2019).

When interpreting the boxplots presented here, please note that the number of Entities represented by each 'box' category can differ significantly from one category (e.g. supply chain activity or region) to the next. For instance, only a small amount of data was found for bauxite and alumina supply chain activities. Hence the distribution of data (if any) appear to be 'tighter' for these two activities, compared to Smelting or Downstream with data from multiple Entities.

## 5.1 Trends in Energy Consumption

Figure 1 and 2 both illustrate the energy profile across the ASI membership's supply chain. The lack of published data for both Bauxite and Alumina supply chain activities is a notable observation. As expected, the Smelting activity presents with the highest energy use but also varies more widely between Entities compared to Remelt and Downstream activities. The median energy use for smelting activities is just under 60 GJ/t product, compared to 5-7 GJ/t product for the Remelt and Downstream supply chain activities. In all activities, the median is closer to the lower quartile, and there are several outliers with much higher energy consumption.

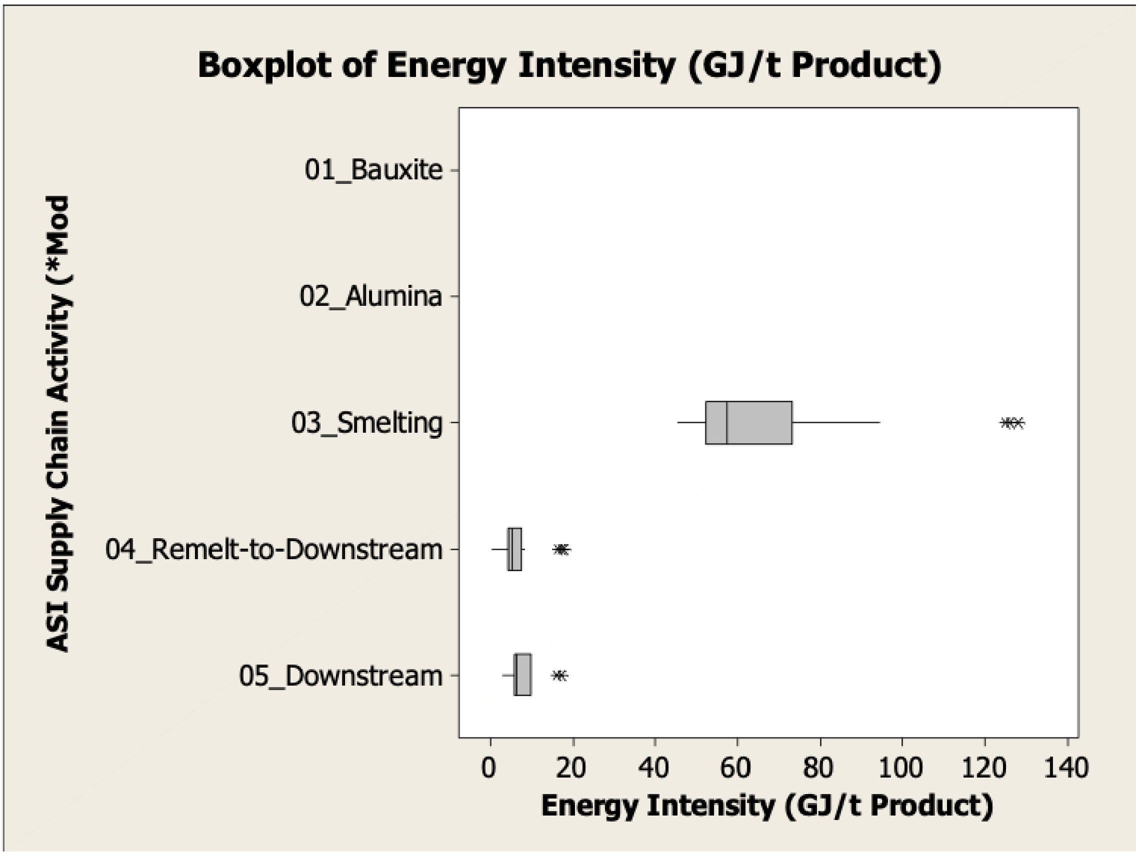



*Figure 1: Boxplot – Energy intensity (GJ/t product) for ASI Entities by supply chain.*

Figure 3 illustrates the distribution of energy profiles by region. Of interest is the considerable variation in the Smelting activity, particularly with Entities in the GCC region. This is related to the 'outlier' data from one of the GCC Entities (GC-2), with energy intensities twice the median of ~60 GJ/t; however, this is because the Entity accounts for *total fuel consumption* from electricity production in its onsite captive gas-fired power plants (often 35-50% efficient and includes thermal losses). Smelting Entities in West Europe appear to have lower energy intensities compared to other regions. Whilst no data is reported from China, data from that region might be expected to be located on the lower end (due to intense economic pressures for smelters to reduce energy consumption).

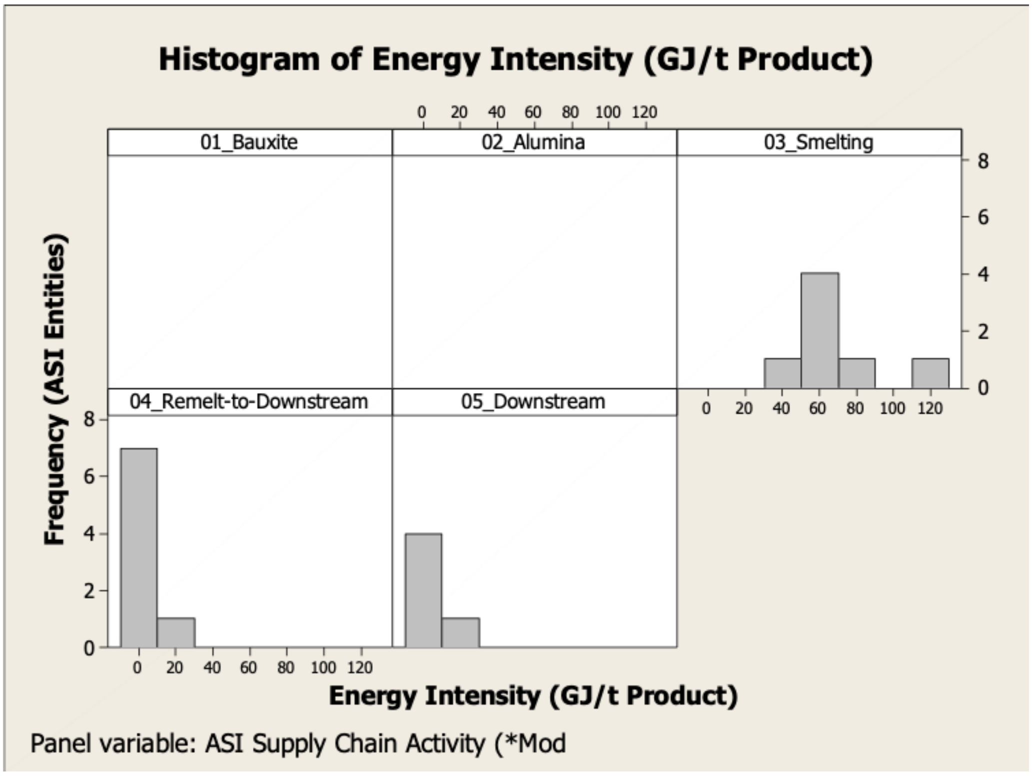



*Figure 2: Histogram – Energy intensity (GJ/t product) by supply chain.*

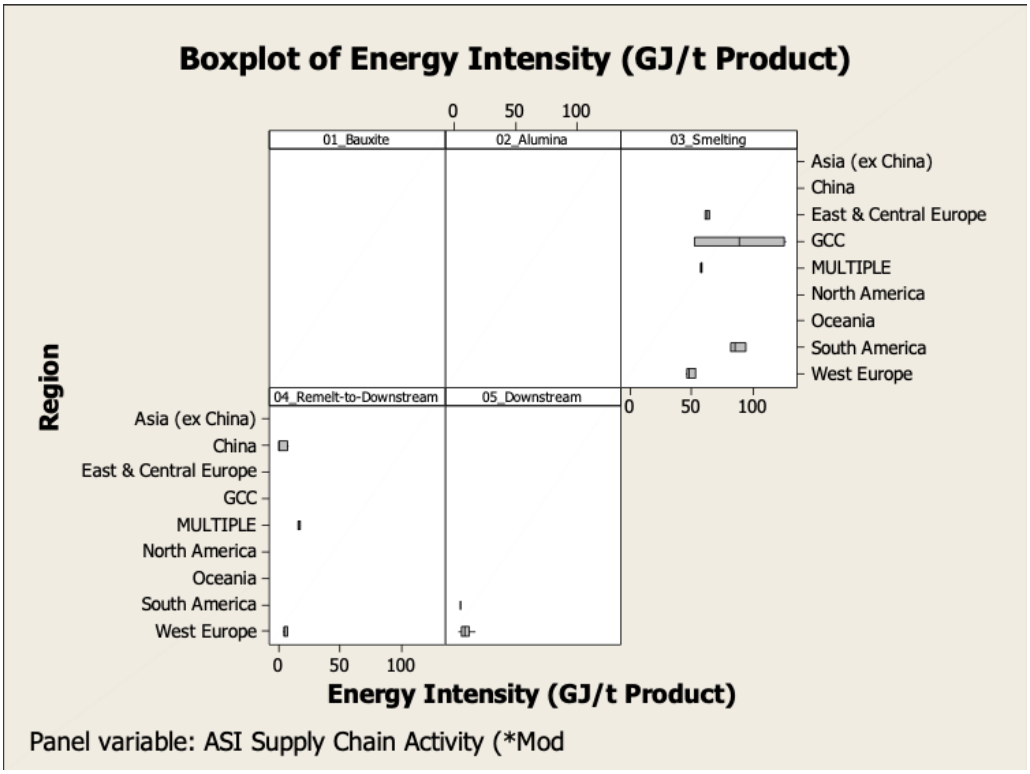



*Figure 3: Boxplot – Energy intensity (GJ/t product) by supply chain and region.*

## 5.2 Trends in Greenhouse Gas Emissions (Scope 1+2)

As expected, the trends in GHG emissions intensity (Figure 4 and Figure 5) match those observed in energy use. As per its high energy profile (Figure 1), the Smelting activity is responsible for the highest emissions across ASI's range of supply chain activities and also displays a broad distribution compared to other supply chain activities.

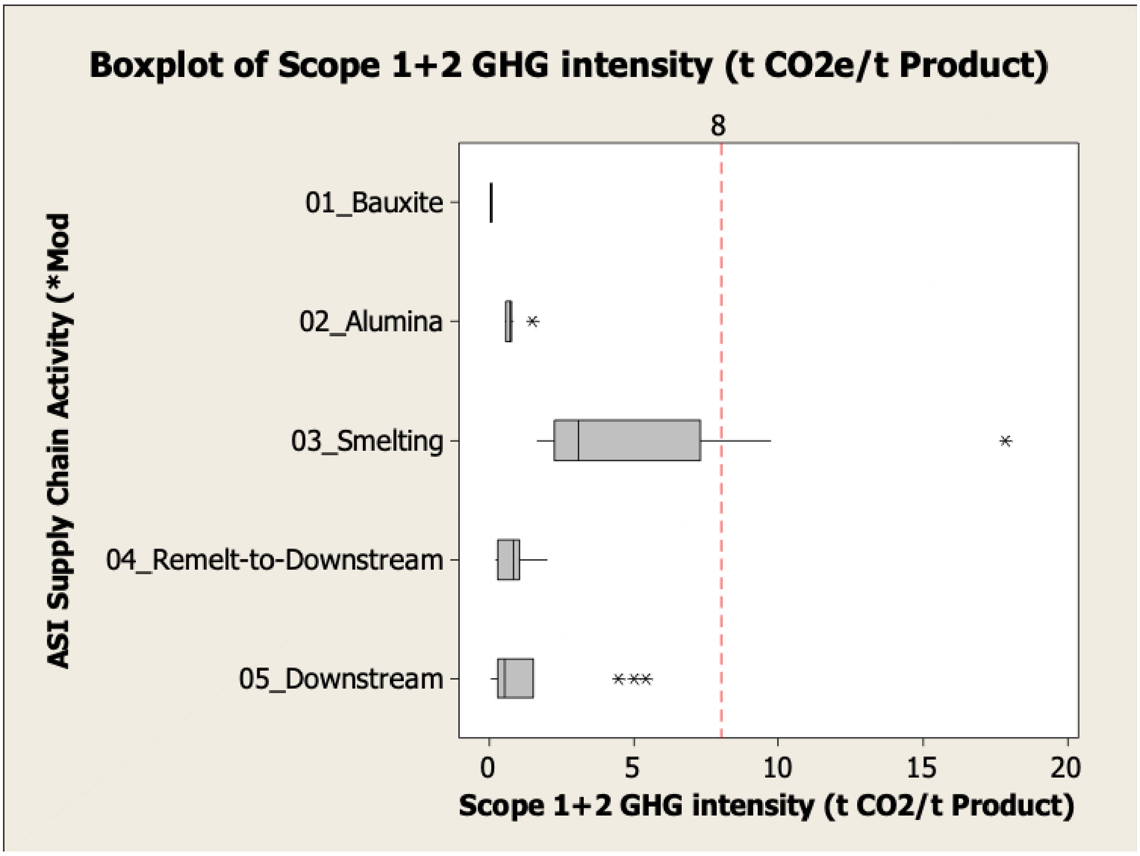



*Figure 4: Boxplot – Scope 1+2 GHG emissions intensity (t $CO_2e$/t Product) by supply chain.*

The median and average emissions intensity for Smelting Entities are 3.1 and 5.7 t $CO_2e$/t Al, respectively. As observed in Figure 5, seven out of 11 reporting Entities are at, or below, levels of 4 t $CO_2e$/t Al. These reflect the set of smelters with hydro-electric power sources. Of the 11 reporting Smelting Entities, nine are below the ASI target (PS criterion 5.3) of 8 t $CO_2e$/t Al.

The wide distribution of Smelting emissions is predominantly determined by the range of electricity sources, from 100% hydro with low emissions intensity per kWh (below 4 t $CO_2e$/t Al) to 100% natural gas (data points around the 8 t $CO_2e$/t Al region), and then 100% coal at the higher end, denoted by the outlier data point (marked as *) at 17.8 t $CO_2e$/t Al.

In terms of other supply chain activities, the histograms (Figure 5) clearly show that the narrow distribution of GHG emissions intensity in Bauxite and Alumina are also due to fewer reporting Entities.

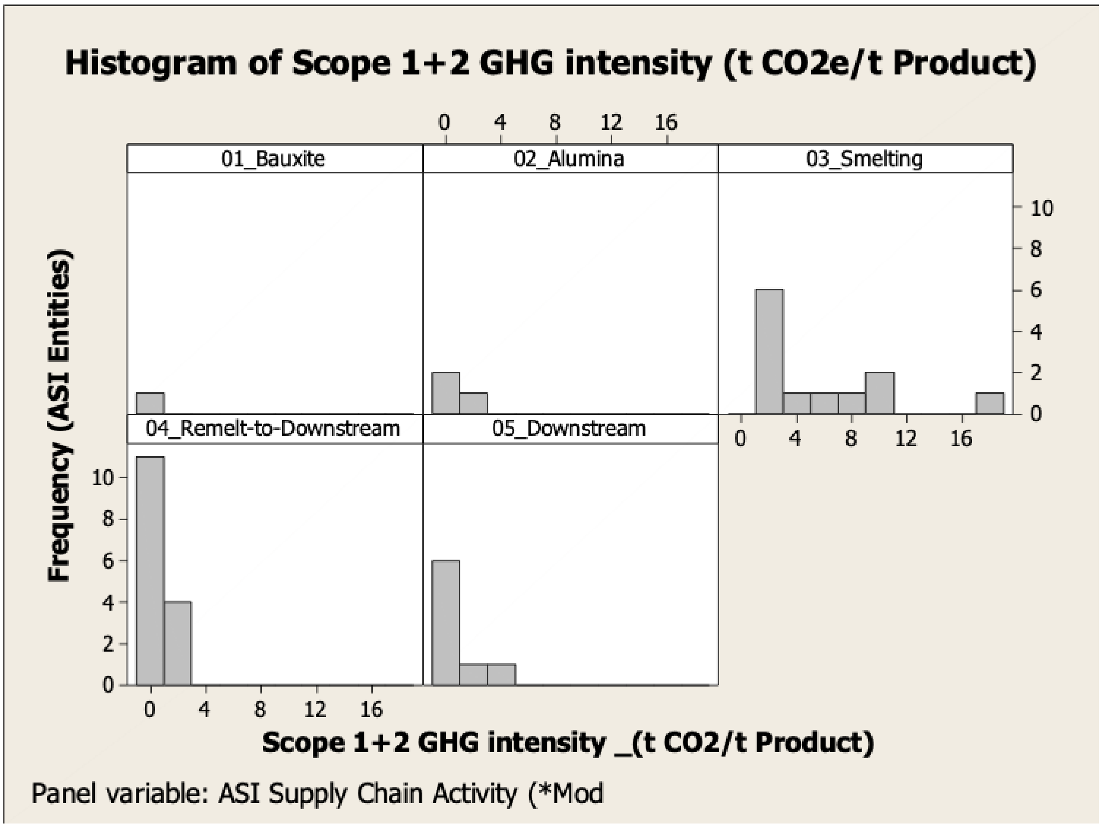



*Figure 5: Histogram – Scope 1+2 GHG intensities (t $CO_2e$/t Product) for each supply chain.*

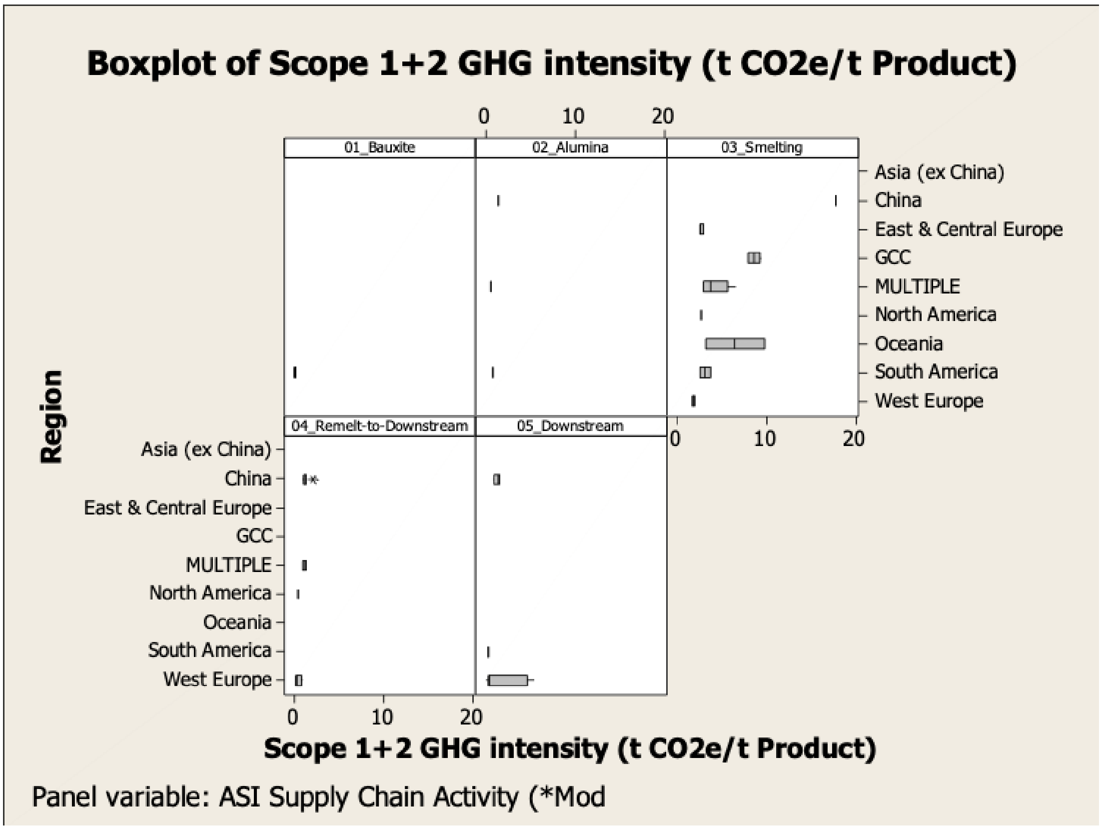



*Figure 6: Boxplot – Scope 1+2 GHG emissions intensity (t $CO_2e$/t Product) by supply chain and region.*

The Remelt-to-Downstream and Downstream activities are also at a lower level of emissions intensity compared to Smelting, with median values of 0.8 and 0.5 t $CO_2e$/t Al, respectively. The most substantial proportion of ASI members are in these two categories, with disclosures of GHG emissions intensity by 15 out of 19 Remelt Entities and 7 out of 13 Downstream Entities.

The boxplots in Figure 6 show the distribution of GHG intensities across all activities in different regions. As in previous charts – the Bauxite and Alumina activities only have few Entities; hence the distribution of GHG intensities is very narrow. The Smelting activity has Entities that are spread across multiple regions, with a wider variation.

## 5.3 Trends for the Aluminium Smelting Activity

To provide some global context in discussing the GHG emissions profile of ASI members, Figure 7 shows a 2018 force-ranked snapshot of GHG emissions intensity (Scope 1+2) for primary aluminium smelters worldwide, from lowest to highest (Carbon Trust, 2020). Those on the lower end of the scale (below 4 t $CO_2e$/t Al) mainly utilise hydro or other non-fossil fuel based sources of electricity, those on the plateau at the higher end (above 15 t $CO_2e$/t Al) from coal, and those in the centre (~8 t $CO_2e$/t Al) from natural gas. This figure suggests that based on 2018 performance, only 22.4 million tonnes of global primary production – roughly 35% of the global market – would be able to meet ASI's current GHG intensity target of 8.0 t $CO_2e$/t Al for smelters if applied today (ASI Performance Standard 5.3).

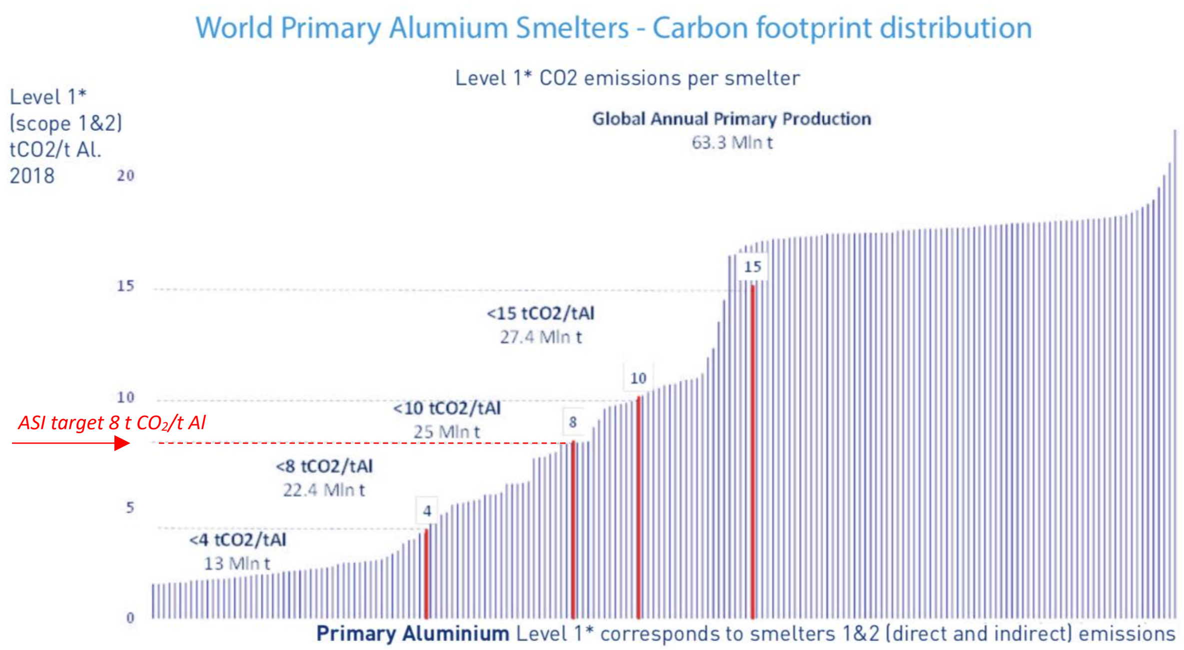



*Figure 7: Ranked global smelting production by Scope 1+2 GHG emissions intensity (t $CO_2e$/t Al) in 2018 (Source: CRU and Carbon Trust, 2020).*

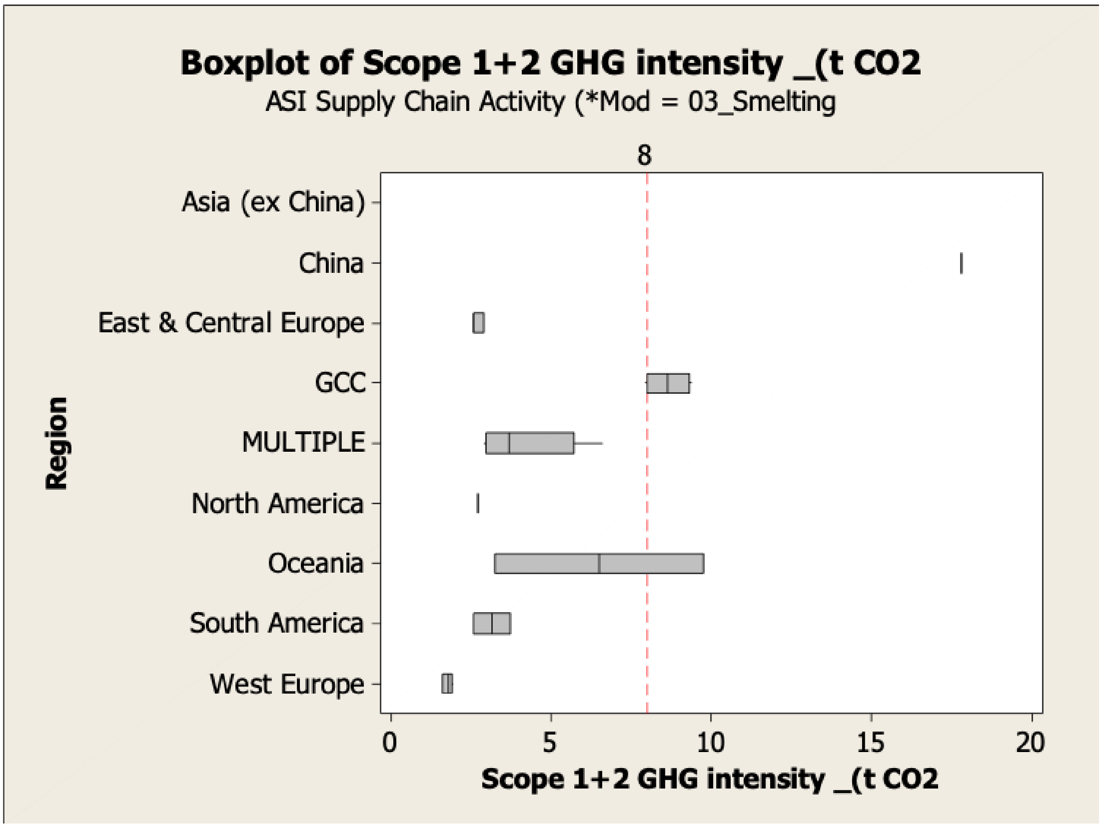



*Figure 8: Boxplot, Smelting activity – Scope 1+2 GHG emissions intensity (t $CO_2$e/t Al) by region.*

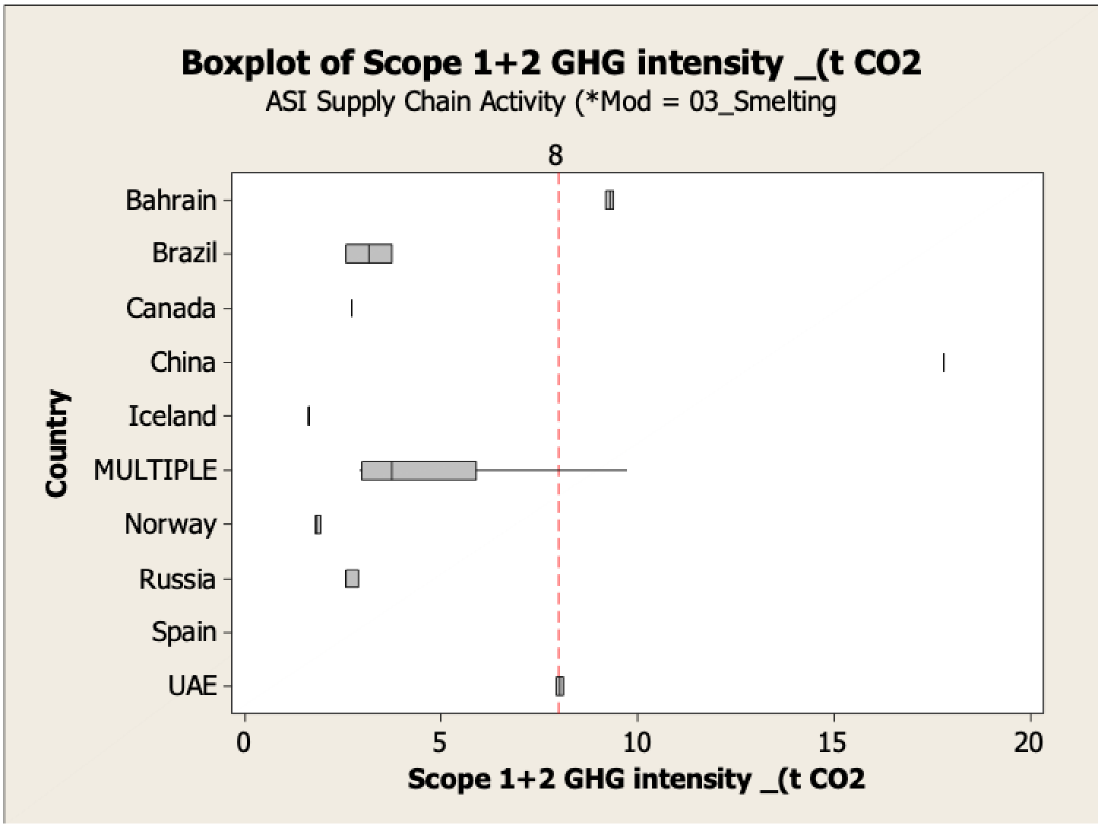



*Figure 9: Boxplot, Smelting activity – Scope 1+2 GHG emissions intensity (t $CO_2$e/t Al) by country.*

This context allows us to interpret the GHG profile of ASI's Smelting Entities, as presented by the boxplots by region and country in Figure 8 and Figure *9*, respectively. Some observations at the regional and country-level are presented next.

### *5.3.1 China*

The highest emissions profile is for an ASI Entity (CH-6) in China – refer to the single data point at 17.8 t $CO_2$e/t Al in both Figure 8 and Figure 9. This is unsurprising given the coal-intensive energy supply in this region. As with this Entity, any Smelting Entity with thermal coal as the primary energy source will find challenges in mapping out a realistic pathway to ASI's target of 8 t $CO_2$e/t Al by 2030. The only route is via major changes in the energy mix.

It is understood based on information obtained (Mo, 2019) and through previous experience, there is a concerted drive in China currently, to shift primary smelting production away from traditional smelting regions (e.g. Henan and other central and eastern provinces) to those in China's west, south-west and north, such as Xinjiang, Inner Mongolia and Yunnan. These latter provinces are more remote and less populated, with lower energy costs and potentially less stringent environmental regulations.

Some reductions in smelting energy intensity (e.g. from 13-14 kWh/t Al levels on a direct current (DC) basis, to 12 kWh/t Al or below) may come through the adoption of the latest smelting technologies as production is shifted to these new regions. However, material reductions in the overall carbon footprint will not come without significant shifts in energy mix. As suggested by both the IAI and IKE modelling (2018) of China's power mix for smelters, production in Xinjiang and Inner Mongolia is still powered by thermal coal, which does little to alter the existing carbon footprint. However, Yunnan and other southwestern provinces of Qinghai and Sichuan are endowed with substantial hydro-electric resources (with 80-85% hydro/renewables in the industrial energy mix). Shifts in production to these regions will, therefore, allow for some material change to the carbon footprint.

It is clear that there is a significant transition underway in China, which will continue for the next ten to twenty years, leading to a major energy transformation in China, particularly towards low-carbon energy sources. This may include uptake of small-scale nuclear, large-scale renewables, grid-scale energy storage, virtual power plants and even Demand-Side Response (DSR) from large energy users such as aluminium smelters – as highlighted in the IEA's *China Power Transformation* report (2019). As described by the IEA and in Wong *et al.* (2020), it is thought that the uptake of modulation technology and operations would allow smelters – both in China and in other parts of the world without access to hydro-power – to rapidly increase the uptake of renewables in their overall energy mix.

Given China is responsible for 55% of today's global primary smelting production capacity, whatever happens in this region will impact the entire industry's global carbon footprint. Therefore, any further engagement and/or uptake of ASI membership and certification by Smelting Entities in this region should be encouraged, with the hope of facilitating positive change over time.

If ASI were to look long-term at engaging and driving positive change in these smelters that are not currently hydro-powered, ASI could consider an alternative engagement and membership pathway (if not certification). Such an engagement arrangement may be best applied to those smelters that cannot practically meet the 8 t $CO_2$e/t Al emissions target by 2030 but still demonstrate real and material reductions over time. For example, this could include smelters that are:

- adopting greater proportions of less traditional renewables (solar and wind, rather than hydro) in its purchased or self-generated energy mix, and/or
- moving to provide 'virtual battery' or Demand-Side Response (DSR) services to energy grids, thereby allowing a greater penetration of solar and wind generation, and in turn reduce the overall carbon footprint of both aluminium *and* energy sectors.

#### *5.3.2 GCC*

The regional plot (Figure 8) suggests that the GCC Smelting Entities are sitting just above ASI's target of 8 t $CO_2$e/t Al for smelters. However on closer inspection at the country (Figure 9) and Entity level (Figure 10), this is made up emissions by one Entity (GC-1) as slightly above this target, and those in the other Entity (GC-2) just below the target. These reflect the carbon footprint of Smelting utilising a predominantly natural gas-based energy mix.

#### *5.3.3 Oceania*

The variation observed in the Oceania region is due to the inclusion of two data sets for Entity OC-3, one including only ASI certified smelters (with two hydro-powered smelters, at <4 t $CO_2$e/t Al) and the second with all smelters within the Entity, including two with non-renewable electricity sources (with overall average just under 10 t $CO_2$e/t Al).

#### *5.3.4 Europe, the Americas and 'Multiple' Regions*

ASI Entities in the remaining regions reviewed – West Europe, East and Central Europe, North America and South America – are all predominantly hydro-powered, and therefore are all below 4 t $CO_2$e/t Al). These include those in Iceland, Norway, Russia, Spain and Brazil. For those Members present across 'multiple' regions, there is a high proportion of hydro or renewables in their Smelting energy mix.

#### *5.3.5 Trends by Specific Entities*

Further Entity-level detail of GHG emissions and energy use (intensity and total) are provided in the bar charts in Figure 10 to Figure 13 (inclusive). These are also arranged by region.

Of the 11 Smelting Entities reporting GHG intensity data (Figure 10), only two ASI Entities, CH-6 and GC-1, are currently above ASI's target of 8 t $CO_2$e/t Al. As mentioned above, the 9.7 t $CO_2$e/t Al data point for Entity OC-3 should be disregarded as this includes non-ASI certified smelters; this is included here only for comparison. It is clear from this analysis that the current 8 t $CO_2$e/t Al target value discourages certification of smelters that currently use coal-based electricity sources.

In terms of energy intensity, GC-2 reported data appears to be unusually high (almost double the Smelting median of 60 GJ/t). Therefore, it is suggested ASI query whether these reported figures are accurate.

In terms of trends in emissions or energy use over time, most Entities are reasonably stable or reducing. Some exceptions include Entity Multi-1 (with varying divestments/investments over time) and GC-1 (2019 jump in total emissions and energy likely from new production coming online). Note that the above evaluation of trends was only possible for Entities that provided more than 1 year's data (this applied to 40% and 60% of Entities for emissions intensity and total GHG emissions, respectively).

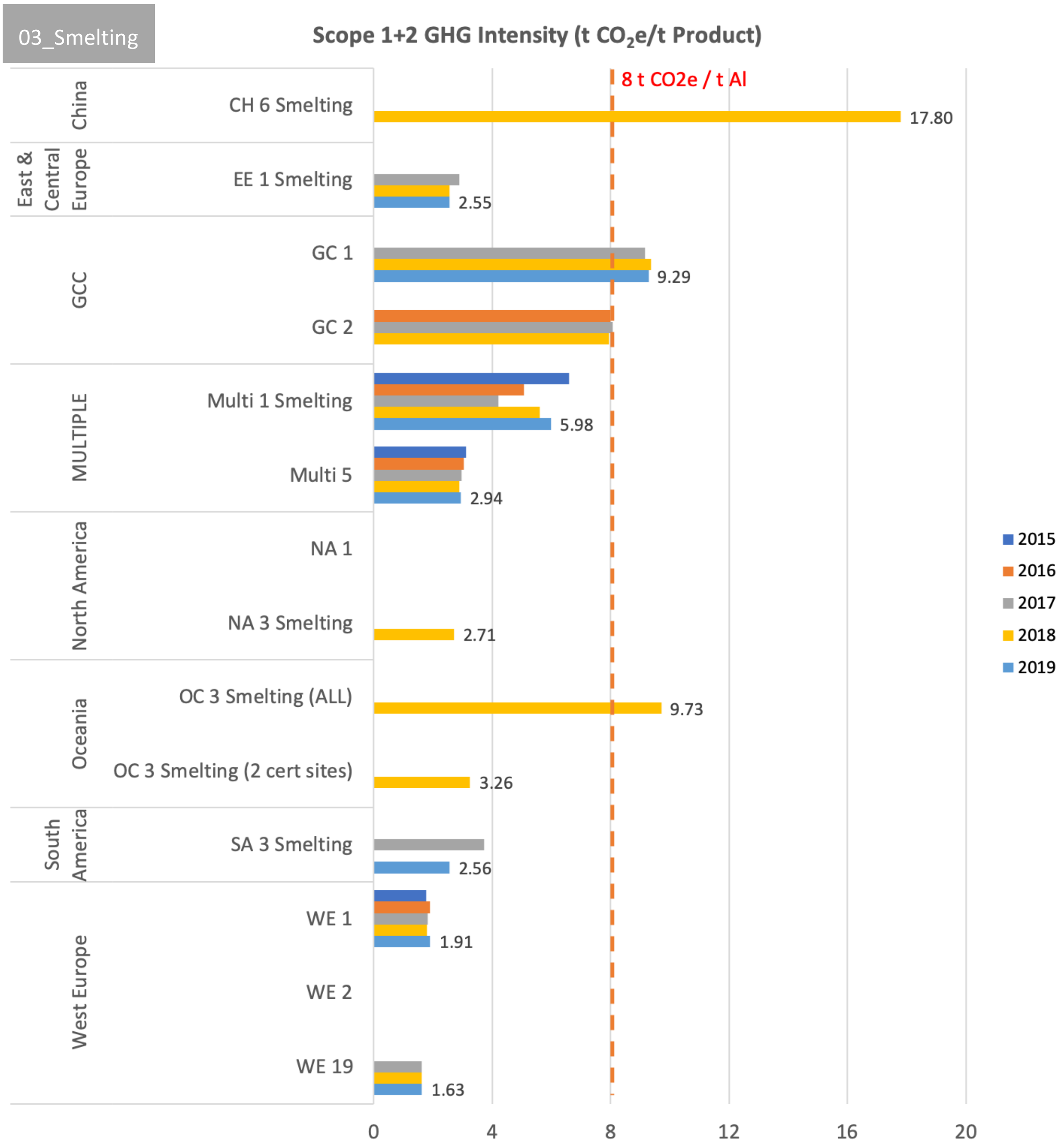



*Figure 10: ASI Smelting activity – Scope 1+2 GHG emissions intensity (t $CO_2e$/t Al) by Entity, with all years of available data shown.*

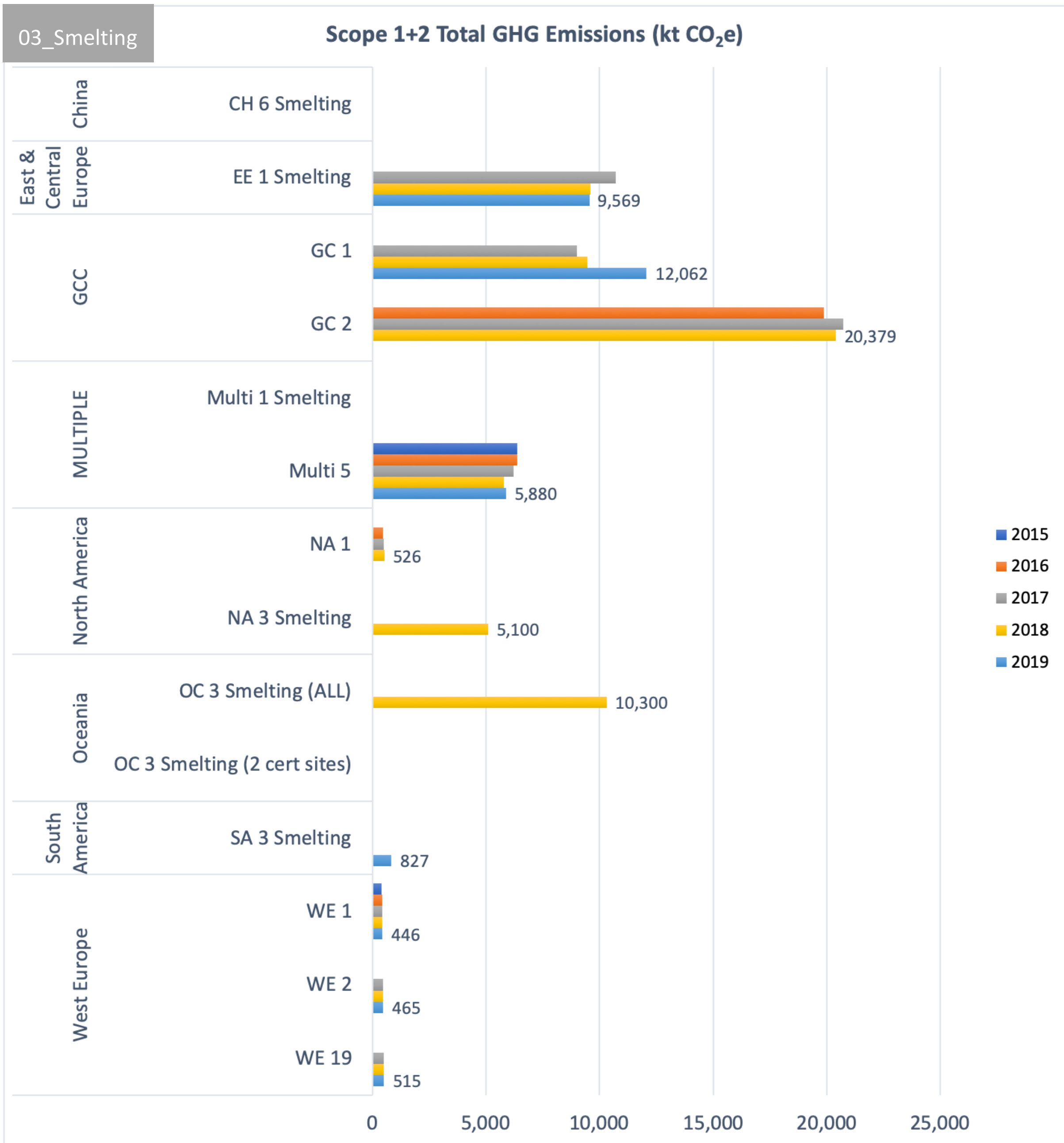



*Figure 11: ASI Smelting activity – Scope 1+2 GHG emission totals (kt $CO_2e$) by Entity, with all years of available data shown.*

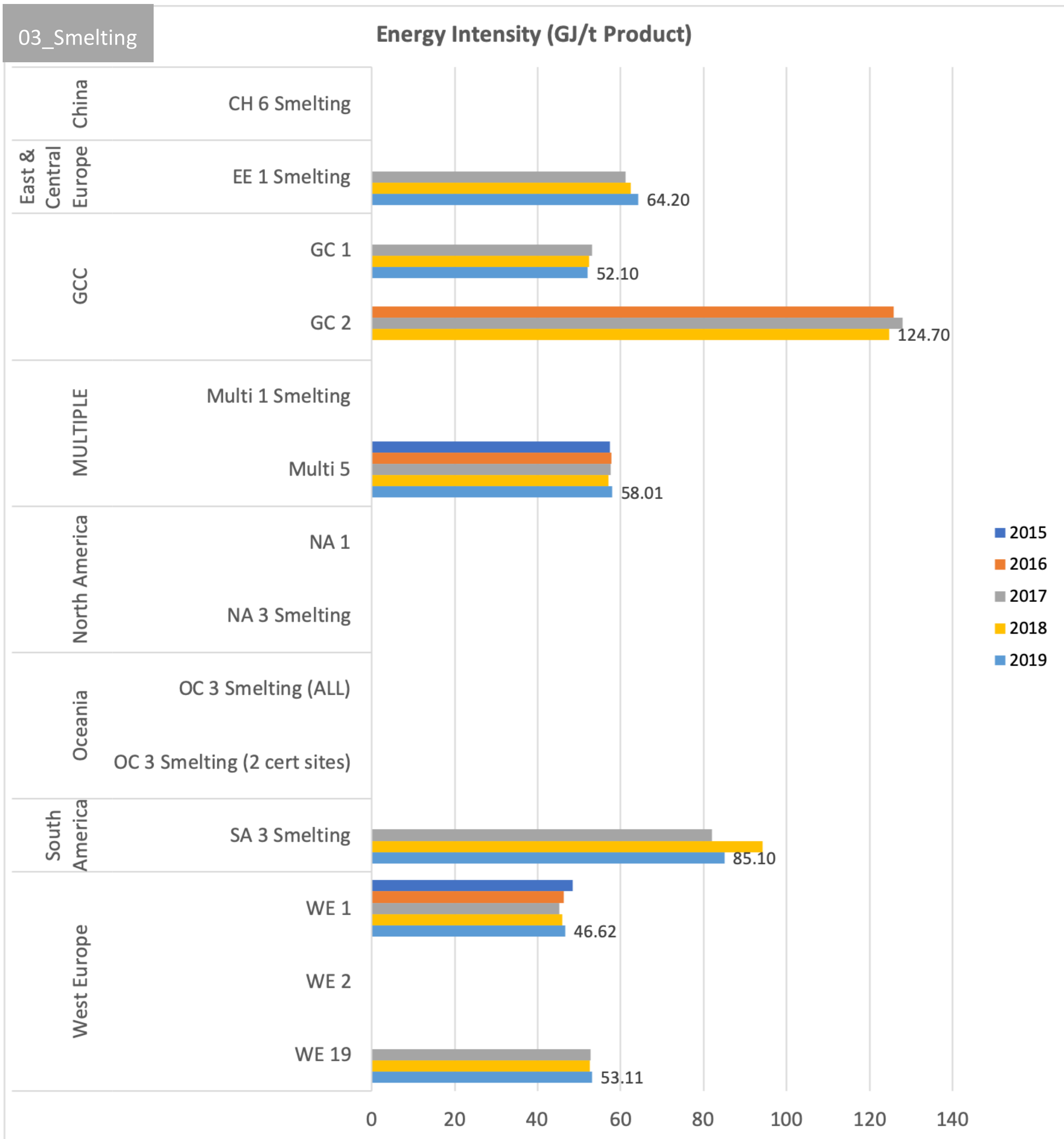



*Figure 12: ASI Smelting activity – Energy intensity (GJ/t Al) by Entity, with all years of available data shown.*

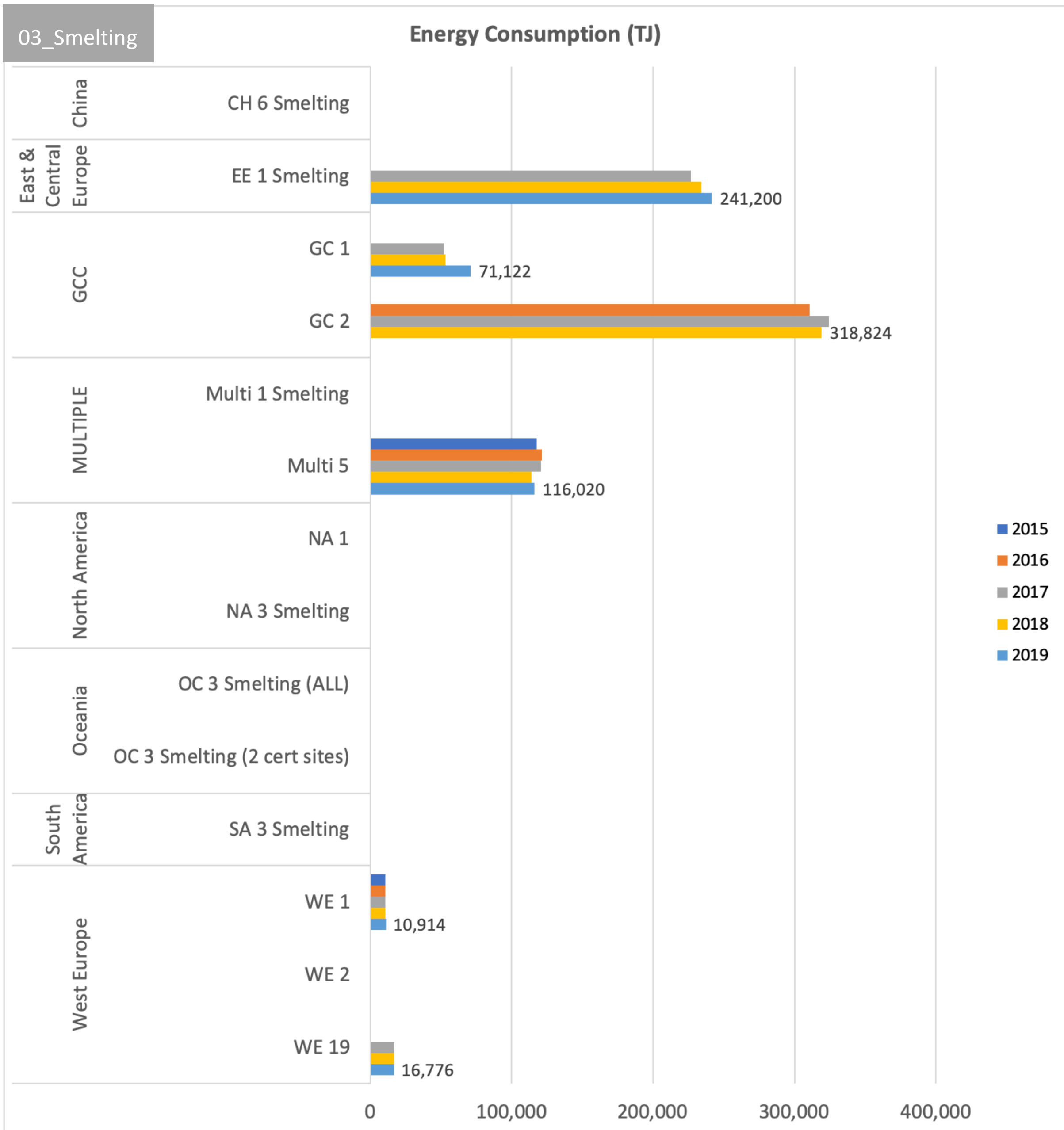



*Figure 13: ASI Smelting activity – Total energy consumption (TJ) by Entity, with all years of available data shown.*

## 5.4 Trends for the Alumina Refining activity

Only three out of five Entities engaged in alumina refining reported GHG intensity data for this supply chain activity (Figure 14). There is a wide variability between Brazil, China and those engaged across multiple countries, with emissions ranging from 0.5 to 1.45 t $CO_2$e/t alumina and with a median of 0.7 t $CO_2$e/t alumina.

However, the IAI's 2015 life cycle inventory modelling and analysis (published 2017) suggests that the carbon footprint attributed to the global alumina production supply chain activity is just under 3.5 t $CO_2$e/t Al – refer to Figure 15. Converted to alumina units (global average of 1.93 t alumina consumed per tonne of primary aluminium), this would be roughly 1.8 t $CO_2$e/t alumina. The ASI dataset is therefore situated well level below the IAI reported global carbon footprint.

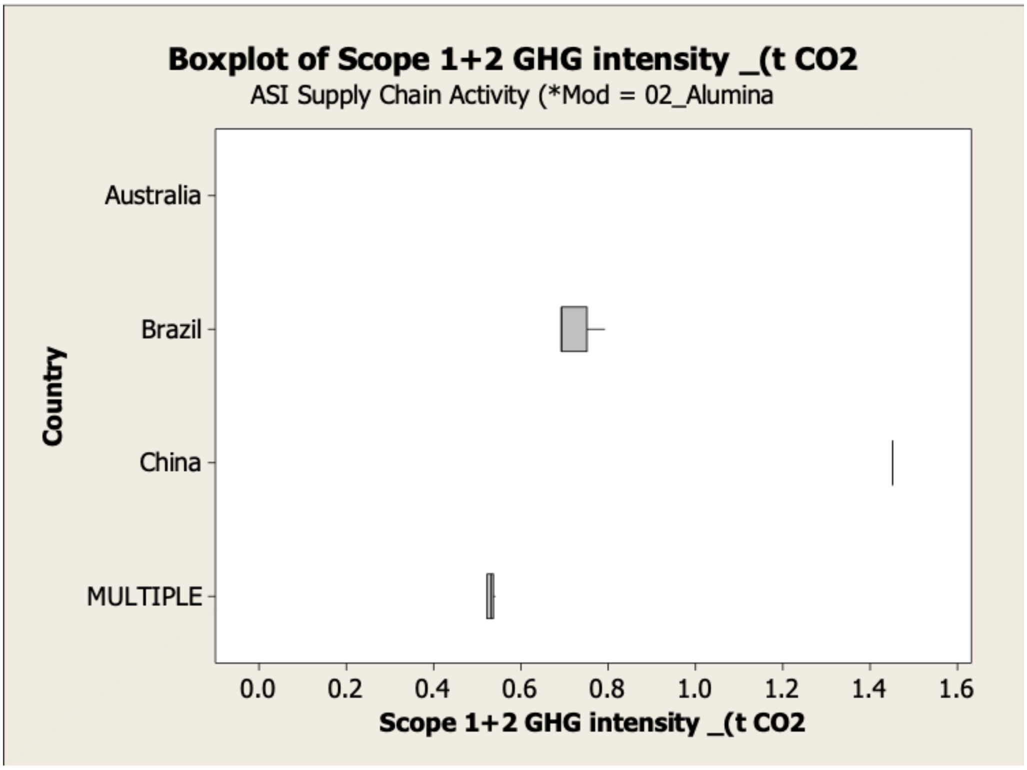



*Figure 14: Boxplot, Alumina activity – Scope 1+2 GHG emissions intensity (t $CO_2$e/t alumina) by country.*

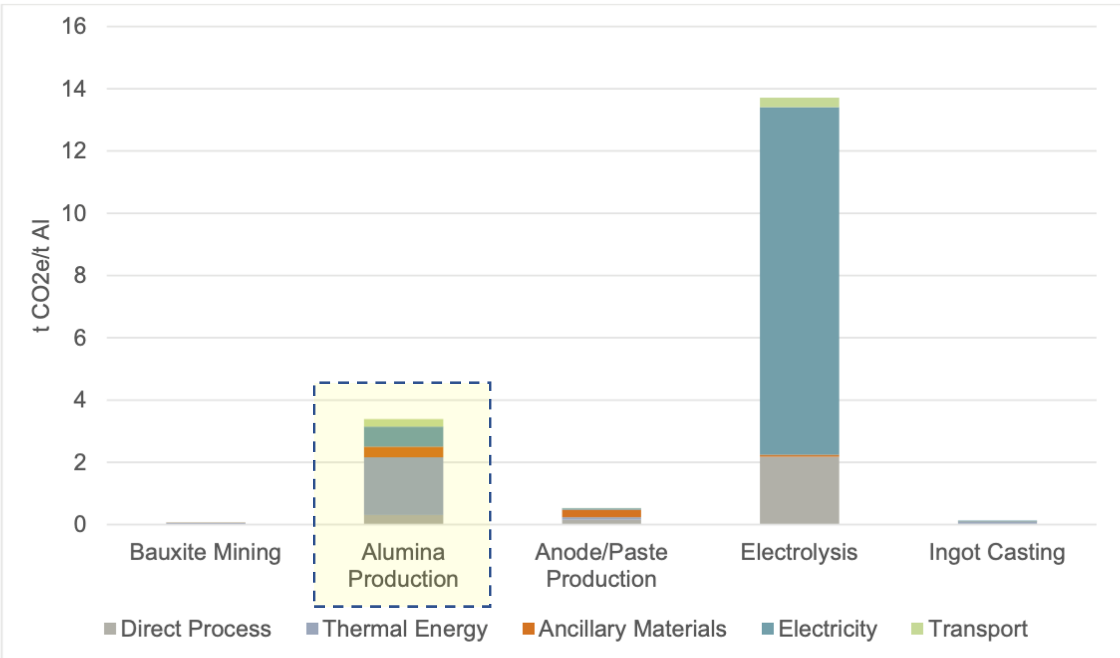



*Figure 15: Global average carbon footprint (t $CO_2$e/t Al) for primary aluminium's supply chain activities, with alumina production highlighted (Source: IAI, 2017).*

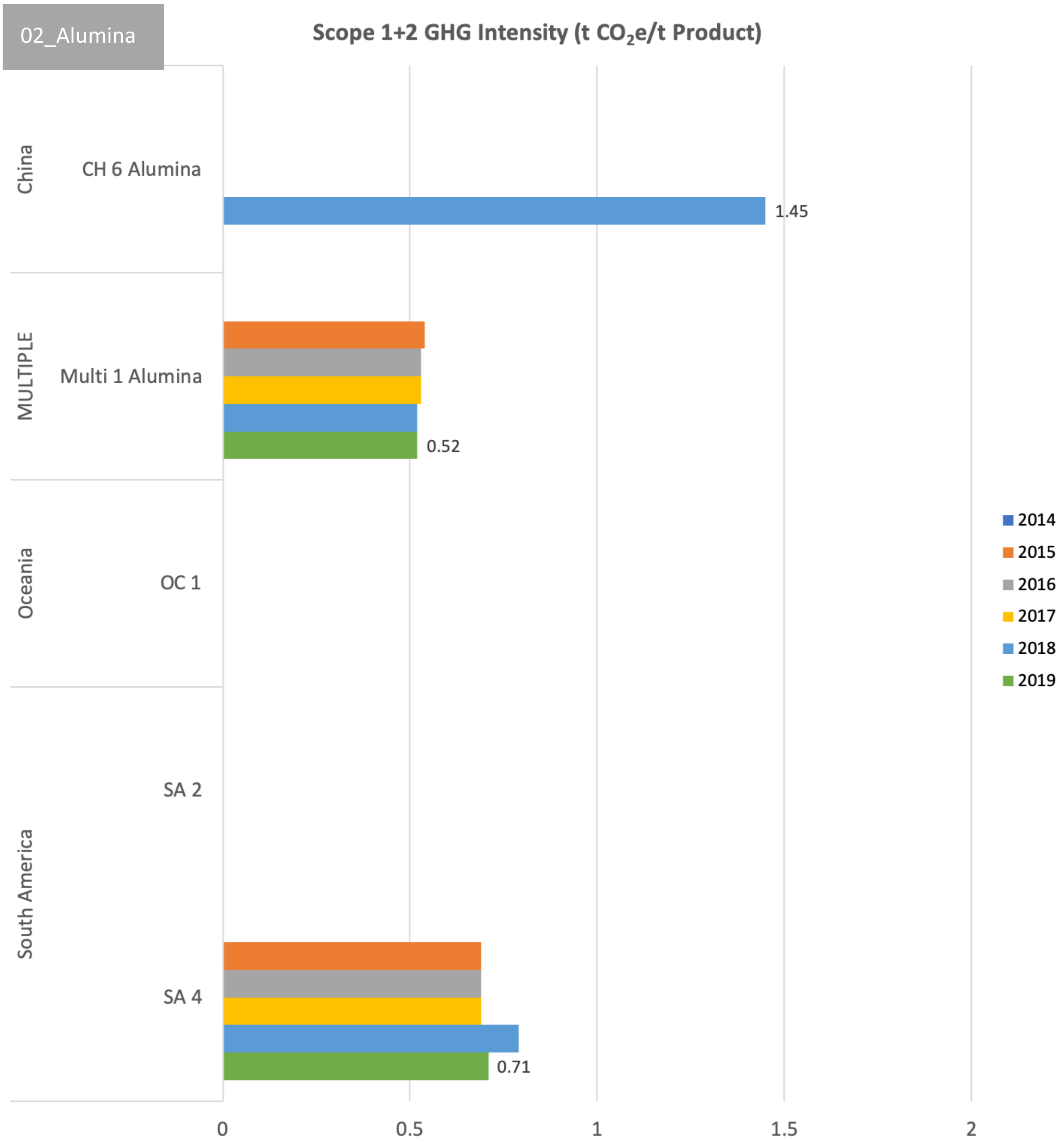



*Figure 16: ASI Alumina activity – Scope 1+2 GHG emissions intensity (t $CO_2$e/t Al) by Entity, with all years of available data shown.*


*Figure 17: ASI Alumina activity – Scope 1+2 total GHG emissions (kt $CO_2e$) by Entity, with all years of available data shown.*

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# Appendix I – List of ASI Entities

ASI Entities reviewed in this work are listed in the table overleaf, including their region, country and listed supply chain activity (as disclosed in ASI certification).

| ASI Member | Entity Name | Region | Country | Bauxite Mining | Alumina Refining | Aluminium Smelting | Aluminium Re-melting/ Refining | Cast-houses | Down-stream |
|---|---|---|---|---|---|---|---|---|---|
| **Alcoa Inc.** | Alcoa Aluminerie de Baie-Comeau | North America | Canada | | | Yes | | Yes | |
| | Alcoa Mosjøen | West Europe | Norway | | | Yes | Yes | Yes | |
| | Alcoa San Ciprián Smelter | West Europe | Spain | | | Yes | | Yes | |
| | Alcoa Western Australia Operations | Oceania | Australia | Yes | Yes | | | | |
| | Alcoa World Alumina (AWA) Juruti Mine | South America | Brazil | Yes | | | | | |
| | Consórcio de Alumínio do Maranhão – ALUMAR | South America | Brazil | | Yes | | | | |
| | Alcoa Corporation | MULTIPLE | MULTIPLE | Yes | Yes | Yes | Yes | Yes | Yes |
| **Aleris** | Aleris Aluminium Duffel BVBA | West Europe | Belgium | | | | Yes | Yes | Yes |
| **Aludium Premium Aluminium** | Aludium Transformación de Productos Alicante | West Europe | Spain | | | | | Yes | Yes |
| | Aludium Transformación de Productos Amorebieta | West Europe | Spain | | | | Yes | Yes | Yes |
| **Aluminium Bahrain** | Aluminium Bahrain B.S.C. (Alba) | GCC | Bahrain | | | Yes | | Yes | |
| **Aluminium Norf GmbH** | Aluminium Norf GmbH ("Alunorf"). | West Europe | Germany | | | | Yes | Yes | Yes |
| **AMAG Austria Metall AG** | AMAG Austria Metall AG | West Europe | Austria | | | | Yes | Yes | Yes |
| **Amcor** | Amcor Flexibles Rorschach | West Europe | Switzerland | | | | | | Yes |
| | Amcor Flexibles Singen | West Europe | Germany | | | | | | Yes |
| **ARCONIC** | Arconic Inc. | MULTIPLE | MULTIPLE | | | | | Yes | Yes |
| **Ball Corporation** | Ball Beverage Packaging EMEA (Europe, Middle East and Africa) | MULTIPLE | MULTIPLE | | | | | | Yes |
| **Bridgnorth Aluminium** | Bridgnorth Aluminium Limited | West Europe | UK | | | | Yes | Yes | Yes |

| ASI Member | Entity Name | Region | Country | Bauxite Mining | Alumina Refining | Aluminium Smelting | Aluminium Re-melting/ Refining | Cast-houses | Down-stream |
|---|---|---|---|---|---|---|---|---|---|
| **C.S. Aluminium Corporation** | C. S. Aluminium Corporation | Asia (ex China) | Taiwan | | | | Yes | Yes | Yes |
| **Companhia Brasileira de Alumínio** | Companhia Brasileira de Alumínio | South America | Brazil | Yes | Yes | Yes | Yes | Yes | Yes |
| **Constantia Flexibles International GmbH** | Constantia Teich, Weinburg, Austria | West Europe | Austria | | | | | | Yes |
| **Constellium** | Constellium Rolled Products Singen GmbH & Co. KG | West Europe | Germany | | | | | Yes | Yes |
| **Emirates Global Aluminium PJSC (EGA)** | Emirates Global Aluminium PJSC - Al Taweelah | GCC | UAE | | | Yes | | Yes | |
| **Eurofoil** | Eurofoil France | West Europe | France | | | | | | Yes |
| | Luxembourg site in Dudelange | West Europe | Luxembourg | | | | | | Yes |
| **Gränges** | Gränges Aluminium (Shanghai) Co., Ltd. | China | China | | | | | Yes | Yes |
| **Gulkula Mining Company Pty Ltd** | Gulkula Mining Company Pty Ltd | Oceania | Australia | Yes | | | | | |
| **Hammerer Aluminium Industries** | Hammerer Aluminium Industries Holding GmbH | West Europe | Austria | | | | Yes | Yes | |
| **Hydro** | Hydro Aluminium Extruded Solutions | West Europe | MULTIPLE | | | | Yes | Yes | Yes |
| | Hydro Aluminium Primary Metal | MULTIPLE | MULTIPLE | | | Yes | Yes | Yes | |
| | Hydro Aluminium Rolled Products | West Europe | MULTIPLE | | | Yes | Yes | Yes | Yes |
| | Hydro Bauxite & Alumina | South America | Brazil | Yes | Yes | | | | |
| | Hydro Extrusion Hoogezand B.V. | West Europe | Netherlands | | | | | | Yes |
| **Jiangsu Dingsheng New Materials Joint-Stock Co., Ltd** | Jiangsu Dingsheng New Materials Joint-Stock Co., Ltd | China | China | | | | Yes | Yes | Yes |
| **Jiangsu Zhongji Lamination Materials Co., Ltd** | Jiangsu Zhongji Lamination Materials Co., Ltd | China | China | | | | | | Yes |
| **Jupiter Aluminum Corporation** | Jupiter Aluminum Corp. | North America | USA | | | | Yes | Yes | Yes |

| ASI Member | Entity Name | Region | Country | Bauxite Mining | Alumina Refining | Aluminium Smelting | Aluminium Re-melting/ Refining | Cast-houses | Down-stream |
|---|---|---|---|---|---|---|---|---|---|
| **Kunshan Aluminium Co., LTD.** | Kunshan Aluminium Co., Ltd. | China | China | | | | | | Yes |
| **Lotte Aluminium Co., Ltd** | Lotte Aluminium Co., Ltd. Ansan Plant | Asia (ex China) | South Korea | | | | | | Yes |
| **Norðurál – Century Aluminum Company** | Norðurál Grundartangi | West Europe | Iceland | | | Yes | | Yes | |
| **Novelis Inc.** | Novelis Deutschland GmbH Werk Ohle | West Europe | Germany | | | | | | Yes |
| | Novelis Europe | West Europe | Germany | | | | Yes | Yes | Yes |
| **Rio Tinto Aluminium Division** | Rio Tinto | MULTIPLE | MULTIPLE | Yes | Yes | Yes | Yes | Yes | |
| | Rio Tinto Aluminium (RTA) Canada | North America | Canada | | Yes | Yes | Yes | Yes | Yes |
| | RTA Pacific Operations | Oceania | MULTIPLE | Yes | Yes | Yes | Yes | Yes | |
| **Shandong Nanshan Aluminium Co. Ltd.** | Shandong Nanshan Aluminium Co., Ltd. | China | China | | Yes | Yes | Yes | Yes | Yes |
| **Shandong Nanshan Aluminium Co. Ltd.** | Yantai Donghai Aluminium Foil Co., Ltd. | China | China | | | | | | Yes |
| **Shanghai Shenhuo Aluminium Foil Co., Ltd** | Shanghai Shenhuo Aluminium Foil Co., Ltd. | China | China | | | | | | Yes |
| **Suntown Technology Group Corporation Limited** | Suntown Technology Group Corporation Limited | China | China | | | | Yes | Yes | Yes |
| **Tianjin Zhongwang Aluminium Co., Ltd** | Tianjin Zhongwang Aluminium Co., Ltd | China | China | | | | Yes | Yes | Yes |
| **UC Rusal** | UC Rusal | East & Central Europe | Russia | Yes | Yes | Yes | | Yes | Yes |
| **Xiamen Xiashun Aluminium Foil Co., Ltd.** | Xiamen Xiashun Aluminium Foil Co., Ltd | China | China | | | | Yes | Yes | Yes |

Atmolite