Analysis of Implementation of Greenhouse Gas (GHG) Emissions Reporting from ASI Certified Entities:
March 2020 – March 2021 Update

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Disclaimer

Executive Summary

This report provides an analysis of greenhouse gas (GHG) emissions and energy use data disclosures by certified ASI Entities (both Performance Standard and Chain of Custody Standard). This is an update of a similar study in 2020 and incorporates recently certified ASI Entities, up to 31 March 2021. The study was commissioned by the *Aluminium Stewardship Initiative (ASI)* and was conducted by *Atmolite Consulting Pty Ltd*.

The findings here represent a snapshot of GHG and energy data disclosures as of June 2021, with granularity at the regional, country and supply chain activity level (from bauxite mining to downstream activities). Also included in this report is a comparison of publicly disclosed data from ASI Entities against data from CRU*'s Emissions Analysis Tool*, for primary aluminium activities.

In total, the review covered 55 ASI Member companies, of which there were 87 ASI Entities (expanding to 115 modified Entities, incorporating multiple supply chain activities by ASI Entities). ASI certifications have increased significantly (by 70%) since the last assessment (51 Entities in 2020). Of the 115 modified Entities, 21 are engaged in aluminium smelting and 9 in alumina refining; a further 9 Entities (all downstream activities) are not certified under the ASI Performance Standard V2 Criteria 5.1-5.3, and hence are not currently required to provide emissions/energy disclosures.

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

Assessing Quality of Data Disclosures from ASI Entities

The overall level and quality of data disclosure for various ASI Entities appears to be improving, compared to the 2020 review. Some improvements have resulted from these independent reviews (2020-21) and feedback to specific Entities regarding their disclosed data. In this 2021 assessment, 73% of certified ASI Entities provide either a comprehensive ('good') or reasonable ('medium) level of data disclosures, relating to their scope of certification; this includes 86% of aluminium smelting Entities and 55% of alumina refining Entities.

As observed in 2020, many newly certified ASI Entities – the majority of which are smaller enterprises located in China and Europe – are publicly disclosing their sustainability performance (e.g. GHG and other emissions, energy, waste, water usage) and social credentials (e.g. human rights, employee policies, communities) on their websites and reporting. Importantly, many of these Entities are now doing these sustainability disclosures *for the first time* in their company's history, as part of the ASI certification process.

Trends in Energy Intensity from ASI Entities

The *Smelting* supply chain activity exhibits the highest energy consumption per unit product, which reflects the large amounts of energy required to electrochemically split the strong Al-O bonds in alumina (Al_2O_3) to produce primary aluminium metal. Smelting has a median intensity of 53 GJ/t Al, compared to 10 GJ/t Al_2O_3 for *Alumina* refining activity, and 9.3 GJ/t product and 5.5 GJ/t product for *Remelt-to-Downstream* and *Downstream* activities, respectively.

Reductions in total energy intensity (GJ/t) over the past three to five years were observed for 12% of all Entities, 22% of *Alumina* refining Entities and 10% of *Smelting* Entities in 2021. Of Smelting Entities where trends could be assessed, almost 85% are either *stable* or *trending down* in energy intensity over time. Overall, *increases* in energy intensity were observed for 13% of all Entities, 11% of *Alumina* refining Entities and 10% of *Smelting* Entities in 2021.

Trends in GHG Emission Intensity (Scope 1+2) from ASI Entities

The *Smelting* activity is responsible for the highest emissions per unit product across the supply chain, with a median of 2.7 and average of 4.3 t CO_2e/t Al. It also has the most significant variation compared to other activities, ranging from 1.3 to 14.0 t CO_2e/t Al, driven by the range of electricity sources – from low carbon hydro, nuclear and renewables, to carbon-intensive coal and a whole power mix in between. The 14 ASI Smelting Entities with a higher share of low carbon (hydro, nuclear and renewables) sources as part of their power mix (often purchased power) are located in *Western* and *Eastern Europe*, *North* and *South America*, *Oceania* and in *multiple* regions. These are all operating at 5 t CO_2e/t and below. The *Gulf Cooperation Council* (*GCC)* Smelting Entities – predominantly using self-generated, natural gas-fired power – are between 8.0 and 9.3 t CO_2e/t Al. The highest emission intensity disclosure, at 14.0 t CO_2e/t Al, is for an Entity in *China,* predominantly using self-generated coal-fired power. Significant changes in the grid-energy mix for smelters which purchase their power, increasing grid connection of self-generating Entities, fuel switching and/or carbon capture, utilisation and storage (CCUS) by self-generating Entities are needed if coal-powered smelters are to meet the current 8 t CO_2e/t Al maximum threshold by 2030.

All other supply chain activities exhibit lower GHG emission intensities per unit product, with narrower distributions, a function of the fact that they are dominated by fuel combustion processes (to provide heat & steam) with similar fuel use and lower (mainly purchased) electricity intensity. *Alumina* refining Entities vary from 0.3 to 1.2 t CO_2e/t Al_2O_3, *Remelt-to-Downstream* from 0.1 to 4.5 t CO_2e/t product, and *Downstream* activities from 0.3 to 1.4 t CO_2e/t product.

Reductions in GHG emission intensity over the past three to five years were observed for 16% of all Entities, 22% of *Alumina* refining Entities and 19% of *Smelting* Entities in 2021. The majority of ASI's Smelting Entities are either *stable* or *trending down* over time in their disclosed emissions intensity; only one Entity exhibited minor *trends up*. Overall, *increases* in GHG emission intensity were observed for 6% of all Entities and 5% of *Smelting* Entities in 2021.

Comparing Data Disclosures with the CRU Emissions Tool

Comparisons were made between Entity data disclosures and CRU's *Emissions Analysis Tool* data set (2021) for six *Bauxite* mining Entities, nine *Alumina* refining Entities and 18 *Smelting* Entities. In general, the *Smelting* category had the best match between the two data sets – 67% of energy disclosures (based on power consumption only) and almost 85% of GHG emission disclosures were in either "good" (<5% discrepancy) or "medium" (5-20% discrepancy) agreement with the CRU data set. Overall, the CRU Emissions Tool is a very useful tool for benchmarking of ASI certified Entities throughout the primary aluminium supply chain, especially for the GHG emissions. It also provides asset-level data for existing 'gaps' in data disclosures, where they are missing or do not directly correlate to the scope of ASI certification.

Recommendations

Recommendations that could be adopted by ASI to further improve the quality, transparency and benchmarking of data disclosures, include:

a) Encouraging disclosures relevant to facility or activity, which allows aggregation to ASI certification scope level (not aggregated data that can include non-certified production sites or multiple processes);

b) Encouraging disclosures of not only electricity use, but total energy use and energy use per energy carrier (fuels, electricity, etc.) which is a more relevant proxy for GHG emissions and carbon footprint (particularly for non-Smelter processes); and

c) Standardising the scope and units of disclosure, both totals and intensities (per unit of production), preferably indicating the specific numerators and denominators used when intensities are reported. These could be implemented through use of standardised data reporting templates, such as those already employed by the International Aluminium Institute (IAI) and other industry associations.

Finally, as per the IAI's *Beyond 2 Degrees Scenario* (B2DS) to 2050 (IAI, 2021), the ultimate goal is decarbonisation of the *entire* aluminium sector, and particularly important for the primary aluminium smelting sector. Success will require *all* aluminium smelters to shift *down* the current emissions curve, particularly those currently using carbon-intensive sources of power. ASI could play a part in incentivising this by providing certification pathways for all smelters on the emissions curve, whilst ensuring clear, significant and time-bound emission reductions are demonstrated.

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1 Introduction

This project – '*Analysis of Implementation of Greenhouse Gas (GHG) Emissions Reporting from Certified ASI Entities: March 2020 - March 2021 Update'* – has reviewed greenhouse gas (GHG) emissions and energy use data disclosures by certified ASI Entities, according to ASI's *Performance Standards* (PS) and *Chain of Custody* (CoC) Standards. This includes an update of data from the previous 2020 project* and the inclusion of new Entities that have since been certified by ASI over the twelve month period up to 31 March 2021.

*The outcomes of the previous 2020 project were detailed in the report entitled '*Data Collation and Validation of Greenhouse Gas Emissions (GHGs) from ASI Members, as of July 2020*', dated 14 November 2020.

This project has been commissioned by the *Aluminium Stewardship Initiative* (ASI) – as part of its Monitoring and Evaluation (M&E) program – and has been prepared by *Atmolite Consulting Pty Ltd* (ATMOLITE).

1.1 Objectives

The main objectives of the project were to:

- Provide an update on energy use and GHG emissions disclosures in ASI Entities previously covered in the 2020 project data set.
- Incorporate recently certified ASI Entities since the completion of the previous 2020 project data set.
- Compare energy use and GHG emissions across the ASI aluminium supply chain activities, from bauxite mining to downstream activities.
- Analyse trends in both (a) the implementation and quality of data disclosures from ASI Entities and (b) in actual reductions of energy use and GHG emissions by these Entities over time.
- Compare / cross-reference publicly disclosed data from ASI Entities with data obtained from the *CRU Emissions Analysis Tool* (CRU International Ltd, 2021), to assess potential data integrity issues.
- Refine the technical context for ASI in its oversight of the Performance Standard Principle 5, which relates to GHG emissions, and in its current Standards Revisions process for both the PS and CoC standards.

1.2 ASI Performance Standard – Principle 5

Focused on Greenhouse Gas Emissions, Principle 5 of the ASI *Performance Standard* (PS) (Version 2, December 2017) mandates for all ASI Entities:

- The reporting and public disclosure of GHG emissions and energy use by source, on an annual basis (PS Criterion 5.1).
- Commitments to reducing GHG emissions over time through the setting of targets and implementation plans to reach these (PS Criterion 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_2e / t Al) by 2030 for existing smelters, or by 2020 for new smelters (PS Criterion 5.3).

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

- Scope 1 as *direct* GHG 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 (Version 1, December 2017), Criterion 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 casthouses or downstream processes.

2 Data Collection and Scope

2.1 ASI Members and Entities

The data collection and validation exercises were based upon the list of ASI Entities certified as of 31 March 2021. Including both PS and CoC certified Entities, data were reviewed for:

- **55** ASI Members, under which there were:
    - **87** ASI Entities*, the scope of which varied from single-site facilities, multiple site facilities, or corporate divisions (across multiple countries). This is a 70% increase in the number of ASI Entities reviewed compared to 51 Entities in the 2020 assessment.
    - **21** ASI Entities engaged in aluminium smelting.

*Note that:

- Some of the 87 Entities reported separate data for individual supply chain activities; these were captured as additional data entries, expanding the 87 Entities to a total of **115** 'modified' Entities. For example, Company 'A' might report data for bauxite, alumina refining and smelting activities, providing up to three unique 'modified' data entities as reported here.
- Ten percent of ASI Entities reviewed (nine out of 87) are not currently certified for ASI's Performance Standard Criteria 5.1-5.3, and therefore are not required to disclose GHG emissions and energy use data under the ASI Performance Standard; currently, these Entities are only certified for ASI's Performance Standard Principle 4 (Materials Stewardship).

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.

This report uses generic labels (regional code and numeral) to refer to specific ASI Entities, where specific commentary is provided. For example, the Entity label '*SAM-1*' refers to Entity #1 in South America. Regions are denoted as follows:

- North America (NAM)
- South America (SAM)
- West Europe (WEU)
- East & Central Europe (EEU)
- China (CHN)
- Asia ex-China (AS)
- GCC (GCC)
- Oceania (OCN), and
- Multiple regions (Multi).

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

55 ASI Members, under which there are:

87 ASI Entities* (PS and CoC inclusive)

*Data obtained for **115** unique entries for ASI Entities (including split-offs for different supply chains within the same Entity).

8 regions		**27** Countries		**6** supply chain activities	
Regions [a]		**Countries**		**Supply Chain Activities** [b]	
North America	4 Entities	Australia	2 Entities	Bauxite Mining	8 Entities
South America	5	Austria	2	Alumina Refining	10
West Europe	38	Bahrain	1	Aluminium Smelting	21
East & Central Europe	3	Belgium	1	Re-melting / Refining	35
China	15	Brazil	5	Casthouse	53
Asia (ex-China)	2	Canada	3	Downstream [d]	59
GCC	2	China	15		
Oceania	3	Croatia	1		
MULTIPLE [c]	14	France	5		
		Germany	7		
		Greece	1		
		Iceland	3		
		Italy	3		
		Luxembourg	1		
		Netherlands	1		
		Norway	2		
		Romania	1		
		Russia	1		
		South Korea	1		
		Spain	5		
		Sweden	1		
		Switzerland	1		
		Taiwan	1		
		Turkey	1		
		UAE	1		
		UK	1		
		USA	1		
		MULTIPLE [c]	19		

[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.

2.2 Collection of Data Disclosures from ASI Entities

2.2.1 Timing of Data Collection

Collection of GHG emissions and energy data disclosures was undertaken from mid-May to end June 2021. The findings reported here, therefore, represent a snapshot of GHG data disclosures as of May-June 2021, and do not consider more recent updates in data disclosures by ASI Entities.

Whilst this exercise focused on the most recent data disclosures available (often 2018, 2019 or 2020), up to five years' historical data were also collected to examine trends over time. Data obtained was on the basis of either calendar year or fiscal year.

2.2.2 Data Disclosure 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.
- *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 Assessment (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 not always 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).
- *In cases where no data was readily available,* attempts to contact the Entity (via ASI) were made to find links to publicly assessable data.

**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

An in-depth review or verification of energy balance or emissions inventory calculations from each ASI Entity was not undertaken, as this was beyond the Terms of Reference for this project. Where unusual data or numbers were observed, these have been highlighted in the database.

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.

Finally, some data aggregation and conversions were required in this study (see Section 3.1) in order to generate a data set that correlated with the certification scope of each ASI Entity. Whilst these aggregate/conversion calculations were internally verified, it is acknowledged that calculation errors are 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), Total 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 (dry), alumina, liquid aluminium, aluminium, other)
- *Supply Chain Activity* – Bauxite Mining, Alumina Refining, Aluminium Smelting, Aluminium Re-melting/Refining, Casthouse, Downstream.

*Note that energy use data obtained refers to total final energy from all sources, i.e. not only electricity, but also other fuels and energy carriers (diesel, natural gas, coal, steam etc.), where available and disclosed by the Entity. In this analysis, total energy use in 'TJ' or 'GWh' units represent direct conversions of one another, using a default factor of 3,600 joules per Watt hour. The primary energy required to deliver the final energy used (e.g. fuel extraction, processing, combustion and transmission losses to deliver a unit of electricity) is not included.

Tables providing graphical outputs of these data are also embedded in the database files. 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 those emissions data considered absent and/or energy variables using other published data. This allows for a more meaningful comparison across the cohort of ASI Entities. For example:

- Missing *intensity values* for emissions and energy use (e.g. t CO_2e/t Al) were calculated from emission and energy 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 many ASI Entities that were *single-site* facilities, disclosures of energy and GHG emissions data for these single sites were not readily available; instead these Entities pointed to data disclosures for their parent / corporate entity (e.g. the ASI Member). However, where the ASI Member had disclosed

relevant emissions and energy data, these were used to 'fill the gaps' for the specific ASI Entities. Specific cases of where this occurred have been reported in the accompanying files.

3.2 Classifying Data for Entities with Multiple Supply Chains

Many ASI Entities are engaged in multiple supply chain activities (as defined by ASI – refer Appendix I), and therefore report aggregated data across multiple, rather than individual activities. Meaningful comparisons of energy use and emissions using ASI's divisions of activities was therefore not possible.

To facilitate a level of comparison by supply chain activity, the aluminium supply chain was redefined into five separate categories, from 'Bauxite' to 'Downstream' as shown in Table 2 (overleaf). This allows for the comparison of several activity combinations. For example, Entities engaged in aluminium smelting often also incorporated casthouse and/or remelting/refining activities, with only one set of data disclosures for the entire Entity; therefore, these combinations were all categorised under the one label "Smelting".

Some further notes regarding the classification of supply chain activities:

- Where data could not be split into the five separate categories, these were allocated a supply chain label, such as "Alumina-to-Downstream", where data encompassed four out of five activities.
- For larger corporate Entities that disclosed separate emissions/energy datasets for different supply chain activities, multiple data entries were used for that ASI Entity in the GHG emissions database provided. For example, if Company *X* provides data for its entire production chain (Bauxite-to-Downstream), as well as separate data for 'Smelting' and 'Alumina' activities, these data are recorded and analysed 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 Bauxite Mining, Alumina Refining
03	**Smelting**	Aluminium Smelting, Casthouse Aluminium Smelting, Remelting/Refining, Casthouse
04	**Remelt-to-Downstream**	Casthouse, Downstream Remelting/Refining, Casthouse Remelting/Refining, Casthouse, Downstream
05	**Downstream**	Casthouse, Downstream Downstream
-	**Bauxite-to-Downstream**	Bauxite Mining, Alumina Refining, Aluminium Smelting, Casthouse, Downstream Bauxite Mining, Alumina Refining, Aluminium Smelting, Remelting/Refining, Casthouse 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 Analysis of Implementation – Quality of Data Disclosure

The following section provides general commentary in the implementation of data disclosures (energy and emissions, as per ASI Performance Standard, Criterion 5.1) by ASI Entities, as of May-June 2021. This includes a comparison of changes from 2020 vs. 2021 assessments.

4.1 Range of Data Sources, Varying Formats and Units

In the 2020 assessment, it was observed that ASI Entities do not follow a standard reporting template or format (e.g. one defined by ASI) for GHG emission and energy use data disclosures. Rather, it was observed that they often vary in format, units and in terms of data sources. This remains the case with latest data disclosures obtained in this 2021 assessment. Of considerable note are the following observations:

- A range of units are used in reporting, particularly for total energy use. This necessitated conversion of data to consistent units (GJ and kWh) for comparison. For energy use disclosures, various units were often used for specific fuels and energy carriers, e.g. m^3 for natural gas, tonnes LPG/LNG, litres (L) diesel, kWh for electricity, standard coal equivalents, etc.
- Many ASI Entities disclose data via a single primary source (e.g. company sustainability report) that directly correlates to the scope of ASI certification. However, others disclose data via multiple sources (e.g. national emissions inventory websites for two different countries, where an Entity scope spanned multiple production facilities); this required additional aggregation of data in order to evaluate emissions and energy use to represent the scope of those ASI Entities.
- Some ASI Entities output multiple products, for example, downstream Entities with plastic, cardboard and aluminium packaging. Understandably, some of these report emissions/energy intensities in units such as 'per tonne packaging unit' (Entity *Multi-2*) or 'per tonne copper equivalent' (Entity *Multi-12*) that are not comparable across ASI's Entities (typically per tonne aluminium, alumina or dry bauxite basis).

4.2 Data Disclosures not Representing Certification Scope of ASI Entities

As reported in the 2020 report, whilst almost all ASI Entities *do* disclose some level of GHG emissions and energy data (exceptions discussed in Section 4.4), a substantial proportion of these disclosures do *not* relate directly to the scope of certification. This represents just over *one-quarter* of ASI Entities (24 out of 87) in the 2021 data set (Table 3).

Often these are related to larger, multi-national organisations, with multiple production sites and supply chain activities owned and/or operated by the company. These typically report aggregated data for the entire company and/or for specific divisions (e.g. primary aluminium, bauxite and alumina divisions), but not necessarily data specific to those under each ASI certification – often these are only a subset of total production facilities. Examples include Entities: *Multi-2, Multi-8, Multi-11, GCC-2, OCN-3,* and *EEU-4.*

Table 3: Proportion of ASI Entities where data disclosures relate directly to scope of ASI certification.

Does Data Disclosure represents scope of ASI certification?	No. ASI Entities	% ASI Entities
Yes	54	62%
No (or unclear)	24	28%
Not applicable*	9	10%
Total	87	100%
*Note – 10% of Entities (nine out of 87) are not certified under ASI Performance Standard Criterion 5.1, and hence are not required to provide data disclosures for emission and energy use.		

4.3 Emission and Energy Disclosures Using Totals vs. Intensity Units

Whilst total values for emissions (t CO_2e) and energy use (GJ or kWh) provide an absolute measure of global warming potential and energy demand respectively from a particular Entity's activities, these are often less useful for benchmarking across Entities and supply chain activities as they do not take into account production scale.

Intensities of emissions (t CO_2e/t product) and energy use (GJ/t or kWh/t product) are preferred indicators for benchmarking the profile of different Entities within the same supply chain activity. Care should be taken when comparing, that the denominated products are in the same category (e.g. per tonne aluminium). Comparing across products can inform on the variability between processes, but variability in performance benchmarking should be limited to similar processes and products. However, in both the 2020 and 2021 assessments, energy intensities (GJ/t or kWh/t) and GHG emission intensities (Scope 1+2, t CO_2e/t) were not found (or could not be estimated using production figures) for just over 50% and 40% of ASI Entities respectively. This reduces the level of transparency and ability to benchmark Entities within the same supply chain activity.

It is acknowledged that ASI PS Criterion 5.1 does not require the disclosure of GHG emissions or energy use in specific units, rather that disclosures of both indicators are undertaken on an annual basis.

Finally, note that for the purposes of benchmarking Smelting Entities, electricity / power usage (in units of GWh or kWh/t Al) has been taken as a proxy for total energy use. This approach was taken due to the variability in energy disclosures – with some disclosing only electricity usage, others total energy (including non-electricity fuel sources), and a small minority also including aspects of primary energy (energy required to deliver the electricity generated, including combustion and transmission losses, etc.).

4.4 Assessing Quality of Data Disclosure (2021 assessment)

An updated rating of the overall level of data disclosures from ASI Entities (relating to the scope of certification) has been provided for the 2021 data set (refer to Table 4). Four qualitative data quality ratings were used – 'Good', 'Medium', 'Poor' and 'No disclosure' – based on the overall completeness of energy, GHG emissions and production data disclosed. These qualitative data ratings were based on the following disclosure scenarios:

- "**Good**" = Entity discloses (a) energy use totals *and* intensities, (b) GHG emission (Scope 1+2) totals *and* intensities, and (c) production is disclosed or can be calculated.
- "**Medium**" = Entity discloses at least (a) energy use totals *or* intensities, (b) GHG emission (Scope 1+2) totals *or* intensities, and (c) possibly production is disclosed or can be calculated.
- "**Poor**" = Entity discloses either energy use data *or* GHG emissions, but not both (per ASI PS criterion 5.1); production possibly not disclosed and cannot be estimated.
- **"No disclosure"** = no data disclosures found that fit the certification scope of the specific ASI Entity, due to the following scenarios:
    - No requirement for data disclosures – Ten percent of ASI Entities reviewed in 2021 (nine Entities, all downstream activities) are currently not certified for ASI's Performance Standard Criteria 5.1-5.3, and therefore are not required to disclose GHG emissions and energy use data.
    - In the majority of other Entities with a 'no disclosure' rating, data disclosures *were* in fact available for the parent company, but *not* data specifically relevant to the certification scope of the ASI Entity (refer to Section 4.2).
    - Outside of the above two scenarios, there were only ***two*** Entities (out of 87 reviewed in 2021) where no data disclosures could be found for the past three years. These Entities were: *WEU-15* in Western Europe and *CHN-15* in China. Attempts were made to contact both Entities for data, however no responses were received before the end of the data collection period.

Table 4: Qualitative 'data quality' ratings in 2021 for all ASI Entities (all activities), as well as for Alumina Refining and Aluminium Smelting activities.

Overall Data Quality Rating	*ALL* Supply Chain Activities		02_Alumina Refining Activity		03_Aluminium Smelting Activity	
	No. Entities	%	No. Entities	%	No. Entities	%
Good	47	41%	2	11%	12	57%
Medium	37	32%	3	44%	6	29%
Poor	11	10%	3	33%	2	10%
No disclosure	20	17%	1	11%	1	5%
No. of data entries*	115		9		21	

*Note – these include additional entries where ASI Entities disclosed data for specific supply chains (e.g. alumina refining, aluminium smelting, etc.).

An assessment of Table 4 provides the following insights on the implementation of data disclosures (Performance Standard, Criterion 5.1) by the certified ASI members:

- 73% of certified ASI Entities provide either comprehensive ("Good") or a reasonable level ("Medium") of data disclosures, relating to the scope of certification. This includes 55% of Entities engaged in alumina refining, and 86% of Entities engaged in aluminium smelting.
- 98% of certified ASI Entities (85 out of 87) *do* provide some level of GHG and energy data disclosures, even if they do not relate directly to the scope of certification.

4.5 Improving Quality of Data Disclosure (comparing 2020 and 2021 assessments)

In order to analyse whether the disclosure quality is improving over time, a similar rating of disclosure quality was applied on the 2020 assessment of ASI Entities. However there has been a 67% increase in new Entities (from 63 to 115) achieving ASI certification since the 2020 assessment – many of these new Entities provided either "Good" or "Medium" levels of data disclosure. To provide a fair analysis of any improvements, only the 2020 cohort of Entities (total of 63) were compared.

Figure 1 illustrates the *overall improvements* in data disclosure for the 2020 cohort of Entities, and compares 2020 and 2021 assessment periods:

- There is an increase from 63% to 87% Entities (from 40 to 55, out of 63) reporting either "Good" or "Medium" disclosures in this latest 2021 review – this is for all supply chain activities. The number of ASI Entities providing incomplete ("Poor") data disclosures has reduced from 27% to 6% (from 17 to four, out of 63).
- Improvements were also noted for Smelting and Alumina refining Entities reviewed in 2020, with an increase from 75% to 86% Smelting Entities (from nine to 12, out of 14) and from 20% to 80% of Alumina Entities (from one to four, out of five Entities) reporting "Good" or "Medium" disclosures in this latest 2021 assessment period.
- Overall, 37% of all 2020 Entities improved in the quality of the disclosure, i.e., improving from a lower rating level from 2020 to 2021.

The above improvement metrics correlate well to what has been observed on a 'case-by-case' basis during the data collection phase of this 2021 project, where an overall improvement is noted in the quality of data disclosure publications by many ASI Members and Entities. This includes the publication of more sophisticated and comprehensive sustainability reporting by many ASI members compared to in 2020. One example is a 'downstream' producer, Entity *NAM*-3, which previously displayed emissions and energy use data in graphical form only and did not disclose actual values, however their latest 2020 sustainability report is significantly more comprehensive.

Furthermore, a reduced need to search for alternative sources of data disclosures (such as CDP reports, which often publish outdated data) is also noted, with many ASI Entities now publishing more up-to-date information on their own websites and sustainability reports.

On the other hand, isolated examples were observed where ASI Entities have reduced their level of data disclosure at the individual site level (e.g. Entity *OCN-3*, with two smelters previously providing individual site sustainability reports/figures, but now no longer).

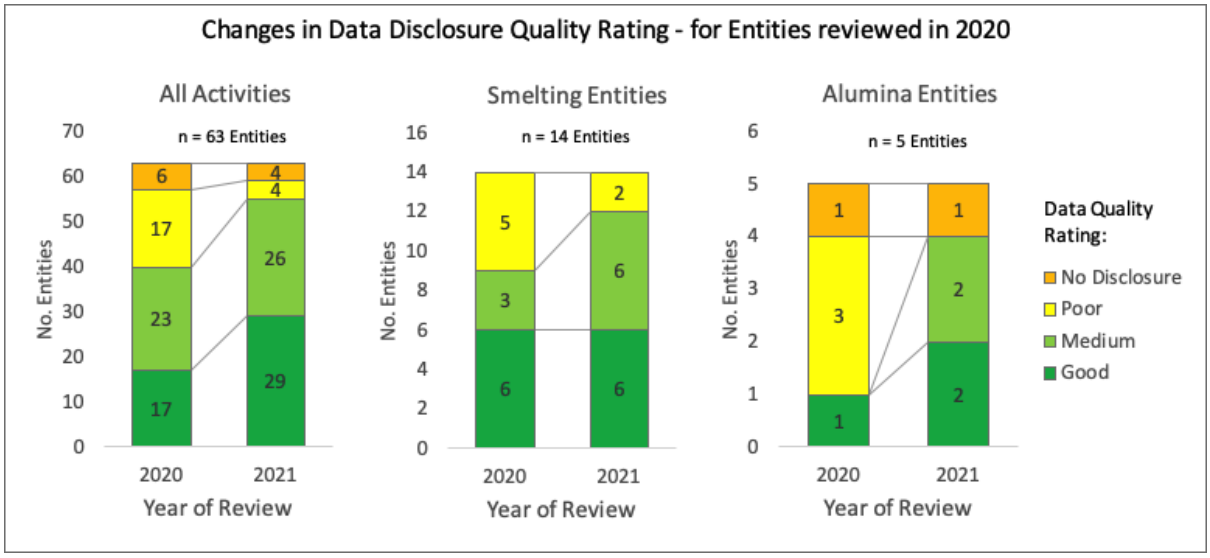


Figure 1: Comparison of data disclosure quality for ASI Entities reviewed in 2020, with all activities (left), Smelting Entities (centre) and Alumina Entities (right).

4.6 Outcomes from ASI Certification – Promising Uptake of Data Disclosures

It is noted that in general, most Entities display their ASI certification(s) prominently in both their Sustainability and Annual Reports, as well as on their websites.

As observed in the 2020 review, many new certified ASI Entities in regions such as China but also in other countries (and in smaller enterprises and/or remelting and downstream activities) are publicly disclosing their sustainability performance (energy, GHG and other emissions, waste, water usage, employee/human rights policies, etc.) on their website. Importantly, many of these Entities have now adopted this practice of providing sustainability disclosures for the first time in the history of their company, which may be attributable to (or at least coincident with) their ASI certification. Whilst there is still room for improvement in the quality, standardisation and format of these data disclosures, ASI continues to play an important role in ensuring data disclosure (both quality and quantity) and transparency improves; ASI's certification process continues to be an important tool in encouraging this.

Improved transparency and the tracking / benchmarking of the energy and emissions profile of ASI Member organisations (and non-Members) is one of the key measures of emission reduction programmes. However, increased disclosures alone will not achieve the significant cuts in the overall carbon footprint of the global aluminium production that is required by climate science (80% absolute emissions, as per IAI 'Beyond 2 Degree Scenario' or B2DS (IAI, 2021)) – rather, these must be coupled with significant changes in technology, finance, consumption patterns, product lifetimes and more across the entire aluminium value chain.

4.7 Recommendations on Data Disclosures

4.7.1 Standardising Data Disclosures

As with the 2020 assessment, it is recommended to standardise data disclosures by ASI Members and Entities. This could significantly enhance transparency and provide an efficient means to profile, compare and benchmark energy and emissions performance across the ASI Membership. These analyses may then inform the work of ASI's ongoing Monitoring & Evaluation program. One option could include the supply of consistent data templates to ASI Entities and mandate the return of their data disclosures direct to ASI on an annual basis. The template could request the following:

- Reporting of data specific to certification scope of each ASI Entity
- Reporting of data for specific supply chain activities, if Entities are engaged in more than one
- Reporting of energy use totals, intensities, sources of total energy, and sources of electricity
- Reporting of GHG emission totals, intensities (with Scope included)
- Reporting in consistent units, particularly for energy use and intensity values.

Similar data reporting templates are already in use by the International Aluminium Institute (IAI, 2017, 2018a and 2020a) for primary supply chain activities, including:

- Survey forms for bauxite mining and other life cycle inventory fields for primary activities (link),
- Energy survey forms for alumina refining (link), and
- Energy survey forms for aluminium smelting including power use, anode production and casting (link).

Other aluminium industry associations (e.g. the European and US Aluminium Associations, or EAA and AA, respectively) may have similar reporting templates for primary and other downstream activities. For further discussion on this recommendation, refer to the 2020 assessment report.

4.7.2 Energy Disclosures for Smelters

It is recommended that Entities engaged in aluminium smelting disclose the following, as per IAI's energy survey forms for smelters (link – IAI, 2018a):

a) Total electricity use (GWh), ideally split by: (i) the smelting / electrolysis process (at the rectifier), and (ii) non-electrolytic processes;

b) Primary energy use – this represents the energy required (in GJ) to produce and deliver the total electricity (GWh) used in (a); and

c) All other energy use (non-electricity sources) by the smelter (in GJ) (including paste and anode production, casting, etc.).

Note – Smelting Entities with captive power generation will have more ready access to the primary energy use data (item (b) above). All Entities should ensure that they also report electricity use (GWh) for the smelting process (item (a).i above), as this allows benchmarking of process energy efficiency.

4.7.3 Minimum Data Disclosure Requirements

Given the variation in quality of data disclosure across the cohort of certified ASI Entities, another suggestion could be the defining of clear minimum requirements for disclosure of energy use and emissions data. These could incorporate aspects such as:

- Whether both totals and intensity values (per tonne product) for energy and emissions need to be disclosed, and
- Whether data disclosures need to directly correlate to the certification scope of the ASI entity.

5 Analysis of Implementation – Emissions & Energy Data

5.1 GHG Emissions and Energy Profile of ASI Members

This section of the Report summarises the profile of GHG emissions and energy data disclosures 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 represent only a sub-set of the ASI member base.

Energy use and emissions *intensities* (GJ/t product and t CO_2e/t product respectively) are used for comparisons across supply chain activities, regions and countries. Care should be taken when comparing intensities as the denominated products might not be in the same category (e.g. per t Al, bauxite, alumina or other). Whilst a comparison of totals is possible (see provided database and graphics), these currently reflect any differences in production scale from one Entity to another and are less useful for comparison. Graphical illustrations of *totals* are not a focus of this report, but are available in Appendix II and in the provided database.

For energy use disclosures, the focus in this Report relates to trends in total final energy consumption and their intensities (units of TJ and GJ/t product, respectively) from *all* sources – not only electricity use, but also other process fuels combusted including natural gas, diesel, coal, steam, etc. This is because 35% of emissions in the overall aluminium industry are from non-electricity related sources and these have a material impact on GHG emissions (IAI, 2020b). Electrical power consumption and intensities (GWh and kWh/t product) can be particularly useful for comparison and benchmarking process performance in Smelting activities in particular, however they do not fully express the energy related global warming potential across the entire aluminium supply chain.

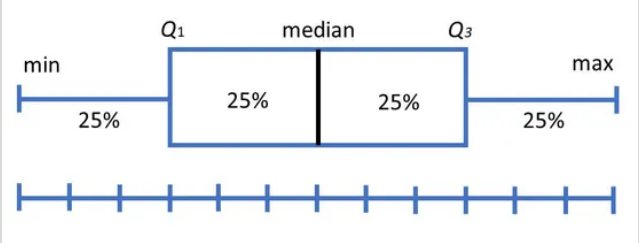
For GHG emissions, the focus in this Report is on trends in Scope 1+2 emissions. Although the number of Entities reporting Scope 3 emissions is increasing, uptake is currently not widespread. Furthermore, some variation in how Entities interpret and define Scope 3 emissions was observed. Graphical illustrations 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 illustrated using *boxplot* charts. Individual value plots (showing individual data entries), histograms and bar charts are also used as an alternative means of data display.

Introducing the Boxplot

Boxplots or '*box and whisker plots*' are a useful way to visualise differences amongst groups of samples (e.g. regions, supply chain activities) – particularly in the range and statistical distribution of data. As shown in the graphic overleaf, the vertical sides of the 'box' illustrate the position of the 25th and 75th percentiles (or 1st and 3rd quartiles), whereas the line inside the box denotes the median (50th 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, note that the number of Entities represented by each 'box' category can vary significantly from one category (e.g. supply chain activity or region) to the next. For instance, data disclosures were found for only one Entity in the Bauxite activity, up to four Entities in Alumina refining, and up to 18 Entities in Smelting. The *individual value plots* provide an alternative view of data, showing not only the spread of data, but also individual values.

5.2 Energy Profile – by Activity

The profile of disclosed energy intensities (GJ per tonne product) – inclusive of electricity and other fuel/energy sources – can be seen in Figures 2 and 3, showing the distribution across different supply chain activities. The individual value plots in Figure 4 provides a deeper view with regional divisions. Note these show only latest data disclosures and excludes historical data.

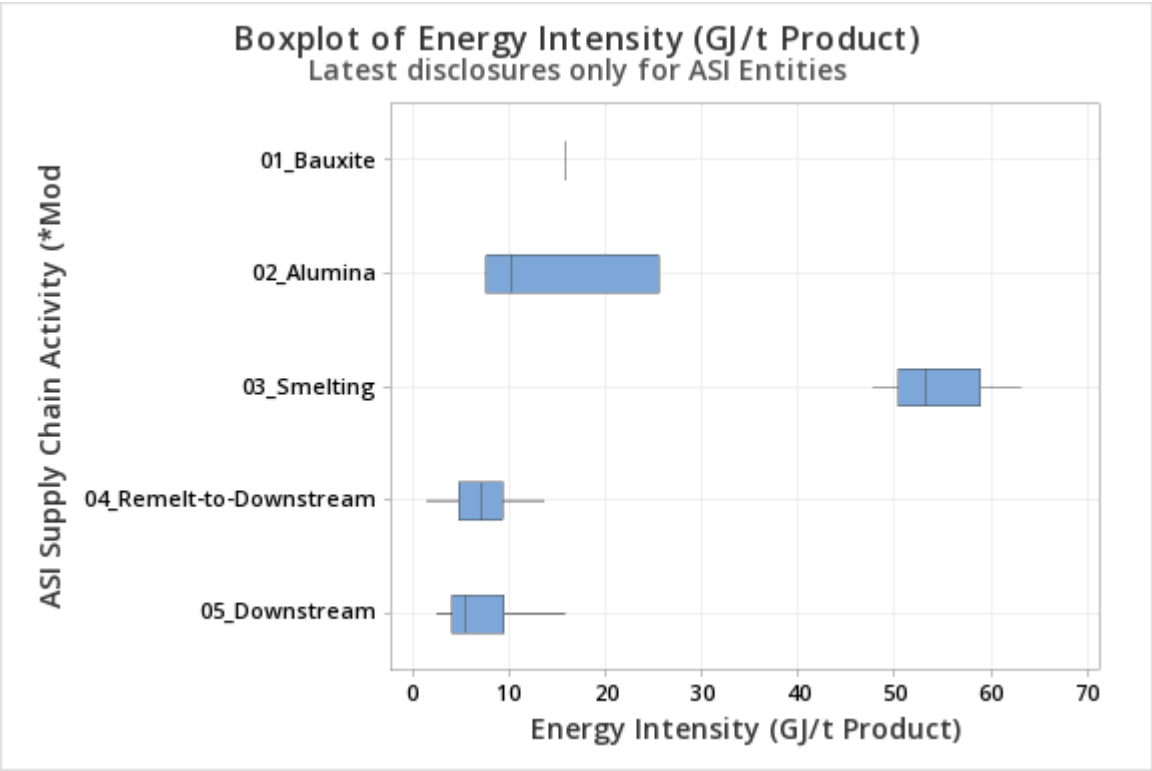


Figure 2: Boxplot – Energy intensity (GJ/t product) for ASI Entities by supply chain (latest disclosures only), with outlier for Smelting category not shown.

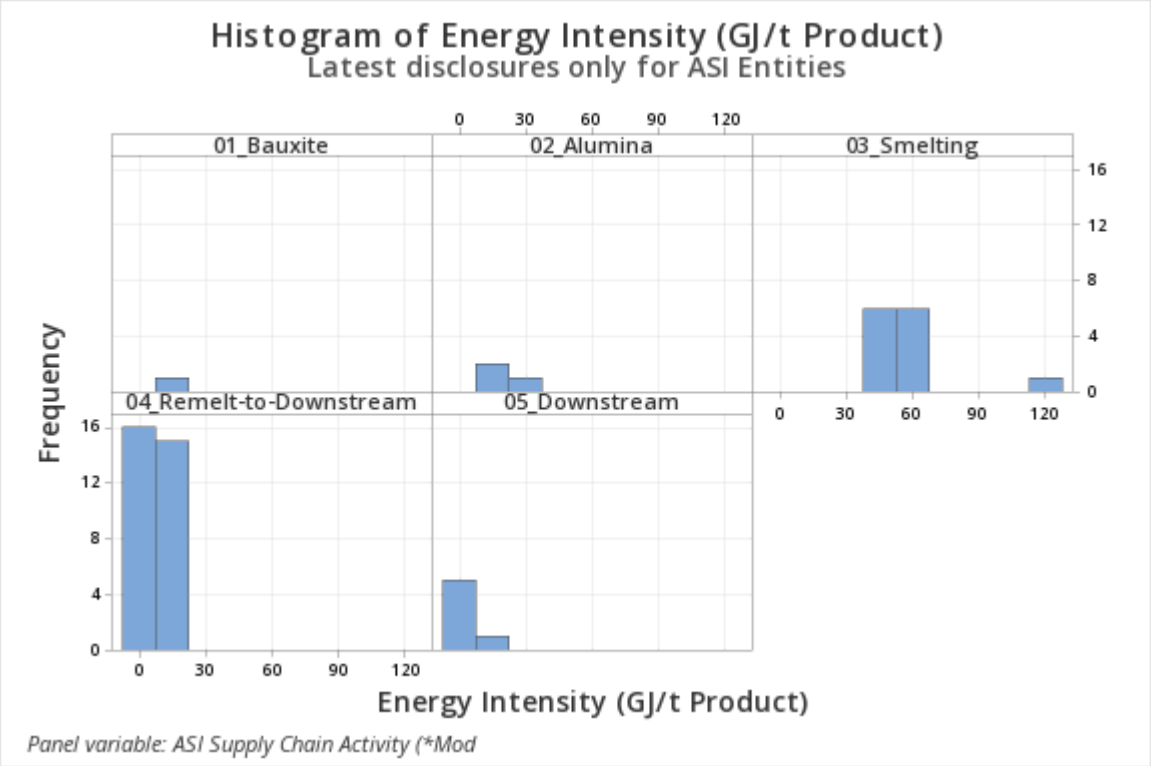


Figure 3: Histogram – Energy intensity (GJ/t product) by supply chain (latest disclosures only), with outlier in Smelting category visible.

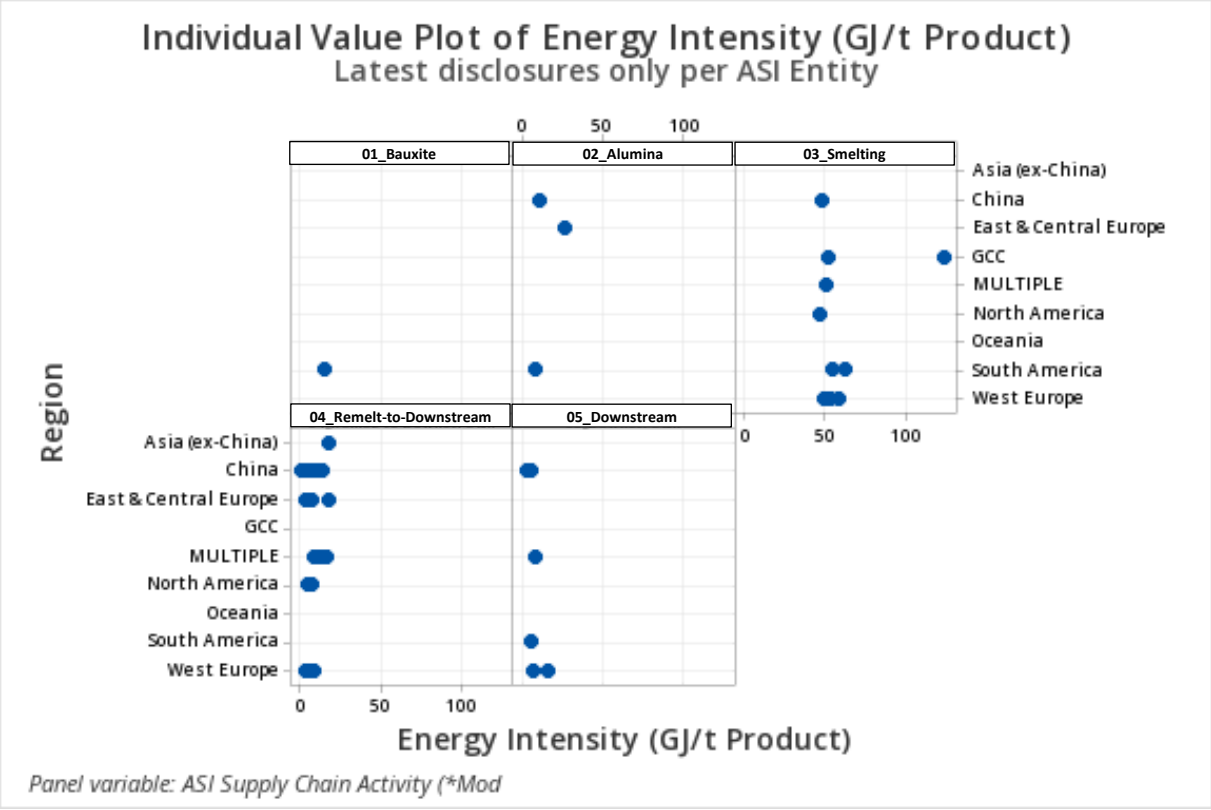


Figure 4: Individual value plot – Energy intensity (GJ/t product) by supply chain and region (latest disclosures only), with outlier in Smelting category visible.

Some general findings relating to the energy intensities by Activity is as follows:

- The *Smelting* activity – with a median of 53 GJ/t Al (n = 13 Entities with data) – is the activity with the highest intensity energy use and second widest distribution, with most Entities ranging from 48 to 63 GJ/t. Note that an outlier value (125 GJ/t, from Entity *GCC-2* – shown in Figures 3 and 4, but not Figure 2) is using a different energy accounting basis, representing *total primary energy* from power generation in its own captive gas-fired power plants. Whilst this outlier should not be directly compared with the other Smelting Entities, this data point has been retained to illustrate the differences in accounting approaches by various ASI Entities, and the need to standardise energy data disclosures (refer to Section 4.7).
- The *Alumina* refining activity – with a median of 10 GJ/t – indicates a broad variation in energy use. However, this is only due to three Entities with energy intensity disclosures (Figure 4), with one Entity (*EEU-4*) reporting an energy use (~25 GJ/t) more than double of other Entities. This is likely due to the inclusion of data from production sites using alternative alumina refining processes (Nepheline ore and Bayer-Sinter processing), which involve additional energy-intensive sintering steps compared to the conventional Bayer process (IPCC, 2019).
- The median energy intensities for *Remelt-to-Downstream* and *Downstream* activities were 9.3 GJ/t (n = 31 Entities) and 5.5 GJ/t product (n = 6 Entities), respectively, both illustrating a narrower distribution and lower energy intensity use.
- The single energy intensity observation for *Bauxite* mining activity (~16 GJ/t) is considered as an outlier observation (reported by a South American Entity*, SAM-4*), but data error is suspected).

The above distributions reflect the fact that energy use is ultimately a function of the processes involved in each activity and their intrinsic energy requirements, over which an individual Entity's performance is then overlain. In the Smelting activity, the electrochemical splitting of strong Al-O bonds in alumina requires large amounts of (electrical) energy. Similarly Alumina refining involves significant thermal energy (including steam production) to digest the bauxite ore, extract the 'hydrated' alumina, and then calcination (at high-temperature) to produce smelter grade alumina. In comparison, the Remelting and casting activity (melting solid aluminium scrap and then solidifying) requires much less energy (mostly thermal). The Downstream activity (the shaping of solid aluminium into forms, usually with electricity but also with thermal) requires even less energy. The Bauxite mining activity requires orders of magnitude less energy, involving only mining and transportation. For more information on global energy requirements by supply chain activity, refer to IAI's *Life Cycle Inventory Data and Environmental Metrics* (IAI, 2018b).

5.3 Energy Profile – Trends over Time

Given a complete data set of energy disclosures for the past five year period is not available for all certified Entities, a rating of energy intensity trends over time was performed for each Entity. Qualitative ratings used for this assessment include the following, and were based on a rough visual assessment of graphical trends:

- **"Increasing"** – energy intensity appears to be increasing over the past three to five years
- **"Stable or variable"** – energy intensity appears either stable or variable

- **"Reducing"** – energy intensity appears to be reducing over past three to five years, which is the target scenario
- For "**Only one data point**" available or "**No disclosures**" – no rating of a trend was possible due to lack of data.

Table 5 illustrates the proportion (%) of *all* ASI Entities, *Alumina* refining Entities and *Smelting* Entities for each rating level in the 2021 assessment period. Some general observations as follows where trends could be rated:

- *Reducing* energy intensity was found for 12% of all Entities, 22% of *Alumina* refining Entities and 10% of *Smelting* Entities.
- Energy intensities remained reasonably stable / variable for 10% of all Entities and 38% of Smelting Entities.
- However, *increases* in energy intensity were observed for 13% of all Entities, 11% of *Alumina* refining Entities and 10% of *Smelting* Entities. Note that these recent trends may have been impacted by greater inefficiencies if production was reduced due to impacts from the ongoing COVID-19 pandemic (e.g. energy usage to keep furnaces or reduction cells running, but less metal produced).
- Assessment of energy trends was not possible in 64% of ASI Entities, due to lack of sufficient data.

Table 5: The overall trend in energy intensity (2021 assessment) for all of ASI's Entities (all activities), as well as for Alumina Refining and Aluminium Smelting activities.

Trend in Energy Intensity (past 3-5 years)	*ALL* Supply Chain Activities		02_Alumina Refining Activity		03_Aluminium Smelting Activity	
	No. Entities	%	No. Entities	%	No. Entities	%
Increasing ↗	15	13%	1	11%	2	10%
Stable ⟶ or Variable ↝	12	10%	-	-	8	38%
Reducing ↘	14	12%	2	22%	2	10%
Only one data point	15	13%	-	-	1	5%
No disclosures	59	51%	6	67%	8	38%
Total No. of Entities*	115		9		21	

*Note – these include additional entries where ASI Entities disclosed data for specific supply chains (e.g. alumina refining, aluminium smelting, etc.).

5.4 GHG Emissions Profile (Scope 1+2) – by Activity

The profile of disclosed GHG emissions (Scope 1 and 2) intensity (t CO_2e/t product) is presented in Figure 5 to Figure 7, showing the distribution across different supply chain activities. The individual value plots in Figure 8 provides a deeper view with regional divisions. Note that (a) these show only

latest data disclosures and excludes historical data; and (b) ASI's current 2030 threshold of 8 t CO_2e/t Al for smelters is also highlighted.

Some general observations as are follows:

- The *Smelting* activity is responsible for the highest emission intensities across the ASI supply chain – with a median of 2.7 and average of 4.3 t CO_2e/t Al – and has the broadest distribution of all activities – ranging from 1.3 to 14.0 t CO_2e/t Al. As discussed later, this wide distribution is driven by the large energy use (see Figure 2), combined with wide variation of power sources used, ranging from low-carbon (hydro, nuclear and renewables), to carbon intensive (gas and coal) and a whole mix in between.
- All other activities exhibit lower GHG emission intensities, with narrower distributions. The *Alumina* refining activity has a range of 0.3 to 1.2 t CO_2e/t alumina, *Remelt-to-Downstream* a range of 0.1 to 4.5 t CO_2e/t product, and *Downstream* activities with a range of 0.3 to 1.4 t CO_2e/t product. An outlier in the *Remelt-to-Downstream* activity (4.5 t CO_2e/t product) is from multiple region Entity (*Multi-11*).
- Note that the data set contains only a low number of *Bauxite* and *Alumina* Entities (n = 1 and 5 Entities, respectively) as shown in Figure 7 and Figure 8.
- Further commentary on *Smelting* and *Alumina* activities is provided in Sections 5.6 and 5.7.

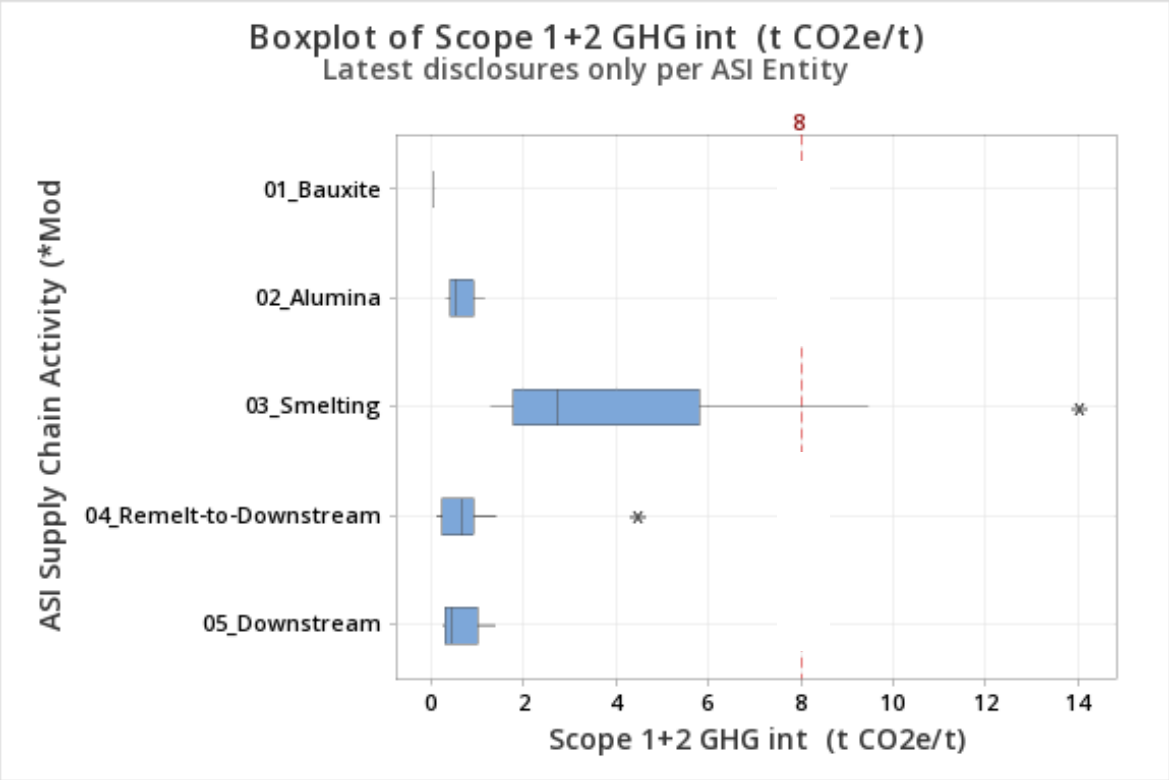


Figure 5: Boxplot – Scope 1+2 GHG emissions intensity (t CO_2e/t Product) by activity (latest disclosures only).

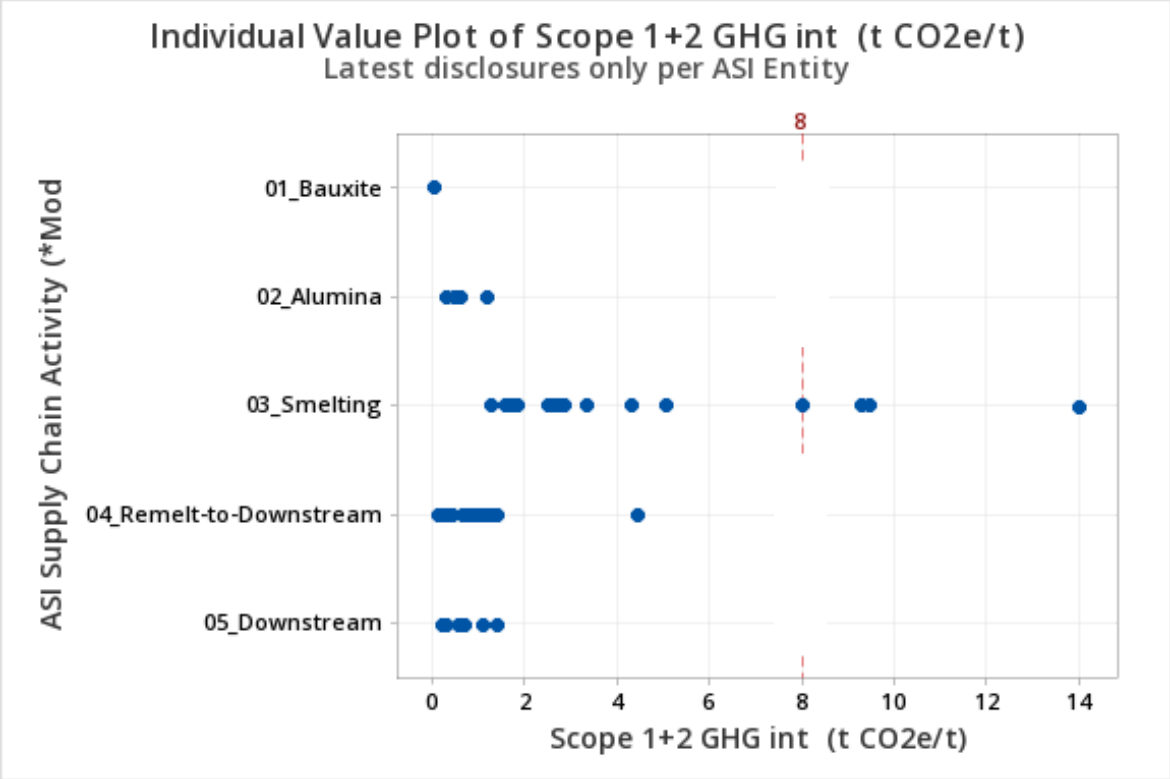


Figure 6: Individual value plots – Scope 1+2 GHG emissions intensity (t CO_2e/t Product) by activity (latest disclosures only).

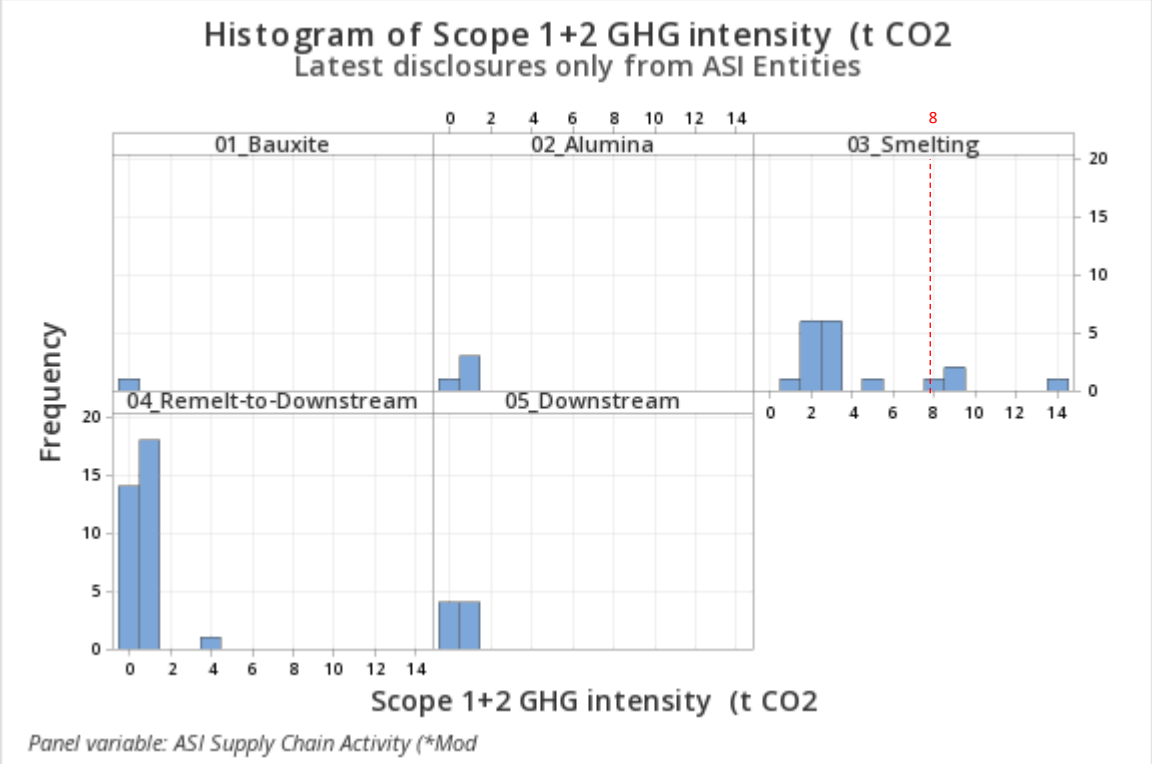


Figure 7: Histogram – Scope 1+2 GHG intensities (t CO_2e/t Product) for each supply chain (latest disclosures only).

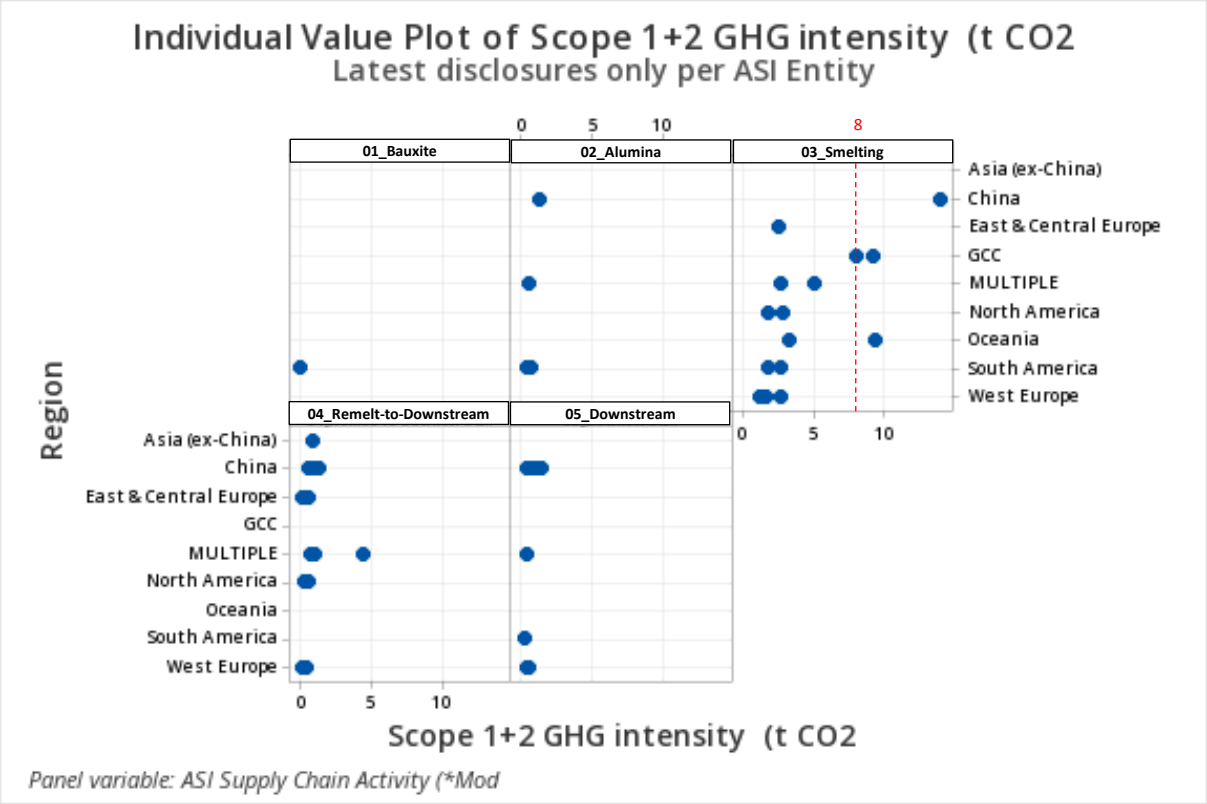


Figure 8: Individual value plot – Scope 1+2 GHG emissions intensity (t CO_2e/t Product) by supply chain and region (latest disclosures only).

5.5 GHG Emissions Profile (Scope 1+2) – Trends over Time

As with Energy, a complete data set of GHG emission disclosures for the past three to five years is not available for all certified Entities. Therefore, a rating of GHG emissions intensity (Scope 1 and 2) trends over time was made for each Entity. The qualitative ratings used for this assessment were as follows, and were based on a rough visual assessment of graphical trends:

- **"Increasing"** – GHG emissions intensity appears to be increasing over past three to five years
- **"Stable or variable"** – GHG emissions intensity appears either stable or variable
- **"Reducing"** – GHG emissions intensity appears to be reducing over past three to five years, which is the target scenario
- For "**Only one data point**" available or "**No disclosure**" – no rating of a trend was possible due to lack of data.

Table 6 illustrates the proportion (%) of *all* ASI Entities, *Alumina* refining Entities and *Smelting* Entities for each rating level for the 2021 assessment period. Some general observations where trends could be rated are as follows:

- *Reducing* GHG emission intensity was found for 16% of all Entities, 22% of *Alumina* refining Entities and 19% of *Smelting* Entities.
- GHG emission intensities remained reasonably *stable / variable* for 24% of all Entities and 22% of *Alumina* refining Entities, and 52% of Smelting Entities.

- However, *increases* in GHG emission intensity were observed for a small number (six percent) of all Entities, and five percent of *Smelting* Entities. No increases were found for *Alumina* refining Entities. Note that some of these recent trends may have been impacted by greater inefficiencies if production was reduced due to impacts from COVID-19 (e.g. furnaces or reduction cells maintained, but less metal produced).
- Assessment of GHG emission trends was not possible in 55% of ASI Entities, due to lack of sufficient data.

Table 6: The overall trend in Scope 1+2 GHG emissions intensity in the 2021 assessment for all of ASI's Entities (all activities), as well as for Alumina Refining and Aluminium Smelting activities.

Trend in GHG Emissions Intensity	**ALL Supply Chain Activities**		**02_Alumina Refining Activity**		**03_Aluminium Smelting Activity**	
(Scope 1+2; past 3-5 years)	No. Entities	%	No. Entities	%	No. Entities	%
Increasing ↗	7	6%	-	-	1	5%
Stable ⟶ *or* Variable ↝	27	24%	2	22%	11	52%
Reducing ↘	18	16%	2	22%	4	19%
Only one data point	14	12%	-	-	2	10%
No disclosures	49	43%	5	56%	3	14%
Total No. of Entities*	115		9		21	

*Note – these include additional entries where ASI Entities disclosed data for specific supply chains (e.g. alumina refining, aluminium smelting, etc.).

5.6 Energy & Emissions Profile – Aluminium Smelting Activity

5.6.1 Commentary on Energy Profile – Smelting

An individual value plot of energy intensity (GJ/t Al) for Smelting Entities grouped by region is shown in Figure 9. Comparisons of energy intensity (GJ/t Al) for individual Entities are shown in Figure 10. As highlighted earlier, energy intensities here for the Smelting activity refer to electricity usage only (in GWh or kWh/t Al), which has been converted to GJ/t Al (using a default factor of 3600 J per Wh) as a proxy for total energy use. This provided a consistent basis to benchmark ASI's Smelting Entities, as some disclosed only electricity usage, while others (South American Entities *SAM-1* and *SAM-4*; multiple region Entity *Multi-9*) provided total energy use (including fuels and non-electricity sources). Note that one Entity (*GCC-2* in the GCC region) disclosed total primary energy (energy required to generate and deliver the electricity consumed) and is not directly comparable to the other Smelting Entities presented; however it is retained here for the purposes of highlighting the differences in disclosures.

Some general observations are as follows:

- Disclosures of energy intensity data were available for only 13 out of 21 Smelting Entities.
- Entities across most regions demonstrate similar ranges of energy intensities, ranging 46-63 GJ/t. Converted back to power units, these relate to approximately 12.8 to 17.5 kWh/kg Al, which are within the expected range for the aluminium smelters. These span smelters employing modern reduction cell technologies with prebake anodes, as well as older (but upgraded) Søderberg cell technologies (Entities *WEU-2* in Western Europe, and *SAM-4* in South America), which tend to operate at higher energy intensities.
- As mentioned earlier, one outlier observation with a GCC-based Entity (*GCC-2*) with energy intensity of 125 GJ/t Al is due to its disclosure of *total primary energy* consumed to generate and deliver electricity in onsite captive gas-fired power plants (typically 35-50% efficient so this indicates thermal loss). It should be noted that such accounting for the energy required to *produce and transmit* the electricity consumed in processes (whether self-generated or purchased), while not currently in scope of the ASI-mandated disclosures, should be considered good practice to enable calculation of a more complete global warming potential of aluminium production.
- The majority of ASI's Smelting Entities are either *stable* or *trending down* in their energy intensities over time. However, two Smelting Entities in South America (*SAM-1* and *SAM-4*) appear to be *trending up* in energy intensity over the past year or two. These increases may be in part due to greater inefficiencies, with disclosed production recently reduced in the two Entities, either due to reduced market demand and/or impacts from the ongoing COVID-19 pandemic, i.e. energy usage maintained to keep reduction cells running, but less metal produced.

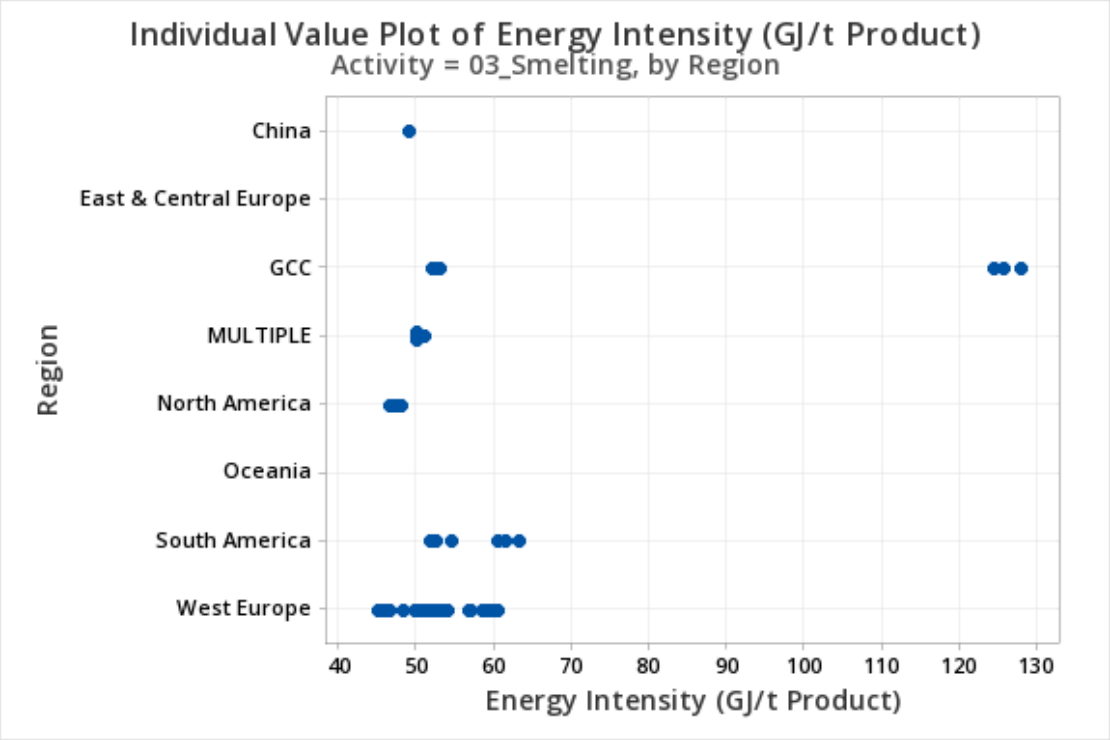


Figure 9: Individual Value Plot, Smelting activity – energy intensity (GJ/t Al) by region (past three to five years data, where available).

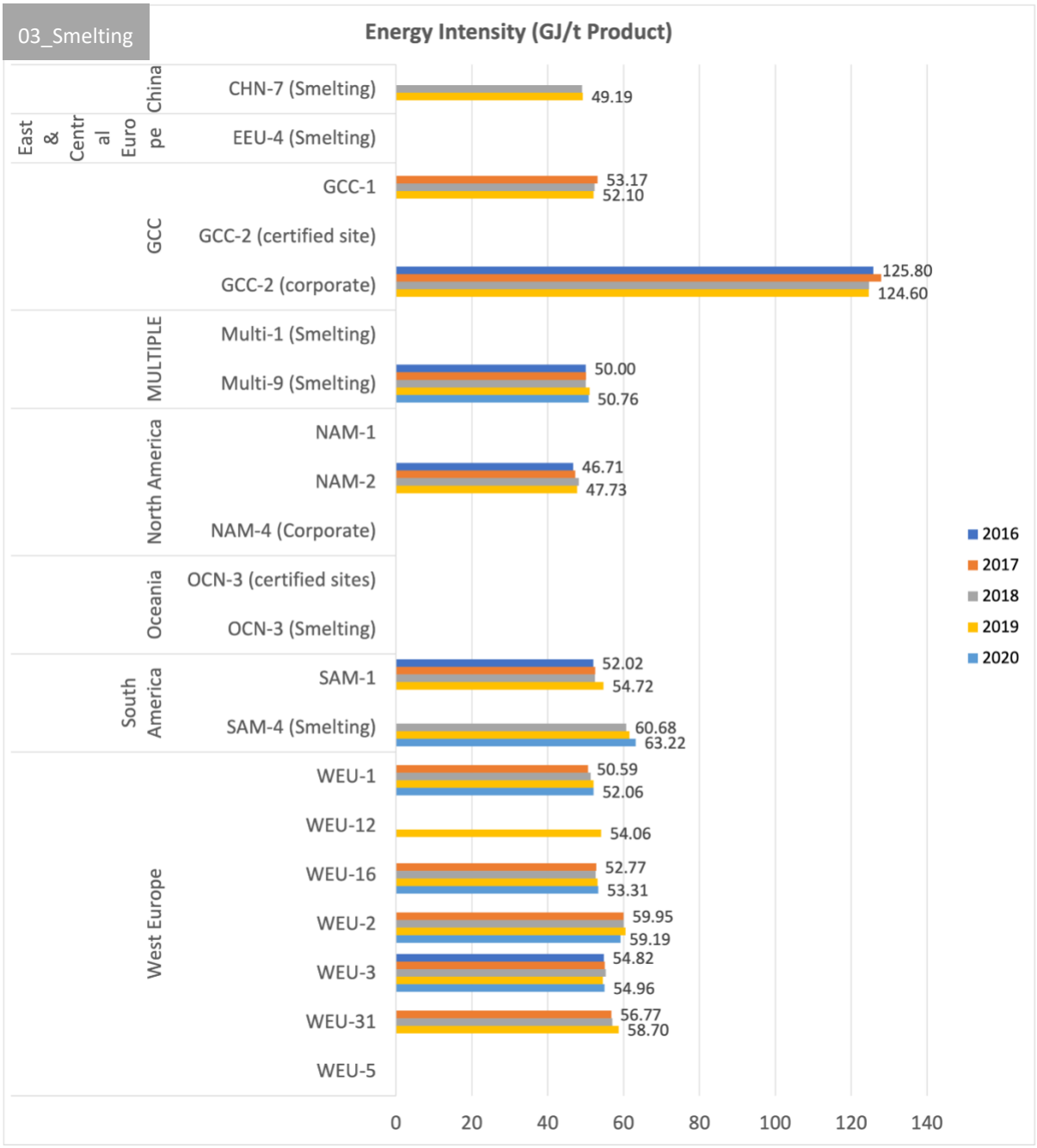


Figure 10: ASI Smelting activity – Energy intensity (GJ/t Al) by Entity, with past three to five years data.

5.6.2 Commentary on GHG Emissions Profile – Smelting

To provide additional context of how ASI's *Smelting* Entities compare with overall global smelting production, Figure 11 presents the distribution of smelters globally on a ranked emissions curve (Scope 1 & 2 intensities, in t CO_2e/t Al), obtained using the CRU Group's (CRU) *Emissions Analysis Tool* (CRU International Ltd, 2021).

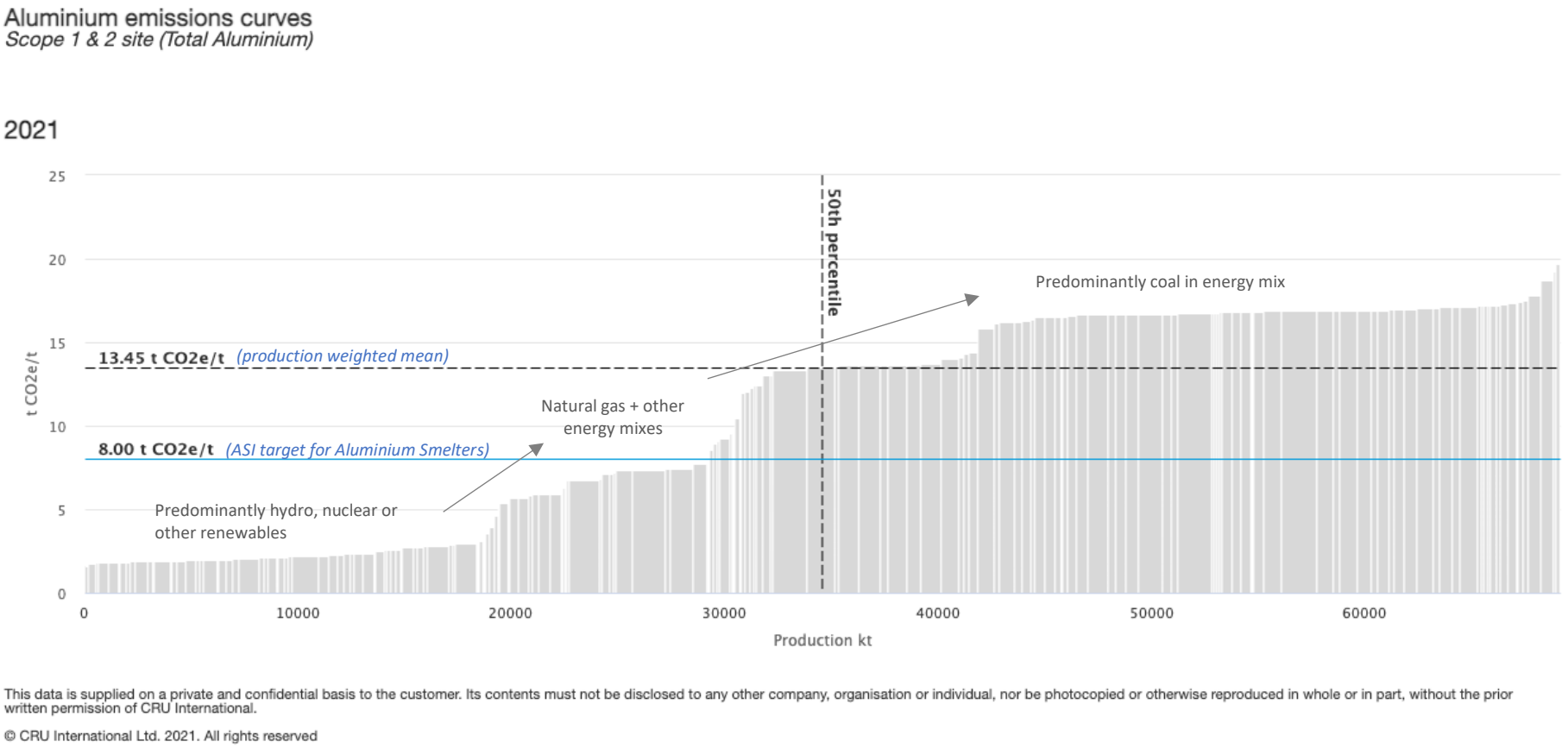


Figure 11: Aluminium smelting – Ranked global emission curves showing Scope 1 and 2 GHG emissions (t CO_2e/t Al) vs. cumulative production (kt) in 2021. (Source: CRU Emissions Tool, © CRU International Ltd, 2021).

The CRU emissions curve indicates that the very wide distribution is primarily due to the different sources of power / electricity production:

- Smelters supplied by 100% low carbon electricity sources (such as *hydropower* or *nuclear*) are at the low end, or left-hand side, of the ranked GHG emission curve (below ~5 t CO_2e/t Al).
- Those with power supplied by predominantly *natural gas* are in the mid-range on the GHG emission curve (~8 tCO_2e/t Al).
- At the upper end of the scale (mid-to-right hand side of the curve, representing smelters in the upper 50% of global production) are smelters with predominantly *coal-fired* power. They have the highest GHG emission intensities (~13 t CO_2e/t Al and above).

The first to third quartiles of this global distribution of GHG emissions intensity is reflected in the ASI cohort of certified Smelting Entities, with a range of 1.3 to 14.0 t CO_2e/t Al shown previously (Figure 5). In order to analyse this distribution in more detail, a breakdown of emissions intensity (t CO_2e/t Al) grouped by region is presented below in Figure 12, with comparisons for individual Entities presented as Figure 13.

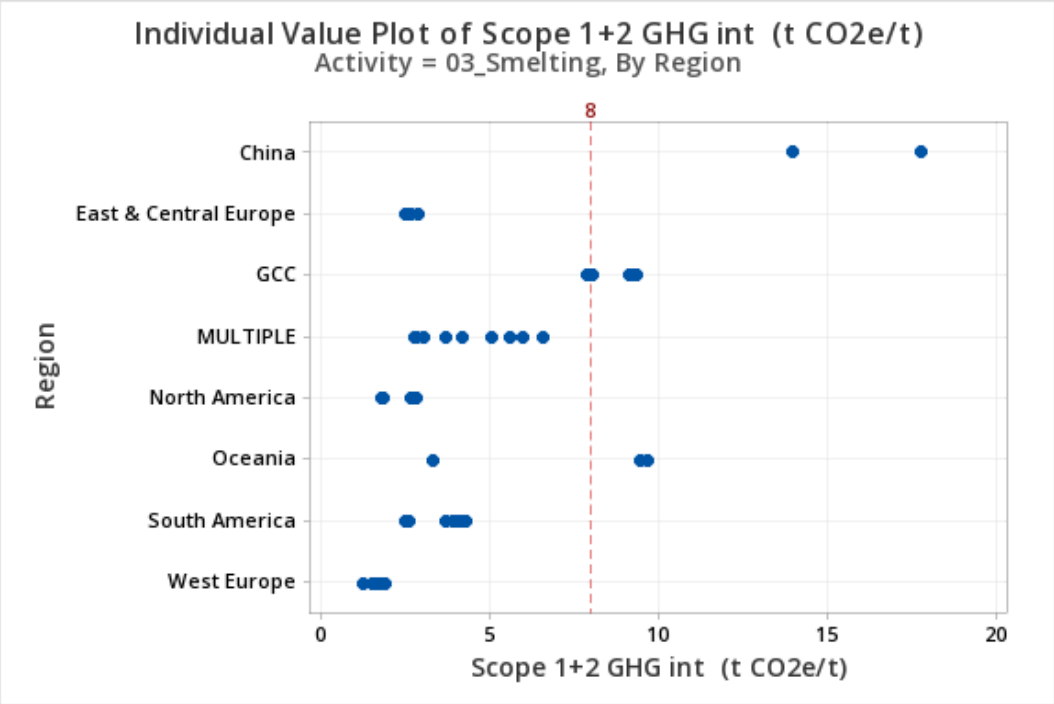


Figure 12: Individual Value Plot, Smelting activity – GHG emissions intensity (t CO_2e/t Al) by region, with past three to five years data, where available; also shown is ASI's current target of 8 t CO_2e/t Al.

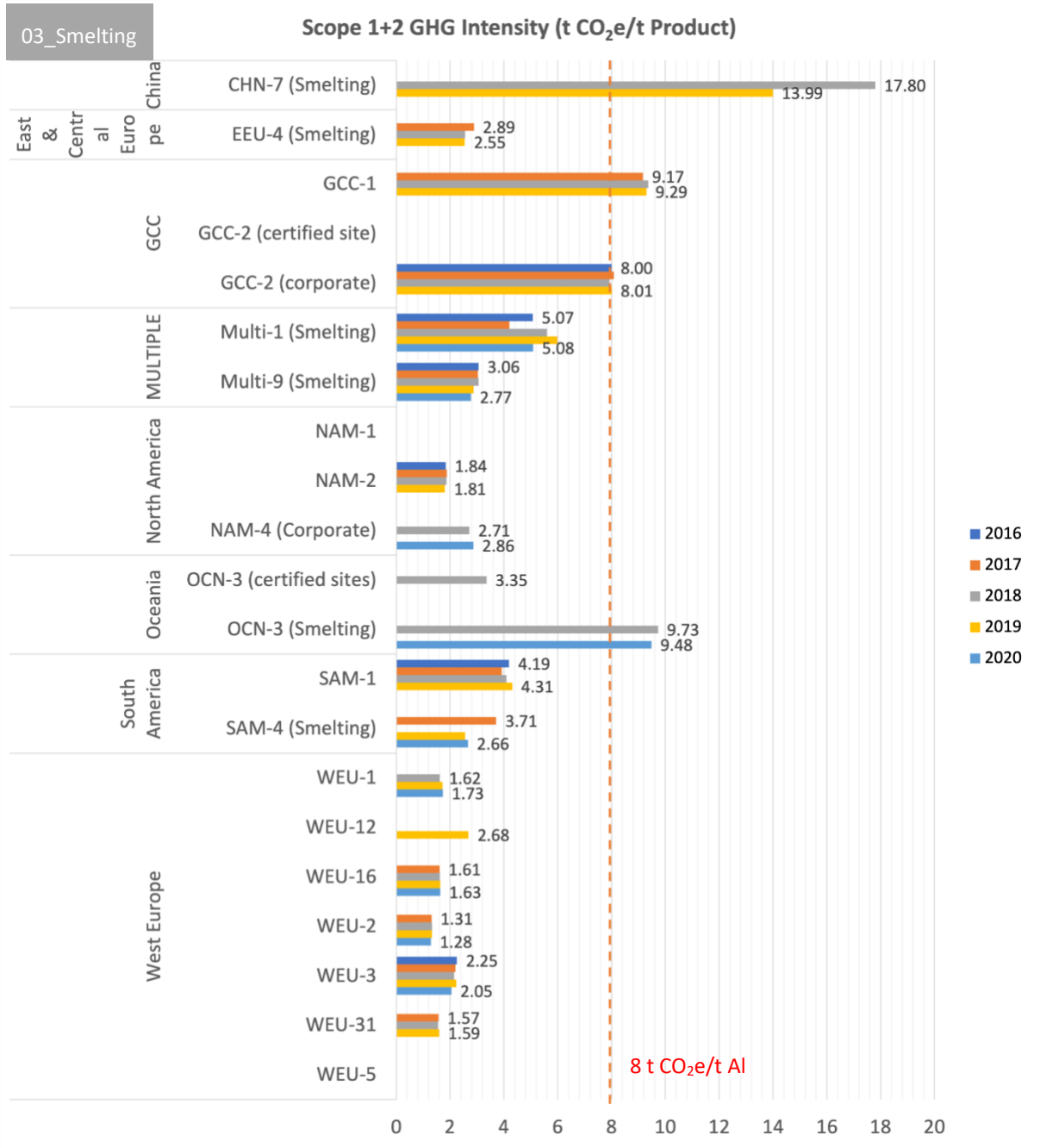


Figure 13: ASI Smelting activity – Scope 1+2 GHG emissions intensity (t CO_2e/t Al) by Entity, with past three to five years historical data where available.

Some general observations for the Smelting activity are as follows:

- The emissions intensity for the fourteen ASI Smelting Entities using hydropower or nuclear power – the majority of those with ASI certification – is 5 t CO_2e/t and below. This includes Entities in *Western* and *Eastern Europe*, *North* and *South America*, those in *multiple* regions and one Entity in *Oceania*. In general, smelting Entities in Western Europe tend to have the lowest emissions intensity.
- Two Smelting Entities from the *GCC* region – *GCC-2* and *GCC-1* are at ~8.0 and 9.3 t CO_2e/t Al respectively, reflecting the fact that the smelters are powered by natural gas.
- One Entity in *China* (*CHN-7*) – the only ASI Smelting Entity powered by coal – has the highest emissions intensity at 14.0 t CO_2e/t Al in 2019. This compares to a value of 17.8 t CO_2e/t Al in 2018 (Figure 13), a difference that reflects the use of an updated power emissions intensity factor (t CO_2e/kWh, obtained by measurement as opposed to the use of an assumed power-grid mix factor) applied to its captive coal-fired power plant in 2020, and as such does not necessarily reflect a true reduction in emissions intensity.
- Note that the *Oceania* region is made up of two data sets, one at 3.4 t CO_2e/t – comprising two hydro-powered smelters (under the same ASI certification) – and a second group with an intensity of 9.5 t CO_2e/t, which includes two predominantly coal-fired smelters (outside ASI certification). Note that this second data set is only included for comparison.
- The majority of ASI's Smelting Entities are either *stable* or *trending down* over time in their disclosed GHG emissions intensity; the only exception is one Entity (*SAM-1*) which exhibited a *minor upward* trend.

5.7 Energy & Emissions Profile – Alumina Refining Activity

5.7.1 Commentary on Energy Profile – Alumina Refining

In the alumina supply chain, a near doubling of ASI certifications has occurred since the 2020 assessment (nine Entities in 2021 compared to five in 2020).

Comparisons of energy intensity (GJ/t Al) for ASI's *Alumina* refining activity, by individual Entity, are shown in Figure 14. Energy intensity disclosures were only available in three of nine Alumina Entities. Some observations of this data set as follows:

- At the lowest end of energy intensities is the refinery of Entity *SAM-5* in South America at ~7.6 GJ/t in 2021, however with fluctuations that are most likely from production disruptions in 2018-19.
- The median intensity of ~10.3 GJ/t is demonstrated by the *CHN-7* refinery in the China region.
- The above two Entities (*CHN-7* and *SAM-5*) are within the typical 9-15 GJ/t range reported by the IAI (2020c) for the alumina refining sector.
- The alumina refineries of *EEU-4* (Eastern and Central Europe region) demonstrate the highest energy intensity of ~25.6 GJ/t. As discussed previously, this is likely due to inclusion of refineries that employ alternative alumina refining processes, i.e. Bayer Sinter and Nepheline processing. These involve additional energy intensive, high-temperature processing steps (e.g. sintering) compared to the conventional Bayer refining process that produces more than 95%

of the global output of metallurgical-grade alumina (IPCC, 2019). Whilst the energy intensity of this Entity is more than double the median, it appears to be demonstrating a downward trend.

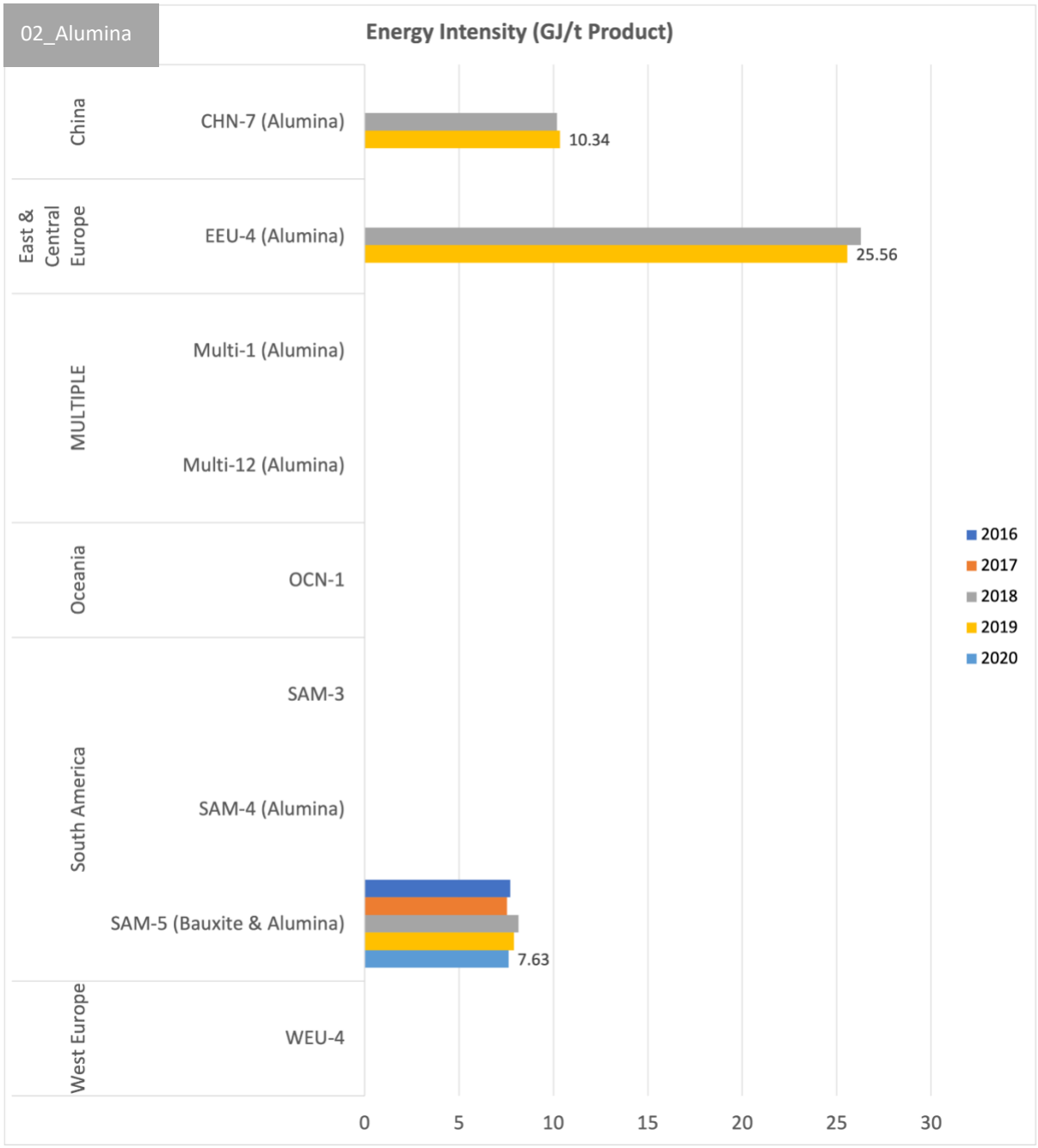


Figure 14: ASI Alumina activity – Energy intensity (GJ/t Al) by Entity, with past three to five years historical data where available.

5.7.2 Commentary on GHG Emissions Profile – Alumina Refining

GHG emission intensity disclosures were available for just four of nine Entities. An individual value plot of GHG emission intensity (Scope 1 & 2, in t CO_2e/t alumina) for Alumina Entities grouped by region is illustrated in Figure 15, with comparisons for individual Entities illustrated in Figure 16. These indicate that:

- Two of four (50%) of Alumina Entities with data disclosures have *clear and significant reductions* in carbon emission intensities:
    - *CHN-7* refinery in China disclosed almost a 20% reduction in emissions (1.45 to 1.19 t CO_2e/t alumina, from 2018 to 2019) through process changes making use of high-pressure steam more efficient (reducing steam consumption);
    - *SAM-4* refinery in South America reduced its carbon intensity by 45% (from 0.55 to 0.31 t CO_2e/t alumina, over 2019 to 2020) through on-site steam production via biomass.
- The remaining two of four (50%) Alumina Entities are either stable in emission intensity or demonstrate a very slight reduction (*SAM-5* and *Multi-1* alumina refineries).

The ASI data set for *Alumina* emissions for all Entities, except those in China, are all below the global industry average emissions intensity for alumina refining of approximately 1.1 t CO_2e/t alumina (given by conversion of 2.1 t CO_2e/t primary Al based on the IAI's *GHG Emissions* dataset for alumina (IAI, 2020b), and dividing by 1.93 t alumina/t primary aluminium).

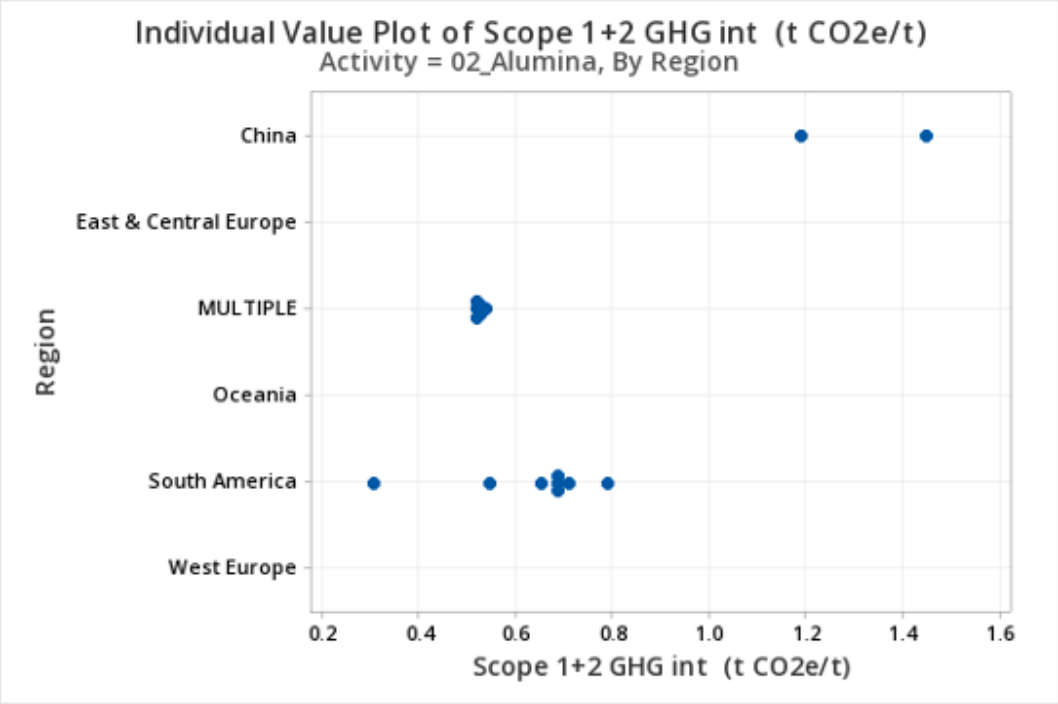


Figure 15: Individual Value Plot, Alumina activity – Scope 1+2 GHG emissions intensity (t CO_2e/t alumina) by region (past three to five years data included, where available).

Figure 16: ASI Alumina activity – Scope 1+2 GHG emissions intensity (t CO_2e/t Al) by Entity, with past three to five years historical data where available.

5.8 Emissions Profile of ASI Certifications compared with Global Distribution

This section of the Report provides a comparison of the emissions profile of ASI certified Entities (in bauxite mining, alumina refining and aluminium smelting activities) against the global distribution of production sites.

To illustrate this, ASI certified Bauxite, Alumina and Smelting production sites have been highlighted in CRU's *Emission Curves* (CRU International Ltd, 2021). These plots provide a ranking of 2021 GHG emissions intensity (Scope 1+2) across the global cohort of bauxite mines (Figure 17), alumina refineries (Figure 18) and primary aluminium smelters (Figure 19) by cumulative production.

5.8.1 Bauxite Mining

Figure 17 shows that most of ASI certifications (eight out of 10, exceptions being mines from Entities *SAM-4* and *OCN-3*) in bauxite mining are below the production-weighted mean (50th percentile by cumulative production) on the global bauxite emission curve. However, the carbon footprint of the bauxite mining activity is comparatively minor (two to three orders of magnitude less) compared to alumina refining and aluminium smelting.

5.8.2 Alumina Refining

Figure 18 demonstrates all ASI certifications in alumina refining are below the production-weighted mean of 1.29 t CO_2e/t alumina on the global alumina emissions curve, with all but two Entities (*CHN-7* and one of *EEU-4's* refineries) below the lowest quartile (first 25% of cumulative production) of the emission curve.

5.8.3 Aluminium Smelting

The Smelting activity is the most significant contributor to the global-average carbon footprint per tonne of primary aluminium. As such this sector receives the most significant focus with respect to emissions reduction. Figure 19 demonstrates that almost all ASI certifications (20 out of 21, with Entity *CHN-7* in China the only exception) are again below both the production-weighted mean of 13.45 t CO_2e/t Al (see Figure 11) and the ASI 2030 certification threshold of 8 t CO_2e/t Al. These values are based on CRU's data set and may differ from Entity disclosures, due to differing bases of accounting.

5.8.4 Suggestions for ASI Engagement

The Smelting emissions curve (both Figure 11 and Figure 19) highlights the scale of challenge faced by primary smelters in achieving significant GHG emission reductions. Over seventy percent of the world's primary production (~45 million tonnes annually) is currently produced using carbon-intensive energy mixes, resulting in partial carbon footprint (Scope 1+2) greater than 5 t CO_2e/t Al – these include production using natural gas-based power, and a large upper fifty percent of production using coal-fired power (with Scope 1+2 carbon footprint greater than 15 t CO_2e/t Al) in their energy mix. It is clear that significant reductions in the primary aluminium sector's total carbon footprint will <u>not</u> be possible, unless rapid and major shifts are implemented by ***<u>all</u>*** smelters, and must include the upper

fifty percent of smelters shifting to a lower point on the sectoral emissions curve (refer to IAI's Beyond 2 Degrees Scenarios (B2DS), IAI 2021).

Figure 19 also illustrates that the current '2030 smelter emissions threshold' of 8 t CO_2e/t Al provides less incentive for smelters in the upper 50% of the emissions curve to consider ASI certification. To engage more of these smelters and provide further incentive, ASI could consider the provision of alternative pathways to certification for smelters above the current 8 t CO_2e/t threshold, whilst still requiring clear, significant and time-bound reductions in GHG emissions. This is currently being considered in ASI's Standards Revision process, under Performance Standard Version 3.0 (draft 1.0) that was recently released for consultation in March-April 2021 (link) (ASI, 2021), with another round of public consultation expected in January 2022.

Smelters within the lowest fifty percent of the emissions curve – and all Entities in other supply chain activities – need to continue their contribution to the efforts of the global aluminium sector to decarbonise (refer to IAI's B2DS, 2021). ASI may wish to consider additional incentive as part of their certification to promote further reductions in GHG emissions intensity.

01_Bauxite Mining – CRU Emission Curves (with ASI Entities highlighted)

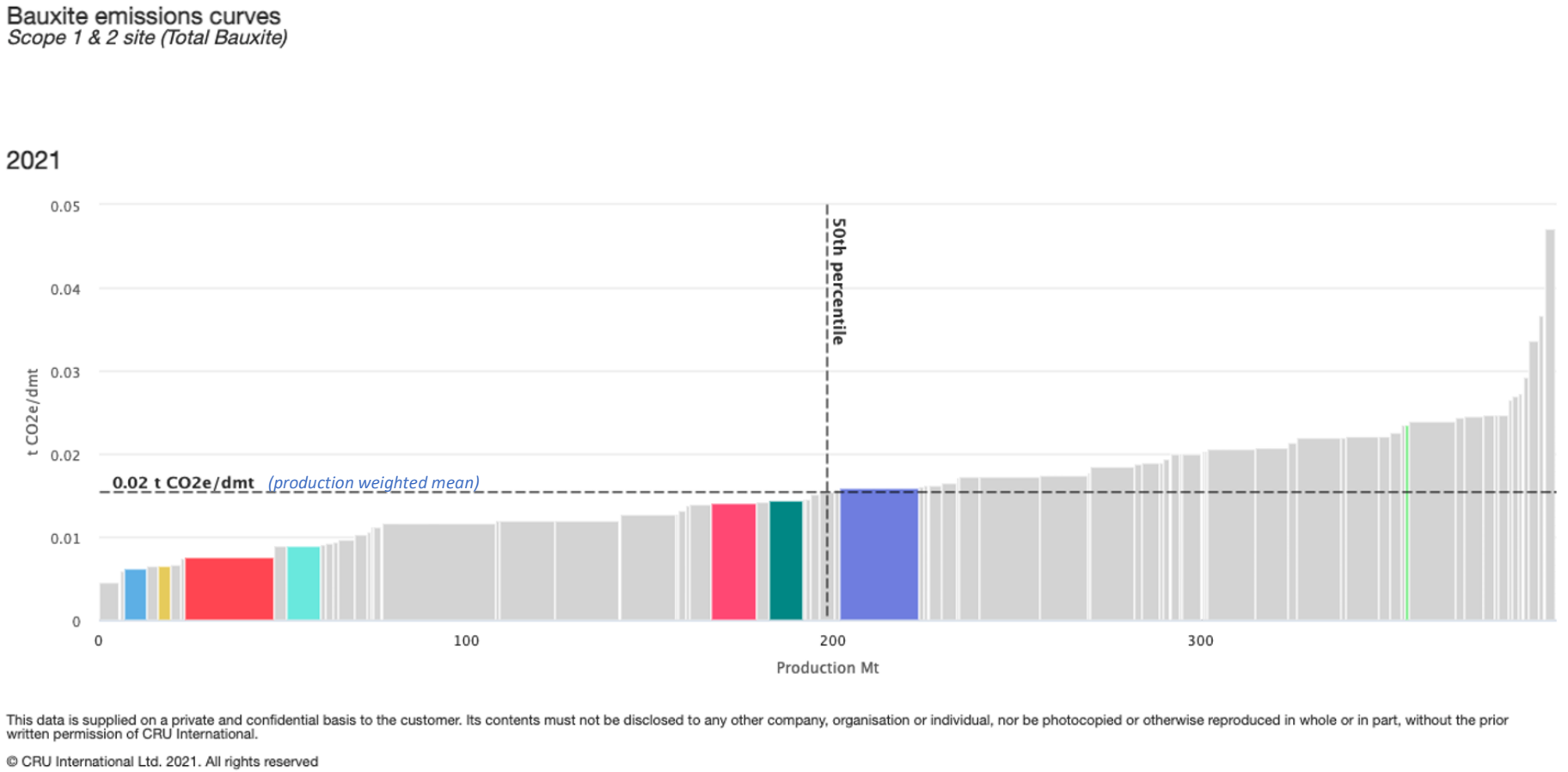


Figure 17: Bauxite Mining – Scope 1 and 2 GHG emissions curves (t CO_2e/dmt bauxite) vs. cumulative production (million tonnes) with ASI certified Entities highlighted in colour, compared to CRU's global data set. (Source: CRU Emissions Analysis Tool, © CRU International Ltd, 2021).

02_Alumina Refining – CRU Emission Curves (with ASI Entities highlighted)

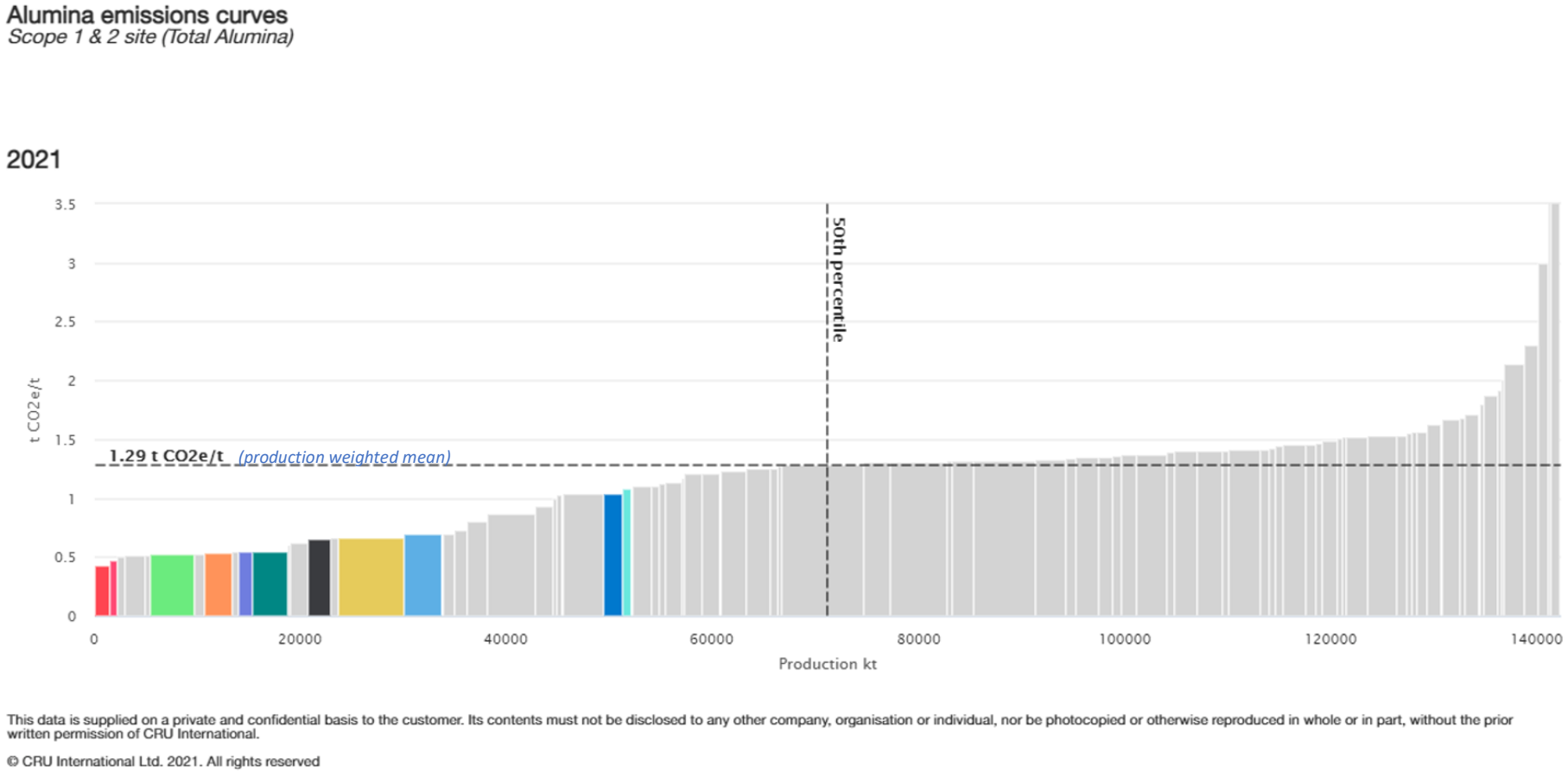


Figure 18: Alumina Refining – Scope 1 and 2 GHG emissions curves (t CO_2e/t alumina) vs. cumulative production (kt) with ASI certified Entities highlighted in colour, compared to CRU's global data set. (Source: CRU Emissions Analysis Tool, © CRU International Ltd, 2021)

03_Aluminium Smelting – CRU Emission Curves (with ASI Entities highlighted)

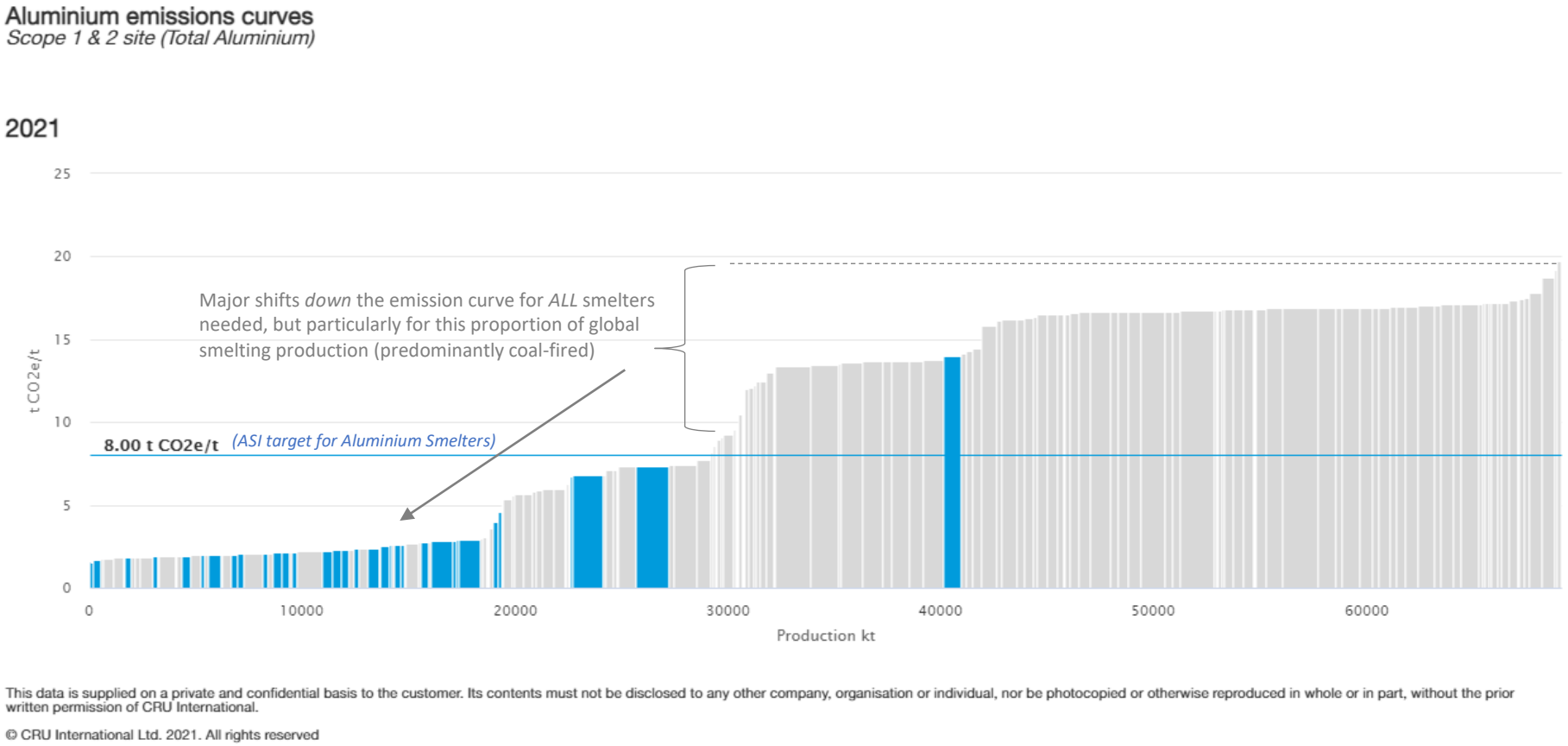


Figure 19: Aluminium smelting – Scope 1 and 2 GHG emissions curves (t CO_2e/t Al) vs. cumulative production (kt) with ASI certified Entities highlighted in colour, compared to CRU's global data set. (Source: CRU Emissions Analysis Tool, © CRU International Ltd, 2021)

6 Comparisons with CRU Emissions Tool

6.1 CRU Emissions Analysis Tool

CRU International Ltd (2021) ('CRU') has developed a web-based '*Emissions Analysis Tool*' (https://emissionsanalysistool.crugroup.com/) which provides a comprehensive, global data set of GHG emissions, energy use, production and corporate ownership for primary aluminium supply chain activities, namely bauxite mining, alumina refining and aluminium smelting. The tool does not yet provide data for aluminium remelting / refining and downstream activities.

The CRU Emissions Analysis Tool:

- Provides GHG emissions data (units, t CO_2e) by individual production sites (assets), rather than by company / entity. This includes Scope 1 and 2 emissions from all energy consumption (including fuel combustion and electricity).
- Provides energy consumption data for all assets/processes – but for electricity only (units, GWh), currently not other (non-electricity) energy carriers.
- Is not based on company data disclosures, rather they are based on CRU's own proprietary modelling and insights.

This section of the Report provides a comparison of ASI Entity data disclosures against data from the CRU Emissions Analysis Tool. Given some Entities do not have emissions data disclosures that match their certification scope, the use of CRU's data set allows for 'filling the gaps' and further benchmarking of the certified ASI Entities' GHG emissions.

6.2 Benchmarking Method for Entity Data Disclosures vs. CRU Data

To compare ASI Entity GHG emissions data disclosures (often encompassing multiple production sites), the CRU Emission Tool data set was collected and processed using the following method:

- Where an ASI Entity certification represents a *single production site,* CRU's energy and emissions data were taken in its entirety, regardless of the Entity's share (% equity) in the site.
- Where an ASI Entity certification incorporates *multiple production sites*, the CRU data for each site is considered in its entirety and aggregated. Exceptions noted include where the ASI Entity's own data disclosure has taken a '% ownership / equity approach'; to match the same accounting basis, emissions and energy use are calculated pro-rata against the Entity's share in the site.

Three qualitative categories have been used to classify the level of agreement between the data sets (Entity disclosures vs. CRU tool). These are:

- "**Good agreement**" – less than 5% discrepancy between the two data sets,
- "**Moderate agreement**" – discrepancy of 5-20%, and
- "**Poor agreement**" – discrepancy of greater than 20%.

Some general observations on the comparison of these are as follows:

- Comparisons were not possible where 'gaps' in the completeness of data disclosures were noted (Sections 4.3 to 4.4).
- Some data disclosures did not relate to the ASI certification scope, but rather aggregated data for the entire company or for specific divisions (Section 4.2).
- The naming and identification of production sites in the CRU tool did not always match those in the ASI certification scope. For example, the naming of the *WEU-12* smelter in the ASI certification differed to the correlated asset in the CRU data set.
- Note that as CRU only provides power use data, comparisons of energy intensities (GJ/t, converted from GWh) were only possible for the Smelting category. Comparisons with disclosures for Alumina and Bauxite activities are not valid, as these activities mainly use thermal sources of energy (rather than electricity).

6.3 Benchmarking Outcomes

In total, there were six Entities compared in bauxite mining, nine Entities for alumina refining and 18 Entities for aluminium smelting. The majority of these Entities were for single production sites, with a few others comprising aggregated data for multiple sites. Comparisons of Entity disclosed vs. CRU datasets for power use (total (GJ) and intensity (GJ/t), converted from GWh units), Scope 1+2 GHG emissions (total (kt CO_2e) and intensity (t CO_2e/t product)) and production data are discussed as follows.

Appendix III provides detailed graphical side-by-side comparison plots of data disclosures vs. CRU data – again by activity and by Entity.

6.3.1 Bauxite Mining

Table 7 provides a comparison of data disclosures against CRU data for the Bauxite mining activity. Data disclosures from only two out of six entities were available for comparison:

- For Entity *SAM-4* (bauxite mine) – there was 'moderate' agreement in production figures; no other data was available for comparison.
- For Entity *SAM-2* (bauxite mine) – there was 'good' agreement for production figures, however, 'poor' agreement in emissions intensity.

Table 7: Comparison of energy use, GHG emission and production "match" between the ASI Entity data disclosure vs. data obtained from CRU Emissions Tool for Bauxite Mining supply chain activity.

Bauxite Mining	Energy Use*		GHG Emission		Production	
Level of discrepancy	**No. of Entities**	**%**	**No. of Entities**	**%**	**No. of Entities**	**%**
Good agreement (<5%)	N/A	N/A	-		1	17%
Moderate agreement (5-20%)	N/A	N/A	-		1	17%
Poor agreement (>20%)	N/A	N/A	1	17%	-	
Entity Data Disclosures *not available* for comparison	N/A	N/A	5	83%	4	67%
Total No. of Entities	6					
* Energy use comparisons not valid as CRU provides only data on power usage, not on non-electricity sources of energy.						

6.3.2 Alumina Refining

Table 8 provides a comparison of data disclosures with the CRU data for the Alumina refining activity, where disclosures were available for five out of nine Entities. For GHG emissions, note that where Entities did not disclose Scope 2 emissions data, comparisons with CRU data were made on the basis of Scope 1 emissions only. Comparisons were made for six out of nine Entities, two of which had a complete data set.

Observations were as follows:

- For GHG emissions, only one 'good' agreement was found with CRU figures (*SAM-5* alumina refinery) and one 'moderate' agreement (*CHN-7* alumina refinery). Note that for two of three Entities with 'poor' agreement, these are based on a comparison of total emissions (not intensities).
- Production disclosures were in 'good' agreement with CRU figures in one Entity (*SAM-5* alumina refinery), but in 'poor' agreement with two other Entities (*CHN-7* and *EEU-4 alumina* refineries).
- Direct comparison of energy use is not valid, as the CRU Tool only provides data for electricity use, which is only a small fraction (<10%) of total energy intensity in the alumina refining sector (IAI, 2020c). However, as noted previously, Entity disclosures are consistent with typical industry figures of ~9-15 GJ/t alumina (IAI, 2020b).

Table 8: Comparison of energy use, GHG emission and production "match" between the ASI Entity data disclosure vs. data obtained from CRU Emissions Tool for Alumina Refining supply chain activity.

Alumina Refining	Energy Use*		GHG Emission		Production	
Level of discrepancy	**No. of Entities**	**%**	**No. of Entities**	**%**	**No. of Entities**	**%**
Good agreement (<5%)	N/A	N/A	1	11%	1	11%
Moderate agreement (5-20%)	N/A	N/A	1	11%	-	
Poor agreement (> 20%)	N/A	N/A	3	33%	2	22%
Entity Data Disclosures *not available* for comparison	N/A	N/A	4	44%	6	67%
Total No. of Entities	9					
* Energy use comparisons not valid as CRU provides only data on power usage, not on non-electricity sources of energy.						

6.3.3 Aluminium Smelting

Table 9 provides a comparison of data disclosures with CRU data for the aluminium smelting activity. Comparisons were from 18 Entities, four of which include multiple production sites:

- Energy use disclosures (essentially electricity consumption) were in 'good' or 'moderate' agreement with the CRU data set for 67% of Entities (12 out of 18). Whilst one Entity (*GCC-2*) was in 'poor' agreement with CRU's figures, the comparison is not valid as the Entity's energy disclosures relate to primary energy (that is consumed to generate and deliver the electricity consumed), which is a different accounting basis.
- For GHG emissions, disclosures for almost 85% of Entities (15 out of 18) were in 'good' or 'moderate' agreement with the CRU data set, whereas two Entities (*SAM-1* and *WEU-2*) were in 'poor' agreement.
- For metal production disclosures, 67% of Entities (12 out of 18) were in 'good' or 'moderate' agreement, with four of 18 Entities with 'poor' agreement.
- In some Entities, total energy use and emission figures compare better than energy and emission intensities due to poor production matches, and vice versa. These are highlighted in Appendix III.

Table 9: Comparison of energy use, GHG emission and production "match" between the ASI Entity data disclosure vs. data obtained from CRU Emissions Tool for Aluminium Smelting supply chain activity.

Aluminium Smelting	Energy Use		GHG Emission		Production	
Level of discrepancy	**No. of Entities**	**%**	**No. of Entities**	**%**	**No. of Entities**	**%**
Good agreement (<5%)	9	50%	7	39%	10	56%
Moderate agreement (5-20%)	3	17%	8	44%	2	11%
Poor agreement (> 20%)	1	6%	2	11%	4	22%
Entity Data Disclosures *not available* for comparison	5	28%	1	6%	2	11%
Total No. of Entities	18					

6.3.4 Summary

Discrepancies between the two datasets are expected as they are derived differently, especially with the CRU Emissions Tool energy modelling being limited to electricity usage only, and due to varying accounting bases taken by individual ASI Entities. In general, the Smelting category had the best matches in Entity disclosures vs. CRU tool data sets. This is likely to be due to: (a) a more complete set of Entity disclosure data to compare with for Smelting, compared to other supply chain activities; (b) electricity use in Smelting being the most significant component of total energy consumption and therefore being a closer match to CRU's basis for power consumption figures. It is important to emphasise that even with "poor" agreement noted in some cases, the two datasets are still in relatively similar ballpark numbers and does not render one higher quality than the other.

Overall therefore, the CRU Emissions Tool is a very useful tool for benchmarking of ASI certified Entities throughout the primary aluminium supply chain, especially for the GHG emissions. It also provides asset-level data for existing 'gaps' in data disclosures, where they do not directly correlate to the scope of ASI certification. Appendix III provides energy and emissions profiles for ASI certified primary production sites using CRU data as a basis (in comparison with Entity Disclosures with 'gaps'). This is an example of how an independent and more 'complete' benchmarking of ASI certified sites could be developed over time.

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Appendices

A brief description of the list of appendices are as follows:

Appendix I – List of ASI Entities
This is a list of certified ASI Entities reviewed in this 2021 assessment of GHG emissions and energy data disclosures.

Appendix II – Dashboard Graphics (Entity Data Disclosures only)
This provides graphical dashboards for Entity disclosed data, categorised by supply chain activity, specifically for (a) overall energy intensity (GJ/t product) and total energy use (TJ), and (b) Scope 1 and 2 GHG emissions intensity (t CO_2e/t product) and total Scope 1 and 2 GHG emissions (kt).

Appendix III – Graphical Comparisons, Entity Data Disclosures vs. CRU Emissions Tool Data
This provides graphical comparisons for latest Entity Data Disclosures vs. corresponding data from the *CRU Emissions Tool*, categorised by bauxite, alumina and smelting supply chain activities, specifically for (a) power intensity expressed as energy intensity (GJ/t product) and total energy use (TJ), and (b) Scope 1 and 2 GHG emissions intensity (t CO_2e/t product) and total Scope 1 and 2 GHG emissions (kt).

Appendix I – List of ASI Entities

ASI Entities reviewed in this work, including region, country and listed supply chain activity (as per ASI certification) are as follows:

ASI Member	Entity Name	Region	Country	Bauxite Mining	Alumina Refining	Aluminium Smelting	Aluminium Re-melting/ Refining	Cast-houses	Down-stream
ALBRAS - Alumínio Brasileiro S/A	ALBRAS - Alumínio Brasileiro S/A	South America	Brazil			Yes		Yes	
Alcoa Corporation	Alcoa Aluminerie de Baie-Comeau	North America	Canada			Yes		Yes	
	Alcoa Corporation	MULTIPLE	MULTIPLE	Yes	Yes	Yes	Yes	Yes	Yes
	Alcoa Fjarðaál ASI Performance Standard	West Europe	Iceland			Yes		Yes	
	Alcoa Lista	West Europe	Norway			Yes	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				
	San Ciprián Refinery	West Europe	Spain		Yes				
Aleris	Aleris Aluminium Duffel BV	West Europe	Belgium				Yes	Yes	Yes
Alu Met GmbH (Austria)	Aluminium GmbH Nachrodt	West Europe	Germany				Yes	Yes	
	Speedline Aluminium Gießerei GmbH	West Europe	Germany				Yes	Yes	
Aludium Premium Aluminium	Aludium Transformación de Productos Alicante	West Europe	Spain					Yes	Yes

ASI Member	Entity Name	Region	Country	Bauxite Mining	Alumina Refining	Aluminium Smelting	Aluminium Re-melting/ Refining	Cast-houses	Down-stream
	Aludium Transformación de Productos Amorebieta	West Europe	Spain				Yes	Yes	Yes
Aluminerie Alouette	Alouette Aluminium Smelter	North America	Canada			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
ALVANCE Aluminium Dunkerque	ALVANCE Aluminium Dunkerque	East & Central Europe	France			Yes		Yes	
AMAG Austria Metall AG	AMAG Austria Metall AG	West Europe	Austria				Yes	Yes	Yes
Amcor	AF Froges Self Assessment	West Europe	France						Yes
	AF Teningen Self-Assessment	West Europe	Germany						Yes
	Amcor Flexibles 5 sites	West Europe	MULTIPLE						Yes
	Amcor Flexibles Rorschach	West Europe	Switzerland						Yes
	Amcor Flexibles Sarrebourg SAS	West Europe	France						Yes
	Amcor Flexibles Singen	West Europe	Germany						Yes
ARCONIC	Arconic Corp	MULTIPLE	MULTIPLE					Yes	Yes
Assan Alüminyum	Assan Alüminyum	East & Central Europe	Turkey				Yes	Yes	Yes
AUDI	Audii C-BEV High-Voltage Battery	MULTIPLE	MULTIPLE						Yes
Ball Corporation	Ball Beverage Packaging EMEA (Europe, Middle East and Africa)	MULTIPLE	MULTIPLE						Yes
BMW AG	BMW Group Werk Landshut -Light-metall Foundry	MULTIPLE	MULTIPLE						Yes
Bridgnorth Aluminium	Bridgnorth Aluminium Limited	West Europe	UK				Yes	Yes	Yes
C.S. Aluminium Corporation	C. S. Aluminium Corporation	Asia (ex-China)	Taiwan				Yes	Yes	Yes

ASI Member	Entity Name	Region	Country	Bauxite Mining	Alumina Refining	Aluminium Smelting	Aluminium Re-melting/ Refining	Cast-houses	Down-stream
Carcano	Carcano	West Europe	Italy						Yes
Century Aluminum Company	Norðurál Grundartangi	West Europe	Iceland			Yes		Yes	
Chalco Ruimin Co.,Ltd.	Chalco Ruimin Co., Ltd.	China	China					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 Neuf-Brisach	West Europe	France				Yes	Yes	Yes
	Constellium Rolled Products Singen GmbH & Co. KG	West Europe	Germany					Yes	Yes
	Constellium Singen AS&I, Dahenfeld & Gottmadingen	West Europe	Germany						Yes
ELVAL Hellenic Aluminium Industry	Elval at Oinofyta	West Europe	Greece				Yes	Yes	Yes
Emirates Global Aluminium PJSC	Emirates Global Aluminium PJSC - Al Taweelah	GCC	UAE			Yes		Yes	
Eurofoil	Eurofoil France	West Europe	France						Yes
	Eurofoil Luxembourg SA	West Europe	Luxembourg						Yes
	Eurofoil Rugles and Eurofoil Dudelange CoC	West Europe	MULTIPLE					Yes	Yes
Gränges	Gränges Aluminium (Shanghai) Co., Ltd.	China	China					Yes	Yes
	Gränges Sweden AB Finspång	West Europe	Sweden					Yes	Yes
Gulkula Mining Company Pty Ltd	Gulkula Mining Company Pty Ltd	Oceania	Australia	Yes					

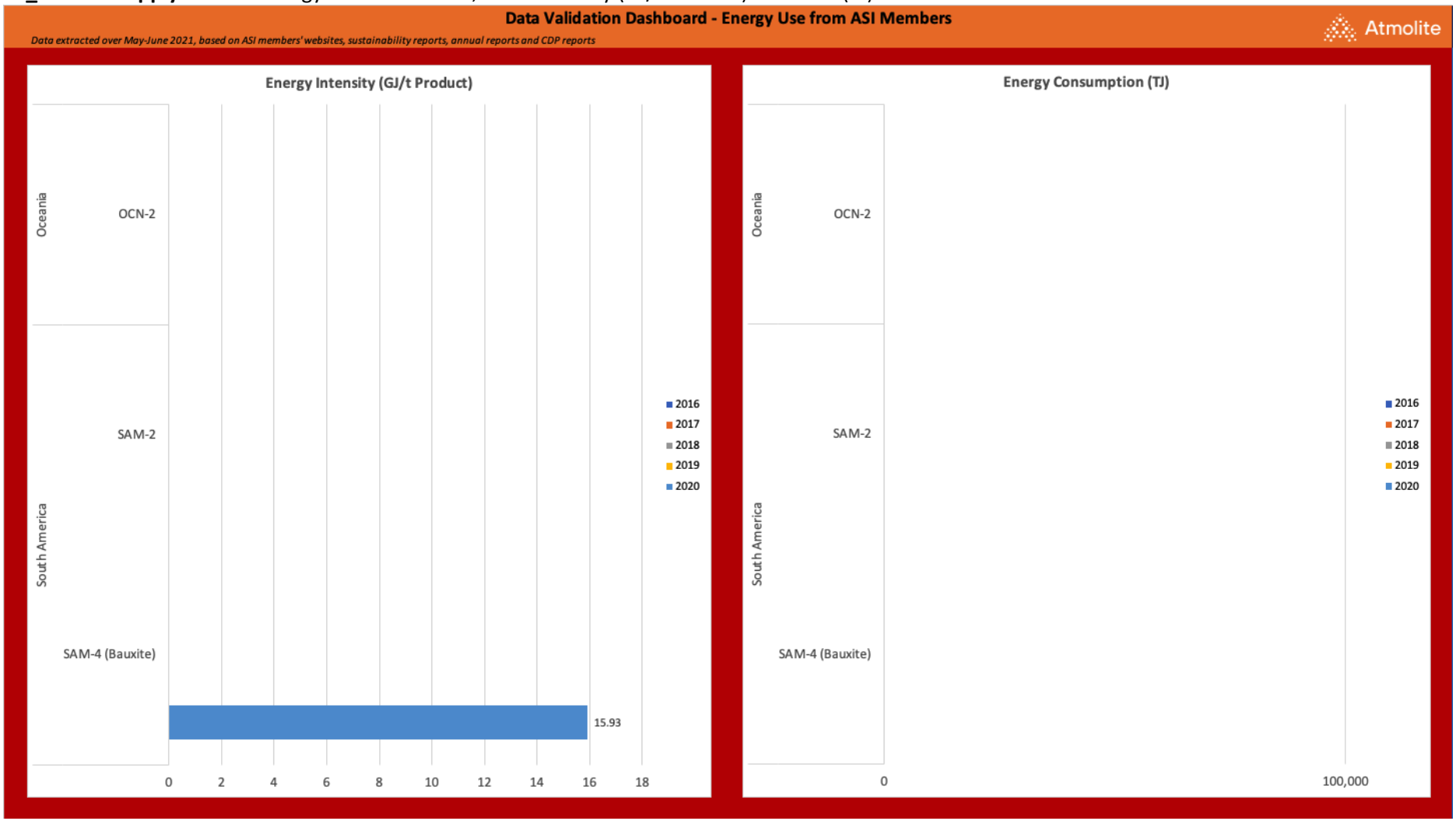
ASI Member	Entity Name	Region	Country	Bauxite Mining	Alumina Refining	Aluminium Smelting	Aluminium Re-melting/ Refining	Cast-houses	Down-stream
Hammerer Aluminium Industries	HAI Santana SRL	East & Central Europe	Romania				Yes	Yes	
	Hammerer Aluminium Industries Holding GmbH	West Europe	Austria				Yes	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				
Impol d.o.o.	Impol Group	East & Central Europe	MULTIPLE				Yes	Yes	Yes
IPI srl	Pierantonio	West Europe	Italy						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	Anhui Maximum Aluminium Industries Co., Ltd.	China	China					Yes	Yes
	Jiangsu Zhongji Lamination Materials Co., Ltd	China	China						Yes
Jupiter Aluminum Corporation	Jupiter Aluminum Corp.	North America	USA				Yes	Yes	Yes
Laminazione Sottile S.p.A.	Laminazione Sottile S.p.A. ; Italcoat S.r.l; Laminazione Sottile S.p.A	MULTIPLE	MULTIPLE						Yes
Lotte Aluminium Co., Ltd	Lotte Aluminium Co., Ltd. Ansan Plant	Asia (ex-China)	South Korea						Yes
Luoyang Wanji Aluminium Processing Co.,Ltd	Luoyang Wanji Aluminum Processing Co., Ltd.	China	China						Yes

ASI Member	Entity Name	Region	Country	Bauxite Mining	Alumina Refining	Aluminium Smelting	Aluminium Re-melting/ Refining	Cast-houses	Down-stream
Novelis Inc.	Novelis Deutschland GmbH Werk Ohle	West Europe	Germany						Yes
	Novelis Europe	West Europe	MULTIPLE				Yes	Yes	Yes
Raffmetal and Fondital	Stabilimento di Casto & Odolo	West Europe	Italy				Yes		
Rio Tinto Aluminium Division	Rio Tinto	MULTIPLE	MULTIPLE	Yes	Yes	Yes	Yes	Yes	
	RTA Canada	North America	Canada		Yes	Yes	Yes	Yes	Yes
	RTA ISAL	West Europe	Iceland			Yes		Yes	
	RTA Pacific Operations	Oceania	MULTIPLE	Yes	Yes	Yes	Yes	Yes	Yes
S.A.DAMM	SA DAMM initial	West Europe	Spain						Yes
Schueco International KG	Schüco KG Metallbau in DE,IT,UK,FR	MULTIPLE	MULTIPLE						Yes
Shandong Nanshan Aluminium Co. Ltd.	Shandong Nanshan Aluminium Co., Ltd.	China	China		Yes	Yes	Yes	Yes	Yes
	Yantai Donghai Aluminium Foil Co., Ltd.	China	China						Yes
Shanghai Shenhuo Aluminium Foil Co., Ltd	Shanghai Shenhuo Aluminium Foil Co.,Ltd	China	China						Yes
Shangqiu Yangguang Aluminium Product Co., Ltd.	Shangqiu Yangguang Aluminium Product Co., Ltd	China	China					Yes	Yes
SIG Combibloc	SIG Group - Curitiba Site	MULTIPLE	MULTIPLE						Yes
StockachAlu	Stockach Alu	West Europe	Germany				Yes	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

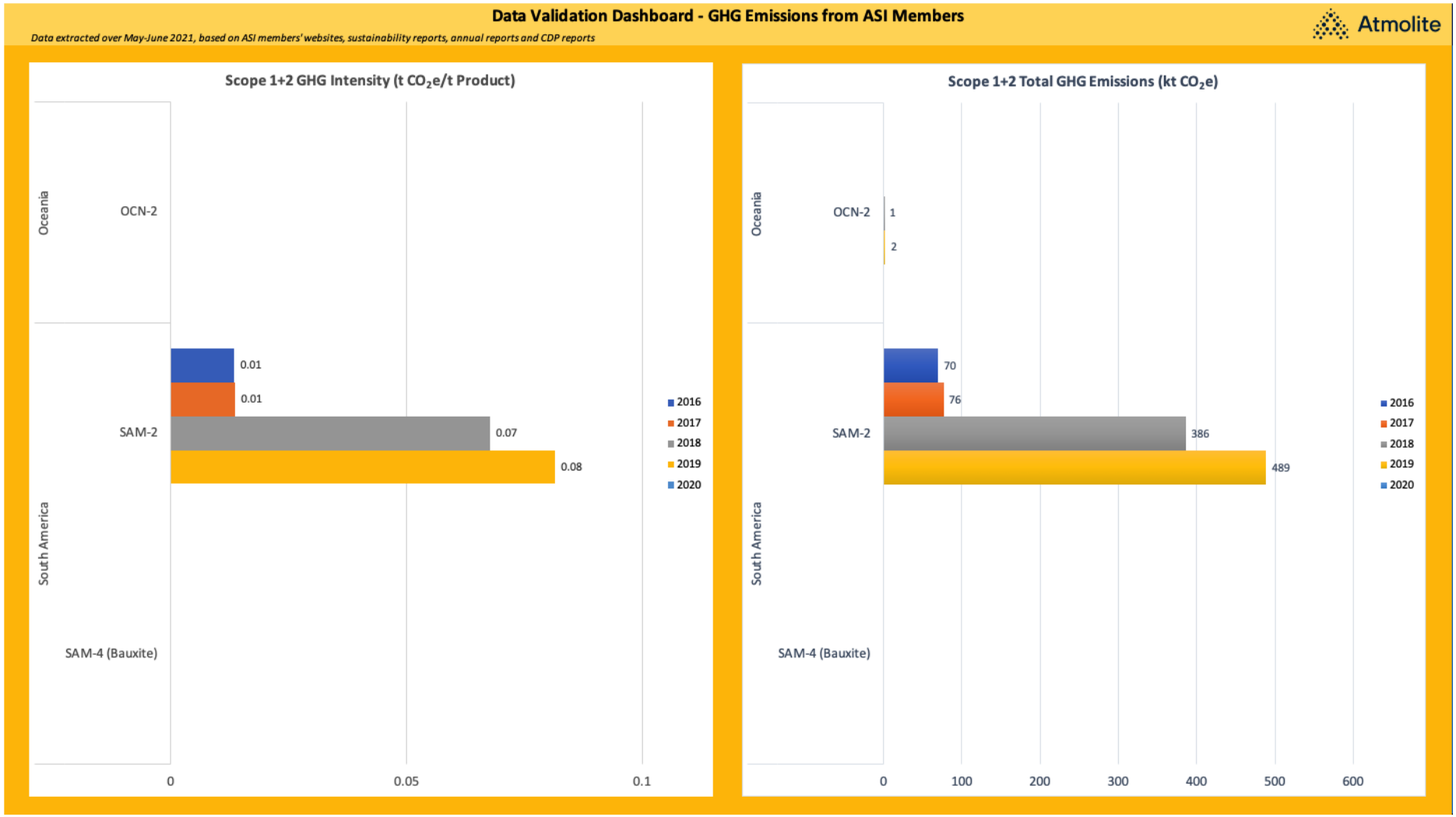
ASI Member	Entity Name	Region	Country	Bauxite Mining	Alumina Refining	Aluminium Smelting	Aluminium Re-melting/ Refining	Cast-houses	Down-stream
UC Rusal	UC Rusal	East & Central Europe	Russia						
Xiamen Xiashun Aluminium Foil Co., Ltd.	Xianmen Xiashun Aluminium Foil Co., Ltd	China	China				Yes	Yes	Yes
Yunnan Yongshun Aluminium Co., Ltd.	Yunnan Yongshun Aluminium Co., Ltd	China	China				Yes		Yes

Appendix II – Dashboard Graphics (Entity Data Disclosures only)

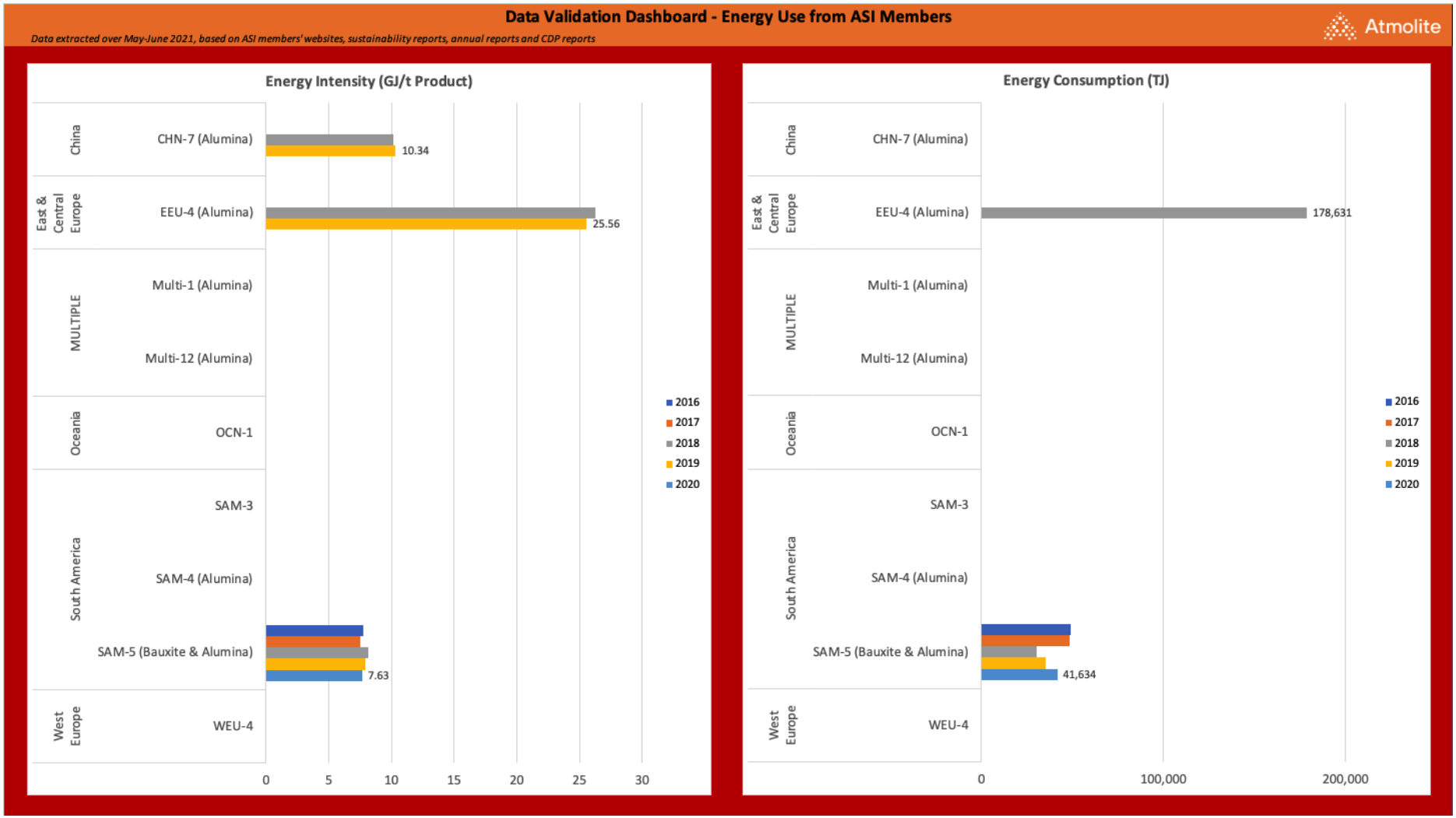
01_Bauxite Supply Chain – Energy Use Disclosures, both intensity (GJ/t Product) and total (TJ)



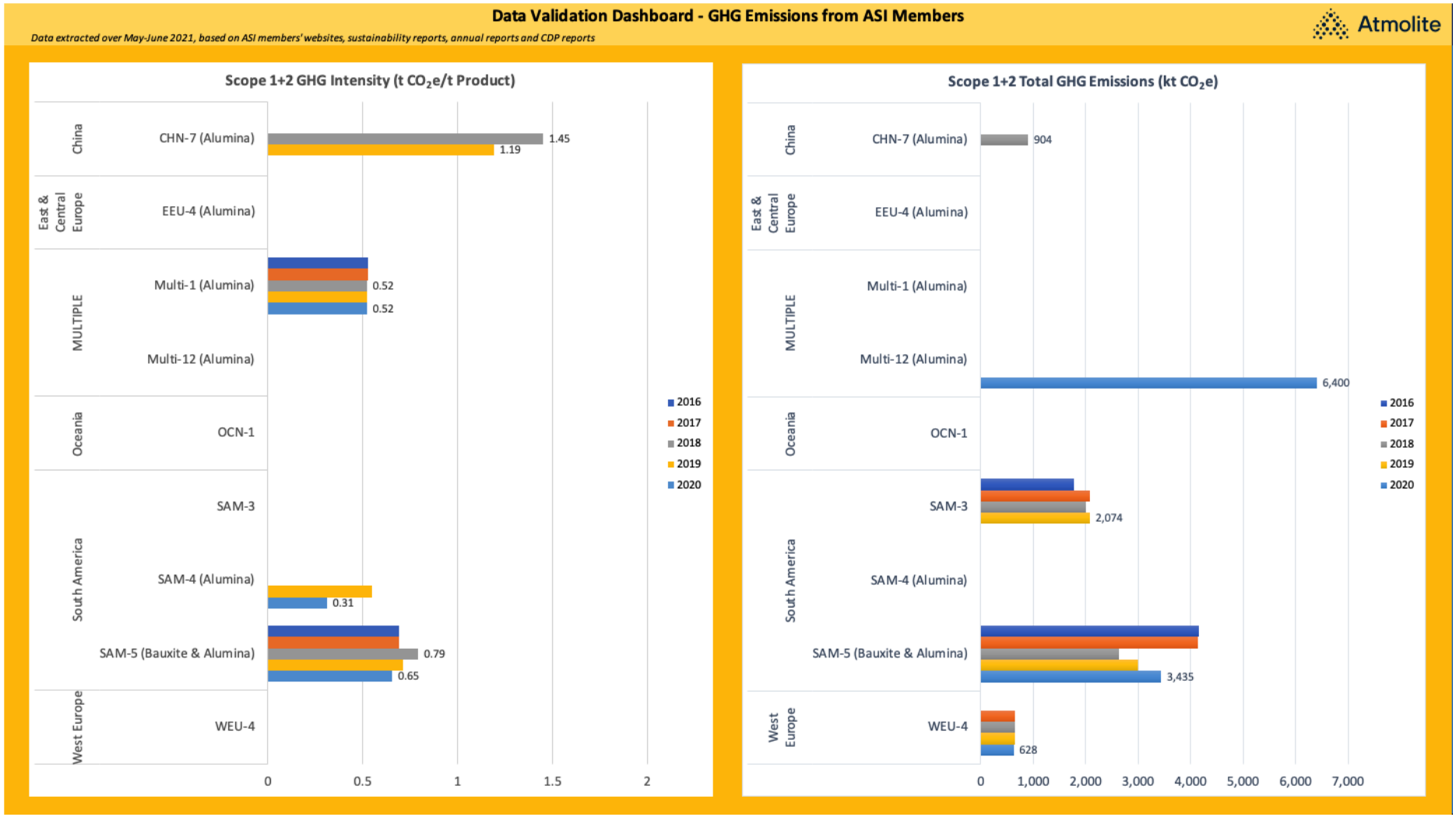
01_Bauxite Supply Chain – GHG Emission (Scope 1 + Scope 2) Disclosures, both intensity (t CO_2e/t Al) and total (kt CO_2e)



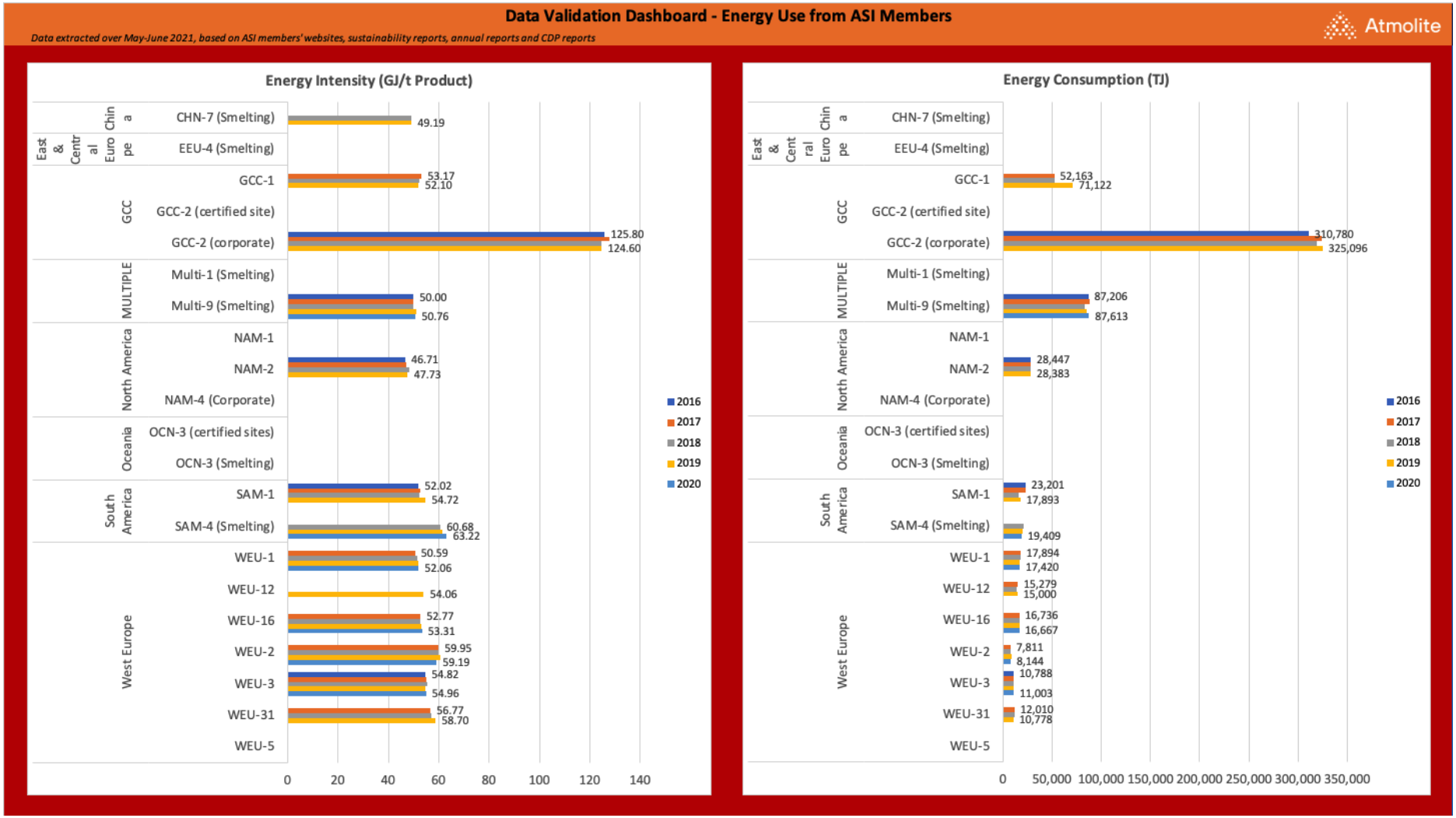
02_Alumina Supply Chain – Energy Use Disclosures, both intensity (GJ/t Product) and total (TJ)



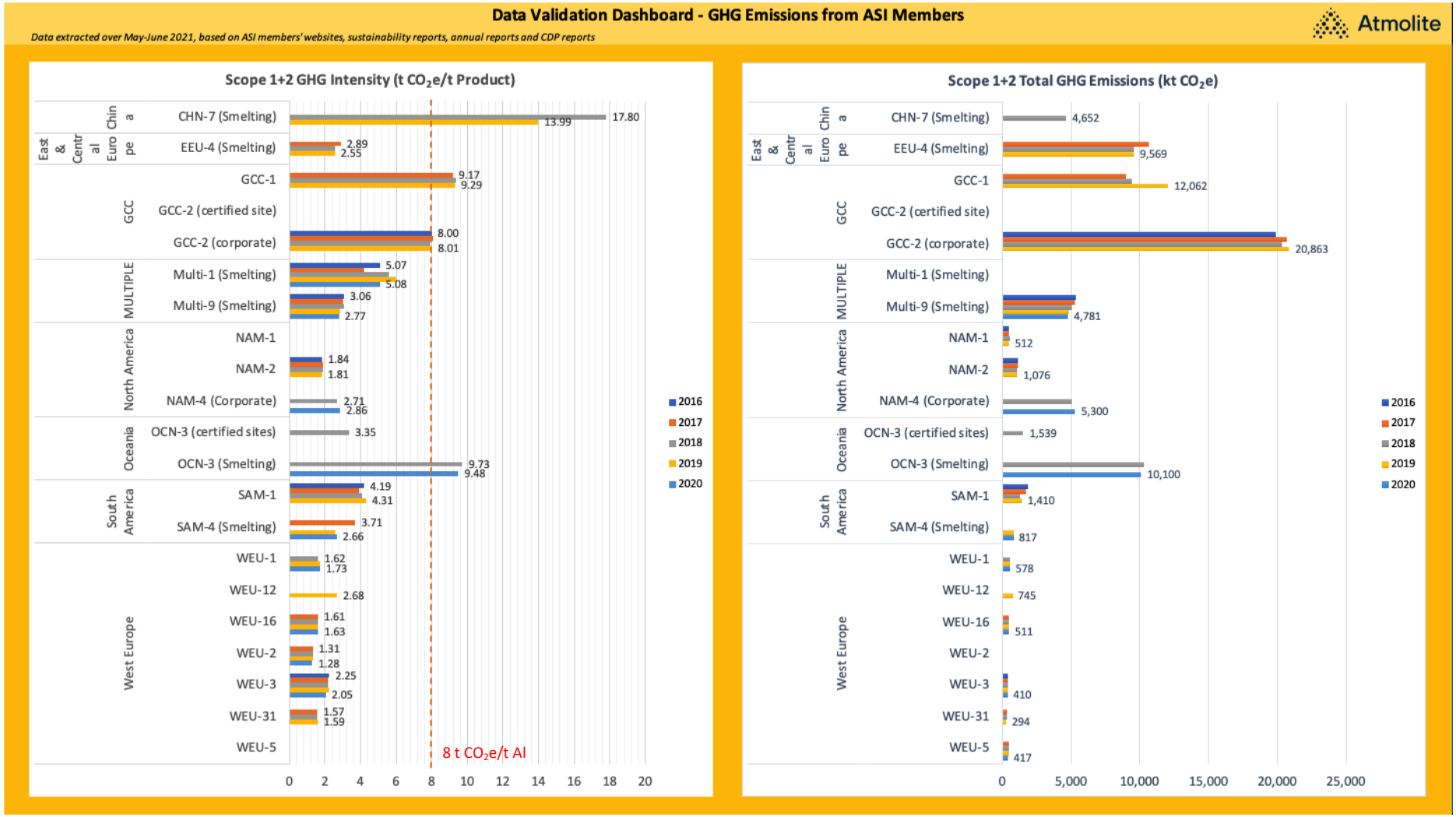
02_Alumina Supply Chain – GHG Emission (Scope 1 + Scope 2) Disclosures, both intensity (t CO_2e/t Al) and total (kt CO_2e)



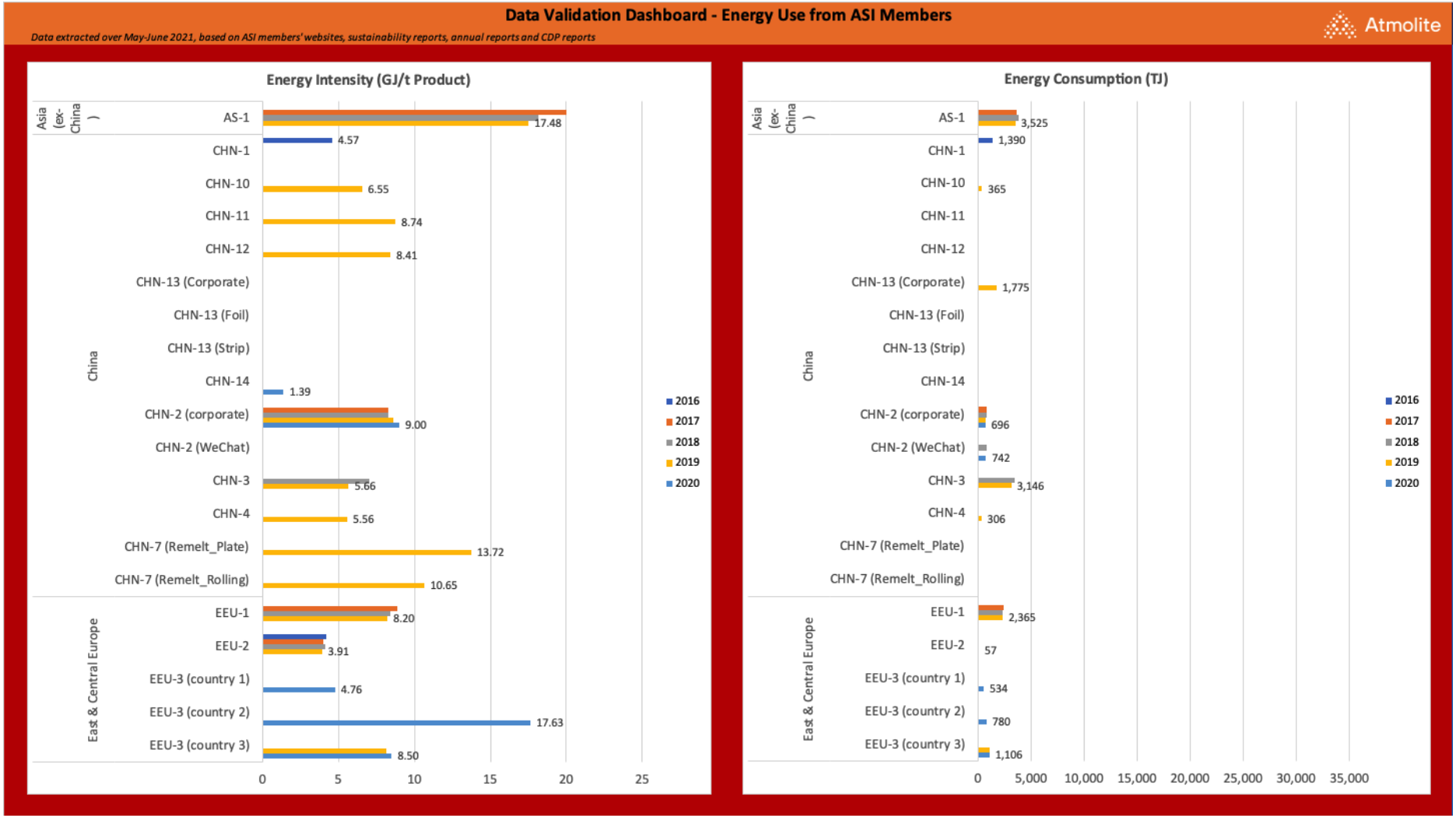
03_Smelting Supply Chain – Energy Use Disclosures, both intensity (GJ/t Product) and total (TJ)



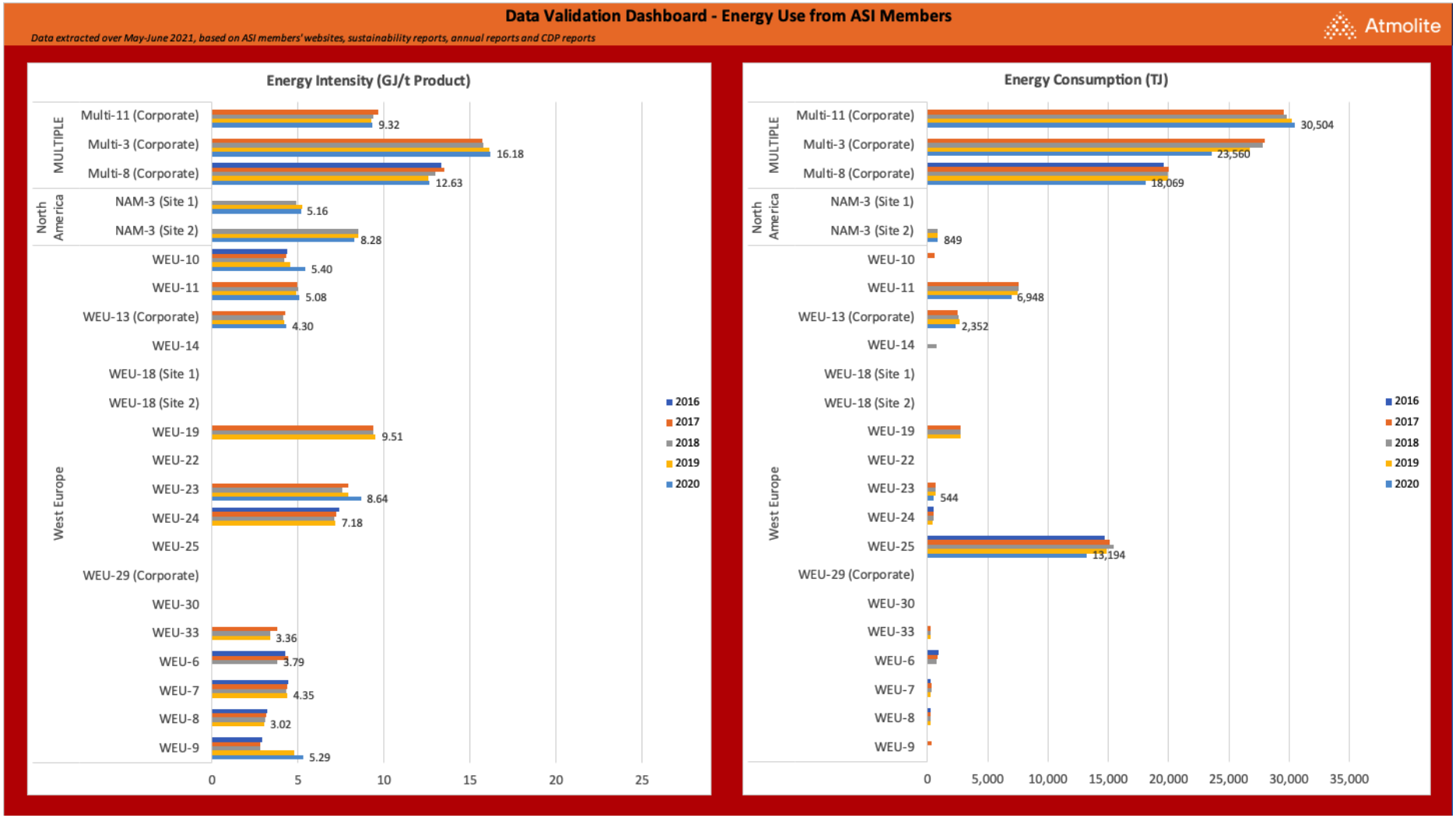
03_Smelting Supply Chain – GHG Emission (Scope 1 + Scope 2) Disclosures, both intensity (t CO_2e/t Al) and total (kt CO_2e)



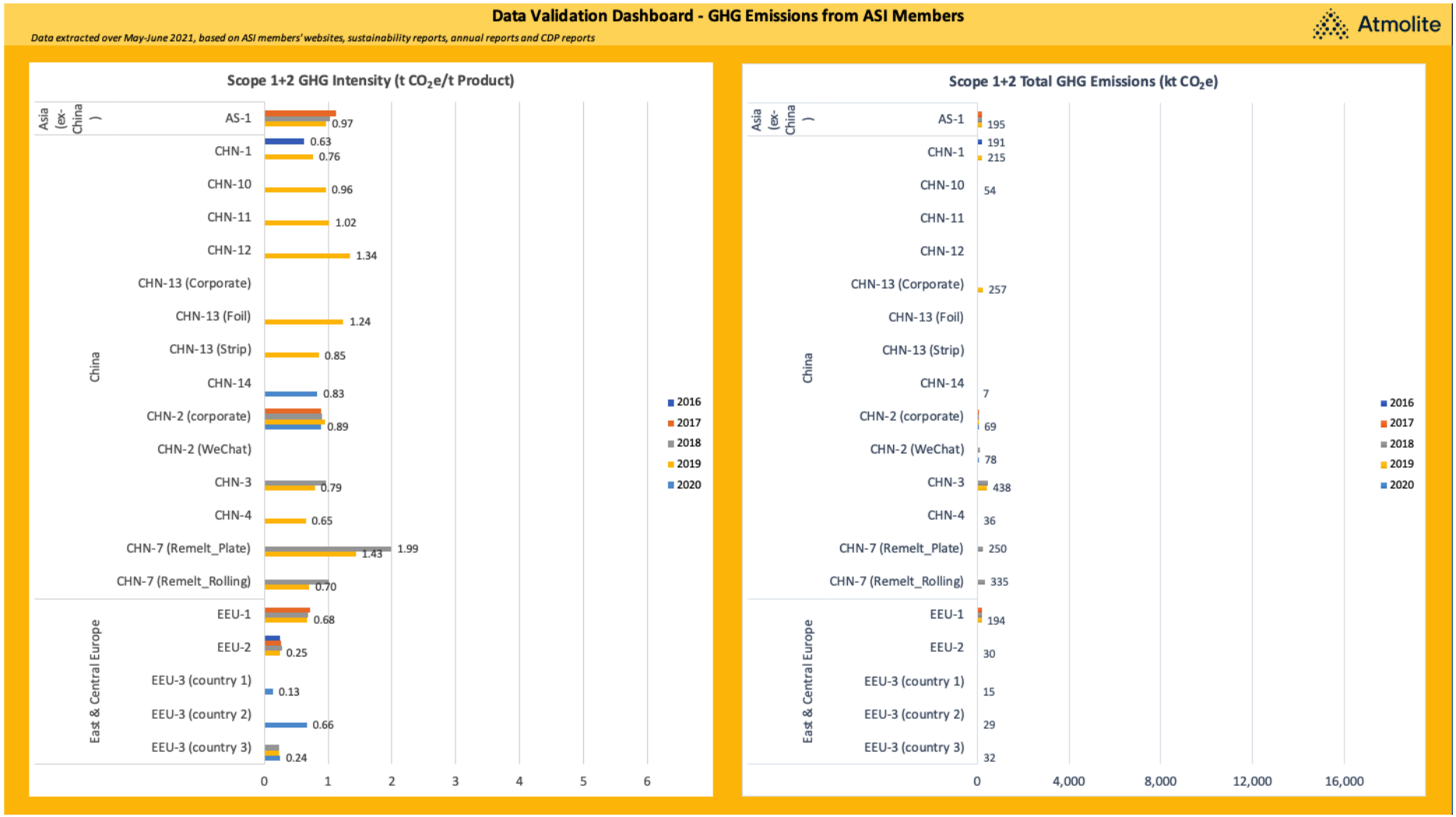
04_Remelting-to-Downstream Supply Chain (Asia, China, Eastern / Central Europe) – Energy Use Disclosures, both intensity (GJ/t Product) and total (TJ)



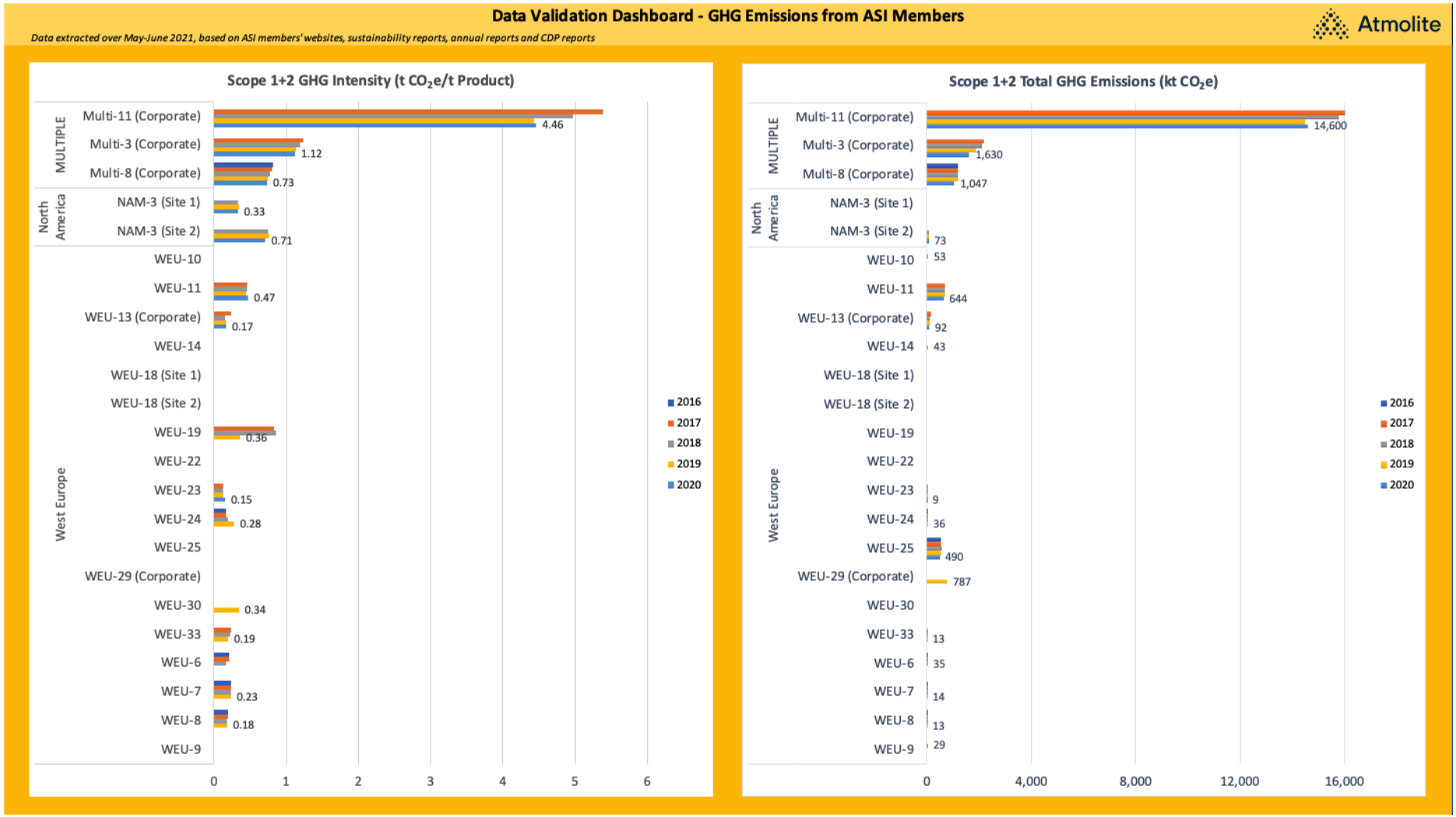
04_Remelting-to-Downstream Supply Chain (North America, Western Europe, Multiple regions) – Energy Use Disclosures, both intensity (GJ/t Product) and total (TJ)



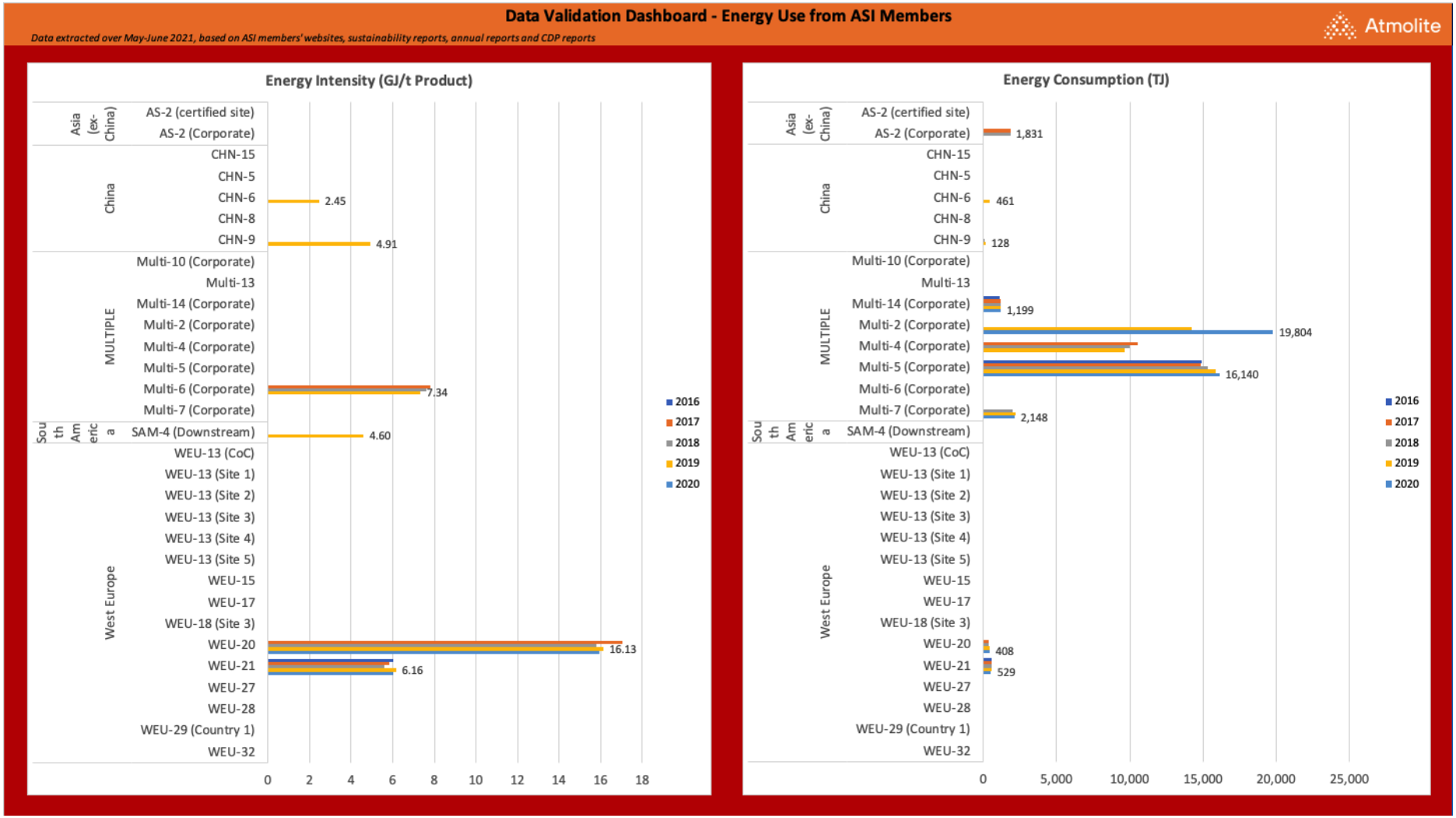
04_Remelting-to-Downstream Supply Chain (Asia, China, Eastern / Central Europe) – GHG Emission (Scope 1 + Scope 2) Disclosures, both intensity (t CO_2e/t Al) and total (kt CO_2e)



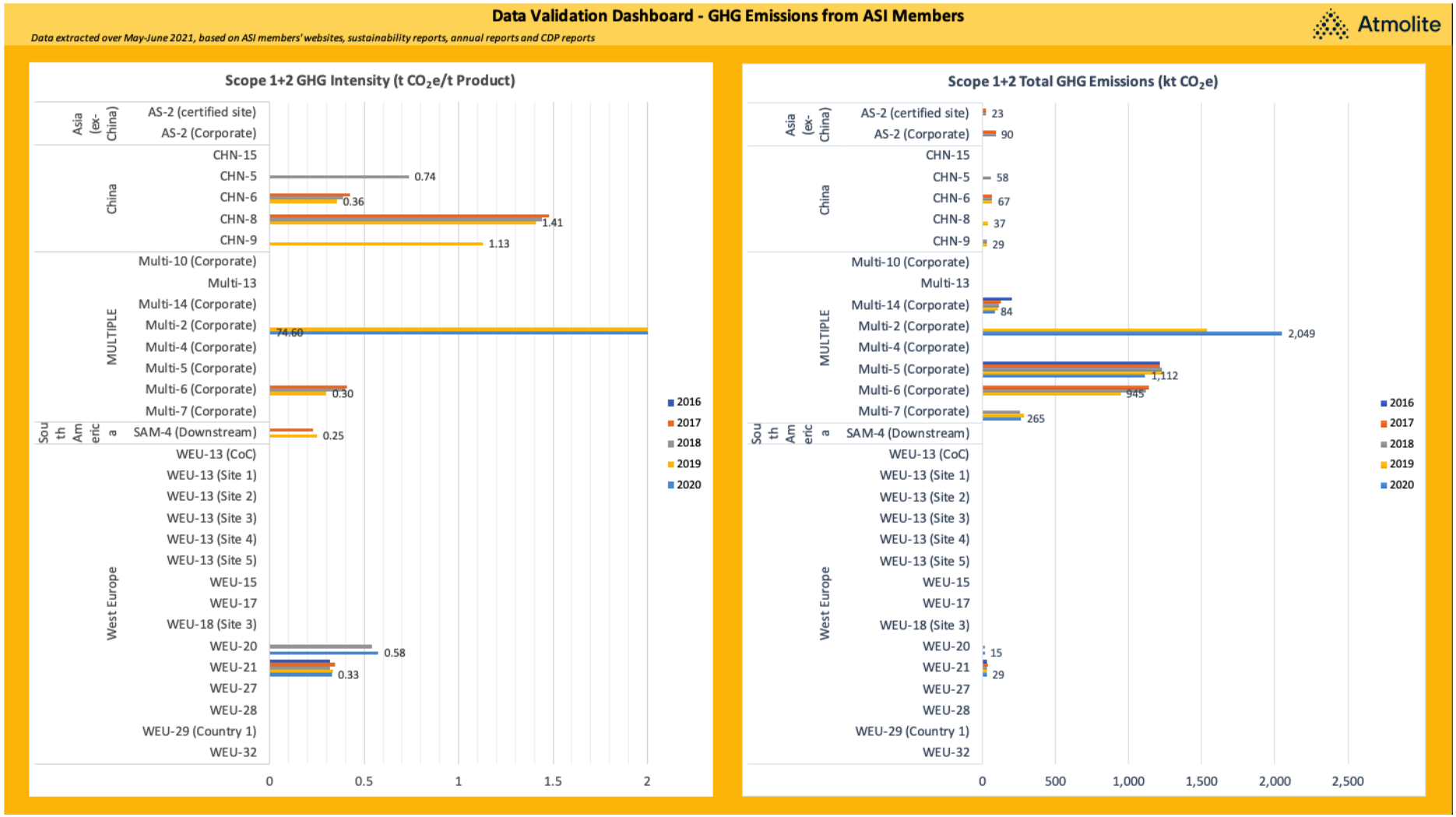
04_Remelting-to-Downstream Supply Chain (North America, Western Europe, Multiple regions) – GHG Emission (Scope 1 + Scope 2) Disclosures, both intensity (t CO_2e/t Al) and total (kt CO_2e)



05_Downstream Supply Chain – Energy Use Disclosures, both intensity (GJ/t Product) and total (TJ)



05_Downstream Supply Chain – GHG Emission (Scope 1 + Scope 2) Disclosures, both intensity (t CO_2e/t Al) and total (kt CO_2e)

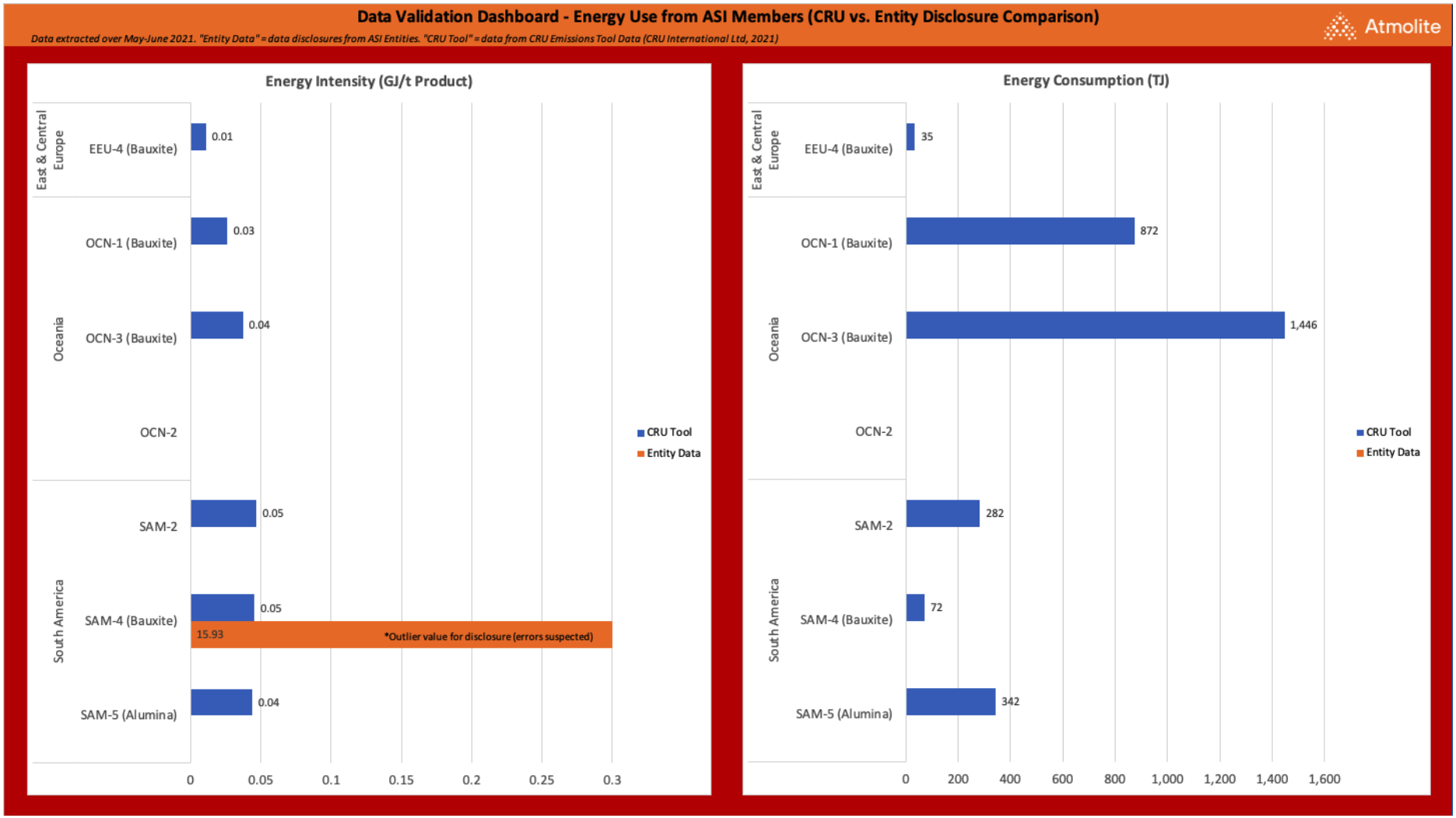


Appendix III – Graphical Comparisons, Entity Data Disclosures vs. CRU Emissions Tool Data

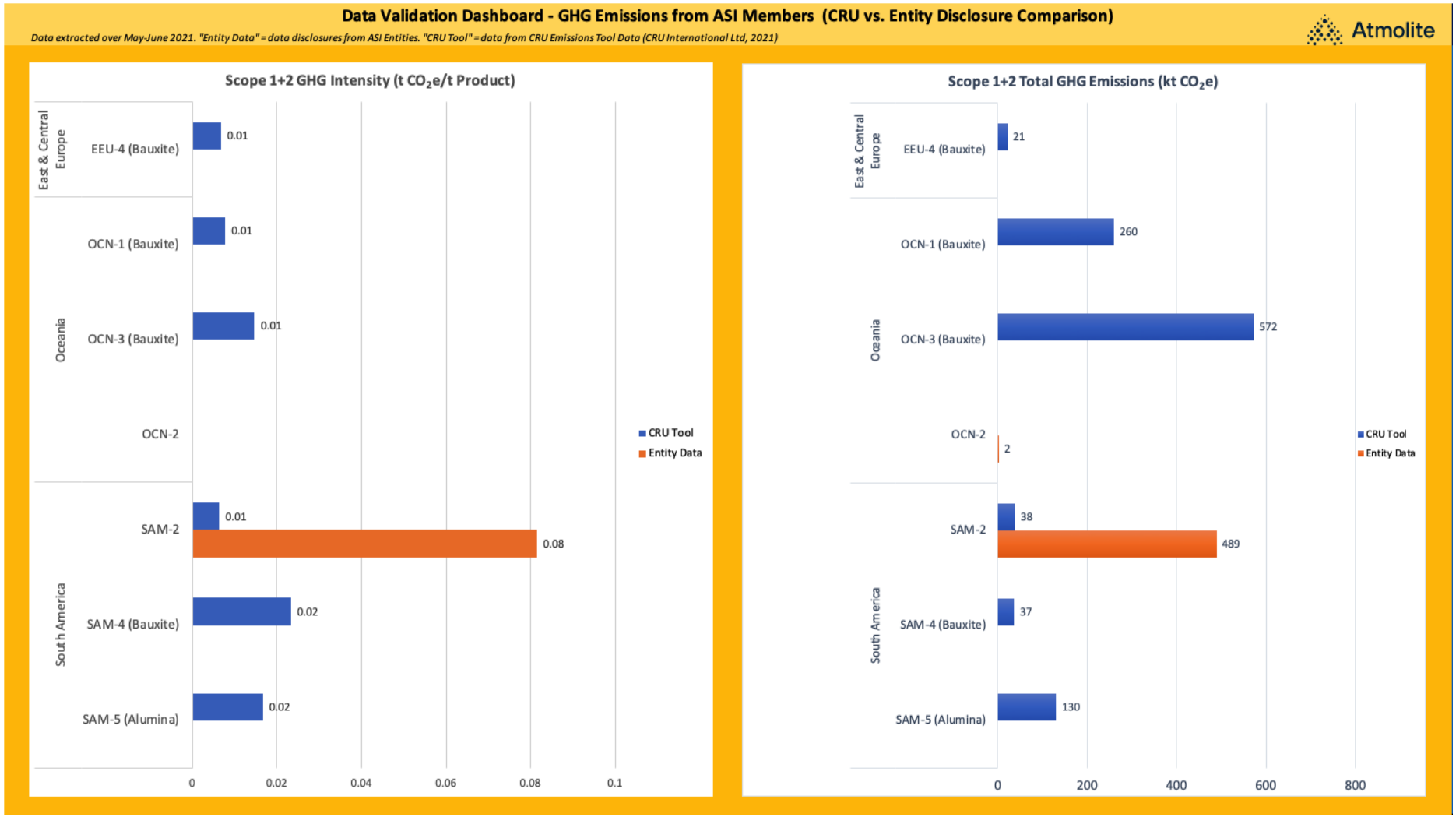
Note – CRU data set provides energy consumption data for all assets/processes – but for electricity only (units, GWh), currently not other (non-electricity) energy carriers. Therefore, comparisons Entity disclosed energy intensities (GJ/t) and CRU power intensities (GJ/t, converted from GWh) are only valid for the Smelting activity (where electricity is a reasonable proxy for total energy use). This is not the case for Bauxite mining or Alumina refining, where electricity is not the major source of energy.

The following graphs provide comparisons of Data Disclosures and CRU Data for only the latest year of data disclosure (typically 2019 or 2020).

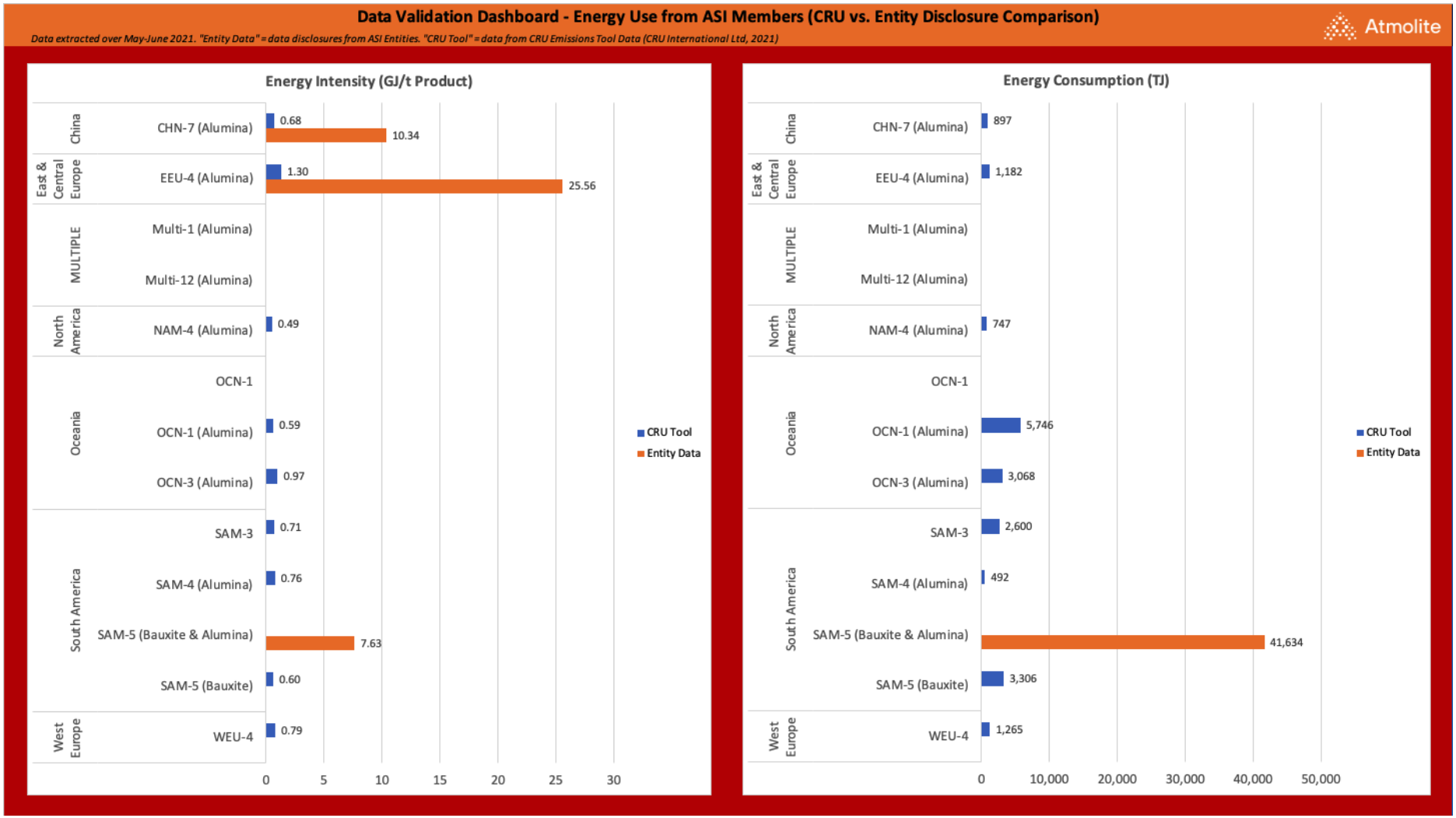
01_Bauxite Supply Chain – Energy Use Disclosures vs. *CRU Emissions Tool* data, both intensity (GJ/t Product) and total (TJ)



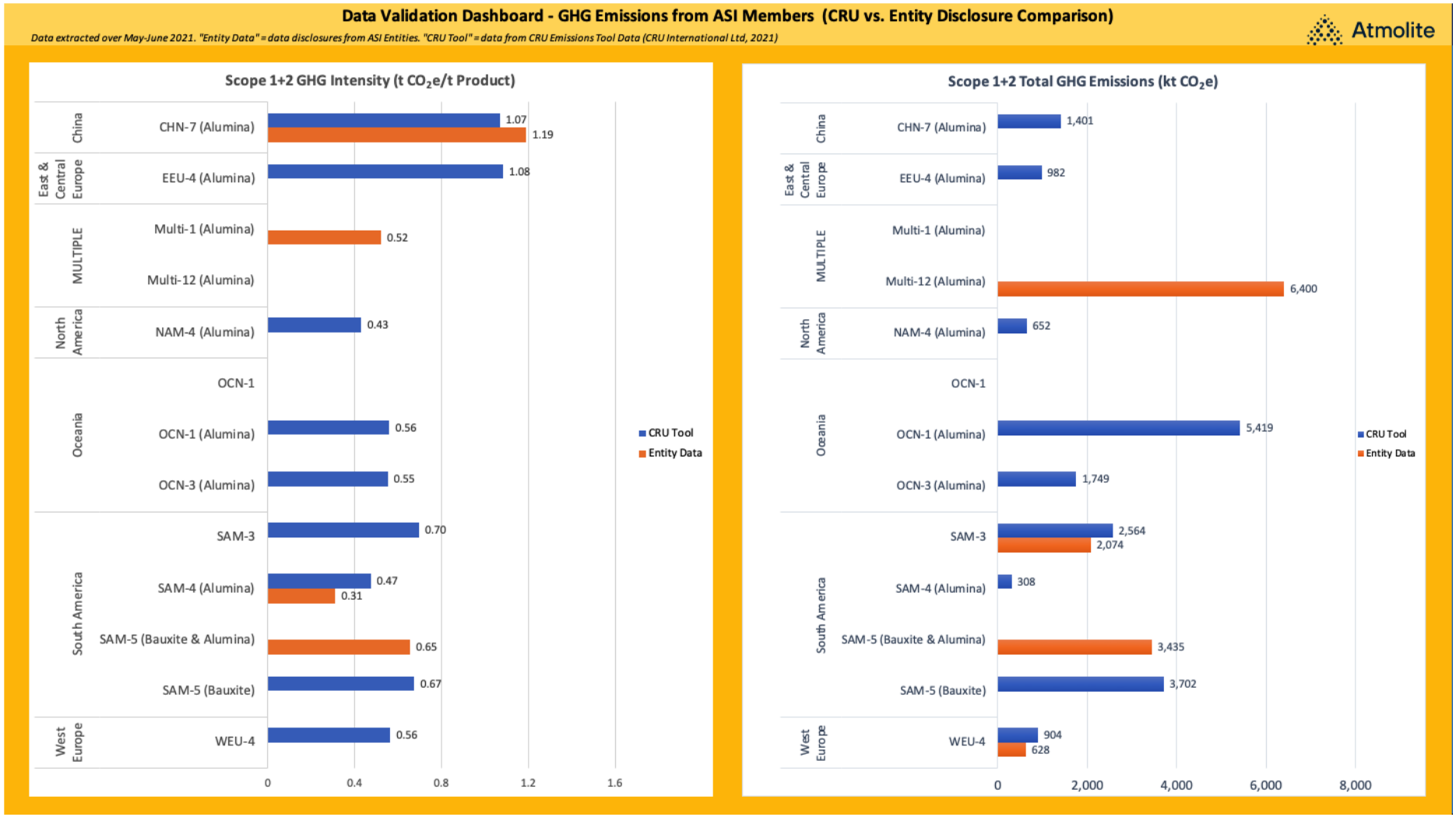
01_Bauxite Supply Chain – GHG Emission (Scope 1 + Scope 2) Disclosures vs. *CRU Emissions Tool* data, both intensity (t CO_2e/t Al) and total (kt CO_2e)



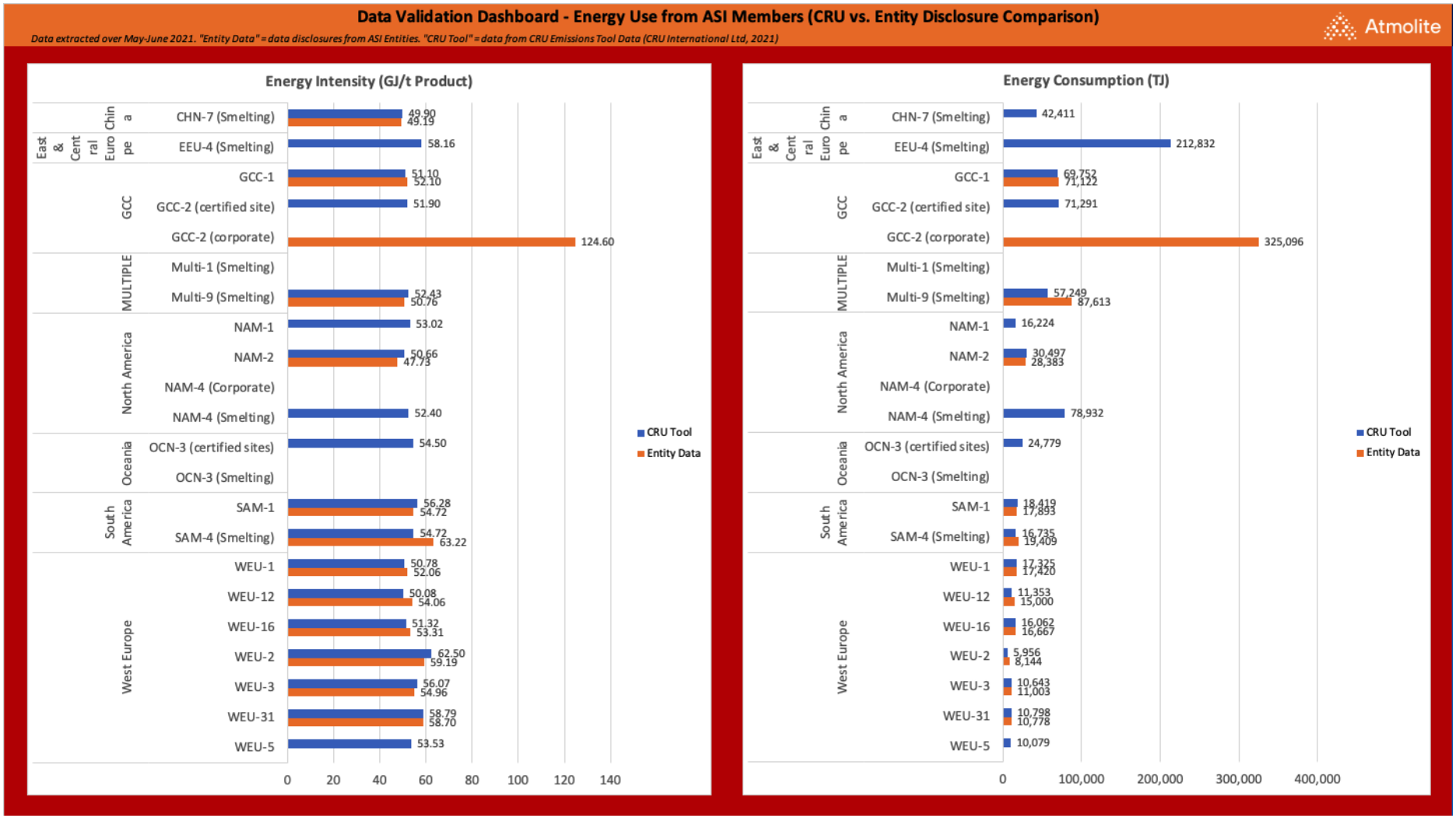
02_Alumina Supply Chain – Energy Use Disclosures vs. *CRU Emissions Tool* data, both intensity (GJ/t Product) and total (TJ)



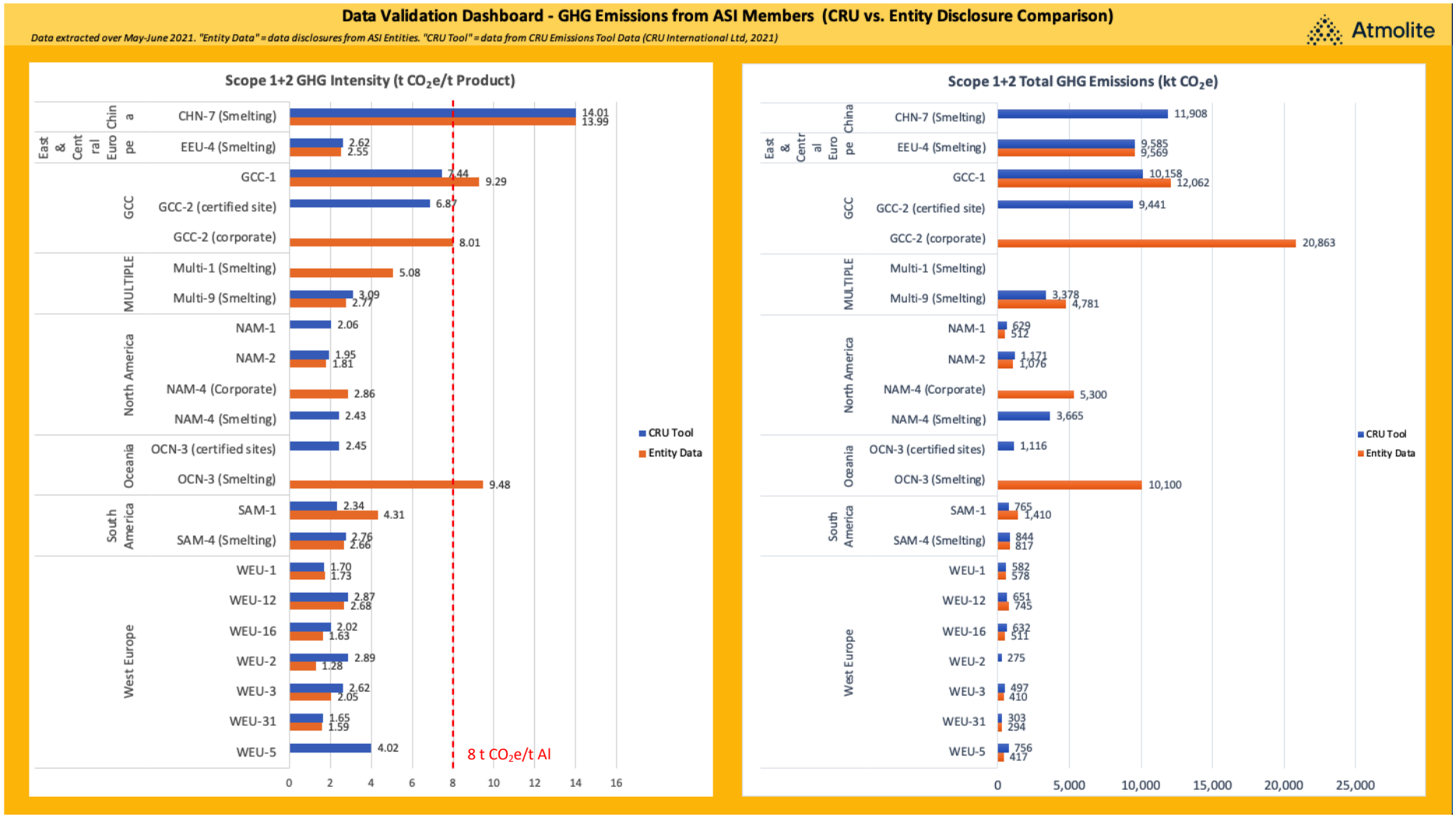
02_Alumina Supply Chain – GHG Emission (Scope 1 + Scope 2) Disclosures vs. *CRU Emissions Tool* data, both intensity (t CO_2e/t Al) and total (kt CO_2e)

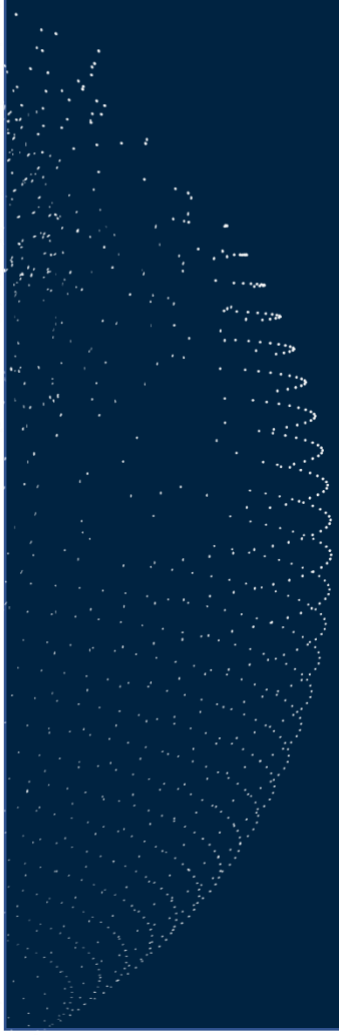


03_Smelting Supply Chain – Energy Use Disclosures vs. *CRU Emissions Tool* data, both intensity (GJ/t Product) and total (TJ)



03_Smelting Supply Chain – GHG Emission (Scope 1 + Scope 2) Disclosures vs. *CRU Emissions Tool* data, both intensity (t CO_2e/t Al) and total (kt CO_2e)





Atmolite