Carbon footprint assessment of Gränges’ aluminium products

Climate impact of flat rolled aluminium products
made by Gränges Aluminium (Shanghai) Co., Ltd.

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TABLE OF CONTENTS

SUMMARY

In line with Gränges' group-wide sustainability framework and accompanying targets to 2025, the company works to develop sustainable product offerings and provide clear and verified sustainability information on its products. This aim is to enable for customers and other stakeholders to understand, evaluate and compare Gränges' products from a sustainability perspective.

Gränges' operations in Shanghai, China, have developed an internal life-cycle assessment (LCA) tool, which enables calculations and declarations of environmental impacts on a product level, starting with the carbon footprint. This carbon footprint assessment report outlines the methodological choices and allocations done to calculate the carbon footprint of products produced in the Shanghai production site, according to the ISO 14040:2006 and ISO 14044:2006 standards as well as ISO 14067:2018. The report is intended for internal as well as external use including customers. Gränges' process for carbon footprint calculations is reviewed and validated by an independent third-party reviewer and the review includes this report, the LCA tool and other documentation.

The calculations are made cradle to factory gate and thus include all process steps from bauxite mining to inbound transports, as well as all Gränges' activities up until delivery from the site. The main materials that are used to produce the products are included, i.e. primary aluminium ingots, sourced slabs and alloying elements, as well as external recycled aluminium. The functional unit is 1 tonne of finished product.

The calculations are made for individual articles and groups of articles, but as the number of articles is very high (more than two thousand) it is beyond the scope of this report to show all the individual results. The report presents example results for three selected products. In general, the majority of the climate impact of Gränges' products comes from the production of primary aluminium, i.e. primary aluminium ingots and purchased slabs, which is an energy intensive process. The impact from Gränges' own operations generally accounts for around 3-6 per cent of the total carbon footprint, and mainly relates to the remelting and casting process where natural gas is used as a main energy source. Impacts from alloying elements generally account for around 1-3 per cent and inbound transports for less than 1 per cent. External recycled aluminium accounts for a very small portion of the climate impact as this material is modelled with a cut-off assumption and only includes climate impacts from processing and transport of the material. Internal recycled aluminium is treated as an internal flow and is recirculated within the product system.

The main implication from the carbon footprint assessment on Gränges' products is that there are five clear ways in which Gränges can reduce the carbon footprint of its products: 1) Source more low-carbon primary aluminium, 2) Source more external recycled materials, 3) Increase internal recycling and reduce volumes of internal scrap sold, 4) Reduce energy intensity in own operations, 5) Increase the use of renewable energy in own operations. Gränges' climate strategy is to take product stewardship and reduce climate impact along the value chain, across the life-cycles of its products.

PREFACE

With the global push for sustainable development and the transformation into a more circular and resource-efficient economy, Gränges' customers are increasingly recognizing the importance of using sustainable materials. Aluminium is often called the "green metal" or "the metal of the future" thanks to its properties such as lightness, durability and infinite recyclability. Gränges works to leverage these unique properties to design and manufacture sustainable products, which can improve resource efficiency and climate performance along the value chain.

Having clear sustainability information on product level enables for Gränges' customers and other stakeholders to understand, evaluate and compare Gränges' products from a sustainability perspective. It also helps Gränges to build a solid fact base for innovation and performance improvements, with the aim to further design and develop customer offerings geared towards sustainability and circularity.

In this carbon footprint assessment report, Gränges presents the methodology, process and assumptions used to calculate the environmental impact of its flat rolled aluminium products, with a focus on the carbon footprint impact. The process and results have been third-party verified and additional information about the verification process can be found on Gränges' website.

AUTHORS

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ABBREVIATIONS

CO_2e = Carbon dioxide equivalents
tonne = metric tonne i.e. 1000 kg

1 INTRODUCTION

Aluminium is generally regarded as a sustainable material based on its recyclability, lightness, corrosion resistance, barrier properties etc. However, production of primary aluminium is energy intensive due to aluminium's strong affinity to oxygen and the process required to split aluminium from said oxygen. Recycling and remelting of aluminium save up to 95 per cent of the energy required to produce primary aluminium, but to maximize value of the aluminium to be remelted, a good sorting of different aluminium alloys is required.

Gränges' production site in Shanghai manufactures flat rolled aluminium products primarily for automotive applications but also for other segments. The process is further described in section 3. The largest product category is material for automotive brazed heat exchangers such as radiators for engine cooling and condensers and evaporators for the air conditioning system. The plant is not connected to a primary smelter. In its remelting operation it uses sourced primary material and sourced or internally recycled raw materials to make rolling slabs. In its cold- and hot-rolling operations, it uses own produced slabs or sourced slabs from primary smelters. Thus, a mix of primary and secondary aluminium is used. The sold product consists of one or several aluminium alloys in a certain dimension and with properties specified by the customer (such as strength, formability, corrosion resistance etc.). The product is generally delivered as a coil, see Figure 1.

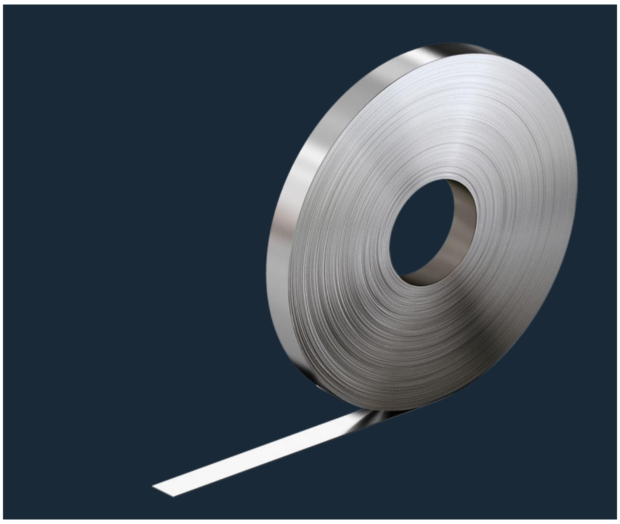

Figure 1. A typical coil delivered from Gränges to customers.

A large part of the manufactured and sold products are so called clad materials. These materials consist of several aluminium alloys rolled together in a hot rolling operation. Process scrap generated in this process and in downstream operations is therefore a mix of two or more alloys, which cannot be separated in an easy way. A smart sorting and use of this process scrap is thus a key factor in achieving a high recovery rate.

This carbon footprint assessment report describes the methodological choices and allocations done to calculate carbon footprint of products according to the ISO 14040:2006 and ISO 14044:2006 standards as well as ISO 14067:2018. It is intended for internal as well as external use including customers.

Gränges process for carbon footprint calculations is reviewed and validated by an independent third-party reviewer, including this report, the LCA tool used in the calculation as well as other documentation describing the process. The third-party verification covers a review of Gränges processes and routines for conducting LCA, to secure that the methodology, data collection, calculations, result preparations and internal verifications delivers correct product carbon footprint results.

2 GOAL AND SCOPE

2.1 Goal

The goal is to have transparent, representative and third-party verified carbon footprint data available for all products. The data shall be structured in a way so that it is easily updated at a pre-determined frequency. The data shall also serve as a fact base for performance improvements with regards to carbon footprint for individual products and the site in total. Communication of results shall be easy for stakeholders to understand, both in terms of calculation methods and the actual carbon footprint of the product. This is valid both internally and externally, so that for example customers can compare results for products from Gränges and similar assessment results from its competitors. The information will be summarized in a carbon footprint certificate. Another goal is to use the environmental performance data to develop product offerings geared towards sustainability and circularity.

2.2 Scope

2.2.1 System boundaries

The calculations are made cradle to factory gate. This means that all process steps from bauxite mining to inbound transports, together with all Gränges' activities up until delivery from the site, are included. Distribution, further processing and use of the products as well as end-of life treatment are excluded initially.

The products covered in this report are produced at Gränges Aluminium (Shanghai) Co., Ltd. located in Shanghai, China. A generic flow chart of the relevant processes is shown in Figure 2.

The main materials that are used to produce the products are included, in terms of primary aluminium ingots, sourced slabs and alloying elements, as well as external recycled aluminium. Packaging materials, rolling oil and emulsions are included but other ancillary materials used in the production (such as process gases, chemicals, materials used in maintenance of equipment etc) have been excluded as they constitute significantly less than 1 per cent of the carbon footprint. Manufacturing of production equipment, buildings and other capital goods, as well as travel to and from work for personnel are also excluded.

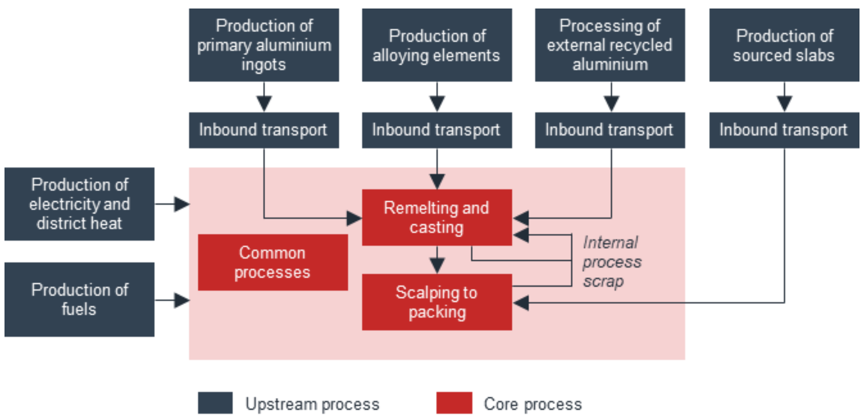

Figure 2. Generic flow chart for upstream (blue) and core (red) processes.

2.2.2 Functional unit

The functional unit is 1 metric tonne of finished product, which is also the unit in which the customer purchases the product. A product is a rolled material with specified characteristics such as alloy composition, dimensions, mechanical properties etc. It is defined with a specific article number.

2.2.3 Environmental impact categories

In this report, we only consider products' carbon footprint, expressed as Global Warming Potential (GWP) using IPCC GWP values for the 100-year time horizon.

Only GHG values for net fossil emissions are reported. Biogenic emissions and removals and GHG emissions and removals resulting from direct land use change (dLUC) is not reported separately. This is due to lack of data, the supplier specific data which is used for primary aluminium and energy only includes fossil emissions. Biogenic and dLUC emissions and removals are, however, assumed to be negligible.

Other impact categories may be added at a later stage. In a pilot study, several other categories were included and showed a very similar trend to carbon footprint. Thus, carbon footprint can at this point be used as a proxy for other environmental impact categories.

2.2.4 Key assumptions

The largest share of the carbon footprint for Gränges' products comes from the production of primary aluminium, in terms of primary aluminium ingots and purchased slabs. When casting slabs internally, each alloy is made on a specific recipe consisting of for example primary aluminium ingots, external recycled aluminium, recycled aluminium from internal processes, alloying elements etc. The ingredients are melted, mixed and cast into large slabs. Externally sourced slabs are made of primary aluminium directly from the smelting operation mixed with the required alloying elements to meet the specified composition. Supplier specific data is used for production of primary aluminium.

External recycled aluminium is modelled with a cut-off assumption, i.e. that the environmental impact of the original primary material production generating the recycled aluminium is not carried over to the recycled aluminium. This is in line with general practice for environmental product declarations in accordance with ISO 14025. Post-consumer and pre-consumer external recycled aluminium are treated in the same way. This is in line with the ISO 14021 definition of recycled content.

Alloying elements are added to the remelting process to achieve the correct composition of an alloy. In general, the share of alloying elements is relatively small, and therefore it is assumed that publicly available sources of alloying elements' environmental impact are good enough.

When calculating the environmental impact of processing from slab to final product (so called 'scalp to pack') four product groups have been identified, see Table 1. Energy consumption is the major contribution to environmental impact within the core processes. To simplify data collection, typical product groups have been identified, which represent all individual products (articles) within the group in terms of energy consumption. Gränges' operation in Shanghai produces very small volumes of unclad tube and unclad thick, which is less than 1% of total production volume. Therefore, unclad tube is combined with clad tube as one product group 'Tube' and unclad thick is combined with clad thick as one product group 'Thick'. If new products are introduced, which do not fit well into these four groups, new groups will be identified and added.

Table 1. Product groups for environmental impact calculation from slab processing and downstream.

Product group	Typical gauge (mm)
Unclad fin	0.07
Clad fin	0.08
Tube (including clad tube and unclad tube)	0.22
Thick (including clad thick and unclad thick)	0.5

Process scrap generated in the internal production route is to a large extent recycled back into products through the remelting process. Thus, the main part of the process scrap is recycled within the core process, only a minor part is sold.

3 PROCESS AND DATA DESCRIPTION

Table 2 shows the input materials and processes included in the complete product system, see also Figure 2 above. Each input material and process are described below including data collection.

Table 2. Upstream and core processes.

Type of process	Process	Reference, chapter
Upstream processes	Primary aluminium	3.1
	External recycled aluminium	3.2
	Alloying elements	3.3
	Purchased slabs	3.4
	Inbound transport	3.5
	Energy	3.6
Core processes	Remelting and casting	3.7.1
	Scalping to packing	3.7.2
	Common processes	3.7.3
	Internal recycled aluminium	3.7.4

3.1 Production of purchased primary aluminium

Aluminium is an abundant metal in the earth crust. It is easily oxidized and is therefore not found in its elemental state. It is bound to oxygen as Al_2O_3 and is generally mined from the mineral bauxite. Bauxite is found mostly in tropical climate areas. Mining of the bauxite is followed by a refining process, which results in commercially pure Al_2O_3. This oxide is then converted to aluminium through an electrolysis process in a so-called aluminium smelter.

The result is primary aluminium with only low amounts of Fe and Si. The electrolysis process is an energy intensive process, in which also emissions of perfluorocarbons (PFC) are generated (included in data from suppliers). The primary aluminium is cast into ingots, billets or slabs, either as commercially pure aluminium or alloyed with desired elements. The environmental impact of primary aluminium ingots covers the process from mining to casting of the ingot. The pre-mining activities concerning exploration and establishment of the mine are not included.

Gränges sources primary aluminium ingots from commodity traders and not directly from the primary aluminium producers. The commodity traders are required to provide verified cradle-to-gate carbon footprint data to Gränges, which they in turn receive from the primary aluminium ingot producers. The majority of primary aluminium volume is based on Chinese industry average, and the producers in Shandong Province have not reported “cradle-to-gate” impact. Gränges collects their “gate-to-gate” impact from their operations, and then estimates the primary aluminium carbon footprint based on the industry average. Such information is usually stated in carbon footprint certificates. The information is used in Gränges carbon footprint assessment calculations, and updates are made annually. If supplier specific data is not available, Chinese industry average data for primary aluminium production is used.

3.2 Processing and transport of external recycled aluminium

Gränges sources recycled aluminium from external recycling companies. Gränges also sources materials from pre-consumer usage, i.e. materials originating in various processing industries. Collection and transport of the recycled aluminium to the recycling companies as well as sorting of recycled materials at the recycling companies’ sites are included.

The collection and transport of recycled aluminium to the recycling companies has been estimated based on data from one recycling company. Energy use in sorting of recycled aluminium has been estimated based on data collected from one supplier. The information is reviewed annually, based on the supplier mix, and updated when needed.

3.3 Production of alloying elements

Gränges sources alloying elements from several suppliers in different forms. Some are sourced in pure form and some are sourced as a master alloy (mixed with aluminium to a certain share). As stated in section 2.2.4, the environmental impact of the alloying elements is low as the share of alloying elements added is generally low. Therefore, the production routes of these elements are not described.

Table 3 shows the major alloying elements used (in terms of sourced volume), the form in which it is used (pure or master alloy), and the assumptions made for data collection. It is assumed that the environmental impact from the production of sourced alloying elements as a master alloy (mixed with aluminium to a certain share) is rather low. The production of alloying elements has been modelled using data from industry associations, published literature and databases. For some of the alloying elements, specific data for the elements are not available. In such cases, the production is estimated either by using available data for similar materials or by using primary aluminium when no data is available. The data are reviewed annually and updated when relevant, e.g. when more recent or more representative data are available.

Table 3. Major alloying elements used in slab production.

Alloying element	Form	Data source
Silicon (Si)	Metal Si	Public data.
Silicon (Si)	AlSi20%	Public data. Modelled based on average data for silicon and primary aluminium.
Copper (Cu)	AlCu50%	Public data. Modelled based on average data for copper and primary aluminium.
Copper (Cu)	1# pure Cu	Public data. Estimated using data for copper sheet.
Copper (Cu)	Scrap Cu	Public data. Estimated using data for copper sheet.
Manganese (Mn)	Mn80NF	Public data. Modelled based on average data for manganese and primary aluminium.
Manganese (Mn)	AlMn20%	Public data. Modelled based on average data for manganese and primary aluminium.
Zinc (Zn)	Zn 1# ingot	Public data.
Titanium (Ti)	AlTi15%	Public data. Modelled based on average data for titanium and primary aluminium.
Titanium (Ti)	AlTi5B1 wire	Public data. Modelled based on average data for titanium, boron, and primary aluminium.
Titanium (Ti)	AlTi10% tray	Public data. Modelled based on average data for titanium and primary aluminium.
Titanium (Ti)	AlTi3C0.15	Public data. Modelled based on average data for titanium and primary aluminium.
Zirconium (Zr)	AlZr10%	Public data. Modelled based on average data for zirconium and primary aluminium.
Iron (Fe)	AlFe20%	Public data. Modelled based on average data for iron and primary aluminium.
Iron (Fe)	Fe powder 99%	Public data. Estimated using data for engineering steel.
Magnesium (Mg)	Mg 99.90% ingot	Public data.
Boron (B)	AlB4%	Public data. Modelled based on average data for boron and primary aluminium.

3.4 Production of purchased slabs

Gränges sources purchased slabs from primary aluminium producers. These slabs are basically produced in the same way as the primary aluminium described in section 3.1. The minor difference in terms of environmental impact is that they are cast in large slabs instead of small ingots. Thus, the same process description is valid as in section 3.1. The slabs are delivered according to Gränges' alloy specifications, and specific suppliers are approved to supply specific alloys.

The slab suppliers to Gränges Aluminium (Shanghai) Co., Ltd. are required to provide cradle-to-gate carbon footprint data of their primary aluminium production, which is used in Gränges' carbon footprint assessment calculations. Updates are made annually.

3.5 Inbound transports

The transport route, in terms of mode of transport (e.g. truck, train, sea) and distance, for each purchased raw material is either known or estimated. Transport distances are based on supplier location. If a specific raw material is delivered by several suppliers, a weighted average distance and route is used based on purchased volume from each supplier. This is valid for external recycled aluminium, alloying elements and primary aluminium ingots.

The environmental impact of the inbound transports of raw materials are modelled using the specific transport routes combined with generic data for different modes of transports.

3.6 Energy sources

Gränges sources electricity and natural gas, which is used in its remelting and casting as well as scalping to packing processes. In addition, Gränges sources diesel, which is used in the “common processes”, e.g. for internal transport.

Electricity is sourced from State Grid Shanghai Municipal Electric Power Company which belongs to East China Grid Company Limited. The sources to the electricity are approximately 30 per cent green power and 70 per cent non-renewable power. Generic data are used for production of natural gas and diesel.

3.7 Gränges’ production process on site

Figure 3 schematically illustrates the on-site process routes of clad and unclad materials. The routes are different and therefore unclad and clad products are separated in the carbon footprint calculations. As shown in Table 1, there is one group of unclad products and three groups of clad products. The reason for dividing into more groups than clad/unclad is a difference in dimensions and to some extent heat treatment.

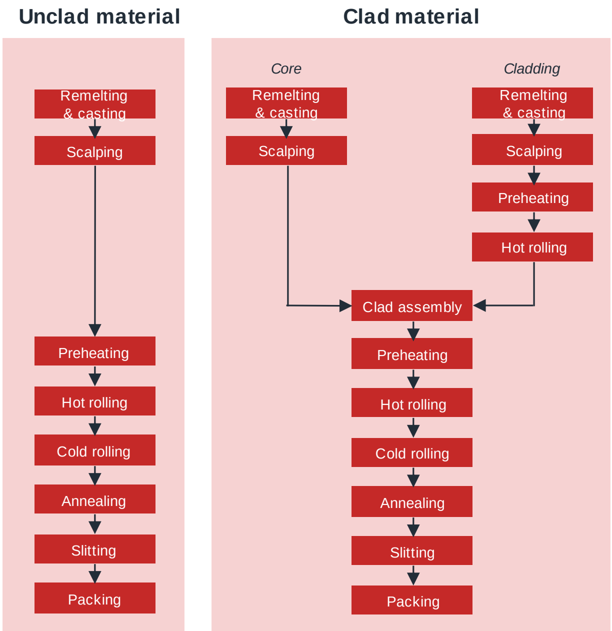

Figure 3. Schematic process route of unclad and clad material.

3.7.1 Remelting and casting

Cost, quality, availability and sustainability are key factors when determining if an alloy should be sourced or cast internally. Generally, the in-house produced alloys contain recycled aluminium while sourced slabs contain primary aluminium. Primary aluminium is required when the specification dictates low content of alloying elements such as iron and silicon.

In-house remelting and casting are done in large furnaces that are fuelled with natural gas. Raw materials are fed into a melting furnace where the right composition is ensured by melting, stirring, sample measurements and addition of raw materials if needed to correct the composition. The melt is then transferred to a holding furnace (except in smaller furnaces where there is a combined melting and holding furnace), where cleaning of the melt from unwanted particles and inclusions is done. After that, the melt is led through a launder system into casting moulds where the metal can solidify and cool down. Square slabs of ca 5-10 tonnes weight are produced.

The raw materials used in production of the slabs are decided by a base recipe for each alloy. This recipe is however somewhat flexible depending on availability of raw materials, specifically the availability of recycled aluminium.

The recipe used in the carbon footprint calculations is an average of all slabs produced for each alloy over one year and is updated annually. The share of each input material is used to calculate the carbon footprint for each alloy.

The energy used is based on the total electricity and natural gas consumption allocated equally to each tonne of slab produced, irrespective of alloy.

3.7.2 Scalping to packing

The exact process route is basically different for each product. However, in the interest of simplicity and not to spend too much detailing efforts on small climate impact contributions, four typical process routes have been defined as shown in Table 1. Figure 4 defines these routes. Only differences in energy consumption are considered for the different process routes.

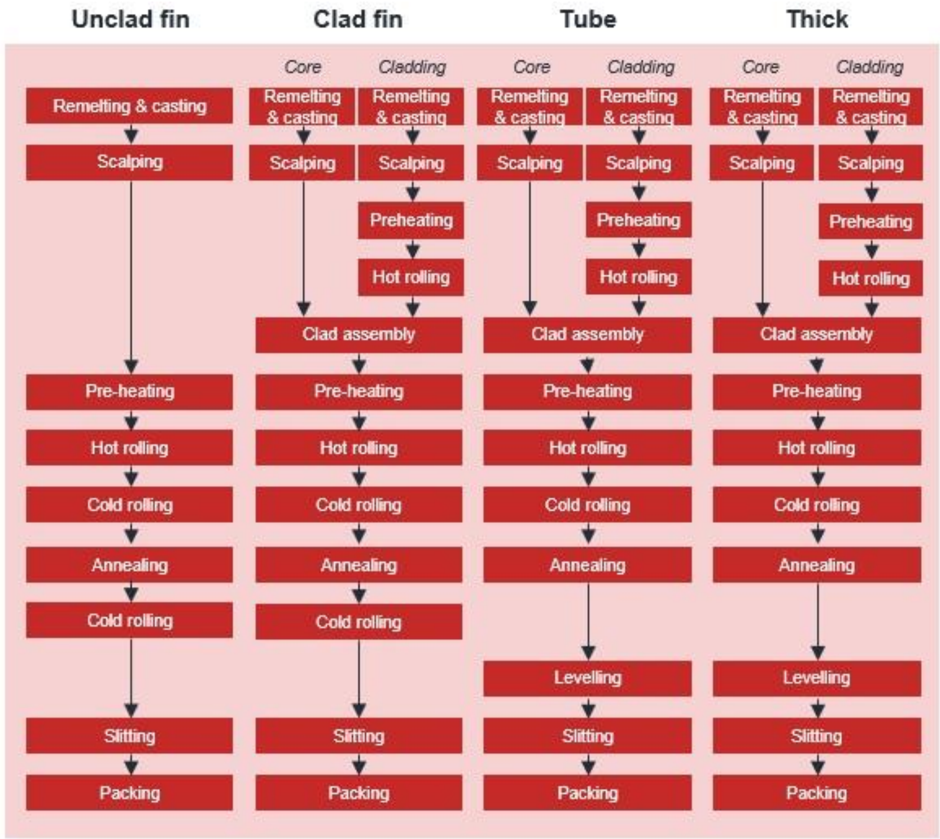

Figure 4. Process routes for different products.

Each product is categorized into one of these groups and if new products do not fit into any of these groups, new groups will be defined. The energy sources used in the processes from scalping to packing are electricity and natural gas. The energy use in each process step is measured as well as the run time for the model products. Comparing run time of these products and total run time in each process, the energy use can be allocated to each model products.

All other relevant consumables and activities are included in “Common processes” covered in section 3.7.3.

3.7.3 Common processes

The common processes concern processes and activities at the site, which are not part of the main process route described above. This includes diesel used for internal transports, natural gas used for canteen, electricity used for air conditioning, packaging materials, rolling oil and emulsions. The climate impact of these processes and activities are however small, especially in comparison to the impacts from sourced raw materials and energy.

The carbon footprint of common processes is allocated evenly to each tonne of product produced.

3.7.4 Internal recycled aluminium

Process scrap is generated along the process steps from slab to final product. This is unavoidable in this type of production and the total amount of such materials generated is used to calculate a recovery rate for each article produced. Depending on where in the process the materials fall, it will come in different forms making it more or less easy to recycle. For clad products, as described in Table 1, process scrap will be a combination of several alloys for scrap generated after the cladding step. Therefore, it is necessarily not recycled to the same alloy as generated the scrap.

The process scrap that is internally recycled carries a carbon footprint equal to the average of all purchased material. If internal recycled aluminium is sold outside the system boundaries, the carbon footprint of that material must be allocated to sold products. The impact of the process scrap is allocated between products as follows:

- process scrap that is recycled internally is allocated to the products that use the scrap as a raw material, based on the assumption that the material ending up as process scrap consists of an average mix of purchased materials. In the calculation, a carbon footprint is assigned to the internal scrap corresponding to the cradle-to-gate impact of the average mix of purchased materials.
- process scrap that is sold is allocated to all products equally, using an average "virtual" yield, which is applied to all products. The "virtual" yield is calculated as the volume of sold products divided by sold products plus sold process scrap and metal losses.

The carbon footprint carried by internal recycled aluminium is updated annually based on amount of sourced metal and respective carbon footprint. The "virtual" yield is also updated annually based on the volume of sold products divided by sold products plus sold process scrap and metal losses.

4 CALCULATIONS AND SELECTED RESULTS

The data described in section 3 have been inserted into an Excel calculation tool where necessary data is collected and compiled from internal and external sources. The data are organized in a way that makes calculation of carbon footprint easy for individual articles and groups of articles, see Appendix 1 for details. Since the number of articles is very high (more than two thousand) it is beyond the scope of this report to show all the individual results.

One selected example with cladding is shown for illustration purposes. The selection is done based on the fact that the raw material input has the strongest influence on environmental impact. This example article is delivered in a relatively high volume to secure reliable data.

The result is shown in Figures 5 and 6. Figure 5 clearly shows the dominating influence of raw material and in particular primary aluminium ingots and internal recycled aluminium. Internal processes and inbound transports of raw materials are minor contributors in comparison. Figure 6 shows a breakdown of the contribution from internal processes, where it is clear that scalping to packing process dominates. As described in section 3.7.4, internal recycled aluminium is modelled as the average mix of purchased materials, where the majority of the climate impact comes from primary aluminium ingots and purchased slabs.

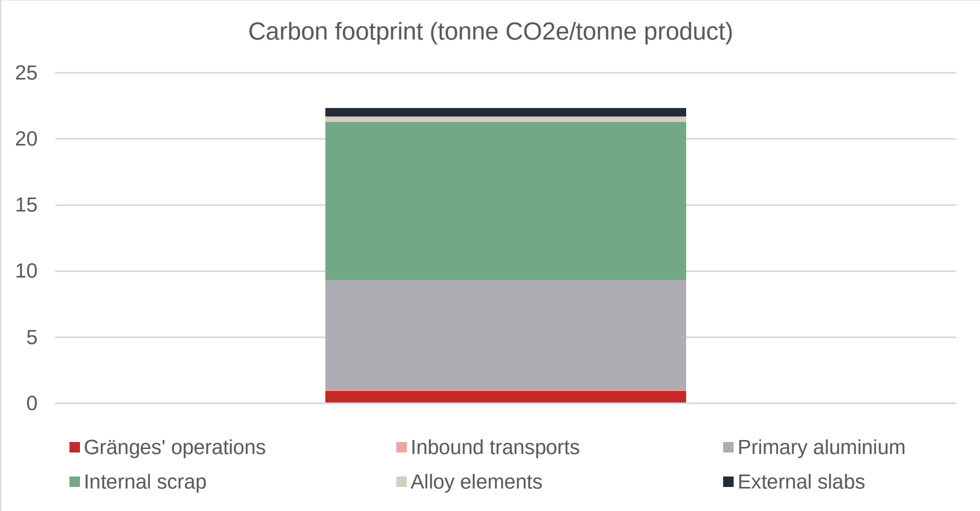

Figure 5. Carbon footprint for selected example article [tonnes CO_2e/tonne product].

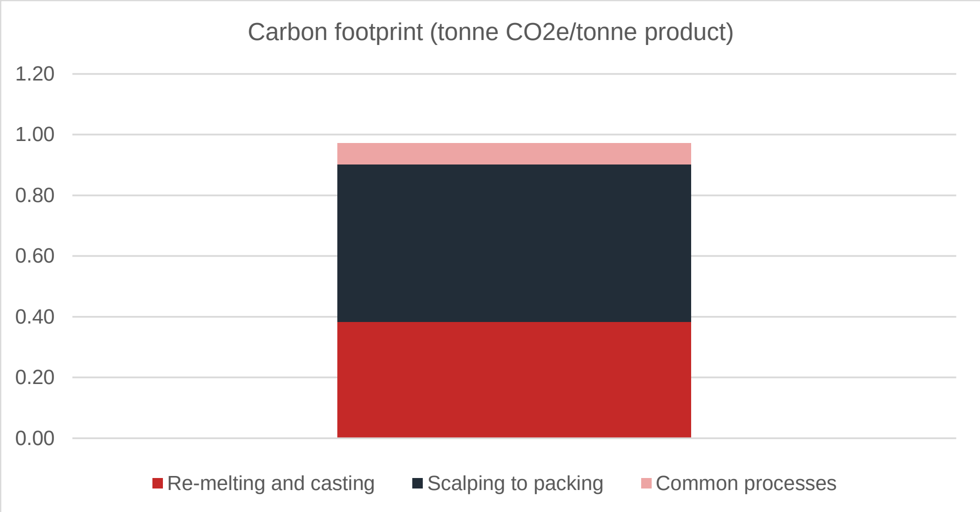

Figure 6. Carbon footprint of Gränges' operations for selected example article [tonnes CO_2e/tonne product].

4.1 Clad tube material FAB97C4

Radiator tube material FAB97C4 has a thickness of 0.35 mm and a slit width of 39.2 mm. The article number is 0547896. The core material is with 36 per cent primary alloy content and about 62 per cent internal recycled aluminium, and about 2 per cent alloying elements (Si, Fe, Cu, Mn, and Ti). The cladding materials contain two different alloys, which have 22 per cent of the total thickness and, in this case, they are mostly remelted and cast internally. They are made from primary aluminium, internal recycled aluminium, and alloying elements (Si, Fe, Cu, Mn, Zn). The processing is very similar to the process route described for clad tube in Figure 4.

As shown in Figure 5, the total carbon footprint is 22.3 tonnes CO_2e/tonne product. About 53 per cent of the carbon footprint comes from internal recycled aluminium, and the amount of primary aluminium ingot added to the core and cladding results in approximately 37 per cent coming from primary aluminium. Internal recycled aluminium represents the largest share of carbon footprint due to the large volume share. Approximately 2 per cent is related to alloying elements. About 4 per cent of the carbon footprint is generated by the internal processing. As shown in Figure 6, the scalping to packing process generates about 53 per cent of the carbon footprint from operations. The remelting and casting process accounts for about 39 per cent of the carbon footprint from operations, and common processes account for the remaining carbon footprint from operations.

5 COMMUNICATION IN CARBON FOOTPRINT CERTIFICATES

The aim of Gränges' third-party verified carbon footprint certificate is to provide Gränges' customers with a credible carbon footprint assessment at product level. The certificate is valid for the specified aluminium product, and the carbon footprint for the product is communicated as a guarantee of a maximum carbon footprint, i.e. below a certain carbon footprint threshold value. This threshold value is approved annually by President Gränges Asia, in conjunction with the annual carbon footprint data update in the internal LCA tool, and after having assessed the range and spread of the current carbon footprint values among the products in the site's total product portfolio.

The carbon footprint certificate refers to the quality standards ISO 14040, ISO 14044 and ISO 14067 as well as the methodological choices used for Gränges' product carbon footprint assessment. It also specifies that the assessment has been third-party verified and includes a validity date and link to the third-party verification statement, which is available on Gränges' website. The certificate also includes a link to this Carbon footprint report, which can be found on Gränges' website.

Upon a customer request, the certificate is prepared and signed by the Key Account Manager (KAM) on behalf of President Gränges Asia. The KAM is responsible to retrieve the product information as well as the applicable carbon footprint threshold from the internal CF tool.

6 CONCLUSIONS AND RECOMMENDATIONS

The following main conclusions can be drawn from the carbon footprint modelling and data;

- There are no real standards in the rolled aluminium industry on how to calculate and allocate carbon footprint. This report can hopefully contribute to such industry standardization and thereby enable comparability in carbon footprint assessments between products and suppliers.
- Allocation of carbon footprint to scrap generated in the process is a challenge, especially when closed loop recycling cannot be used, i.e. when the scrap cannot be recycled back to the same product specification that generated it. Scrap consuming alloys could be regarded as unfairly punished by the chosen allocation method. Further work can be required.

- The main drivers for reduced carbon footprint and carbon intensity are:
    - Sourcing of more low-carbon primary aluminium.
    - Sourcing of more external recycled materials.
    - Increasing internal recycling and reduce volumes of internal scrap sold.
- Process related drivers have much less influence on the carbon footprint than metal related drivers when low carbon energy sources are used. Still, the most important ones are:
    - Reducing energy intensity in own operations.
    - Increasing the use of renewable energy in own operations.

Recommendations to further work;

- Extend the impact categories in addition to carbon footprint.
- Extend the modelling to other plants in addition to Gränges Shanghai.
- Analyze further the need for an improved allocation model for internal process scrap.

7 REFERENCES

EN ISO 14040. Environmental management – Life cycle assessment – Principles and framework. ISO 14040:2006

EN ISO 14044. Environmental management – Life cycle assessment – Requirements and guidelines. ISO 14044:2006

ISO 14067. Greenhouse gases -- Carbon footprint of products -- Requirements and guidelines for quantification and communication. ISO 14067:2018

8 APPENDIX

Gränges’ carbon footprint (CF) tool is built in the spreadsheet software Excel. It aims to automatically calculate the environmental impacts of the company’s products and articles, initially covering the product carbon footprint. The following tabs are included in the Excel sheet to allow for calculation of carbon footprint for individual articles in the ‘Summary’ tab.

No.	TAB	DESCRIPTION	SOURCES
1.1	Summary	Calculates the full carbon footprint (kg CO_2e/tonne) for a specific article.	-
1.2	Calculated	Shows the carbon footprint result per article and process step. This structure enables to group articles, alloys, budget classes.	-
1.3	Version Log	Logs all changes and by whom.	-
2.1	Excluded articles	Shows test articles not calculating.	

2.2	External homogenization	Excluded in GAS model	
2.3	Emission Factors	Shows the carbon footprint (kg CO_2e/tonne) from consumables, inbound transports and CtG (Cradle to gate) for all raw material.	The data is pasted from the file Emission_factor.xlsx which is updated annually by Gränges with support from IVL.
2.4.1	Process	Shows the electricity energy in kWh/tonne produced per process and product mix from scalping to pack. The data is collected from total volume per process and total energy used per process, then calculated per product mix. Also shows the energy for common processes.	The data is collected from Gränges Shanghai SPI system and pasted into the model.
2.4.2	Process (natural gas)		for preheating, annealing and homogenizing process, we add m^3/tonne and transfer to kwh when summarizing at 1.1.
2.5	Virtual Yield	Remelting virtual yield is finished sawed slab minus burn losses. Process virtual yield is finished delivered material minus sold scrap.	The data is collected from IVL. Sold scrap is collected from the annual Environmental Data Collection.
3.1	Article weight	Shows output weight and product mix and alloy number per article.	The data is collected from Gränges Shanghai SPI system and pasted into the model.
3.2	Article weight & Group	Shows output weight and product mix and alloy number per article.	The data is collected from Gränges Shanghai SPI system and pasted into the model.
3.3	Article yield	Shows output weight and product mix and alloy number per article.	The data is collected from Gränges Shanghai SPI system and pasted into the model.
3.4	Coil structure	Shows which alloys are included per article; slab core alloys, clad layer alloys and clad percentage of the full package.	The data is collected from Gränges Shanghai SPI system and pasted into the model.
3.5	Homogenized	If the article is homogenized it will show number 1, if not homogenized it will show number 0.	whether the article is homogenized or not is decided by core layer.
3.6	Slab source	Shows the slab source, internal or external weight and its percentage per alloy.	The data is collected from Gränges Shanghai SPI system and pasted into the model.

3.7	Slab structure	Shows all the components in kg per alloy used for remelting and casting of internal slabs. Includes alloying elements, type of recycled materials, primary aluminium etc.	The data is collected from Gränges Shanghai SPI system and pasted into the model.
3.8	Slab yield	Shows the yield after sawing of the internal casted slabs per alloy.	The data is collected from Gränges Shanghai SPI system and pasted into the model.
4.1	kWh to CO_2	Converts the remelting energy used from kWh/tonne to CO_2e/tonne by using data from production energy consumption and data from “emission factors”.	
4.2	Slab alloying elements CO_2	Calculates the carbon footprint for the alloying elements part in slabs manufactured by Gränges. Calculation separated into CtG (Cradle to gate) and inbound transports.	
4.3	Slab structure aggregated	Calculates the total volume and type of input material per alloy for the internal cast slabs.	