GRÄNGES

Carbon footprint assessment of Gränges Konin aluminium products

Climate impact of flat rolled aluminium products
made by Gränges Konin.

Version: 1.0
Date: Mar 27, 2023
Issued by: R&I Director

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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 Konin, Poland, 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 Konin production site, according to the ISO 14001 Environmental management systems — Requirements with guidance for use, and in cooperation with Gränges Finspång and with elements of 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, it is beyond the scope of this report to show all the individual results. The report presents example results for four 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 1-5 per cent of the total carbon footprint, and mainly relates*s to the remelting and casting process where electric and mainly gas furnaces are used. Impacts from alloying elements generally account for arou*nd 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

This Carbon Footprint report has been compiled by R&I team for the LCA/CF project conducted in Konin in 2022 and 2023. The structure of the report is analogous to Gränges Finspång's report.

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 Konin manufactures flat rolled aluminium products primarily for automotive applications but also for packaging, construction and bottle closures. The process is further described in section 3. One of the largest product category is material for automotive applications such as brazed heat exchangers (radiators for engine cooling and condensers and evaporators for the air conditioning system) and auto body structures. 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 delivered as a coil or sheet, see Figure 1.

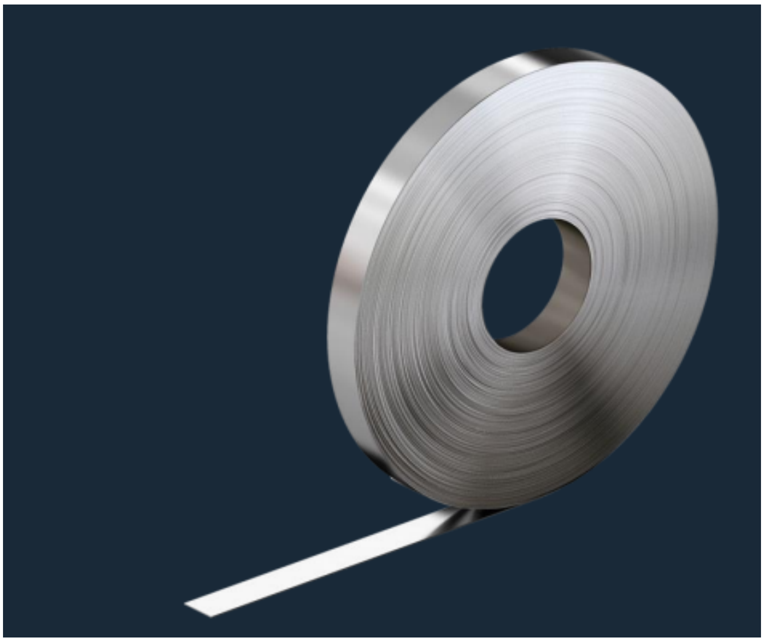

Figure 1. A typical coil delivered from Gränges to customers.

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 14001 Environmental management systems — Requirements with guidance for use, and in cooperation with Gränges Finspång and with some elements from 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 Konin, Poland. 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 auxiliary 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.

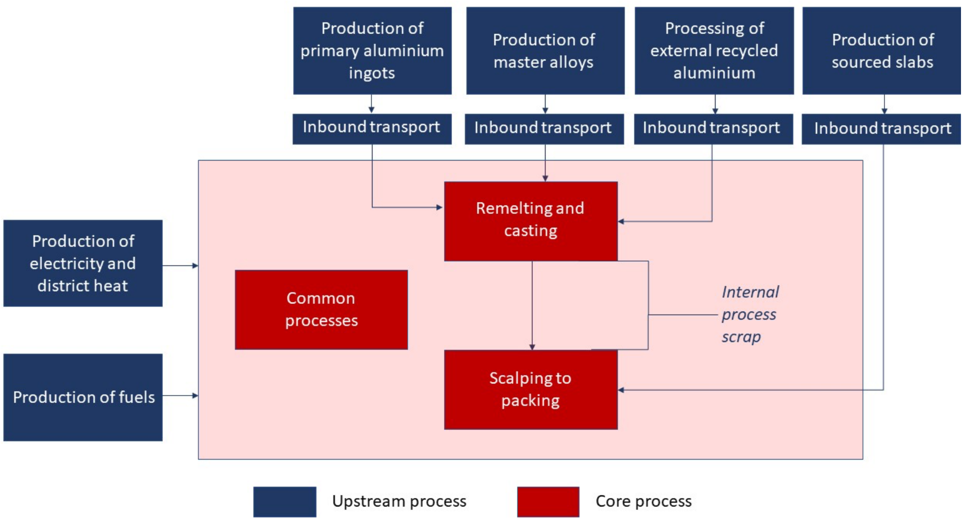

Figure 2. Generic flow chart for upstream (blue) and core (red) processes.

2.2.2 Functional unit

The functional unit is 1 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

Our LCA/CF activities are guided by a set of principles implemented in this area by Gränges Finspång. Similarly, to the one in Gränges Konin, we assumed that 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 exemple 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. For other products which do not fit well into these four groups, new groups can be identified and added. For new products or alloys, the additional information and calculation can be added to the Excel calculation tool.

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

Product group	Typical gauge (mm)
8011A	0.225
HF421	0.07
5754	0.9
LH436	0.23

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 clad scrap 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 is 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. 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, European industry average data for primary aluminium production is used.

3.2 Processing and transport of external recycled aluminium

Gränges Konin acquires recycling aluminum from external recycling companies. Some of the materials come from post -consumer materials (i.e. aluminum from recycled with operation) or from applications such as energy industry and power cables. Gränges Konin also provides pre-consumer materials, i.e. materials from various branches of the processing industry, closure industry etc. The receipt and transport of recovered aluminum to recycling companies, as well as sorting recycling materials at recycling companies. In our emission factors database, we make a suitable calculation for RSI, together with IVL, on basis of external databases, that we use: 1. RSI from recycled processed varnished Konin scrap (i.e. by Scepter or other external processing service) emission factor **0.43 kgCO2e/kg** and for 2. RSI from recycled & reworked dross from Konin (i.e. in Scepter or other (external processing service) emission factor **0.70 kgCO2e/kg**. For the rest of possessed external scrap we calculated emission factor 0.003 kgCO2e/kg. The main reason is that our all-scrap suppliers do not have any certificates of carbon footprint for us up till now.

3.3 Production of alloying elements

The in-house production of master alloys takes place in small electrically powered kilns (2 kilns of 3 tonnes). The raw materials are fed into the furnace and melted according to the appropriate recipe (80% primary aluminum + 20% silicon or 20% electrolytic manganese), then a sample is taken to check the correct chemical composition. The next step is the casting of ingots using a casting machine. The liquid metal is poured into ingot moulds and cooled with water. Solid ingots are stacked, marked and stored. The master alloys can also be purchased and the carbon footprint is calculated in cooperation with IVL.

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 Konin 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 Konin S.A. is supplied with natural gas, which is used in the processes of melting material in the foundry department and heating aluminum blocks and rolls in the production stages of the rolling mill department.

The plant buys electricity from one supplier, which in turn buys energy through the Polish Power Exchange. This means that this energy can come from several contractors. After the end of the calendar year, by the end of the first quarter of the following year, the electricity supplier presents the structure of fuels and other primary energy carriers used to generate electricity sold to Gränges Konin. For 2021, the share of renewable energy was approximately 22%.

Gränges Konin also obtains thermal energy in the form of steam and district heating.

Steam is purchased from an external company that produces steam by recovering energy from a hazardous waste disposal process. The steam in Gränges Konin is used in the production processes on the finishing lines of the rolling mill department and for heating the production hall of the rolling mill.

District heating, in turn, is obtained from the municipal heating network and is used only to heat buildings and halls belonging to Gränges Konin. The municipal heating network is supplied from two sources, i.e. the Konin Power Plant and the Municipal Waste Management Plant. In the case of the Konin Power Plant, approximately 99% of the energy comes from renewable sources (biomass), while the Municipal Waste Management Plant obtains 100% of the energy produced from municipal waste incineration.

In addition, Gränges is supplied with diesel fuel for internal transport.

3.7 Gränges' production process on site

Figure 3 schematically illustrates an example of 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 are three examplegroups of unclad products and one group of clad products. All products follow the same similar path from casting to packing. Some products have more cold rolling passes than others (depending on final thickness) and some have more annealing than others (depending on temperature or material properties required). The environmental impact of all these process steps is calculated based on the allocation method as defined above in the assumptions section.

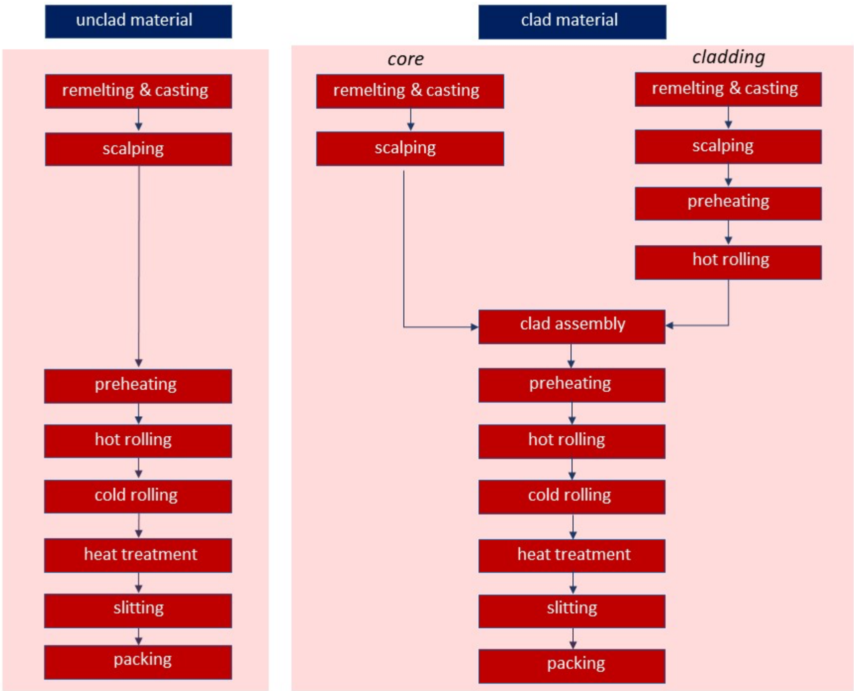

Figure 3. Schematic example of a process route for unclad and clad materials.

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. 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 fueled with either electricity or 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, 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. Rectangular slabs of ca 5-11 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. Four example process routes have been defined as shown in Table 1 and Figure 4 defines these routes. Differences in energy consumption is considered for the different process routes.

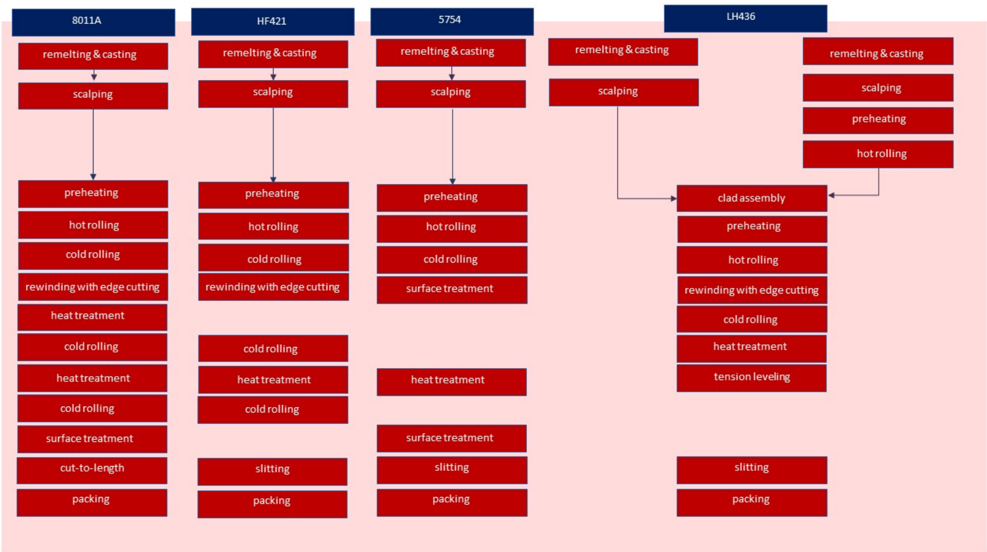

Figure 4. Process routes for different products.

A product can be categorized in one of these example groups and if the product do not fit into any of these groups, a new group can be defined. The energy source used in processes from scalping to packing is 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, district heating used for heating of buildings, 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 process scrap will be a combination of several alloys for scrap generated after the cladding step. Clad scrap is difficult to recycle because of its chemical composition. Some of the scrap is melted down, some is sold.

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 it is beyond the scope of this report to show all the individual results.

Four selected examples with and without cladding as well as with high and low primary aluminium content, are shown for illustration purposes. The selection is done based on the fact that the raw material input has the strongest influence on environmental impact and the four examples are very different in this respect. Each of the four examples are articles delivered in a relatively high volume to secure reliable data.

The results are shown in Figures 5 and 6. Figure 5 clearly shows the dominating influence of raw material and in particular primary aluminium ingots and purchased slabs. Internal processes and inbound transports of raw materials are minor contributors in comparison, except when the share of primary aluminium in the raw material mix is low. Figure 6 shows a breakdown of the contribution from internal processes, where it is clear that remelting and casting dominate. Thus, when slabs are sourced instead of produced in-house, the contribution from Gränges core processes is small.
The energy mix for remelting and casting consists of 70 percent natural gas and 30 percent electricity. However, due to the higher specific emission factor for electricity, electric furnace

production accounts for close to 60 percent of the total emissions from the remelting and foundry processes.

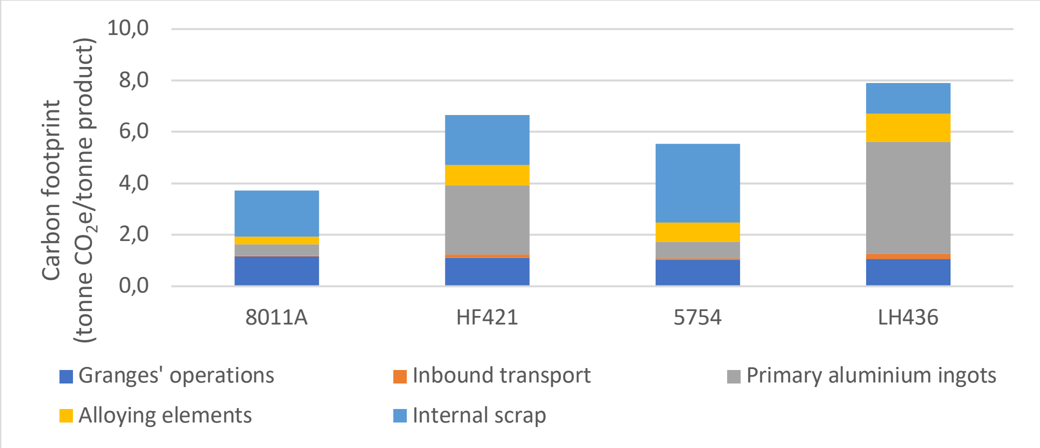

Figure 5. Carbon footprint for four selected example articles [tonnes CO_2e/tonne product].

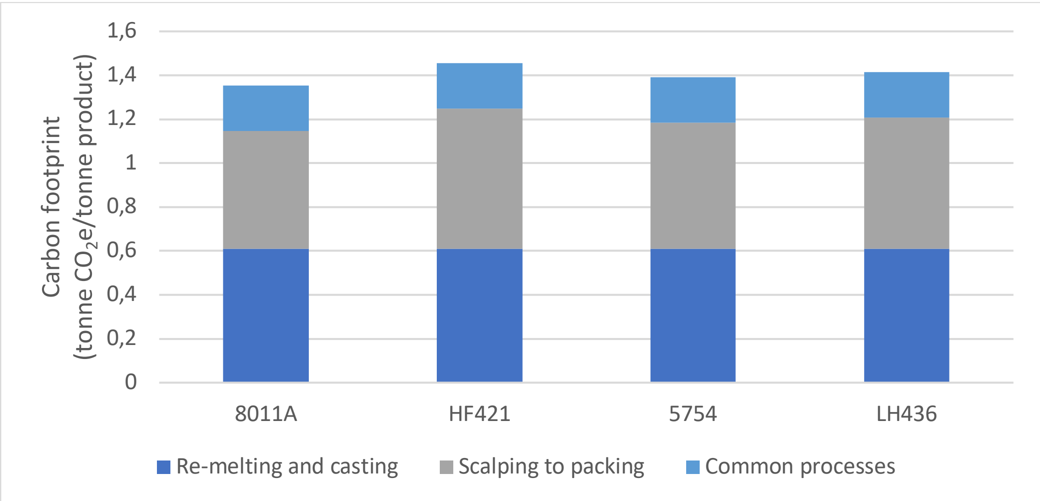

Figure 6. Carbon footprint of Gränges' operations for four selected example articles [tonnes CO_2e/tonne product].

4.1 Unclad material 8011A for bottle closures

Unclad material 8011A has a thickness of 0.225 mm, width of 1051.85 mm and length 888.91 mm. The article number is 110127. All slabs are produced internally. The raw material mix used for internally produced slabs is approximately 55 per cent external recycled aluminium, 5 per cent primary aluminium ingots, 5 per cent of master alloys and 45 per cent internal recycled aluminium. In addition, Mn alloy is added together with small additions of other alloying elements (Fe, Si and Mg).

As shown in Figure 5 (left bar), the total carbon footprint is 4.128 tonnes CO_2e/tonne product. Even though the share of primary aluminium ingot is really low, it still generates 0.45 tonnes CO_2e/tonne product.

4.2 Unclad fin material HF421

Unclad fin material HF421 has a thickness of 0.070 mm and a slit width of 16 mm. The article number is 121311. The raw material mix used for internally produced slabs is approximately

6 per cent external recycled aluminium, about 50 per cent primary aluminium ingots and 37 per cent internal recycled aluminium.

As shown in Figure 5 (middle bar), the total carbon footprint is 7.1 tonnes CO_2e/tonne product.

4.3 Unclad thick material 5754

Unclad thick material 5754 has a thickness of 0.9 mm and a slit width of 720 mm. The article number is 118912. The raw material mix used for internally produced slabs is approximately62 per cent external recycled aluminium, about 9 per cent primary aluminium ingots and 27 per cent internal recycled aluminium. In addition, we use 2 per cent of master alloys with Mn, Ti and Mg.
The total carbon footprint is 5.94 tonnes CO_2e/tonne product.

4.4 Clad tube material LH436

Clad tube material LH436 has a thickness of 0.23 mm and a slit width of 26.6 mm. The article number is 121311. The core is remelted and cast internally. The raw material mix used for slabs production is approximately 62 per cent external recycled aluminium, about 9 per cent primary aluminium ingots and 7 per cent alloying elements. The cladding material is 16-24 per cent of the total thickness and remelted and cast internally. It is made from primary aluminium ingot (24 per cent) with almost 50 per cent of master alloys. The processing is very similar to the process route described for clad tube in Figure 4.

As shown in Figure 5 (right bar). The total carbon footprint is 8.3 tonnes CO_2e/tonne product.

5 COMMUNICATION WITH 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 the Steering Committee of LCA Gränges Konin, 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 Specialists appointed by Steering Committee of LCA Gränges Konin. The team is responsible to retrieve the product information as well as the applicable carbon footprint threshold from the internal CF tool.

6 CONCLUSIONS AND RECOMMENDATIONS

All LCA/CF projects were conducted on general basis with experience from Gränges Finspång and in cooperation with IVL, mainly for development and shortage of emission factor data on domestic market and from local suppliers. The following main conclusions can be drawn from the experience gained during model development and carbon footprint data collection.

- There are no real standards in the aluminum rolling industry on how to calculate and allocate the carbon footprint. We hope that this report will contribute to such industry standardization and thus enable comparability of carbon footprint assessments between products and suppliers.
- Assigning a carbon footprint to the scrap generated in the process is challenging, especially when closed-loop recycling cannot be applied, i.e. when scrap cannot be recycled back to the same product specification that generated it. Scrap-consuming alloys can be seen as being unfairly "punished" by the chosen method of allocating additional CO_2 emissions. There is still work to be done in this area to define the method.
- The main drivers of reducing the carbon footprint and carbon intensity are:
    - Sourcing more low-emission primary aluminium, e.g. green ingots with very low carbon footprint.
    - Use of green energy in production and production processes.
    - Sourcing more external recycled materials.
    - Increasing internal recycling and reducing the amount of internal scrap sold, preferably not selling scrap at all and reprocessing it entirely within own operations (recycling).
- Process-related factors have a much lower impact on the carbon footprint than metal-related factors when low-carbon energy sources are used.
- However, the most important ones are:
    - Reducing energy consumption in own operations.
    - Increasing the use of renewable energy in own operations, including the use of available green energy guarantees of origin (GOO's).

Recommendations for further work.

- Using the modeling results to increase the share of recycling and maximize use of external scrap in own production.
- Recover more waste heat from the processes by using recuperation in Casthouse
- Less natural gas consumption by improve strips annealing (shorter time of annealing with the same physical product properties means less energy consumption).

7 REFERENCES

ISO 14001 Environmental management systems — Requirements with guidance for use.
And also with cooperation with Gränges Finspång, some regulations from standards:
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.

NR	TAB /Excel Sheet	DESCRIPTION	SOURCES

1.	Summary	Calculates the full carbon footprint (kg CO_2e/tonne) for a specific article after input article number (short no).	-
	CF	Shows the carbon footprint result per finished article and process steps. This structure enables to group articles, alloys, by cells: NR_KROTKI, POZYCJA GRUPA GATUNEK OPIS_KOD SCOPE 1 SCOPE 2 SCOPE 3 CF (CF also contains the calculated weighted average of CO_2 emissions for verification with the performance reported in 2021)	-
	Version Log	Logs all changes and by whom made in file.	-
1	Process	This sheet groups production process on electric or natural gas furnaces, calculates energy factors in kWh/t used for algorithm in further calculations. Shows the electricity energy in kWh/tonne consumes per process and product group from scalping to pack. The data is collected from total volume per process and total energy used per process, then calculated per process. Finally, it shows the energy for common processes.	Data collected from internal Production Dept. i.e.: Casthouse and Mill plant technology and Erp IFS system.
2	2. Component	Shows the production volume of articles and cells: PART_NO KKG CF$_SHORT_PART_NO PART_PRODUCT_FAMILY RWY RPO STU GAT GRB SZE DLG COMPONENT_PART KKGSK QTY_PER_ASSEMBLY TYPE	Data is collected from the file generated from erp IFS by Production Operating and Planning Dept.
3	3 Slabsource	Shows the production data (dimensions and alloys) of produced slabs Data in cells: GAT KLIENT_NAZWA PART_NO	Data is collected from the file generated from erp IFS by Production Operating and Planning Dept.

		QUANTITY	
4	4 Emission Factors	Shows the carbon footprint (kg CO_2e/tonne) from consumables, inbound transports and CtG (Cradle to gate) for all raw material used in Plant.	The data is pasted from the file *Emission_factor.xlsx* which is updated annually by Gränges Konin team with support from IVL.
5	5 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 aluminum etc. Gives data od production chemical standards for alloys with primary aluminum, alloys additives etc. In [kg]	Data collected from Casthouse engineers and from ERP IFS
6	6 Slab structure aggregated	Gives summary of data od production chemical standards for alloys with primary aluminum, alloy's additives etc. In [kg] Shows all the components in kg per alloy used for remelting and casting of internal slabs. Includes alloying elements, type of recycled materials, primary aluminum etc.	
7	7 Homogenized	Shows all homogenized alloys. In this sheet 1 means that homogenization process will be realized Here are cells: Gatunek, Homogenizacja, Czy homogenizowany?	Data collected from Mill Dept. Engineers and Technologists and form ERP IFS
8	8 kW 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".	Data collected from Mill Dept. Engineers and Technologists and form ERP IFS
9	Slab alloy elements CO_2	Slab Alloy Material CO_2 Transport	Data collected from Mill Dept. Engineers and Technologists and form ERP IFS
10	10 Production	Shows the input and output weight per article.	Data collected from Production Planning Dept

11	11 Marszruty i uzyski (proces path and yield)	Shows the yield per article and product group. Shows process paths for finished goods. Column are named: WORK_CENTER GRUPA_CR Uzysk EE kWh / t GZ kWh / t	Data collected from Mill Dept. Engineers and Technologists and form ERP IFS