

# LCA REPORT FOR

Aluminium Profiles of SANLEV SA

Athens, March 2023

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# 1. Introduction

The specific LCA Report has been developed by **Sanlev SA** aiming at the assessment of the LCA of each product.

The Life Cycle Assessment methodology (LCA) is used to determine which impacts a product or a service has on the environment. LCA provides the framework for assessing the potential environmental impacts of products. However, an LCA is a study of the environmental impacts from the processes inside the system boundaries, defined in the goal and scope of the study. Therefore, it must be mentioned that all the environmental impacts, from a product or service, cannot be taken into account.

The framework for LCA includes:

- Definition of goal and scope. The system boundaries must be clearly stated, since it has a direct impact on the result of the study.
- Life Cycle Inventory Analysis: At this stage, the data regarding all processes inside the system boundaries are gathered and the inputs and outputs of the product system are presented.
- Life Cycle Impact Assessment: The data from the inventory analysis is further processed in the impact assessment stage, where pollutant emissions are sorted into different categories depending on what environmental impact they contribute to. These categories include global warming, acidification and eutrophication, etc. Through the impact assessment the total environmental impact of the studied system can be evaluated.
- Life Cycle Interpretation Sensitivity Analysis: The results will be interpreted by investigating how the variation in the output of a numerical model can be attributed to variations of its input factors.

The above-mentioned information is presented in the following chapters.



#### 1.1 Company information

**Sanlev SA** has been designing and producing specialized extruded aluminium profiles since 1971. The privately owned facilities of Sanlev SA are located in the industrial zone at Aspropyrgos, Attiki, Greece.

The company is active in Greece as well as in other European countries. With the assistance of an experienced design department Sanlev SA provides services for tailor-made aluminium profiles. Special investment has also been targeted on equipment for different kinds of fabrication such as microperforation, punching types, cutting at different angles & lengths, bending of profiles etc. The powder coating plant, uses the latest available technology and has a full range of glossy, mat, special shades and a variety of colors ensuring a superior quality product.

The vision of Sanlev SA is evolving services and products, sharing of knowledge, communication and ideas, prioritizing investment and education of staff in order to meet the requirements of society and clients, build a long-lasting relationship and focusing on clients' needs with personal contact.

**Sanlev SA** has developed and implemented an Integrated Quality Management System, Production Control, Environment and Occupational Health and Safety according to standards ISO 9001:2015, ISO 14001: 2015, ISO 45001: 2018 respectively, following national, European and international legal and regulatory requirements, as well as all other compliance requirements governing its operation, with full respect for man, society and the environment. Also, owns the quality sign of the latest SEASIDE CLASS of Qualicoat, which is the highest quality mark for the protection of powder coated profiles in seaside environments.





Reporting organization	Sanlev Calibre Hellas SA
	Lousiou 1, Thesi Tzitzili
	193 00, Aspropyrgos, Attiki
	+30 21 0557 2209
Location of the production site	Sanlev Calibre Hellas SA
	Lousiou 1, Thesi Tzitzili
	193 00, Aspropyrgos, Attiki
	+30 21 0557 2209
Product Category Rules (PCR)	CEN standard EN 15804 serves as the Core Product Category
	Rules (PCR) PCR 2019:14, Version 1.11
	UN CPC code: 41532 Bars, rods, and profiles of aluminium



#### Practitioner of LCA Study



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## 2. Goal and Scope of the study

#### Goal

The main goal of this Life Cycle Assessment (LCA) is to assess the environmental impacts associated with **extruded and powder coated aluminium profiles** manufactured by **Sanlev SA**. This LCA was performed aiming at the development of specific Environmental Product Declarations for specific products. The intended use of this report as well as EPDs aims to inform construction companies, fabricators, architectural industry and designers.

Life Cycle Analysis preparation follows the ISO 14044:2006 "Environmental management – Life cycle assessment – Requirements and guidelines" and ISO 14040:2006 "Environmental management – Life cycle assessment – Principles and framework" standards. LCA Study was performed also based on the requirements of the following standards: ISO 14025:2006 Environmental labels and declarations — Type III environmental declarations — Principles and procedures for the preparation of the environmental product declaration, EN 15804:2012+A2:2019 Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products and Product Category Rules PCR "2019:14 Construction products" (Version 1.11).

#### Scope of the study

The scope of the product system under investigation includes all the steps involved in the production of **extruded and powder coated aluminium profiles.** The LCA was carried out under a cradle-to-gate with modules C1-C4 and module D perspective.

Aluminium profiles comply with the general requirements of EN 15088:2005 "Aluminium and aluminium alloys - Structural products for construction works - Technical conditions for inspection and delivery" and the painting method is certified with a quality sign of the latest Qualicoat which is the highest quality mark for the protection of powder coated profiles in seaside environments.

For more information about aluminium profiles please visit <u>https://www.sanlev.gr/modular.html</u> where all specifications of the products are available.



#### 2.1 Declared unit

The declared unit is 1 kg of aluminium profile.

#### 2.2 System boundaries

The approach followed is "Cradle to gate with modules C1-C4 and module D" covering the Product stage which is mandatory stage, the End-of-life stage and the Benefits and loads beyond the system boundary. The following life stages were considered:

A1: Raw material extraction and processing, processing of secondary material input (includes electricity, water supply and packaging production),

A2: Transportation of all raw materials to the manufacturing plant,

A3: Manufacturing process (includes the energy for the extrusion and waste management of the production),

C1: De-construction, demolition,

- C2: Transport to waste processing,
- C3: waste processing for reuse, recovery and/or recycling,
- C4: Disposal,

D: Reuse, recovery and/or recycling potentials, expressed as net impacts and benefits.

The life cycle stages A4–A5 and B, which are optional were not included in the LCA study due to the fact that there is significant uncertainty in the product construction and use phase.



Table 1	- Reporting	modules	declared,	geography,	share	of	specific	data	(in	GWP-GHG
indicator)	and data var	riation								

	Pr s	oduct tage	:	Constr proc sta	uction cess ge	Use stage					E	nd o sta	f life ge	•	Resource recovery stage		
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction	Transport	Waste processing	Disposal	Reuse-Recovery- Recycling-potential
Module	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	<b>B</b> 6	B7	C1	C2	C3	C4	D
Modules declared	х	х	х	ND	ND	ND	ND	ND	ND	ND	ND	ND	х	х	х	х	Х
Geography	GLO	GLO	EU	ND	ND				ND				EU			GR	GLO
Specific data used	>	95%		-	-	-					-		-	-			
Variation – products	Not	releva	nt	-	-	-					-		-	-			
Variation – sites	Manu in d	ufactur one site	ed e	-	-	-				-			-	-			

X: Included, ND: Not Declared

#### 2.3 Geographical Boundaries

The **aluminium profiles** were manufactured in the industrial unit of **Sanlev SA** located in Aspropyrgos, Attiki. Raw materials are transported from industrial units mainly located in Europe as well as Turkey.

#### 2.4 Time representativeness

All specific data used in this study is for the reporting year 2021.



#### 2.5 Cut-off rules and exceptions

All inputs and outputs were included in the calculation of the unit process of the production stage. The cut-off criteria were 1% for the total mass input and 5% for energy usage and mass that was included, according to EN 15804 and PCR 2019:14.

The materials that were <1% for the total mass and that were excluded: specific packaging material, fuel for forklifts and minor materials. The biogenic carbon in packaging was lower than 1%. Environmental impacts from the deconstruction of aluminium profiles at End-of-life stage (module C1) were <5% for energy usage and mass and there were not included in LCA calculations.

The following activities and processes have been exempted from the LCA report: the manufacturing processes of the capital goods or spare parts, infrastructure for general management, office and headquarters operations as well as people activities (common activities, travel for work etc.) and waste streams relating to maintenance of equipment. Also, transport of finished products (A4), application of product (A5), and use stage (B1-B7) were excluded.

#### 2.6 Data Quality

All the data used to model the manufacturing process for the specific products covered by this EPD, are specific data and there are no data gaps. Data for raw material supply and transport to the manufacturing plant and production (A1-A3) are based on specific consumption data for the specific production process taking place at the production site in Aspropyrgos for the reference year 2021.

Generic datasets were used for the upstream processes (production of raw material and transportation) as well as for the End-of-Life stage calculations. For this reason, the European life cycle inventory database Ecoinvent v.3.8 & EuGeos' 15804+A2\_IA v4.1 have been used, as this database contains the most extensive and updated information and its scope coincides with the geographical, technological and temporal area of the project.

All the datasets used for calculations cover the area of Europe for the materials produced in Europe or global. Technological coverage is specific or average. The LCA was modelled with OpenLCA 1.11.0.



#### 2.7 Environmental Impact Categories

The environmental impacts have been calculated based on the requirements of EN 15804:2012+A2:2019 Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products and EPD Product Category Rules (PCR) 2019:14 Construction products (Version 1.11). The database used for the calculation of impacts is Ecoinvent v.3.8 & EuGeos' 15804+A2\_IA v4.1.

The impact assessment is carried out for the following impact categories:

- Acidification
- Climate change
  - o GWP CO2 uptake
  - o GWP biogenic
  - o GWP fossil
  - GWP land transformation
  - o GWP total
- Depletion of abiotic resources
  - o ADPE elements
  - ADPF fossil fuels
- Eutrophication
  - o Freshwater
  - o Marine
  - o Terrestrial
- Ozone depletion
- Photochemical ozone formation
- Water use
- Output flows
  - o Components for reuse
  - o Exported energy
  - o Materials for energy recovery
  - o Materials for recycling
- Resources energy
  - o Non-renewable
  - o Renewable
  - o Net use of fresh water
  - Use of secondary materials
  - o Use of non-renewable secondary fuels



- Use of renewable secondary fuels
- Waste
  - o Hazardous, disposed
  - Non-hazardous, disposed
  - o Radioactive, disposed

#### 2.8 Assumptions

The following assumptions have been made in this EPD:

- LCA study does not include the manufacturing processes of the capital goods or spare parts.
- It does not include equipment maintenance.
- The environmental impact of infrastructure for general management, office and headquarters operations is not included.
- The impact caused by people (common activities, travel for work) was not considered.
- The environmental impact of external transport has been calculated using lorries from the Ecoinvent 3.8. database, EURO 5. These lorries have been selected to reflect the most realistic scenario possible.
- The scenarios included are currently in use and are representative for one of the most probable alternatives.
- Concerning module C1 the impacts of deconstruction/dismantling of the building is assumed to be zero due to falling below the 5% cut-off criteria according to EN 15804 for energy used for the dismantling of aluminium profiles during deconstruction as well as taking into account the report of Sphera "Aluminium Extrusion EPD Background Report".
- For module C2 a distance of 100km and EURO 5 truck is assumed for the transportation of aluminium waste after deconstruction.
- Regarding modules C3 and C4 the assumption of recycling rate of metal building products is 90% and the remaining 10% of aluminium waste end in landfill.

#### 2.9 Allocation

Taking into account that all the products are produced implementing the same production procedure, there is no allocation in different production subsystems (sub -processes). There are no co-products produced using other production procedures.



Regarding the input of raw materials as well as packaging materials, it was based on the total materials that were bought. The material losses from manufacture were lower than 1%.

Electricity, LPG, water, coating powder, chemicals, lubricants and packaging were calculated based on the division of total consumptions, indicated in invoices, by the mass of final products. Also, waste has been divided by the total quantity of products.

Therefore, no allocation method was used (economic or physical) for electricity or raw materials.

Economic allocation was not used in any case.



## 3. Life Cycle Inventory Analysis (LCI)

#### 3.1 Products

Aluminium profiles are manufactured in plenty of shapes, sizes, textures, and colors depending on the use focusing on the quality of the final product, the flawless powder coated surface of the profiles, strong adhesion and durability.

Some of the uses are for architectural profiles, special profiles, standard profiles, roller shutters, ladders, solar panels, ventilation, furniture, automotive, marine applications, solar collectors, lighting, blinds, bicycles and more.

The particular LCA Report refers to the following products:

- Extruded Aluminium Profiles
- Powder Coated Aluminium Profiles



UN CPC code: 41532 Bars, rods, and profiles of aluminium

HS code 7604 Bars, rods and profiles, of aluminium, n.e.s.

For more information about aluminium profiles please visit <u>https://www.sanlev.gr/modular.html</u> where all specifications of the products are available.

#### Content information

The main components of the products covered by this EPD are presented in Table 1.

•	5	
Components	Extruded Aluminium Profile	Powder Coated Aluminium Profile
Aluminium billets	100%	>94%
AI	>98%	>98%
Mg	<0.6%	<0.6%
Si	<0.8%	<0.8%
Fe	<0.3%	<0.3%
Others	<0.2%	<0.2%
Powder Coating	-	<6%

Table 2. Content of aluminium profiles covered by this EPD



Aluminium billets consist minimum of 70% recycled aluminium and the products are 100% recyclable. Aluminium billets are coming in bulk by trucks. Also, other materials are coming by trucks.

The final products are wrapped with stretch film and crepe paper and sent to the clients by trucks. All packaging used is recyclable.

No substances included in the Candidate List of Substances of Very High Concern for authorization under REACH Regulations are present in the aluminium profiles above the threshold for registration with the European Chemicals Agency (< 0,1% wt/wt).

#### 3.2 Description of the manufacturing process

The manufacturing process starts with the aluminium billets heated and then pushed by a hydraulic cylinder through a die with the required cross-section. The aluminium profile extruded is then cool down, stretched and cut to the desired length. This is followed by aging with heat treatment in order to improve the mechanical properties of the products. The products continue either for packaging and storage or for coating. The extruded aluminum profiles to be painted by powder coating are cleaned with soap and chemical baths in order to passivate the surface and then powder coated electrostatically.

Final products are packaged with stretch film and crepe paper. The manufacturing process is shown in the next diagram (Figure 1).



Figure 1: Manufacturing process of the products.





Figure 2: Components and ancillary materials composing the product.

#### 3.3 Description of unit processes

The **Process Units** taken into account for the development of the LCA for aluminium profiles include:

- Production of raw materials in other industrial units (A1)
- Production of packaging material (plastic packaging and kraft paper) (A1)
- Electricity production (A1)
- Water supply (A1)
- Transportation of raw materials from other industrial units to the industrial unit in Aspropyrgos (A2)
- Production of final products in the industrial unit in Aspropyrgos using heat form LPG (A3)
- Waste management (A1-A3)



- Demolition of the building and dismantling of aluminium profile form the building at the End-of-Life stage (C1)
- Transportation of aluminium waste at the End-of-Life stage to recycling unit or landfill (C2)
- Waste processing of aluminium waste at the End-of-Life stage by remelting process (C3)
- Disposal of aluminium waste at the End-of-Life stage at landfill (C4)
- Net benefits for using secondary billets instead of primary ingot aluminium (D)



Figure 3: Diagram of unit processes in each module for extruded and painted aluminium profiles.

#### 3.4 Specific data sources, allocation and dataset sources



The development of the LCI in the LCA Software tool was based on entering input and output data for each Process Unit as shown in Tables 3 to 6.

#### • Production of raw materials (A1)

Each material has been combined with a dataset containing LCI-data, selected from databases Ecoinvent v.3.8 & EuGeos' 15804+A2\_IA v4.1. In the production of raw materials included data sets for aluminium billets, lubricants for the hydraulic press, chemicals for pretreatment (coated powder product), powder coat (coated powder product) and water indicated in invoices for the reference year. All data set were from the representative geographical area.

#### • Production of packaging material (A1)

Specific data for the reference year were used for packaging material based on quantity of plastic packaging and crepe paper for packaging indicated in invoices. All packaging materials are recyclable.

The production of polyethylene packaging film polyethylene and kraft paper production has been combined with a dataset containing LCI-data, selected from databases Ecoinvent v.3.8 & EuGeos' 15804+A2\_IA v4.1.

#### • Energy Production (A1)

Specific data for the reference year were used for electricity consumption. Data were taken from invoices for the reference year.

Electricity has been combined with a dataset containing LCI-data, selected from database Ecoinvent v.3.8 & EuGeos' 15804+A2\_IA v4.1 for Greece. A data set was modified according to Greece's energy residual mix 2021 provided from DAPEEP.

# • Transportation of raw materials from other industrial units to the industrial unit in Aspropyrgos (A2)

The transportation of raw materials is performed by land and sea transport. Raw materials are coming from Greece and Turkey.

The dataset used for Land Transport represents the service of 1tkm freight transport in a lorry of the size class 16-32 metric tons gross vehicle weight (GVW) and Euro 5 emissions class.



The dataset used for Sea Transport represents the transport of one ton of freight by a container ship over one kilometer. The DWT (load capacity) of the container ship is 43,000 tonnes, and it is estimated to transport an average of 7,200 million tonne.km per year for 25 years (the average DWT and annual kilometers are weighted averages over the size class from data in IMO (2015)). The dataset represents the entire transport life cycle including the production and maintenance of the container ship, the transportation of freight, and the construction of the port.

The material production is modeled using datasets from Ecoinvent v.3.8 & EuGeos' 15804+A2\_IA v4.1 database and specific data from the transportation distances of raw materials from other units.

# • Production of final products in the industrial unit in Aspropyrgos and waste management (A3)

Specific data for the reference year were used for waste taken from the Waste Registry. Also, specific data used for LPG used for heating in the production of the products included in this product unit.

The data used as Input in the Process Unit include all the components in order to produce the product expressed as kg/kg of product. The components (raw materials) for each product are calculated based on the materials used for the manufacture (material composition for each product).

#### • End-of-Life stage (C1-C4, D)

The End-of Life stage is modeled using datasets from Ecoinvent v.3.8 & EuGeos' 15804+A2\_IA v4.1 database and generic data from the European Aluminium General Programme Instructions 1 (Version 3).

Input and Outputs are from the representative geographical area (Europe) and are based on assumptions as it was mentioned above.

All the material inputs and outputs used in the openLCA to calculate the environmental impacts of the products are presented in the Table 3 to Table 6 as well as the excel spreadsheet LCI Spreadsheet Sanlev.xlsx.





#### **Table 3:** Material inputs, transportation inputs and End of Life stage inputs for Extruded Aluminium Profile.

Module	Raw material su	upply (A1)							
Materials	Raw Material input	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Aluminium Profile
Secondary aluminium alloy (billets)	Specific data	treatment of aluminium scrap, new, at remelter	C:Manufacturing/24:Manufacture of basic metals/242:Manufacture of basic precious and other non- ferrous metals/2420:Manufacture of basic precious and other non- ferrous metals	EU	2005-2019	ecoinvent 3.8	treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S	kg/ kg of product	0.66
Primary aluminium alloy (billets)	Generic data	aluminium ingot, primary production	C:Manufacturing/24:Manufacture of basic metals/242:Manufacture of basic precious and other non- ferrous metals/2420:Manufacture of basic precious and other non- ferrous metals	GLO	2015-2019	ecoinvent 3.8	aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S	kg/ kg of product	0.34
Lubricants/ Hydraulic Oils	Specific data	lubricating oil production	C:Manufacturing/19:Manufacture of coke and refined petroleum products/192:Manufacture of refined petroleum products/1920:Manufacture of refined petroleum products	EU	2000-2020	ecoinvent 3.8	lubricating oil production   lubricating oil   Cutoff, S	kg/ kg of product	0.002
Water	Specific consumption data divided by total production	Tap water	E:Water supply; sewerage, waste management and remediation activities/36;Water collection,treatment and supply/3600:Water collection, treatment and supply	EU without Switerland	2012-2019	ecoinvent 3.8	market for tap water   tap water   Cutoff, S	kg/ kg of product	0.53



Electricity	Specific consumption data divided by total production	Electricity, medium voltage	D:Electricity, gas, steam and air conditioning supply	GR	2021	ecoinvent 3.8	electricity, medium voltage, production mix   Cutoff, U modified for 2021 based on energy mix	kWh/ kg of product	0.45
Plastic Packaging	Specific data of plastic packaging divided by the total production	packaging film, low density polyethylene	C:Manufacturing/22:Manufacture of rubber and plastics products/222:Manufacture of plastics products/2220:Manufacture of plastics products	EU	1993-2019	ecoinvent 3.8	packaging film production, low density polyethylene   packaging film, low density polyethylene   Cutoff, S	kg/ kg of product	0.001
Paper Packaging	Specific data of paper packaging divided by the total production	kraft paper production	C:Manufacturing/17:Manufacture of paper and paper products/170:Manufacture of paper and paper products/1701:Manufacture of pulp, paper and paperboard	EU	2015-2021	ecoinvent 3.8	kraft paper production   kraft paper   APOS, S	kg/ kg of product	0.02
Module	Manufacturing (	(A3)							
Materials	Raw Material input	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Aluminium Profile
LPG	Specific consumption data divided by total production	heat production, LPG	D:Electricity, gas, steam and air conditioning supply/35:Electricity, gas, steam and air conditioning supply/353:Steam and air conditioning supply/3530a: Steam and air conditioning supply based on liquid fuels	EU without Switerland	1991-2019	ecoinvent 3.8	heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S	kWh/ kg of product	0.76
Module	Transportation	of raw materla	ls (A2)						
Material Transported	Means of Transport	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Aluminium Profile
Aluminium alloy (billets)	Land Transport freight, 24 tn track capacity	transport, freight, lorry 16-32 metric ton, EURO5	H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	ecoinvent 3.8	transport, freight, lorry 16- 32 metric ton, EURO5   transport, freight, lorry 16- 32 metric ton, EURO5   Cutoff, S	kg*km/ kg of product	79.02
Aluminium	Sea Transport	transport, freight sea	H:Transportation and storage/ 50: Water transport/ 501: Sea and	GLO	2007-2019	ecoinvent	transport, freight, sea,	t*nmi/ kg of	0.12



		container ship	coastal water transport/ 5012: Sea and coastal freight water transport				freight, sea, container ship   Cutoff, S		
Lubricants/ Hydraulic Oils	Land Transport freight, 24 tn track capacity	transport, freight, lorry 16-32 metric ton, EURO5	H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	ecoinvent 3.8	transport, freight, lorry 16- 32 metric ton, EURO5   transport, freight, lorry 16- 32 metric ton, EURO5   Cutoff, S	kg*km/ kg of product	0.31
LPG	Land Transport freight, 24 tn track capacity	transport, freight, lorry 16-32 metric ton, EURO5	H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	ecoinvent 3.8	transport, freight, lorry 16- 32 metric ton, EURO5   transport, freight, lorry 16- 32 metric ton, EURO5   Cutoff, S	kg*km/ kg of product	0.33
Plastic Packaging	Land Transport freight, 24 tn track capacity	transport, freight, lorry 16-32 metric ton, EURO5	H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	ecoinvent 3.8	transport, freight, lorry 16- 32 metric ton, EURO5   transport, freight, lorry 16- 32 metric ton, EURO5   Cutoff, S	kg*km/ kg of product	0.03
Paper Packaging	Land Transport freight, 24 tn track capacity	transport, freight, lorry 16-32 metric ton, EURO5	H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	ecoinvent 3.8	transport, freight, lorry 16- 32 metric ton, EURO5   transport, freight, lorry 16- 32 metric ton, EURO5   Cutoff, S	kg*km/ kg of product	0.39
Module	End of life stage	e (C1-C4)							
Materials	Raw Material input	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Aluminium Profile
Aluminium waste at End of Life transportation form building to recycling unit or lanfill (C2)	Generic data	transport, freight, lorry 16-32 metric ton, EURO5	H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	ecoinvent 3.8	transport, freight, lorry 16- 32 metric ton, EURO5   transport, freight, lorry 16- 32 metric ton, EURO5   Cutoff, S	kg*km/ kg of aluminium waste	100.00



Aluminium waste at End of Life for remelting (C3)	Generic data	aluminium scrap, post- consumer, prepared for melting	E:Water supply; sewerage, waste management and remediation activities/38:Waste collection, treatment and disposal activities; materials recovery/383:Materials recovery/3830:Materials recovery	EU	2005 - 2019	ecoinvent 3.8	treatment of aluminium scrap, post-consumer, by collecting, sorting, cleaning, pressing   aluminium scrap, post- consumer, prepared for melting   Cutoff, S	kg / kg of aluminium waste	0.90
Aluminium waste at End of Life to landfill (C4)	Generic data	municipal solid waste	E:Water supply; sewerage, waste management and remediation activities/38:Waste collection, treatment and disposal activities; materials recovery/382:Waste treatment and disposal/3821:Treatment and disposal of non-hazardous waste	GR	2018-2019	ecoinvent 3.8	market for municipal solid waste   municipal solid waste   Cutoff, S	kg / kg of aluminium waste	0.10
Module	Reuse, Recovery	y, Recycling Po	tential (D)						
Materials	Raw Material input	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Aluminium Profile
Materials Aluminium waste at End of Life	Raw Material input	Name aluminium ingot, primary production	Category C:Manufacturing/24:Manufacture of basic metals/242:Manufacture of basic precious and other non- ferrous metals/2420:Manufacture of basic precious and other non- ferrous metals	Data set Location GLO	Date of used literature for the data set 2015-2019	Source ecoinvent 3.8	Data set aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S	Unit kg/ kg of aluminium waste	Aluminium Profile



Module	Waste Management (A3)											
Waste	Raw Material input	Name	Category	Data set Location	Date of used literature for the data set	Source	Data Set	Unit	Quantity of waste/ Aluminium Profile			
Hazardous waste(11 01 11*, 19 02 05*, 08 02 01)	Waste production according to electronic waste registry	hazardous waste, for incineration	E: Water supply; sewerage, waste management and remediation activities > 38: Waste collection, treatment and disposal activities; materials recovery > 382:Waste treatment and disposal > 3822: Treatment and disposal of hazardous waste	Europe without Switzerland	2011 - 2019	ecoinvent 3.8	market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S	kg/ kg of product	0.72			
Scrap aluminium (12 01 03)	Waste production according to electronic waste registry	aluminium waste from filing and turning, for recycling	E:Water supply; sewerage, waste management and remediation activities/38:Waste collection, treatment and disposal activities; materials recovery/382:Waste treatment and disposal/3821:Treatment and disposal of non-hazardous waste	Europe without Switzerland	2011-2019	ecoinvent 3.8	market for scrap aluminium   scrap aluminium   Cutoff, S	kg/ kg of product	0.18			
Paper and paperboard (15 01 01 )	Waste production according to electronic waste registry	paper waste, for recycling	E:Water supply; sewerage, waste management and remediation activities/38:Waste collection, treatment and disposal activities; materials recovery/382:Waste treatment and disposal/3821:Treatment and disposal of non-hazardous waste	GR	2018-2019	ecoinvent 3.8	market for waste paperboard   waste paperboard   Cutoff, S	kg/ kg of product	0.002			

#### Table 4: Material outputs for Extruded Aluminium Profile.



Module	Raw materia	al supply (A1)							
Materials	Raw Material input	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Coated Aluminium Profile
Secondary aluminium alloy (billets)	Specific data	treatment of aluminium scrap, new, at remelter	C:Manufacturing/24:Manufacture of basic metals/242:Manufacture of basic precious and other non- ferrous metals/2420:Manufacture of basic precious and other non- ferrous metals	EU	2005-2019	ecoinvent 3.8	treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S	kg/ kg of product	0.62
Primary aluminium alloy (billets)	Generic data	aluminium ingot, primary production	C:Manufacturing/24:Manufacture of basic metals/242:Manufacture of basic precious and other non- ferrous metals/2420:Manufacture of basic precious and other non- ferrous metals	GLO	2015-2019	ecoinvent 3.8	aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S	kg/ kg of product	0.32
Powder Coating	Specific data	coating powder production	C:Manufacturing/20:Manufacture of chemicals and chemical products/202:Manufacture of other chemical products/2022:Manufacture of paints, varnishes and similar coatings, printing ink and mas	EU	1996 - 2019	ecoinvent 3.8	coating powder production   coating powder   Cutoff, S	kg/ kg of product	0.06
NaOH 50% solution	Specific data	Sodium hydroxide, without water, in 50% solution state	C:Manufacturing/20:Manufacture of chemicals and chemical products/201:Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms/2011:Manufacture of basic chemicals	GLO	2011 - 2019	ecoinvent 3.8	market for sodium hydroxide, without water, in 50% solution state   sodium hydroxide, without water, in 50% solution state   Cutoff, S	kg/ kg of product	0.003
(BONDERITE C- AD G2498) & (BONDERITE M-FE LF-3820) & (BONDERITE C - AD 0508 LF)	Specific data	non-ionic surfactant	C:Manufacturing/20:Manufacture of chemicals and chemical products/202:Manufacture of other chemical products/2023:Manufacture of soap and detergents, cleaning and polishing preparations, pe	GLO	2015 - 2020	ecoinvent 3.8	non-ionic surfactant production, fatty acid derivate   non-ionic surfactant   Cutoff, S	kg/ kg of product	0.001

#### **Table 5**. Material inputs, transportation inputs and End of Life stage inputs for Powder Coated Aluminium Profile.



(BONDERITE C- IC DX-255 A) & (BONDERITE M- NT 400 R IM)	Specific data	hydrogen fluoride production	C:Manufacturing/20:Manufacture of chemicals and chemical products/201:Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms/2011:Manufacture of basic chemicals	EU	1979 - 2020	ecoinvent 3.8	hydrogen fluoride production   hydrogen fluoride   Cutoff, S	kg/ kg of product	0.01
(BONDERITE M- NT 400)	Specific data	titanium dioxide production	C:Manufacturing/20:Manufacture of chemicals and chemical products/201:Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms/2011:Manufacture of basic chemicals	EU	2005 - 2019	ecoinvent 3.8	titanium dioxide production, chloride process   titanium dioxide   Cutoff, S	kg/ kg of product	0.002
Lubricants/ Hydraulic Oils	Specific data	lubricating oil production	C:Manufacturing/19:Manufacture of coke and refined petroleum products/192:Manufacture of refined petroleum products/1920:Manufacture of refined petroleum products	EU	2000-2020	ecoinvent 3.8	lubricating oil production   lubricating oil   Cutoff, S	kg/ kg of product	0.002
Water	Specific consumption data divided by total production	Tap water	E:Water supply; sewerage, waste management and remediation activities/36;Water collection,treatment and supply/3600:Water collection, treatment and supply	EU without Switerland	2012-2019	ecoinvent 3.8	market for tap water   tap water   Cutoff, S	kg/ kg of product	1.86
Electricity	Specific consumption data divided by total production	Electricity, medium voltage	D:Electricity, gas, steam and air conditioning supply	GR	2021	ecoinvent 3.8	electricity, medium voltage, production mix   Cutoff, U modified for 2021 based on energy mix	kWh/ kg of product	0.45
Plastic Packaging	Specific data of plastic packaging divided by the total production	packaging film, low density polyethylene	C:Manufacturing/22:Manufacture of rubber and plastics products/222:Manufacture of plastics products/2220:Manufacture of plastics products	EU	1993-2019	ecoinvent 3.8	packaging film production, low density polyethylene   packaging film, low density polyethylene   Cutoff, S	kg/ kg of product	0.001
Paper Packaging	Specific data of paper packaging	kraft paper production	C:Manufacturing/17:Manufacture of paper and paper products/170:Manufacture of	EU	2015-2021	ecoinvent 3.8	kraft paper production   kraft paper   APOS, S	kg/ kg of product	0.02



	divided by the total production		paper and paper products/1701:Manufacture of pulp, paper and paperboard						
Module	Manufacturi	ng (A3)							
Materials	Raw Material input	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Aluminium Profile
LPG	Specific consumption data divided by total production	heat production, LPG	D:Electricity, gas, steam and air conditioning supply/35:Electricity, gas, steam and air conditioning supply/353:Steam and air conditioning supply/3530a: Steam and air conditioning supply based on liquid fuels	EU without Switerland	1991-2019	ecoinvent 3.8	heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S	kWh/ kg of product	1.30
Module	Transportati	on of raw mate	erials (A2)						
Material Transported	Means of Transport	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Coated Aluminium Profile
	Land Transport	transport,	H:Transportation and storage/49:Land transport and		0000 0010	ecoinvent	transport, freight, lorry 16-32 metric ton, EURO5	ka*km/ ka	70.00
Aluminium alloy (billets)	freight, 24 tn track capacity	16-32 metric ton, EURO5	transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	3.8	transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S	of product	79.02
Aluminium alloy (billets) Aluminium alloy (billets)	freight, 24 tn track capacity Sea Transport	16-32 metric ton, EURO5 transport, freight, sea, container ship	transport via pipelines/492:Other land transport/4923:Freight transport by road H:Transportation and storage/ 50: Water transport/ 501: Sea and coastal water transport/ 5012: Sea and coastal freight water transport	GLO	2009 - 2019 2007-2019	3.8 ecoinvent 3.8	transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S transport, freight, sea, container ship   transport, freight, sea, container ship   Cutoff, S	of product t*nmi/ kg of product	0.12
Aluminium alloy (billets) Aluminium alloy (billets) Powder Coating	freight, 24 tn track capacity Sea Transport Land Transport freight, 24 tn track capacity	16-32 metric ton, EURO5 transport, freight, sea, container ship transport, freight, lorry 16-32 metric ton, EURO5	transport via pipelines/492:Other land transport/4923:Freight transport by road H:Transportation and storage/ 50: Water transport/ 501: Sea and coastal water transport/ 5012: Sea and coastal freight water transport H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	GLO	2009 - 2019 2007-2019 2009 - 2019	3.8 ecoinvent 3.8 ecoinvent 3.8	transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S transport, freight, sea, container ship   transport, freight, sea, container ship   Cutoff, S transport, freight, lorry 16-32 metric ton, EURO5   transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S	of product t*nmi/ kg of product kg*km/ kg of product	0.12
Aluminium alloy (billets) Aluminium alloy (billets) Powder Coating Chemicals	freight, 24 tn track capacity Sea Transport Land Transport freight, 24 tn track capacity Land Transport freight, 24 tn track capacity	16-32 metric ton, EURO5 transport, freight, sea, container ship transport, freight, lorry 16-32 metric ton, EURO5 transport, freight, lorry 16-32 metric ton, EURO5	transport via pipelines/492:Other land transport/4923:Freight transport by road H:Transportation and storage/ 50: Water transport/ 501: Sea and coastal water transport/ 5012: Sea and coastal freight water transport H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport via pipelines/492:Other land transport/4923:Freight transport via pipelines/492:Other land transport/4923:Freight transport by road	EU GLO EU EU	2009 - 2019 2007-2019 2009 - 2019 2009 - 2019	3.8 ecoinvent 3.8 ecoinvent 3.8 ecoinvent 3.8	transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S transport, freight, sea, container ship   transport, freight, sea, container ship   Cutoff, S transport, freight, lorry 16-32 metric ton, EURO5   transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S transport, freight, lorry 16-32 metric ton, EURO5   transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S	of product t*nmi/ kg of product kg*km/ kg of product kg*km/ kg of product	0.12 3.27 0.19



	freight, 24 tn track capacity	16-32 metric ton, EURO5	transport via pipelines/492:Other land transport/4923:Freight transport by road				transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S		
LPG	Land Transport freight, 24 tn track capacity	transport, freight, lorry 16-32 metric ton, EURO5	H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	ecoinvent 3.8	transport, freight, lorry 16-32 metric ton, EURO5   transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S	kg*km/ kg of product	0.56
Plastic Packaging	Land Transport freight, 24 tn track capacity	transport, freight, lorry 16-32 metric ton, EURO5	H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	ecoinvent 3.8	transport, freight, lorry 16-32 metric ton, EURO5   transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S	kg*km/ kg of product	0.03
Paper Packaging	Land Transport freight, 24 tn track capacity	transport, freight, lorry 16-32 metric ton, EURO5	H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	EU	2009 - 2019	ecoinvent 3.8	transport, freight, lorry 16-32 metric ton, EURO5   transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S	kg*km/ kg of product	0.39
Module	End of life st	age (C1-C4)							
Materials	Raw Material input	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Aluminium Profile
Materials Aluminium waste at End of Life transportation form building to recycling unit or lanfill (C2)	Raw Material input Generic data	Name transport, freight, lorry 16-32 metric ton, EURO5	Category H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road	Data set Location	Date of used literature for the data set 2009 - 2019	Source ecoinvent 3.8	Data set transport, freight, lorry 16-32 metric ton, EURO5   transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S	Unit kg*km/ kg of aluminium waste	Aluminium Profile
Materials Aluminium waste at End of Life transportation form building to recycling unit or lanfill (C2) Aluminium waste at End of Life for remelting (C3)	Raw Material input Generic data Generic data	Name transport, freight, lorry 16-32 metric ton, EURO5 aluminium scrap, post- consumer, prepared for melting	Category H:Transportation and storage/49:Land transport and transport via pipelines/492:Other land transport/4923:Freight transport by road E:Water supply; sewerage, waste management and remediation activities/38:Waste collection, treatment and disposal activities; materials recovery/383:Materials recovery/3830:Materials recovery	Data set Location EU EU	Date of used literature for the data set 2009 - 2019 2005 - 2019	Source ecoinvent 3.8 ecoinvent 3.8	Data set transport, freight, lorry 16-32 metric ton, EURO5   transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S treatment of aluminium scrap, post-consumer, by collecting, sorting, cleaning, pressing   aluminium scrap, post- consumer, prepared for melting   Cutoff, S	Unit kg*km/ kg of aluminium waste kg / kg of aluminium waste	Aluminium Profile 100.00 0.90



			treatment and disposal/3821:Treatment and disposal of non-hazardous waste						
Module	Reuse, Reco	very, Recycling	g Potential (D)						
Materials	Raw Material input	Name	Category	Data set Location	Date of used literature for the data set	Source	Data set	Unit	Aluminium Profile
Aluminium waste at End of Life	Generic data	aluminium ingot, primary production	C:Manufacturing/24:Manufacture of basic metals/242:Manufacture of basic precious and other non- ferrous metals/2420:Manufacture of basic precious and other non- ferrous metals	GLO	2015-2019	ecoinvent 3.8	aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S	kg/ kg of aluminium waste	-0.24
Aluminium waste at End of Life	Generic data	aluminium scrap, post- consumer, prepared for melting	C:Manufacturing/24:Manufacture of basic metals/242:Manufacture of basic precious and other non- ferrous metals/2420:Manufacture of basic precious and other non- ferrous metals	EU	2005 - 2021	ecoinvent 3.8	treatment of aluminium scrap, post-consumer, prepared for recycling, at remelter   aluminium scrap, post- consumer, prepared for melting   APOS, S	kg / kg of aluminium waste	0.24



Module	Waste Managen	nent (A3)							
Waste	Raw Material input	Name	Category	Location	Date of used literature for the data set	Source	Data Set	Unit	Quantity of waste/ Aluminium Profile
Hazardous waste (11 01 11*, 19 02 05*, 08 02 01)	Waste production according to electronic waste registry	hazardous waste, for incineration	E: Water supply; sewerage, waste management and remediation activities > 38: Waste collection, treatment and disposal activities; materials recovery > 382:Waste treatment and disposal > 3822: Treatment and disposal of hazardous waste	Europe without Switzerland	2011 - 2019	ecoinvent 3.8	market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S	kg/ kg of product	0.72
Scrap aluminium (12 01 03)	Waste production according to electronic waste registry	aluminium waste from filing and turning, for recycling	E:Water supply; sewerage, waste management and remediation activities/38:Waste collection, treatment and disposal activities; materials recovery/382:Waste treatment and disposal/3821:Treatment and disposal of non-hazardous waste	Europe without Switzerland	2011-2019	ecoinvent 3.8	market for scrap aluminium   scrap aluminium   Cutoff, S	kg/ kg of product	0.18
Paper and paperboard (15 01 01 )	Waste production according to electronic waste registry	paper waste, for recycling	E:Water supply; sewerage, waste management and remediation activities/38:Waste collection, treatment and disposal activities; materials recovery/382:Waste treatment and disposal/3821:Treatment and disposal of non-hazardous waste	GR	2018-2019	ecoinvent 3.8	market for waste paperboard   waste paperboard   Cutoff, S	kg/ kg of product	0.002

#### Table 6: Material outputs for Powder Coated Aluminium Profile.



#### 3.5 Impact Assessment methodologies and characterization factors

The impact assessment method used was EN 15804\_A2 (core indicators and additiomal). According to Open LCA database EN 15804\_A2 for use with Ecoinvent v.3.8, characterization factors aligned with EN15804\_A2 file published by European Commission JRC; Ecoinvent flow nomenclature checked. The characterization factors are presented in the following table.

Name	Description	Reference unit
EI acidification	from openLCIA methods 2_04 ILCD 2011+	molc H+ eq
EI climate change GWP CO2 uptake	from openLCIA methods 2_04 GHG Protocol	kg CO <sub>2</sub> eq
EI climate change, GWP biogenic	from JRC EN15804 methods	kg CO₂ eq
EI climate change, GWP fossil	from EI climate change, GWP total (non- fossil and biogenic removed)	kg CO₂ eq
EI climate change, GWP land transformation	from JRC EN15804 methods	kg CO₂ eq
EI climate change, GWP total	from openLCIA methods 2_04 EF Method (updated)	kg CO₂ eq
EI depletion of abiotic resources - ADPE elements	CML-IA v 4.8, 2016 - AD elements	kg Sb-Eq
EI depletion of abiotic resources - ADPF fossil fuels	CML-IA v 4.1, 2012 - AD fossil fuels	MJ
EI eutrophication, freshwater	from openLCIA methods 2_04 ILCD 2011+	kg P eq, kg PO₄ eq
EI eutrophication, marine	from openLCIA methods 2_04 ILCD 2011+	kg N eq
EI eutrophication, terrestrial	from openLCIA methods 2_04 ILCD 2011+	molc N eq
EI ozone depletion	from openLCIA methods 2_04 EF Method (adapted)	kg CFC 11 eq
EI photochemical ozone formation	from openLCIA methods 2_04 EF method (adapted)	kg NMVOC eq
EI water use, AWARE	method included in openLCA LCIA method package 2.1.2	m <sup>3</sup>
Output flows - components for reuse		kg CRU
Output flows - exported energy		MJ EE
Output flows - materials for energy recovery		kg MER



Name	Description	Reference unit
Output flows - materials for recycling		kg MFR
Resources - energy, non- renewable - PENRT	non-renewable energy resources: fossil, nuclear and primary forest	MJ-Eq
Resources - energy, renewable - PERT	cumulative renewable energy resources: biomass, geothermal, kinectic, hydro, solar	MJ-Eq
Resources - net use of fresh water - FW		m <sup>3</sup> FW
Resources - use of secondary materials - SM	total secondary material inputs in the system	kgSM
Resources -use of non- renewable secondary fuels - NRSF	non-renewable secondary fuel inputs to the system	MJSF
Resources -use of renewable secondary fuels - RSF	renewable secondary fuel inputs to the system	MJSF
Waste - hazardous, disposed - HW	total hazardous waste to landfill & incineration	kgHW
Waste - non-hazardous, disposed -NHW	total non-hazardous waste to landfill & incineration	kgW
Waste - radioactive, disposed - RW	total radioactive waste, as mass	kgRW
Additional indicators		
Name	Description	Reference unit
Ecotoxicity, freshwater	from openLCIA methods 2_04 EF Method (adapted)	CTUe
Human toxicity, cancer effects	from openLCIA methods 2_04 EF Method (adapted)	CTUh
Human toxicity, non-cancer effects	from openLCIA methods 2_04 EF Method (adapted)	CTUh
lonising radiation, HH	from openLCIA methods 2_04 EF Method (adapted)	kBq U-235 eq
Land use	from openLCIA methods 2_04 EF Method (adapted)	Pt



# 4. Life Cycle Impact Assessment, Interpretation and conclusions

#### 4.1 Life cycle impact Assessment Results

The environmental indicators for each one of the specific products are presented in the following tables.

The estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

#### 4.1.1 Extruded aluminium profile

The results in the following table are for 1 kg of Extruded aluminium profile.

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
AP	molc H+ eq	4,80E-02	0,00E+00	3,84E-05	8,03E-03	1,94E-05	-2,54E-02
GWP – uptake	kg CO₂ eq	5,29E-01	0,00E+00	1,01E-04	4,00E-02	2,47E-05	-3,75E-02
GWP – biogenic	kg CO₂ eq	-1,85E-01	0,00E+00	-3,68E-06	-1,60E-02	7,70E-02	2,30E-02
GWP – fossil	kg CO₂ eq	9,01E+00	0,00E+00	1,67E-02	4,55E-01	7,19E-03	-4,51E+00
GWP - Iuluc	kg CO <sub>2</sub> eq	2,62E-02	0,00E+00	5,91E-06	1,01E-03	1,95E-06	-1,69E-02
GWP - total	kg CO₂ eq	9,03E+00	0,00E+00	1,67E-02	4,59E-01	7,67E-02	-4,52E+00
ADP – minerals and metals	kg Sb-Eq	5,63E-05	0,00E+00	4,51E-07	1,49E-04	1,80E-08	-1,12E-05
ADP - fossil	MJ	9,99E+01	0,00E+00	2,48E-01	6,96E+00	3,60E-02	-5,65E+01
EP - freshwater	kg P eq	3,49E-03	0,00E+00	1,23E-06	6,23E-04	3,17E-06	-1,50E-03
EP – freshwater <sup>2</sup>	kg PO4 eq	1,07E-02	0,00E+00	3,77E-06	1,91E-03	9,74E-06	-4,61E-03
EP – marine	kg N eq	7,69E-03	0,00E+00	5,26E-06	6,21E-04	1,75E-04	-4,41E-03
EP - terrestrial	molc N eq	7,96E-02	0,00E+00	5,59E-05	7,39E-03	5,45E-05	-4,52E-02
ODP	kg CFC11 eq	4,99E-07	0,00E+00	3,79E-09	5,19E-08	3,74E-10	-1,74E-07
POCP	kg NMVOC eq	2,18E-02	0,00E+00	2,78E-05	2,09E-03	3,95E-05	-1,23E-02
WDP	m <sup>3</sup>	3,22E+00	0,00E+00	3,78E-01	6,39E-01	1,33E-03	-1,14E+00

Potential environmental impact - Results per declared unit

#### Use of resources – Results per declared unit

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
PENRE	MJ	1,03E+02	0,00E+00	2,53E-01	8,07E+00	3,80E-02	-5,81E+01
PENRM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ	1,03E+02	0,00E+00	2,53E-01	8,07E+00	3,80E-02	-5,81E+01
PERE	MJ	1,38E+01	0,00E+00	3,55E-03	1,13E+00	1,43E-03	-5,48E+00
PERM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	1,38E+01	0,00E+00	3,55E-03	1,13E+00	1,43E-03	-5,48E+00
FW	m <sup>3</sup>	1,77E+01	0,00E+00	3,25E-03	2,58E+00	3,22E-03	-1,18E+01
SM	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00



#### Output flows – Results per declared unit

Indicator	Unit	A1-A3	C1	C2	С3	C4	D
Components for reuse	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Exported energy	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Materials for energy recovery	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Materials for recycling	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00

#### Waste production - Results per declared unit

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
HW	kg	2,41E+00	0,00E+00	2,55E-04	0,00E+00	1,47E-04	-9,39E-01
NHW	kg	1,38E+01	0,00E+00	1,75E-02	0,00E+00	1,03E-01	-6,32E+00
RW	kg	1,64E-04	0,00E+00	1,73E-06	0,00E+00	1,83E-07	-7,12E-05

#### Additional indicators- Results per declared unit

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
Ecotoxicity, freshwater	CTUe	2,52E+00	0,00E+00	8,26E-03	1,18E+00	3,92E-02	-2,25E-01
Human toxicity, cancer effects	CTUh	9,35E-09	0,00E+00	5,17E-12	1,30E-09	5,54E-11	-4,79E-09
Human toxicity, non-cancer effects	CTUh	1,08E-06	0,00E+00	3,20E-10	2,72E-07	3,24E-10	-6,29E-07
Ionising radiation, HH	kBq U-235 eq	2,87E-01	0,00E+00	1,30E-03	6,92E-02	2,15E-04	-1,25E-01
Land use	Pt	8,62E+01	0,00E+00	2,51E-01	7,34E+00	8,92E-02	-1,19E+01
Particulate	disease inc.	5,40E-07	0,00E+00	1,09E-09	2,71E-08	1,40E-09	-3,25E-07

Disclaimer 1: The results of the environmental impact indicators ADP and WDP shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator. Disclaimer 2: Eutrophication aquatic freshwater shall be given in both kg PO4 eq and kg P eq.

#### 4.1.2 Powder Coated Aluminium Profile

The results in the following table are for 1 kg of Powder coated aluminium profile.

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
AP	molc H+ eq	5,31E-02	0,00E+00	3,84E-05	8,03E-03	1,94E-05	-2,54E-02
GWP – uptake	kg CO <sub>2</sub> eq	1,73E-01	0,00E+00	1,01E-04	4,00E-02	2,47E-05	-3,75E-02
GWP – biogenic	kg CO <sub>2</sub> eq	-4,64E-02	0,00E+00	-3,68E-06	-1,60E-02	7,70E-02	2,30E-02
GWP – fossil	kg CO <sub>2</sub> eq	9,74E+00	0,00E+00	1,67E-02	4,55E-01	7,19E-03	-4,51E+00
GWP - Iuluc	kg CO <sub>2</sub> eq	2,54E-02	0,00E+00	5,91E-06	1,01E-03	1,95E-06	-1,69E-02
GWP - total	kg CO₂ eq	9,77E+00	0,00E+00	1,67E-02	4,59E-01	7,67E-02	-4,52E+00
							_

#### Potential environmental impact - Results per declared unit



Indicator	Unit	A1-A3	C1	C2	C3	C4	D
ADP – minerals and metals	kg Sb-Eq	6,23E-05	0,00E+00	4,51E-07	1,49E-04	1,80E-08	-1,12E-05
ADP - fossil	MJ	1,14E+02	0,00E+00	2,48E-01	6,96E+00	3,60E-02	-5,65E+01
EP - freshwater	kg P eq	4,59E-03	0,00E+00	1,23E-06	6,23E-04	3,17E-06	-1,50E-03
EP - freshwater	kg PO4 eq	1,41E-02	0,00E+00	3,77E-06	1,91E-03	9,74E-06	-4,61E-03
EP – marine	kg N eq	8,09E-03	0,00E+00	5,26E-06	6,21E-04	1,75E-04	-4,41E-03
EP - terrestrial	molc N eq	8,16E-02	0,00E+00	5,59E-05	7,39E-03	5,45E-05	-4,52E-02
ODP	kg CFC11 eq	6,46E-07	0,00E+00	3,79E-09	5,19E-08	3,74E-10	-1,74E-07
POCP	kg NMVOC eq	2,29E-02	0,00E+00	2,78E-05	2,09E-03	3,95E-05	-1,23E-02
WDP	m3	3,55E+00	0,00E+00	3,78E-01	6,39E-01	1,33E-03	-1,14E+00

#### Use of resources – Results per declared unit

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
PENRE	MJ	1,19E+02	0,00E+00	2,53E-01	8,07E+00	3,80E-02	-5,81E+01
PENRM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ	1,19E+02	0,00E+00	2,53E-01	8,07E+00	3,80E-02	-5,81E+01
PERE	MJ	1,06E+01	0,00E+00	3,55E-03	1,13E+00	1,43E-03	-5,48E+00
PERM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	1,06E+01	0,00E+00	3,55E-03	1,13E+00	1,43E-03	-5,48E+00
FW	m <sup>3</sup> 1,71E+01	1,71E+01	0,00E+00	+00 3,25E-03 2,	2,58E+00	3,22E-03	-1,18E+01
SM	kg	kg 0,00E+00	0 0,00E+00 0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00

#### Output flows – Results per declared unit

Indicator	Unit	A1-A3	C1	C2	С3	C4	D
Components for reuse	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Exported energy	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Materials for energy recovery	kg	0,00E+00	0,00E+00 0,00E+00 0,0	0,00E+00 0,00E+00	0,00E+00	0,00E+00	
Materials for recycling	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00

#### Waste production – Results per declared unit

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
HW	kg	2,39E+00	0,00E+00	2,55E-04	0,00E+00	1,47E-04	-9,39E-01
NHW	kg	1,94E+01	0,00E+00	1,75E-02	0,00E+00	1,03E-01	-6,32E+00
RW	kg	2,10E-04	0,00E+00	1,73E-06	0,00E+00	1,83E-07	-7,12E-05

#### Additional indicators- Results per declared unit

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
Ecotoxicity, freshwater	CTUe	4,03E+00	0,00E+00	8,26E-03	1,18E+00	3,92E-02	-2,25E-01



Indicator	Unit	A1-A3	C1	C2	C3	C4	D
Human toxicity, cancer effects	CTUh	9,54E-09	0,00E+00	5,17E-12	1,30E-09	5,54E-11	-4,79E-09
Human toxicity, non-cancer effects	CTUh	1,07E-06	0,00E+00	3,20E-10	2,72E-07	3,24E-10	-6,29E-07
Ionising radiation, HH	kBq U-235 eq	3,69E-01	0,00E+00 1,30E-03 6,92E-02 2,15E-04	2,15E-04	-1,25E-01		
Land use	Pt	3,85E+01	0,00E+00	2,51E-01	7,34E+00	8,92E-02	-1,19E+01
Particulate	disease inc.	5,32E-07	0,00E+00	1,09E-09	2,71E-08	1,40E-09	-3,25E-07

Disclaimer 1: The results of the environmental impact indicators ADP and WDP shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator. Disclaimer 2: Eutrophication aquatic freshwater shall be given in both kg PO4 eq and kg P eq.

#### 4.2. Evaluation and Sensitivity Analysis

Sensitivity Analysis (SA) investigates the effects of the choices made regarding methods and data on the outcome of the study. Based on Sensitivity Analysis, a verification of the choices concerning inputs, outputs, unit processes, and stages is performed.

The two products were analyzed and checked for which inputs/outputs processes and/or flows affect each environmental indicator. The amounts correspond to 1kg of aluminium profile.

An Impact Analysis was performed using OpenLca software, for all the environmental indicators from the EN 15804\_A2\_2020 impact assessment method, in order to find the inputs/outputs that affect each environmental indicator.

The Impact Analysis of Extruded aluminium profile and Powder Coated aluminium profile is shown in Figure 4 and Figure 6 respectively, where the most important inputs /outputs that influence the values of each environmental indicator are presented.

Also, the contribution of inputs /outputs in the impact value of specific environmental indicators is presented in Figures 5 and 7 (Contribution Tree tab of openLCA) for the same products. The results that are given, provide a percentile and mass amount about each process and/or flow that affect a particular environmental indicator.

From the Sensitivity Analysis performed for the Extruded Aluminium Profile (Figure 4), it is shown that:

• Approximately all the environmental indicators are influenced by the primary aluminium ingot (billet) which consists the 34% of the total product. Primary aluminium ingot



(billet) is the main contributor in approximately all the indicators and flows except of the indicators: GWP CO<sub>2</sub> uptake in which the main contributor was kraft paper production, GWP -biogenic in which the main contributor was hazardous waste and ADPE -elements in which the main contributor was the treatment of aluminium scrap. The other input parameters differ depending on the environmental indicator (treatment of aluminium scrap which refers to the recycled aluminium used in the billets, hazardous waste, electricity production). In the most indicators the impact result of the two most important inputs shows values at least one order of magnitude higher that the other parameters, which means that most of the other parameters do not influence the results significantly.

As Figure 5 shows, the top four contributors to GWP total are aluminium ingot (billets) with contribution of 66.85%, hazardous waste with 19.96%, electricity production with 6.71% and treatment of aluminium scrap with 3.48%. The amount of aluminium ingot which is primary aluminium content in billets in the Extruded Aluminium Profile is 0.34 kg/kg of products meaning that 34% of aluminium ingot in the product gives us a contribution of 66.85% while the recycled content of the billet which is approximately 0.66 kg/kg of product (66%) gives 3.48% for GWP total. These four parameters are responsible for 97% of the impact value.

Based on the above, all the critical data (aluminium ingot, hazardous waste, electricity and treatment of aluminium scrap) for the calculation of the environmental indicators, have been collected from specific data with significant accuracy (bills, invoices etc.) ensuring the quality of the LCA results.

From the Sensitivity Analysis performed for the Powder Coated Aluminium Profile (Figure 6), it is shown that:

Approximately all the environmental indicators are influenced by the primary aluminium ingot (billet) which consists the 32% of the total product. Primary aluminium ingot (billet) is the main contributor in approximately all the indicators and flows except of the indicators: GWP-CO<sub>2</sub> uptake in which the main contributor was kraft paper production, GWP-biogenic in which the main contributor was hazardous waste and ADPE-elements in which the main contributor was the treatment of aluminium scrap. The other input parameters differ depending on the environmental indicator (hazardous waste, electricity production, powder coating production). In the most indicators the impact result of the two most important inputs shows values at least one



order of magnitude higher that the other parameters, which means that most of the other parameters do not influence the results significantly.

As Figure 7 shows, the top contributors to GWP total are aluminium ingot (billets) with contribution of 61.33%, hazardous waste with 19.49%, electricity production with 6.55%, coating powder production with 4.33%, heat production with 4.33% and treatment of aluminium scrap with 3.19%. The amount of aluminium ingot in the Powder Coated Aluminium Profile is 0.32 kg/kg of product meaning that 32% of aluminium ingot in the product gives us a contribution of 61.33% while the recycled content of the billet which is approximately 0.62 kg/kg of product (62%) gives only 3.19% for GWP total. The above parameters are responsible for more than 99% of the impact value.

Specific data were used for the calculation of an LCI of all of the above parameters.

Additionally, an analysis of the environmental impact results of the three life cycle stages of module A, separately (A1, A2, A3) was performed for both aluminium profiles. This choice was based on the ability of the product to contain input processes and/or flows in each of the three life cycle stages. The results for all the environmental impacts for Extruded Aluminium Profile and Powder Coated Aluminium Profiles, displayed separately for the three life cycle stages, are shown in tables 7 and 8.

From the Analysis of the environmental impacts for each life cycle stage for both products it is shown that:

- the life cycle stage A1 has the highest contribution to all of the environmental impacts. The A1 contains the production and/or supply of raw materials, electricity and packaging material production.
- The life cycle stage A2 (transportation of raw materials to the production facility), shows the lowest contribution out of the three stages to all of the environmental impacts. This is reasonable considering that all raw materials come from an area nearby the manufacturing site.
- The life cycle stage A3 contains the manufacturing of the products and the waste managements. The contribution of this stage to the sum of the environmental impacts is lower than the A1 module and higher than module A2.
- As shown in Figures 8 and 9 the contribution of module A1 in all the presented indicators is the highest and derives from the aluminium ingot content of the billets.
   Follows modules A3 and C3 which includes the remelting process at End-of-life stage



of the product. Module D represent the reuse of aluminium profiles after End-of-life stage and this is shown with the negative values.

Name	Impact result	Unit
v I= El acidification	0.05087	molc H+ eq
> P advancedori > P advance	0.03590	mole H+ eq
P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	0.00208	molc H+ eq
> P heat production, light fuel oil, at industrial furnace IMW I heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	0.00069	molc H+ eq
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	0.00452	molc H+ eq
> P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	0.00589	molc H+ eq
✓ I El climate change GWP CO2 uptake	0.14950	kg CO2 eq
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	<ul> <li>0.05291</li> </ul>	kg CO2 eq
> P kraft paper production   kraft paper   APOS, S - RER	<ul> <li>0.05717</li> </ul>	kg CO2 eq
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	0.01301	kg CO2 eq
> P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	0.02412	kg CO2 eq
✓ III El climate change, GWP biogenic	-0.04459	kg CO2 eq
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	-0.03241	kg CO2 eq
> P heat and power co-generation, biogas, gas engine   electricity, high voltage   Cutoff, S - GR	0.00109	kg CO2 eq
> P kraft paper production   kraft paper   APOS, S - RER	<ul> <li>-0.01206</li> </ul>	kg CO2 eq
P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	0.00912	kg CO2 eq
P market for waste paperboard   waste paperboard   Cutoff, S - GR	0.00427	kg CO2 eq
P treatment of aluminium scrap, new, at remeiter   aluminium, wrought alloy   Cutoff, S - KEK	-0.01494	kg CO2 eq
► El climate change, GWP tossil	9.51081	kg CO2 eq
P aluminium ingot, primary, to aluminium, wrought alloy market jaluminium, wrought alloy j Cutori, S - GLO	0.30437	kg CO2 eq
P electricity production, natural gas, combined cycle power plant   electricity, nigh voltage   cutort, s - bas and the second second planticity of the second s	0.13472	kg CO2 eq
> P electricity voltage transformation more implete metalian voltage percently, mediant voltage patient, so ok > D hast production light fuel oil st induction function function induction of the that have noticed and 10 ctoff S - Europe without Switzerland	0.33123	kg CO2 eq
P met production, ignit red on, at industrial number inwinities, district or industrial, other man natural gies (cutor), so curper without switzenand pravlet for hostardous waste for incineration (hasted or incineration) [Citted [S. Europe without switzenand]	1 80721	kg CO2 eq
P material mazalodas waste, for incline atom prazalodas waste, for incline atom products, a Catope without switzenand     D tratament of aluminium scran new at rematerial aluminium wrought allocal Citatof S. RER	0.32857	kg CO2 eq
V E Elimite change GWD and transformation	0.02519	kg CO2 eq
Learning of the second se	0.02387	kg CO2 eq
Peletricity production by dro number storage electricity, binh voltage Loutoff S - GR	0.00042	kg CO2 eq
Percently production, myore, pumped subject reacting, myore one product subject and the s	0.00040	kg CO2 eq
P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	0.00030	ka CO2 ea
V E El climate change. GWP total	9.53656	ka CO2 ea
P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	6.37478	kg CO2 eg
> P electricity production, natural gas, combined cycle power plant   electricity, high voltage   Cutoff, S - GR	0.13476	kg CO2 eg
> P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	0.33173	kg CO2 eq
> P heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	0.24704	kg CO2 eq
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1.90386	kg CO2 eq
> P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	0.33156	kg CO2 eq
✓ I = El depletion of abiotic resources - ADPE elements	5.65919E-5	kg Sb-Eq
P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	<ul> <li>1.57620E-5</li> </ul>	kg Sb-Eq
P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	8.18773E-6	kg Sb-Eq
P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	3.06215E-5	kg Sb-Eq
El depletion of abiotic resources - ADPF tossil fuels	109.34996	MJ
P aluminium ingot, primary, to aluminium, wrought allog market jaluminium, wrought allog   Cutoff, S - GLO	/9.80330	MU
P electricity production, lightle j electricity, high vortage j Cutor, s - ou pelastricity production actual para combined outle parater allocativity high voltage   Cutorf, S - GP	1.30051	MI
P electricity production, natural gas, combined cycle power plant ("electricity, might voltage) (cutoff, s = 6k	6 15650	MI
> P electricity voltage dansionation more inperiod workage percenticity, medium voltage percent, s = 6k	3 30867	MI
P market for brazerdous waste for incineration I brazerdous waste for incineration I Critical S- Europe without Switzerland market for brazerdous waste for incineration I brazerdous waste for incineration I Critical S- Europe without Switzerland	9 21632	MI
P Instance to failumining scan new at remeter (alumining would talk) (Cutoff 5 - RFR	4.94269	MI
V E El eutrophication. freshwater	0.00456	ka P ea
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	.0.00212	kg P eq
> P electricity production, lignite   electricity, high voltage   Cutoff, S - GR	0.00022	kg P eq
> P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	0.00074	kg P eq
> P electricity voltage transformation from medium to low voltage   electricity, low voltage   Cutoff, S - GR	7.44957E-5	kg P eq
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	I 0.00065	kg P eq
> P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	0.00068	kg P eq
✓ I≡ El eutrophication, marine	0.00801	kg N eq
P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	0.00623	kg N eq
P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	0.00030	kg N eq
> P heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	0.00011	kg N eq
P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	0.00068	kg N eq
P treatment or aluminium scrap, new, at remeiter   aluminium, wrought alloy   Cutoff, S - RER	0.00037	kg N eq
Destrophication, terrestrial	0.08107	mole N eq
P aurimium ingot, primary, to auminium, wrought alloy market j auminium, wrought alloy   Cutoft, 5 - 600	0.00384	mole N eq
> precedency volage transformation norming to medium volage jetectricity, medium volage jettor 5 - 0K > Dest production light find is a find transformation norming to medium volage jettor a find that the set of	0.00170	mole N eq
P receiption of the production in grin rule of a minimum environment of the production in grin rule of a minimum environment of the production in grin rule of a minimum environment of the production in the p	0.00110	mole N eq
P market for nazarous waste for minimation prozarous waste for inclination [Utor), 5 - Europe without switzerland D treatment of a jumpium screen new at member 1 alimnium wrought allow 10 rutor (5 - EUROPE without switzerland)	0.00732	mole N eq
F account of infinition scrap, new, accenticer anomalian, wrought alloy [Cuton, 5 - New F E factorie depletion	5,71047F-7	ka CEC11 ea
> P aluminium inact. primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	2,45063E-7	ka CFC11 ea
P electricity production, natural gas, combined cycle power plant   electricity, hind voltage   Cutoff, S - GR	4.19911E-8	kg CFC11 ea
> P electricity production, oil   electricity, high voltage   Cutoff, S - RoW	6.39467E-9	kg CFC11 eq
> P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	1 2.97907E-8	kg CFC11 eq
> P heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	5.47612E-8	kg CFC11 eq
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1.46014E-7	kg CFC11 eq
D treatment of aluminium scrap, new at remelter Laluminium, wrought alloy LOutoff, S., PEP.	2 450055 0	he CEC11 as



✓ IE Iphotochemical ozone formation	0.02235	kg NMVOC eq
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	0.01730	kg NMVOC eq
> P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	0.00055	kg NMVOC eq
> P heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	0.00038	kg NMVOC eq
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	0.00188	kg NMVOC eq
> P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	0.00141	kg NMVOC eg
		· ·
	112 10206	MUT
E resources - energy, non-renewable - PENNI	113.18280	IVU-Eq
P aluminium ingot, primary, to aluminium, wrought alloy market a aluminium, wrought alloy   Cutoπ, S - GLO	82.04038	IVU-Eq
> P electricity production, lighter electricity, high voltage [ Cutoh, s - ok	1.50070	NU-Eq
> P electricity production, natural gas, combined cycle power plant [electricity, nigh vortage] Cutor, 5 - 0k	2.24020	NU-Eq
P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	0.33090	MD-Eq
P heat production, light ruel oil, at industrial furnace IMW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	3.33159	MD-Eq
P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoft, S - Europe without Switzerland	9.72419	MJ-Eq
P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	5.52452	MJ-Eq
I = resources - energy, renewable - PERI	10.37509	MJ-Eq
P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	7.72930	MJ-Eq
P electricity production, photovoltaic, 570kWp open ground installation, multi-Si   electricity, low voltage   Cutoff, S - RoW	0.16457	MJ-Eq
P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	0.43907	MJ-Eq
> P kraft paper production   kraft paper   APOS, S - RER	0.65662	MJ-Eq
P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	0.40855	MJ-Eq
P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	0.68882	MJ-Eq
✓ I resources - net use of fresh water - FW	17.75394	m3FW
P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	16.63121	m3FW
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	0.69230	m3FW
P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	0.33062	m3FW
✓ III waste - hazardous, disposed - HW	2.41510	kgHW
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	1.32574	kgHW
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1.05608	kgHW
> P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	0.02612	kgHW
✓ 📃 waste - non-hazardous, disposed -NHW	19.04595	kgW
P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	8.91550	kgW
P electricity production, lignite   electricity, high voltage   Cutoff, S - GR	1.09215	kgW
> P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	3.57879	kgW
> P electricity voltage transformation from medium to low voltage   electricity, low voltage   Cutoff, S - GR	0.36254	kgW
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1.29085	kgW
> P market for scrap aluminium   scrap aluminium   Cutoff, S - Europe without Switzerland	0.33502	kgW
> P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	3.20112	kgW
V 🔄 waste - radioactive, disposed - RW	0.00018	kgRW
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	0.00010	kgRW
> P electricity production, nuclear, pressure water reactor   electricity, high voltage   Cutoff, S - BG	2.67059E-6	kgRW
> P electricity production, oil   electricity, high voltage   Cutoff, S - RoW	2.86613E-6	kgRW
> P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	5.69924E-6	kgRW
> P heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	1 2.46407E-5	kgRW
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	2.13677E-5	kgRW
P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	1.51073E-5	kgRW
Finner 4. Increase Angle is afficiencial Alemainium Deafile of fallows from the surplus	- ! O I	~ ^

Figure 4: Impact Analysis of Extruded Aluminium Profile as follows from the analysis in OpenLCA software.

Impact category IE El climate change, GWP total Contribution Process Amount Unit ✓ 100.00% P Extruded aluminium profile 9.53656 kg CO2 eq 
 100.00%
 P Extruded aluminium profile

 66.85%
 P aluminium ingot, primary, to aluminium, wrought alloy market | aluminium, wrought alloy | Cutoff, S - GLO

 19.96%
 P market for hazardous waste, for incineration | hazardous waste, for incineration | Cutoff, S - Europe without Switzerland

 > 06.71%
 P electricity, medium voltage, production mix | Cutoff, U modified for 2021 based on energy mix - CUT OFF S - GR

 03.43%
 P treatment of aluminium scrap, new, at remeter | aluminium, wrought alloy | Cutoff, S - RER
 6.37478 kg CO2 eq 1.90386 kg CO2 eq . 0.64001 kg CO2 eq 0.33156 kg CO2 eq Constraints of animated presentation of the second se 0.24704 kg CO2 eq 0.01336 kg CO2 eq 00.11% R kraft paper production | kraft paper | APOS, S - RER 0.01017 kg CO2 eq 0.00435 kg CO2 eq 

 00.11%
 ¥ kratt paper production | kratt paper | APOS, S - KER

 00.05%
 P packaging film production, low density polyethylene | packaging film, low density polyethylene | Cutoff, S - RER

 00.04%
 P market for vaste paperboard | vaste paperboard | Cutoff, S - GR

 00.03%
 P market for scrap aluminium | scrap aluminium | Cutoff, S - Europe without Switzerland

 00.02%
 P transport, freight, sea, container ship | transport, freight, sea, container ship | Cutoff, S - GLO

 0.00392 kg CO2 eq 0.00308 kg CO2 eq 0.00218 kg CO2 eq Respectively, res 0.00208 kg CO2 eq 0.00018 kg CO2 eq 00.02% 00.00%

Figure 5: Contribution of inputs/outputs to the impact GWP total of Extruded Aluminium Profile.



Name	^	Impact	result	Unit
~ IE 6	acidification		0.05312	molc H+ eq
> F	aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	= (	0.03375	molc H+ eq
> F	coating powder production   coating powder   Cutoff, S - RER	ı (	0.00371	molc H+ eq
> F	electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	i (	0.00208	molc H+ eq
> F	🕴 heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	1 (	).00118	molc H+ eq
> F	P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	i (	).00452	molc H+ eq
> F	treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	I (	).00553	molc H+ eq
✓ IE E	l climate change GWP CO2 uptake		).17311	kg CO2 eq
>	aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO		J.04973	kg CO2 eq
	coating powder production   coating powder   Cutor, S - KEK		J.02488	kg CO2 eq
2 1	<ul> <li>Krait paper production   Krait paper   APOS, S - NEK</li> <li>market for bazardoux wate for incineration   bazardoux wate for incineration   Cutoff S - Europa without Switzerland</li> </ul>		0.01301	kg CO2 eq
	marker on negatioods wasker, on methation prozarodos wasker on methation processing semanal semanal		0.02267	kg CO2 eq
VIER	I climate change GWP higgs in climate plantman, weaght any feator, 5 ket	-	0.04644	ka CO2 ea
> F	aluminium inodu primarv. to aluminium, wrought allov market I aluminium, wrought allov I Cutoff. S - GLO		0.03046	ka CO2 ea
> F	coating powder production   coating powder   Cutoff, S - RER	ı -(	0.00341	kg CO2 eg
> F	heat and power co-generation, biogas, gas engine   electricity, high voltage   Cutoff, S - GR	1 (	0.00109	kg CO2 eq
> F	kraft paper production   kraft paper   APOS, S - RER	(	0.01206	kg CO2 eq
> F	market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	• (	0.00912	kg CO2 eq
> F	market for waste paperboard   waste paperboard   Cutoff, S - GR	1	0.00427	kg CO2 eq
> F	non-ionic surfactant production, fatty acid derivate   non-ionic surfactant   Cutoff, S - GLO	ı -(	0.00114	kg CO2 eq
> F	treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	• - (	).01404	kg CO2 eq
✓ IE E	il climate change, GWP fossil	9	9.74364	kg CO2 eq
> F	aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO		5.98270	kg CO2 eq
>	coating powder production   coating powder   Cutoff, S - RER	1 (	J.42202	kg CO2 eq
>	<ul> <li>electricity production, natural gas, combined cycle power plant   electricity, high voltage   Cutoff, S - GR</li> <li>electricity results and the second se second second sec</li></ul>		J.13472	kg CO2 eq
>	<ul> <li>electricity voitage transformation from high to medium voitage   electricity, medium voitage   Cutoff, S - GR</li> </ul>		J.33129	kg CO2 eq
	<ul> <li>neat production, light rue oil, at industrial rumace living [neat, district or industrial, other than natural gas [Cutor, S - Europe without Switzenand]</li> <li>mandation benefation with the second sec</li></ul>		1.00721	kg CO2 eq
21	<ul> <li>market for nazarobus waste, for inclineation   nazarobus waste, for inclineation   cuton   cuton   security without switzenand</li> <li>bit restment of alumping scrap, percent action in a security without switzenand</li> </ul>		0 20005	kg CO2 eq
2 1 2	- deather of administratic stap, new, at remeter partministri, wrought anoy ( Catori, 5 - KEK	· · ·	0.02544	kg CO2 eq
× := 1	a luminium inorth minimum visual antivinium visual tallov market Laluminium visual tallov L Cutoff S - GLO	- 1	0.02244	kg CO2 eq
	a cating nowler production ( costing nowder   Cutoff S - RFR		0.00038	ka CO2 ea
	electricity production hydro pumped storage lefectricity, bioh voltage   Qutoff S - GR		0.00042	ka CO2 ea
5	market for hazardous waste. for incineration   hazardous waste. for incineration   Cutoff. S - Europe without Switzerland		0.00040	ka CO2 ea
> F	onn-ionic surfactant production, fatty acid derivate   non-ionic surfactant   Cutoff, S - GLO	1 (	0.00129	kg CO2 eg
> F	P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	(	0.00028	kg CO2 eq
✓ 1∃ E	l climate change, GWP total		9.77013	kg CO2 eg
> P	aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	-	5.99230	kg CO2 eq
> P	coating powder production   coating powder   Cutoff, S - RER	1	0.42343	kg CO2 eq
> P	electricity production, natural gas, combined cycle power plant   electricity, high voltage   Cutoff, S - GR		0.13476	i kg CO2 eq
> P	electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	1	0.33173	kg CO2 eq
> P	heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	1	0.42256	i kg CO2 eq
> P	market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1 - C	1.90386	i kg CO2 eq
> P	treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	1	0.31167	7 kg CO2 eq
✓ [] E	l depletion of abiotic resources - ADPE elements	6.	23442E-5	kg Sb-Eq
> P	aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	· 1/	48163E-5	kg Sb-Eq
> P	coating powder production   coating powder   Cutoff, S - REK	1 6.	34710E-6	kg Sb-Eq
> P	nyarogen nuonae production   nyarogen nuonae   Lutorr, S - KEK market kenandeur unter fan ingenetien en benedeur en ter fan ingenetien   C + F C - Franzelike et Suitesten et	1.	24380E-0	Kg Sb-Eq
> P	market for nazardous waste, for incineration   nazardous waste, for incineration   Cutorr, S - Europe without switzenand	- 2	18//3E-0	kg SD-Eq
	I depletion of abiotic resources - ADPE fossil fuels	= 2.0	14,30781	/ kg so-eq / MI
× 1	aluminium inoot, primary, to aluminium, wought alloy market Laluminium, wrought alloy I Cutoff, S - GLO	. · · ·	75.01517	7 MJ
S P	coating powder production I coating powder I Cutoff, S - RER	1	7.06734	4 MJ
S P	electricity production, lignite   electricity, high voltage   Cutoff, S - GR	-	1.36031	MJ
> P	electricity production, natural gas, combined cycle power plant   electricity, high voltage   Cutoff. S - GR		2.23708	8 MJ
> P	electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	1	6.15650	MJ
> P	heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	1	5.65945	MJ
> P	market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1	9.21632	MJ
> P	treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	1	4.64612	2 MJ
~ ∎≣ E	l eutrophication, freshwater		0.00459	kg P eq
> P	aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	•	0.00199	kg Peq
> P	coating powder production   coating powder   Cutoff, S - RER	1	0.00018	8 kg P eq
> P	electricity production, lignite   electricity, high voltage   Cutoff, S - GR	1	0.00022	2 kg P eq
> P	electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	1	0.00074	kg Peq
> P	electricity voltage transformation from medium to low voltage   electricity, low voltage   Cutoff, S - GR	7.	44957E-5	kg Peq
> P	market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	L	0.00065	kg Peq
> P	treatment of aluminium scrap, new, at remeiter   aluminium, wrought alloy   Cutoff, S - RER	· · · ·	0.00064	kg Peq
✓ IE E	europhication, marine		0.00809	kg N eq
> P	aiuminium ingor, primary, to aiuminium, wrought alioy market jaiuminium, wrought alioy   Cutoff, S - GLO		0.00586	kg Neq
> P	Columny powder production   coating powder   Cutor, S - KEK		0.00035	kgivieq
> P	economy voltage italisionnation non nighto menum voltage jetectricity, menum voltage j Cutom, S - GK I heat production, light fuel pil, at industrial furnace 1MW   heat district prindustrial, other than patient out of C - Europe without Switzerland	1	0.00030	kg Neq
> P	market for brazidous waste for incineration I brazidous wate for incineration I Cited S. Europe without switzerland	1	0.00016	ka Nea
	treatment of aluminium scrap new at remeter a lauminium wrought allow I Cutoff S. PER	i.	0.00034	ka Nea
/ F	i carante i	1		1.1211.144



a IT Distriction to addite		0.00160	
I clientrophication, terrestrial	_	0.06001	mole N eq
P autominum rigot, primary, to autominum, wrought andy market janominum, wrought andy j Cutofi, S - GLO		0.00001	mole N eq
P coarring powder production   coarring powder   cutor, s - REK	-	0.00556	mole N eq
> P electricity voltage transformation from high to medium voltage jeaction; medium voltage jeaction; so - ok best enduction, likely full all strainers 1MW heat district residuation detection and catefit. S. Europe without Suiterchard	-	0.001/0	mole N eq
P near production, ignitial run in a industrial run ace now pread, busited on matural gas ( cubit, s - busited e windout switzenand ) production, ignitial e units for instruments for instruments for instruments for instruments ( States) and ).	-	0.00196	mole N eq
P market to nazaroous waste, for incineration in nazaroous waste, for incineration (cutor), 5 - Europe without switzenand	-	0.00752	mole N eq
P treatment of aufminium scrap, new, at remeiter pauminium, wrought anoy potion, s - KeK		6 461075 7	hold iveq
	_	0.40127E-7	kg CFC11 eq
P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cuton, S - GLO		2.30359E-7	kg CFC11 eq
> P coating powder production   coating powder   Cutoff, S - KER		4.70787E-8	kg CFCTT eq
> P electricity production, natural gas, combined cycle power plant   electricity, high voltage   Cutoff, S - GR	I	4.19911E-8	kg CFC11 eq
P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	1	2.9/90/E-8	kg CFC11 eq
P heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	<u>ا</u>	9.36687E-8	kg CFC11 eq
P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	<u> </u>	1.46014E-7	kg CFC11 eq
P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	1	3.25151E-8	kg CFC11 eq
V 📔 El photochemical ozone formation		0.02293	kg NMVOC eq
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO		0.01626	kg NMVOC eq
> P coating powder production   coating powder   Cutoff, S - RER	1	0.00130	kg NMVOC eq
> P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	1	0.00055	kg NMVOC eq
> P heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe without Switzerland	1	0.00065	kg NMVOC eq
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1	0.00188	kg NMVOC eq
> P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	1	0.00133	kg NMVOC eq
V 📑 resources - energy, non-renewable - PENRT		119.168	57 MJ-Ea
> P aluminium ingot, primary, to aluminium wrought alloy market I aluminium, wrought alloy I Cutoff, S - GLO		77.122	67 MJ-Eq
> P costing powder production I costing powder I Cutoff S - RFR		8.179	90 MI-Eq
> P compared production production product product production productin production pr		1 369	76 MI-Eq
> Detectivity production, ngmite (according), mgm rough (according) for the second se second second sec		2 240	20 MI-Eq
> D electricity production, indicating as, combined spee power priority electricity, medium voltage Locating, S. GR.		6 220	06 MLEa
P electricity voltage dialsoftmation from high to meaning voltage jetechcity, meani		0.550	SE NALE-
P neat production, light fuel oil, at industrial furnace 100W   neat, district or industrial, other than natural gas   Cutorr, S - Europe without switzerial	Ja I	0.098	os IVIJ-Eq
P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	- 1	9.724	19 MJ-Eq
P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	1	5.193	05 MJ-Eq
✓ III resources - energy, renewable - PERT		10.570	78 MJ-Eq
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO		7.265	54 MJ-Eq
> P coating powder production   coating powder   Cutoff, S - RER	1	0.636	75 MJ-Eq
> P electricity production, photovoltaic, 570kWp open ground installation, multi-Si   electricity, low voltage   Cutoff, S - RoW		0.164	57 MJ-Eq
> P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	1	0.439	07 MJ-Eq
P kraft paper production   kraft paper   APOS, S - RER	1	0.656	62 MJ-Eq
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1	0.408	55 MJ-Eq
> P treatment of aluminium scrap, new at remeter Laluminium wrought alloy I Cutoff S - RFR		0.647	49 MI-Eq
V E recourses - not use of fresh water - FW		17.050	24 m3EW
> D aluminium inort primary traduminium woulds allow market laluminium woulds allow I Gutoff S- GLO		15 622	24 m3FW
P autoimum migde production location control and market autoimum, wrought and production (S - 600 -		0.035	00
> P coating powder production ( coating powder ( Cutor, S - KEK		0.275	08 m3FW
P market for hazardous waste, for incineration   hazardous waste, for incineration   Cuttor, S - Europe without Switzerland	- 1	0.692	30 m3FW
P treatment of aluminium scrap, new, at remeiter   aluminium, wrought alloy   Cutoff, S - KEK		0.310	1/9 m3FW
✓ IE waste - hazardous, disposed - HW		2.38	967 kgHW
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO		1.24	520 kgHW
> P coating powder production   coating powder   Cutoff, S - RER	1	0.04	67 kgHW
> P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland		1.05	508 kgHW
P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER		0.02	455 kgHW
✓ I= waste - non-hazardous, disposed -NHW		19.35	192 kgW
D aluminium inget, reimany to aluminium, wrought allow market Laluminium, wrought alloy I Cutoff, S - GLO		8 38	)57 kgW
D costing production Locating production Costing and Costing SPEP		0.02	557 kgW
> P destrictive reduction limite laberticity induced cutor, 5 - net D destrictive reduction limite laberticity induced cutoff S - GP	- 1	1.00	015 kgW
P electricity production, lightle feechicity, light voltage   Cuton, s - ok	- 1	1.09	213 KgVV
P electricity voitage transformation from high to medium voitage   electricity, medium voitage   cutoff, S - GK		3.57	S/9 KgVV
P electricity voltage transformation from medium to low voltage   electricity, low voltage   Cutoff, S - GR		0.36	254 kgW
P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1	1.29	J85 kgW
P market for scrap aluminium   scrap aluminium   Cutoff, S - Europe without Switzerland		0.33	02 kgW
> P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER		3.00	905 kgW
✓ IE waste - radioactive, disposed - RW		0.00	021 kgRW
> P aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO		9.44638	E-5 kgRW
> P coating powder production   coating powder   Cutoff, S - RER		2.11945	E-5 kgRW
> P electricity production, nuclear, pressure water reactor   electricity, high voltage   Cutoff, S - BG		2.67059	E-6 kgRW
> P electricity production, oil   electricity, high voltage   Cutoff, S - RoW		2.86613	E-6 kgRW
> P electricity voltage transformation from high to medium voltage   electricity, medium voltage   Cutoff, S - GR	1	5,69924	E-6 kgRW
> P heat production, light fuel oil, at industrial furnace 1MW I heat, district or industrial, other than natural gas I Cutoff, S - Europe without Switzerla	nd I	4,21478	E-5 kgRW
P market for hazardous waste for incineration   hazardous waste for incineration   Cutoff S - Europe without Switzerland		2,13677	F-5 kgRW
P treatment of aluminium scrao, new, at remelter Laluminium, wrought alloy I Cutoff S - RFR		1,42009	E-5 kgRW
/ i contract of a contract of			a a ngitti

Figure 6: Impact Analysis of Powder Coated Aluminium Profile as follows from the analysis in OpenLCA software.

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Contribution	Process		Amount	Unit
✓ 100.00%	P Powder coated aluminium profile	-	9.77013	kg CO2 eq
61.33%	📔 aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, S - GLO	-	5.99230	kg CO2 eq
19.49%	P market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, S - Europe without Switzerland	1.1	1.90386	kg CO2 eq
> 06.55%	P electricity, medium voltage, production mix   Cutoff, U modified for 2021 based on energy mix - CUT OFF S - GR	$\mathbf{I}_{i} = \mathbf{I}_{i}$	0.64001	kg CO2 eq
04.33%	P coating powder production   coating powder   Cutoff, S - RER	$\mathbf{I}_{i} = \mathbf{I}_{i}$	0.42343	kg CO2 eq
04.33%	P heat production, light fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, S - Europe witho	1.1	0.42256	kg CO2 eq
03.19%	P treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, S - RER	$\mathbf{I}_{i} = \mathbf{I}_{i}$	0.31167	kg CO2 eq
00.18%	P hydrogen fluoride production   hydrogen fluoride   Cutoff, S - RER		0.01743	kg CO2 eq
00.14%	P transport, freight, lorry 16-32 metric ton, EURO5   transport, freight, lorry 16-32 metric ton, EURO5   Cutoff, S - RER		0.01397	kg CO2 eq
00.12%	P titanium dioxide production, chloride process   titanium dioxide   Cutoff, S - RER		0.01192	kg CO2 eq
00.10%	P kraft paper production   kraft paper   APOS, S - RER		0.01017	kg CO2 eq
00.04%	📔 packaging film production, low density polyethylene   packaging film, low density polyethylene   Cutoff, S - RER		0.00435	kg CO2 eq
00.04%	P market for waste paperboard   waste paperboard   Cutoff, S - GR		0.00392	kg CO2 eq
00.04%	P market for sodium hydroxide, without water, in 50% solution state   sodium hydroxide, without water, in 50% solution state   Cutoff,		0.00388	kg CO2 eq
00.03%	P market for scrap aluminium   scrap aluminium   Cutoff, S - Europe without Switzerland		0.00308	kg CO2 eq
00.03%	P non-ionic surfactant production, fatty acid derivate   non-ionic surfactant   Cutoff, S - GLO		0.00268	kg CO2 eq
00.02%	📔 transport, freight, sea, container ship   transport, freight, sea, container ship   Cutoff, S - GLO		0.00218	kg CO2 eq
00.02%	P lubricating oil production   lubricating oil   Cutoff, S - RER		0.00208	kg CO2 eq
00.01%	P market for tap water   tap water   Cutoff, S - Europe without Switzerland		0.00064	kg CO2 eq

OImpact category

Figure 7: Contribution of inputs/outputs to the impact GWP total of Powder Coated Aluminium Profile.



**Figure 8** Contribution of each module in the environmental impact of GWP total, Acidification, Eutrophication Acidification potential, Potential of ozone depletion, water use and waste for the Extruded aluminium profile.



**Figure 9** Contribution of each module in the environmental impact of GWP total, Acidification, Eutrophication Acidification potential, Potential of ozone depletion, water use and waste for the Powder Coated Aluminium Profile.



 Tables 7.1 – 7.5: Separate Modules A1-A3 for Extruded Aluminium Profile.

Indicator	Unit	A1	A2	A3	
AP	molc H+ eq	4,27E-02	1,01E-04	5,22E-03	
GWP – uptake	kg CO₂ eq	5,16E-01	8,64E-05	1,33E-02	
GWP – biogenic	kg CO₂ eq	-1,98E-01	-4,14E-06	1,35E-02	
GWP – fossil	kg CO₂ eq	6,85E+00	1,55E-02	2,15E+00	
GWP - Iuluc	kg CO₂ eq	2,57E-02	6,22E-06	4,16E-04	
GWP - total	kg CO₂ eq	6,86E+00	1,55E-02	2,16E+00	
ADP – minerals and metals	kg Sb-Eq	4,75E-05	3,77E-07	8,41E-06	
ADP - fossil	MJ	8,71E+01	2,26E-01	1,26E+01	
EP - freshwater	kg P eq	2,83E-03	1,07E-06	6,53E-04	
EP – freshwater <sup>2</sup>	kg PO4 eq	8,69E-03	3,29E-06	2,00E-03	
EP – marine	kg N eq	6,87E-03	2,16E-05	7,94E-04	
EP - terrestrial	molc N eq	7,08E-02	2,38E-04	8,50E-03	
ODP	kg CFC11 eq	2,94E-07	3,47E-09	2,02E-07	
POCP	kg NMVOC eq	1,95E-02	7,20E-05	2,27E-03	
WDP	m <sup>3</sup>	2,89E+00	1,09E-03	3,28E-01	

#### Table 7.1: Potential environmental impact – Results per declared unit

#### Table 7.2: Use of resources- Results per declared unit

10	Unit	A1	A2	A3
PENRE	MJ	9,01E+01	2,30E-01	1,31E+01
PENRM	MJ	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ	9,01E+01	2,30E-01	1,31E+01
PERE	MJ	1,34E+01	3,03E-03	4,23E-01
PERM	MJ	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	1,34E+01	3,03E-03	4,23E-01
FW	m <sup>3</sup>	1,70E+01	2,83E-03	7,03E-01
SM	kg	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00

#### Table 7.3: Output flows- Results per declared unit

Indicator	Unit	A1	A2	A3
Components for reuse	kg	0,00E+00	0,00E+00	0,00E+00
Exported energy	MJ	0,00E+00	0,00E+00	0,00E+00
Materials for energy recovery	kg	0,00E+00	0,00E+00	0,00E+00
Materials for recycling	kg	0,00E+00	0,00E+00	0,00E+00

#### Table 7.4: Waste production- Results per declared unit

Indicator	Unit	A1	A2	A3
HW	kg	1,35E+00	2,37E-04	1,06E+00
NHW	kg	1,21E+01	1,44E-02	1,65E+00
RW	kg	1,16E-04	1,58E-06	4,63E-05



Indicator	Unit	A1	A2	A3	
Ecotoxicity, freshwater	CTUe	1,25E+00	6,92E-03	1,26E+00	
Human toxicity, cancer effects	CTUh	7,76E-09	5,32E-12	1,59E-09	
Human toxicity, non-cancer effects	CTUh	1,04E-06	2,73E-10	3,85E-08	
Ionising radiation, HH	kBq U-235 eq	2,19E-01	1,16E-03	6,68E-02	
Land use	Pt	8,19E+01	2,03E-01	4,11E+00	
Particulate matter, HH	disease inc.	4,91E-07	9,43E-10	4,80E-08	

#### Table 7.5: Additional indicators Results per declared unit

Tables 8.1–8.5: Separate Modules A1-A3 for Powder Coated Aluminium Profile

Indicator	Unit	A1	A2	A3	
AP	molc H+ eq	4,73E-02	1,03E-04	5,71E-03	
GWP – uptake	kg CO₂ eq	1,59E-01	9,02E-05	1,35E-02	
GWP – biogenic	kg CO₂ eq	-5,99E-02	-4,27E-06	1,35E-02	
GWP – fossil	kg CO₂ eq	7,40E+00	1,61E-02	2,32E+00	
GWP - Iuluc	kg CO₂ eq	2,50E-02	6,44E-06	4,26E-04	
GWP - total	kg CO₂ eq	7,42E+00	1,61E-02	2,33E+00	
ADP – minerals and metals	kg Sb-Eq	5,34E-05	3,94E-07	8,53E-06	
ADP - fossil	MJ	9,91E+01	2,35E-01	1,49E+01	
EP - freshwater	kg P eq	3,93E-03	1,12E-06	6,56E-04	
EP – freshwater <sup>2</sup>	kg PO4 eq	1,21E-02	3,43E-06	2,01E-03	
EP – marine	kg N eq	7,20E-03	2,18E-05	8,69E-04	
EP - terrestrial	molc N eq	7,20E-02	2,40E-04	9,32E-03	
ODP	kg CFC11 eq	4,02E-07	3,61E-09	2,40E-07	
POCP	kg NMVOC eq	2,03E-02	7,31E-05	2,54E-03	
WDP	m <sup>3</sup>	3,21E+00	1,13E-03	3,30E-01	

#### Table 8.2: Use of resources- Results per declared unit

Indicator	Unit	A1	A2	A3
PENRE	MJ	1,03E+02	2,40E-01	1,55E+01
PENRM	MJ	0,00E+00	0,00E+00	0,00E+00
PENRT	MJ	1,03E+02	2,40E-01	1,55E+01
PERE	MJ	1,01E+01	3,16E-03	4,32E-01
PERM	MJ	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	1,01E+01	3,16E-03	4,32E-01
FW	m <sup>3</sup>	1,63E+01	2,95E-03	7,09E-01
SM	kg	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00



Table	8.3:	Output	flows-	Results	per	declared	unit
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Indicator	Unit	A1	A2	A3
Components for reuse	kg	0,00E+00	0,00E+00	0,00E+00
Exported energy	MJ	0,00E+00	0,00E+00	0,00E+00
Materials for energy recovery	kg	0,00E+00	0,00E+00	0,00E+00
Materials for recycling	kg	0,00E+00	0,00E+00	0,00E+00

#### Table 8.4: Waste production- Results per declared unit

Indicator	Unit	A1	A2	A3
HW	kg	1,33E+00	2,46E-04	1,06E+00
NHW	kg	1,77E+01	1,51E-02	1,66E+00
RW	kg	1,45E-04	1,64E-06	6,38E-05

#### Table 8.5: Additional indicators- Results per declared unit

Indicator	Unit	A1	A2	A3	
Ecotoxicity, freshwater	CTUe	2,76E+00	7,22E-03	1,26E+00	
Human toxicity, cancer effects	CTUh	7,95E-09	5,51E-12	1,59E-09	
Human toxicity, non-cancer effects	CTUh	1,03E-06	2,84E-10	3,85E-08	
Ionising radiation, HH	kBq U-235 eq	3,01E-01	1,21E-03	6,68E-02	
Land use	Pt	3,42E+01	2,12E-01	4,11E+00	
Particulate matter, HH	disease inc.	4,83E-07	9,83E-10	4,80E-08	



#### 4.3 Interpretation and Conclusions

All inputs and outputs were included in the calculation of the unit process of the production stage. The cut-off criteria were 1% for the total mass input that was accounted for and 5% for energy usage and mass that was included, according to EN 15804:2012+A2:2019 and PCR 2019:14 Construction products (Version 1.11). The inputs and outputs below 1% that were not included, do not affect the impact analysis results.

Concerning data quality, all the data used to model the manufacturing process for the specific products covered by this EPD, are specific data and there are no data gaps. Only for modules C and D the data used were generic and provided from European Aluminium General Programme Instructions report.

Quantitative data for raw material, auxiliary materials, packaging production and energy have been collected from specific industrial data (bills, invoices, production etc.). The uncertainty in these data is lower than 1%. Therefore, uncertainty in the LCIA results is defined by the uncertainty of the generic data used for the calculation of category indicators.

A critical review was performed, by an internal expert based on ISO 14044:2006 according to 6.2. The review was performed at the end of the LCA study including an assessment of LCI model and an analysis of data sets.

A review was performed by an internal expert based on ISO 14040:2006 and ISO 14044:2006 according to 6.2. The critical review was conducted at the end of the LCA report including an assessment of LCI model and an analysis of individual data sets according to ISO/TS 14071:2016. The reviewer after the study of the LCA report provided comments and recommendations via video call meetings. A critical review statement is given in the Appendix.

Also taking into account that more than 95% of the impact values are influenced by specific parameters, it seems that completeness in the evaluation of LCIA has been achieved.

Based on the data presented in the previous sections, the main conclusions drawn are:

• The most important parameter characterizing category indicator results is the production of primary billet used as raw material (aluminium ingot) except for indicators GWP CO<sub>2</sub>-uptake, GWP-biogenic and ADPE-elements.



- The other parameters that are important and affect the results are waste treatment, electricity production in both products and coating powder production in the powder coated aluminium profile and the degree that the parameter affects the results depends on the indicator.
- The recycled aluminium scrap (treatment of aluminium scrap) which makes up the 70% of the billets affects the results as well, and the degree that affects the results depends on the indicators.
- Transportation does not affect the results on a big scale because most of the raw materials are transported from an area close to the manufacturing plant.
- The different cycle stages are ranked for the majority of the environmental impacts in the following order: A1, A3, A2, from higher to lower. It must be mentioned that in several cases transportation is included in the datasets of the raw materials (A1).



## 5. References

- 1. General Programme Instructions of the International EPD® System. Version 3.01.
- 2. ISO 14040:2006 Environmental management Life cycle assessment. Principles and framework.
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- 4. ISO 14020:2000 Environmental labels and declarations General principles.
- 5. ISO 14025:2010 Environmental labels and declarations Type III Environmental Declarations– Principles and procedures.
- 6. PCR "2019:14 Construction products" (Version 1.11).
- EN 15804:2012+A2:2019 Sustainability of construction works Environmental product declarations – Core rules for the product category of construction products.
- 8. European Aluminium General Programme Instructions (Version 3, 23/09/2020).
- EPD Background Report: Cradle-to-Gate Assessment for Aluminum Extrusions (2022), v 1.1., Sphera.
- 10. Environmental Profile Report for the aluminium Refining industry (2021), European Aluminium.
- 11. Residual Energy Mix 2021 from Renewable Energy Sources Operator & Guarantees of

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# 6. Abbreviations

#### List of Abbreviations

AP	Acidification potential	
GWP – biogenic	Global Warming Potential biogenic	
GWP – fossil	Global Warming Potential fossil fuels	
GWP – luluc	Global Warming Potential land use and land use change	
GWP - total	Global Warming Potential total	
ADP – minerals and	Abiotic depletion potential for non-fossil resources	
metals		
ADP – fossil	Abiotic depletion potential for non-fossil resources	
EP – freshwater	Eutrophication potential, fraction of nutrients reaching freshwater end	
	compartment	
EP – marine	Eutrophication potential, fraction of nutrients reaching marine end	
	compartment	
EP – terrestrial	Eutrophication potential	
ODP	Depletion potential of the stratospheric ozone layer	
POCP	Formation potential of tropospheric ozone	
WDP	Water deprivation potential, deprivation – weighted water consumption	
PENRE	Use of non-renewable primary energy excluding nonrenewable	
	primary energy resources used as raw materials	
PENRM	Use of non-renewable primary energy resources used as	
	raw materials	
PENRT	Total use of non-renewable primary energy resources	
PERE	Use of renewable primary energy excluding renewable	
	primary energy resources used as raw materials	
PERM	Use of renewable primary energy resources used as raw	
	materials	
PERT	Total use of renewable primary energy resources	
FW	Use of net fresh water	
SM	Use of secondary material	
NRSF	Use of non – renewable secondary fuels	
RSF	Use of renewable secondary fuels	
HW	Hazardous waste disposed	
NHW	Non-hazardous waste disposed	
RW	Radioactive waste disposed	



APPENDIX



# **Critical Review Statement**

Information			
Title:	LCA Report for Aluminium Profiles of SANLEV SA		
Commissioner of the LCA study:	SANLEV CALIBRE SA		
Practitioner of the LCA study:	Terra Nova LTD		
Critical Reviewer:	Roula Chandrinou		

A review was performed by an expert based on ISO 14040:2006 and ISO 14044:2006 according to 6.2. This critical review was assigned to Roula Chandrinou, Environmentalist at Terra Nova Ltd, who was not involved in the Life Cycle Assessment (LCA) study and reporting. She is an expert on internal procedures, experienced in Environmental Management Systems and Principles as well as familiar with ISO 14044.

The critical review was conducted at the end of the LCA report including an assessment of LCI model and an analysis of individual data sets according to ISO/TS 14071:2016 The reviewer after the study of the LCA report provided comments and recommendations during videocall meetings according to the requirements of ISO 14040 and ISO 14044 and EN 15804:2012+A2:2019 and PCR 2019:14 Construction products (Version 1.11). The reviewer's justification or recommendations were provided in written form.

The LCA study performed for Extruded Aluminium Profile and Powder Coated Aluminium Profile for SANLEV SA is:

- in conformance with ISO 14040 and ISO 14044 concerning the methods used,
- the data used are appropriate and reasonable in relation to the goal of the study,
- the study report is transparent and consistent.

The study was found to be in conformance with ISO 14040 and 14044. The report has a clear structure and the important LCA aspects are addressed. The inventory analysis is clearly analyzed, where the inventory selection, data collection procedure and data accuracy are described. Allocation principles are explained and impact assessment methodologies are reported. There were some findings (calculation of recycling content, product pictures were not representative) that were fulfilled after review.



Date: 09.03.2023 Name: Roula Chandrinou Signature: