Aluminum Specialty Products

EPD Background Report

On behalf of Ceilings and Interior Systems Construction Association

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On behalf of Sphera Solutions, Inc. and its subsidiaries

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List of Acronyms

ADP	Abiotic Depletion Potential
AP	Acidification Potential
CISCA	Ceiling and Interior Systems Construction Association
EoL	End-of-Life
EP	Eutrophication Potential
EPD	Environmental Product Declaration
GaBi	Ganzheitliche Bilanzierung (German for holistic balancing)
GWP	Global Warming Potential
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
ODP	Ozone Depletion Potential
PCR	Product Category Rules
SFP	Smog Formation Potential
TRACI	Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts

Glossary

Life cycle

A view of a product system as “consecutive and interlinked stages … from raw material acquisition or generation from natural resources to final disposal” (ISO 14040:2006, section 3.1). This includes all material and energy inputs as well as emissions to air, land and water.

Life Cycle Assessment (LCA)

“Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle” (ISO 14040:2006, section 3.2)

Life Cycle Inventory (LCI)

“Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle” (ISO 14040:2006, section 3.3)

Life Cycle Impact Assessment (LCIA)

“Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product” (ISO 14040:2006, section 3.4)

Life cycle interpretation

“Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations” (ISO 14040:2006, section 3.5)

Functional unit

“Quantified performance of a product system for use as a reference unit” (ISO 14040:2006, section 3.20)

Allocation

“Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems” (ISO 14040:2006, section 3.17)

Closed-loop and open-loop allocation of recycled material

“An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.”

“A closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials.”

(ISO 14044:2006, section 4.3.4.3.3)

Foreground system

"Those processes of the system that are specific to it … and/or directly affected by decisions analyzed in the study." (JRC 2010, p. 97) This typically includes first-tier suppliers, the manufacturer itself and any downstream life cycle stages where the manufacturer can exert significant influence. As a general rule, specific (primary) data should be used for the foreground system.

Background system

"Those processes, where due to the averaging effect across the suppliers, a homogenous market with average (or equivalent, generic data) can be assumed to appropriately represent the respective process … and/or those processes that are operated as part of the system but that are not under direct control or decisive influence of the producer of the good…." (JRC 2010, pp. 97-98) As a general rule, secondary data are appropriate for the background system, particularly where primary data are difficult to collect.

Critical Review

"Process intended to ensure consistency between a life cycle assessment and the principles and requirements of the International Standards on life cycle assessment" (ISO 14044:2006, section 3.45).

1. Goal of the Study

The Ceilings and Interior Systems Construction Association (CISCA) is a trade association representing companies that manufacture metal specialty products for ceilings and interior coverings, among other products. The goal of the study is to assess the “cradle-to-gate with options” potential environmental impacts of aluminum specialty products for the purpose of creating Environmental Product Declarations (EPD) for aluminum specialty panels sold and installed in North America by CISCA members. The analyses were conducted according to UL Environment’s product category rules (PCR) for metal ceiling and interior wall panel systems (UL Environment, Dec 2018) (UL Environment, Jan 2020) . This study covers aluminum specialty products, which include ceilings, wall panels, trims, and column covers. The latter products are similar to metal ceiling panels and are manufactured from the same materials on common equipment.

The intended audience for this report includes the program operator, UL Environment (ULE), the reviewer who will be assessing the LCA for conformance to the PCR, as well as the CISCA member companies who participated in the study. In addition, Sphera strongly recommends making this report available upon request to all third parties to whom the EPD is communicated. Facility-specific information has been aggregated to create an industry average[1] weighted by production mass; therefore, confidential information specific to each company is not available in this report.

Results presented in this document do not constitute comparative assertions. However, these results will be disclosed to the public in an EPD, which architects and builders will be able to use to compare CISCA’s products with similar products presented in other EPDs that follow the same PCR in a building context. In order to be published by a program operator, the EPD will undergo a verification for conformance to the PCR.

[1] The term “industry average” in this case refers to the industry as represented by CISCA members. There are other industry associations that represent companies which also produce metal specialty products.

2. Scope of the Study

The following sections describe the general scope of the project to achieve the stated goals. This includes, but is not limited to, the identification of specific product systems to be assessed, the product function(s), functional unit and reference flows, the system boundary, allocation procedures, and cut-off criteria of the study.

2.1. Product Systems

This LCA study covers the North American market average of aluminum specialty products, sold and installed in North America by CISCA members. These specialty products include wall panels, trims, and column covers and are represented by the following product codes:

- Construction Specifications Institute (CSI)
    - 05 75 30 Column covers
    - 07 42 13 Metal wall panels
    - 07 42 93 Metal soffit/ceiling panels
    - 09 51 33 Acoustical metal pan ceilings
    - 09 51 33 13 Acoustical snap-in metal pan ceilings
    - 09 54 00 Specialty ceilings
    - 09 54 05 Specialty ceilings
    - 09 54 23 Linear metal ceilings
    - 09 78 13 Metal interior wall paneling
- UNSPSC
    - 30161602 Ceiling panels

The participating member companies for aluminum product manufacturing include:

– Accent Ceilings and Walls	www.accentceilings.com
– Armstrong Ceiling Solutions	www.armstrongceilings.com
– CertainTeed Ceilings Corporation	www.CTSpecialtyceilings.com
– Gordon, Inc.	www.gordon-inc.com
– Lindner	www.lindner-group.com
– Rockfon	www.rockfon.com
– USG & USG Ceilings Plus, LLC	www.usg.com

Aluminum specialty products are manufactured from metal coil or sheet and are perforated and shaped to customer specifications. Depending on the application, the aluminum may be coated or laminated with additional materials. This study does not include the manufacturing of ceiling grid, regardless of product use or panel material type.

2.2. Declared Unit

Since this study excludes the use stage, a declared unit of 1 kg of aluminum specialty product is used for the analysis—in accordance with the PCR. The CISCA member companies were surveyed and a conversion from mass to area of sample panels of various thicknesses of aluminum is provided in Table 2-1. This is provided as a sample conversion as the weight of aluminum specialty products can vary between 0.28 and 2.6 pounds per square foot.

Table 2-1: Exemplary reference flows [m^2]

Example Panel Thickness (in.)	**Sheet weight per sq. ft.** (lbs./ft^2)	**Sheet weight per sq. m** (kg/m^2)	**Area per 1 kg of product** (m^2)
0.020	0.28	1.4	0.73
0.032	0.45	2.2	0.46
0.040	0.56	2.7	0.36
0.063	0.88	4.3	0.23
0.090	1.3	6.2	0.16
0.125	1.8	8.6	0.12
0.188	2.6	13	0.078

2.3. System Boundaries

The aluminum specialty products scope includes the product and construction stage (A1 – A5) as well as the end-of-life (C1 – C4) and the benefits and loads beyond system boundaries module (D). The use stage (B1-B7) is excluded from the scope of the LCA and EPD.

Table 2-2 summarizes major components being considered for inclusion and exclusion from the study and has been shaped by the need to accurately reflect the environmental burden associated with the declared unit without knowing its specific application in the building context.

2.3.1. Time Coverage

The study is intended to represent aluminum specialty products manufactured and installed in 2018. The majority of primary data collected from CISCA members represents 12 continuous months of production during the 2018 calendar year. Background datasets for upstream and downstream data are representative of the years 2009 – 2018 and were obtained from the GaBi 2019 databases.

2.3.2. Technology Coverage

The study is intended to represent a production-weighted, industry-average environmental profile of the participating CISCA member companies' technologies and supply chain. Data on raw material inputs and manufacturing are primary data collected from the individual member companies' manufacturing facilities. Energy use and waste disposal are based on measured data during the reference time period. Table 3-2 and Table 3-3 in section 3.3 provide more detail on the sources for the data used.

Table 2-2: System boundaries

Included	Excluded
✓ Raw materials production (metals, minerals, etc.) (A1) ✓ Energy production (A1) ✓ Specialty product manufacturing (A3) ✓ Use of auxiliary materials, water, and energy during manufacturing (A3) ✓ Packaging of products (A1-A3) ✓ Emissions to air, water, and soil during manufacturing (A3) ✓ Transportation to construction site (A4) ✓ Transport of raw materials (A2) ✓ Disposal of packaging (A5) ✓ Energy and materials for construction (A5) ✓ Disposal stage (C1-C4) ✓ Benefits and loads beyond the system boundary (D)	× Construction of capital equipment × Maintenance and operation of support equipment × Human labor and employee commute × Low-volume product coatings × Use stage (B1-B7) × Grid, hanger wires, attachments to the structure

2.3.3. Geographical Coverage

This background LCA study represents products sold and installed in North America. The included company data is primarily from manufacturing facilities in the United States and Canada, but also includes information from one European and one Chinese facility manufacturing aluminum products exported to North America.

Manufacturing energy consumption was modeled with regional energy LCIs. Proxy datasets were used in some cases for raw material inputs to address the lack of regionally specific data on some materials. These proxy datasets were chosen for their technological representativeness of the actual materials and typically represent global or European production. Data collected is representative of North America, with exceptions as noted in Table 3-3.

2.4. Allocation

2.4.1. Multi-output Allocation

Multi-output allocation generally follows the requirements of ISO 14044, section 4.3.4.2 (ISO, 2006). Most of the manufacturers included in this study produce steel specialty products in addition to aluminum specialty products. These manufacturers do not track their energy consumption or process materials in sufficient granularity to allow for a direct correlation to a particular product; therefore, onsite energy, emissions, waste, and process materials were allocated by area of product. The aluminum and steel raw materials and scrap were not allocated as they are used for either aluminum or steel products.

Allocation of background data (energy and materials) taken from the GaBi 2019 databases is documented online at http://documentation.gabi-software.com/.

2.4.2. End-of-Life Allocation

The net scrap approach was used to treat manufacturing wastes and end-of-life treatment for packaging. Metal scrap generated during the production module (A3) and at end-of-life (C3) was looped back to the raw materials module (A1) as secondary material is assumed to enter the system burden-free and is assumed to be used at the same quality it is produced. Net scrap output from the product system is then calculated and used to determine the net material credit (burdens minus benefits) for recycling (D). All relevant recycling operations, such as re-melting of scrap, are accounted for within the model. In cases where the production waste or packaging materials are sent to landfill, waste composition, regional leakage rates, and landfill gas capture and utilization rates (flaring vs. power production) are considered in the development of the background landfill dataset.

2.5. Cut-off Criteria

No cut-off criteria are defined for this study. As summarized in section 2.3, the system boundary was defined based on relevance to the goal of the study. For the processes within the system boundary, all available energy and material flow data have been included in the model. In cases where no matching life cycle inventories are available to represent a flow, proxy data have been applied based on conservative assumptions regarding environmental impacts.

The choice of proxy data is documented in Chapter 3. The influence of these proxy data on the results of the assessment has been carefully analyzed and is discussed in Chapter 5.

2.6. Selection of LCIA Methodology and Impact Categories

According to the Product Category Rules for Building-Related Products and Services: Part A: Life Cycle Assessment Calculation Rules and Report Requirements (UL Environment, Dec 2018), the following inventory items shall be calculated and declared:

- RPRE: Renewable primary resources used as energy carrier (fuel) (MJ)
- RPRM: Renewable primary resources with energy content used as material (MJ)
- NRPRE: Non-renewable primary resources used as energy carrier (fuel) (MJ)
- NRPRM: Non-renewable primary resources with energy content used as material (MJ)
- SM: Secondary materials (kg)
- RSF: Renewable secondary fuels (MJ)
- NRSF: Non-renewable secondary fuels (MJ)
- RE: Recovered energy (MJ)
- FW: Use of net fresh water resources (m^3)

The following parameters describing waste categories and output material flows are also required to be declared:

- HWD: Hazardous waste disposed (kg)
- NHWD: Non-hazardous waste disposed (kg)
- HLRW: High-level radioactive waste (kg)
- ILLRW: Intermediate- and low-level radioactive waste (kg)
- CRU: Components for re-use (kg)
- MFR: Materials for recycling (kg)

- MER: Materials for energy recovery (kg)
- EE: Exported energy (MJ)

The PCR also requires that the following life cycle impact assessment categories be declared:

- GWP: Global warming potential, 100 year (excluding biogenic CO_2) (kg CO_2 eq.)
- AP: Acidification potential (kg SO_2 eq.)
- EP: Eutrophication (kg N eq.)
- ODP: Ozone depletion potential (kg CFC-11 eq.)
- SFP: Smog formation potential (kg O_3 eq.)
- ADPF: Abiotic resource depletion potential, fossil (MJ LHV)

It shall be noted that the above impact categories represent impact *potentials*, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the functional unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

2.7. Interpretation to Be Used

The results of the LCI and LCIA were interpreted according to the Goal and Scope. The interpretation addresses the following topics:

- Identification of significant findings, such as the main process step(s), material(s), and/or emission(s) contributing to the overall results
- Evaluation of completeness, sensitivity, and consistency to justify the exclusion of data from the system boundaries as well as the use of proxy data.
- Conclusions, limitations and recommendations

No grouping or further quantitative cross-category weighting has been applied. Instead, each impact is discussed in isolation, without reference to other impact categories, before final conclusions and recommendations are made.

2.8. Data Quality Requirements

The data used to create the inventory model shall be as precise, complete, consistent, and representative as possible with regards to the goal and scope of the study under given time and budget constraints.

- Measured primary data are considered to be of the highest precision, followed by calculated data, literature data, and estimated data. The goal is to model all relevant foreground processes using measured or calculated primary data.
- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. The goal is to capture all relevant data in this regard.
- Consistency refers to modeling choices and data sources. The goal is to ensure that differences in results reflect actual differences between product systems and are not due to inconsistencies in modeling choices, data sources, emission factors, or other artefacts.

- Reproducibility expresses the degree to which third parties would be able to reproduce the results of the study based on the information contained in this report. The goal is to provide enough transparency with this report so that third parties are able to approximate the reported results. This ability may be limited by the exclusion of confidential primary data and access to the same background data sources
- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope. The goal is to use the most representative primary data for all foreground processes and the most representative industry-average data for all background processes. Whenever such data were not available (e.g., no industry-average data available for a certain country), best-available proxy data were employed.

An evaluation of the data quality with regard to these requirements is provided in section 5 of this report.

2.9. Type and format of the report

In accordance with the ISO requirements (ISO, 2006) this document aims to report the results and conclusions of the LCA completely, accurately and without bias to the intended audience. The results, data, methods, assumptions and limitations are presented in a transparent manner and in sufficient detail to convey the complexities, limitations, and trade-offs inherent in the LCA to the reader. This allows the results to be interpreted and used in a manner consistent with the goals of the study.

2.10. Software and Database

The LCA model was created using the GaBi 9.2 Software system for life cycle engineering, developed by Sphera. The GaBi 2019 LCI database (service pack 39) provides the life cycle inventory data for several of the raw and process materials obtained from the background system.

2.11. Verification

A critical review of the background report and a verification of the EPD was conducted by Dr. Thomas Gloria of Industrial Ecology Consultants on behalf of CISCA's program operator UL Environment. This conformity assessment was performed against ISO 14044, EN15804 (European Standards, 2013), and the selected PCR (UL Environment, Jan 2020).

3. Life Cycle Inventory Analysis

3.1. Data Collection Procedure

All primary data, including product composition and manufacturing details, were collected from CISCA member companies using customized data collection templates. Upon receipt, each questionnaire was cross-checked for completeness and plausibility using mass balances and benchmarking. If gaps, outliers, or other inconsistencies occurred, Sphera engaged with the data provider to resolve any open issues.

3.2. Metal Specialty Products

3.2.1. Overview of Product System

This study covers an industry average of aluminum specialty products, sold and installed in North America by CISCA members. These specialty products include ceiling and wall systems, extruded trims, brake-formed shapes, column covers, and acoustical treatments. This study does not include attachments to the structure or primary structural systems of the building, as per the Metal Ceilings product category rule PCR (UL Environment, Jan 2020).

3.2.2. Manufacturing

There are two basic processes used by CISCA members for manufacturing metal specialty products: coil-coating and post-painting. The major difference is whether the metal coil is coated before the product is manufactured, or whether the product is painted after it has been shaped. The two processes are depicted in Figure 3-1.

Most manufacturers receive the metal for their products in the form of master coil, as shown in Figure 3-1. In the case of coil-coating, as depicted on the left of Figure 3-1, the coil may be sent directly to a third party for coil coating. The coated coil is then cut to size, sometimes perforated, and a non-woven, acoustic insulation may be fused to the back. Then the metal panel may be roll-formed, bent, or shaped in other ways to match the product or customer specifications. Finally, the product is packaged for shipping.

The post-paint manufacturing process, shown on the right of Figure 3-1, has many of the same steps as the coil-coating process. The major difference is that the metal is coated after it is formed into a product rather than before.

The main material input to the manufacturing process is the metal for the panel. In addition, coatings and small amounts of process materials are needed, such as lubricants for the machines. Energy is also needed to perform the manufacturing and move the materials.

Manufacturing also produces some metal scrap. Scrap is assumed to contribute to the materials for recycling metric before being used to calculate the net scrap input to the product stage. This net scrap input is then used to calculate credit associated with module D (once the other stages are factored in).

Figure 3-1: Metal specialty product manufacturing processes coil-coating (left) & post-painting (right)

3.2.3. Product Installation

Products are assumed to be transported an average of 800 km from the manufacturing facility to the job site. For manufacturing facilities outside the United States, transportation via ship to the U.S. was added based on each facility's location.

Products are assumed to be manually installed. The installation stage includes the production and disposal of any installation waste as well as the disposal of packaging (following the PCR guidance on waste fate—see Table 3-1). Per the PCR, 7% installation waste is assumed. The products covered under this declaration vary. As such, no information on environmental impact mitigation measures during installation is provided here.

Table 3-1: Packaging disposal assumptions

Material Type	Recycling Rate	Landfill Rate	Incineration Rate
Plastics	15%	68%	17%
Metals	57%	34%	9%
Pulp (cardboard, paper)	75%	20%	5%

3.2.4. Disposal

Upon removal from the building, products are assumed to be transported 200 km to a recycling facility or landfill. 85% of the products are assumed to be recovered for recycling and the remaining 15% disposed to landfill based on PCR guidance.

3.3. Background Data

3.3.1. Fuels and Energy

National/regional averages for fuel inputs and electricity grid mixes were obtained from the GaBi 2019 databases. Table 3-2 shows the most relevant LCI datasets used in modeling the product systems. Electricity consumption was modeled using national/regional grid mixes that account for imports from neighboring countries/regions.

Documentation for all GaBi datasets can be found at http://www.gabi-software.com/support/gabi/gabi-database-2019-lci-documentation/.

Table 3-2: Key energy datasets used in inventory analysis

Energy	Location	Dataset	Data Provider	Reference Year	Proxy?
Electricity	Canada	CA: Electricity grid mix	thinkstep	2016	No
Electricity	China	CN: Electricity grid mix	thinkstep	2016	No
Electricity	Germany	DE: Electricity grid mix	thinkstep	2016	No
Electricity	USA	US: Electricity grid mix CAMX	thinkstep	2016	No
Electricity	USA	US: Electricity grid mix RFCW	thinkstep	2016	No
Electricity	USA	US: Electricity grid mix SPSO	thinkstep	2016	No
Electricity	USA	US: Electricity grid mix SRSO	thinkstep	2016	No
Technical Heat	USA	US: Thermal energy from natural gas	thinkstep	2016	No
Technical Heat	USA	US: Thermal energy from gasoline	thinkstep	2016	No
Technical Heat	USA	US: Thermal energy from propane	thinkstep	2016	No
Technical Heat	USA	US: Thermal energy from heavy fuel oil (HFO)	thinkstep	2016	No
Technical Heat	USA	US: Thermal energy from biomass (solid)	thinkstep	2016	No
Technical Heat	USA	US: Thermal energy from biogas	thinkstep	2016	No
Technical Heat	USA	US: Thermal energy from light fuel oil (LFO)	thinkstep	2016	No

3.3.2. Raw Materials and Processes

Data for upstream and downstream raw materials and unit processes were obtained from the GaBi 2019 database. Table 3-3 shows the most relevant LCI datasets used in modeling the production of Aluminum specialty product system. Documentation for all GaBi datasets can be found at http://www.gabi-software.com/support/gabi/gabi-database-2019-lci-documentation/.

Table 3-3: Key material and process datasets used in inventory analysis

Material / Process	Geographic Reference	Dataset	Data Provider	Ref. Year	Proxy?
Acoustic fleece	Germany	DE: Cellulose fibre boards (EN 15804 A1-A3) US: Glass fibres DE: Polymethylmethacrylate granulate (PMMA) DE: PVAc adhesive (estimation)	thinkstep thinkstep thinkstep thinkstep	2018 2018 2018 2018	No No No No
Aluminum sheet	Europe	EU28+EFTA: Primary aluminium ingot EU28: Aluminium sheet (2015)	European Aluminium (EA) European Aluminium (EA)	2015 2015	No No
Cellulose fiber insulation	Germany	DE: Cellulose fibre boards (EN 15804 A1-A3)	thinkstep	2018	No
Cold rolled aluminum sheet	China	CN: Aluminium sheet	thinkstep	2018	No
Cold rolled aluminum sheet	USA	RNA: Cold Rolled Aluminum AA	Aluminum Association (AA)	2010	No
Extruded aluminum	USA	RNA: Extruded Aluminum AA	Aluminum Association (AA)	2010	No
Glass wool	USA	US: Glass fibres	thinkstep	2018	No
Lubricant	USA	US: Lubricant at refinery	thinkstep	2016	No
Protective film	USA	US: Polyethylene film (LDPE/PE-LD)	thinkstep	2018	No
Rock loose fill	USA	EU-28: Mineral wool (Flat roofs) (EN15804 A1-A3)	thinkstep/Saint-Gobain	2018	Geo. Tech.
Waste treatment	USA	US: Municipal waste water treatment (mix)	thinkstep	2018	No
Waste treatment	USA	US: Glass/inert on landfill	thinkstep	2018	No

Table 3-4: Packaging material datasets used in inventory analysis

Material / Process	Geographic Reference	Dataset	Data Provider	Ref. Year	Proxy?
Corrugate	USA	US: Average Corrugated Product	CPA	2017	No
Paper	USA	US: Kraft paper (EN15804 A1-A3)	thinkstep	2018	No
Polyester	USA	EU-28: Polyester (PET) fabric	thinkstep	2018	Geo.
PE film	USA	US: Polyethylene film (LDPE/PE-LD)	thinkstep	2018	No
Polystyrene	USA	RNA: General purpose polystyrene, at plant	thinkstep/USLCI	2009	No
Steel banding	USA	DE: Steel cold rolled coil <1,5mm	thinkstep	2018	Geo.
Wood pallet	USA	RNA: Softwood plywood	CORRIM	2011	Tech.
Fasteners	USA	EU-28: Fixing material screws stainless steel (EN15804 A1-A3)	thinkstep	2018	Geo.
Polyurethane	USA	US: Thermoplastic polyurethane (TPU, TPE-U) adhesive	thinkstep	2018	No

3.3.3. Transportation

Average transportation distances and modes of transport are included for the transport of the raw materials to production facilities.

The GaBi 2019 database was used to model transportation. Truck transportation within the United States was modeled using the GaBi US truck transportation datasets. Fuels were modeled using the geographically appropriate datasets.

One manufacturer included in this study provided data for manufacturing of aluminum specialty products in Europe and China. As discussed in Section 2.3, the goal of this study is to provide information for an average product sold and installed in North America, therefore transportation for this manufacturer was modelled to include container shipping of the product and packaging from Europe and China to the United States. The transportation datasets used in this study are shown in Table 3-5.

Table 3-5: Transportation and road fuel datasets

Mode / fuels	Geographic Reference	Dataset	Data Provider	Ref. Year	Proxy?
Class 8b truck (basic enclosed)	USA	US: Truck - LTL/dry van (EPA SmartWay)	thinkstep	2018	no
Ship	GLO	GLO: Bulk commodity carrier, average, ocean going	thinkstep	2018	no
Heavy fuel oil	USA	US: Heavy fuel oil at refinery (2.5wt.% S)	thinkstep	2016	no
Diesel	USA	US: Diesel mix at filling station	thinkstep	2016	no

4. LCIA Results

Life cycle impact assessment results are summarized below in Table 4-1 and Figure 4-1. See EPD for breakdown of results for inventory metrics and Appendix B for modules A1 to A3 statistics to address retroactive participation requirements.

Table 4-1: TRACI 2.1 impact assessment results for 1 kg of aluminum product

TRACI v2.1	A1-A3	A4	A5	C2	C3	C4	D
GWP 100 [kg CO_2 eq]	8.83E+00	1.10E-01	8.35E-01	1.99E-02	0.00E+00	6.71E-03	-2.85E+00
ODP [kg CFC-11 eq]	3.96E-08	-6.31E-16	2.77E-09	-1.08E-16	0.00E+00	-3.46E-16	-1.27E-10
AP [kg SO_2 eq]	4.48E-02	4.08E-04	3.97E-03	5.83E-05	0.00E+00	3.67E-05	-1.87E-02
EP [kg N eq]	1.17E-03	3.48E-05	1.67E-04	5.53E-06	0.00E+00	4.12E-06	-3.16E-04
SFP [kg O_3 eq]	4.21E-01	9.16E-03	3.40E-02	1.30E-03	0.00E+00	6.06E-04	-1.46E-01
ADP fossil [MJ, surplus]	9.33E+00	2.21E-01	6.99E-01	3.78E-02	0.00E+00	1.32E-02	-1.76E+00

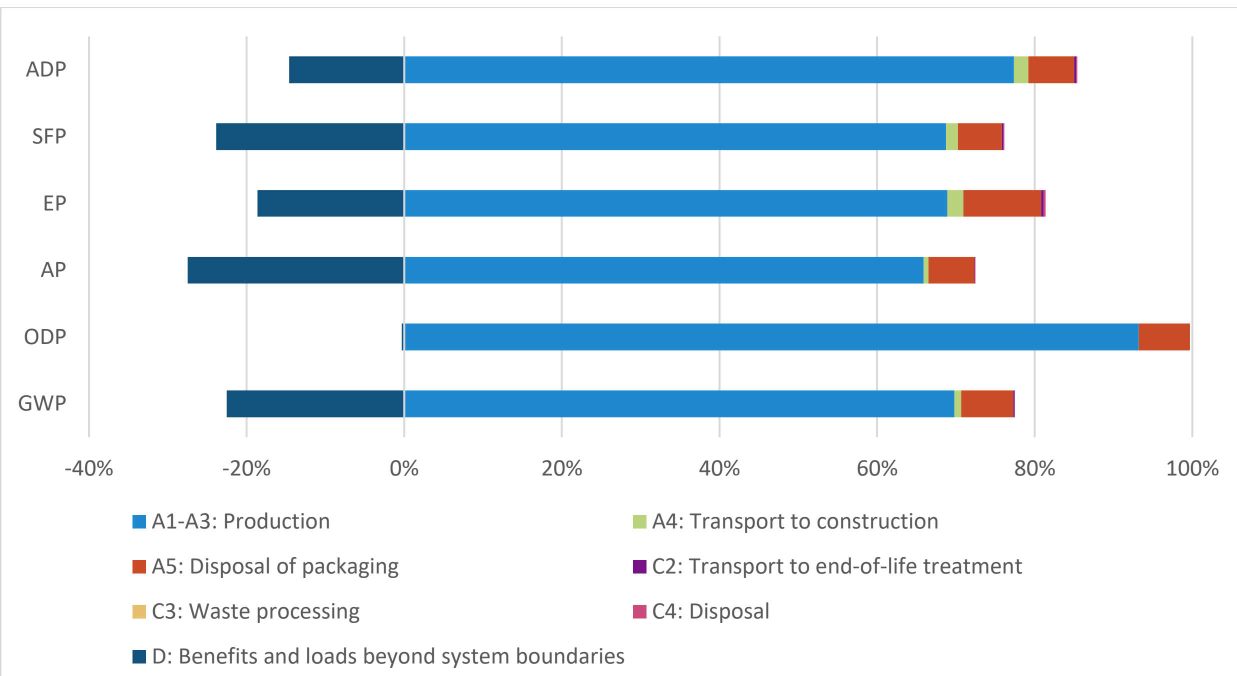

Figure 4-1: Contribution analysis for 1 kg of aluminum specialty product

5. Interpretation

5.1. Identification of Relevant Findings

The raw material module (A1) is associated with the largest impact relative to the other modules across all assessment categories. Considering this study also includes benefits and loads beyond the system boundary (D), negative contributions from material credits given to recycled metal is the next biggest driver across all categories. This is followed by the production module (A3), transport module (A4), and installation module (A5).

Aluminum production accounts for most of the raw material potential impact followed by the coil coating process. Inbound transportation (A2) drives 1-3% of the impact across all categories, with the highest impact (3%) in smog formation. The production module (A3) contributes to 8-21% impact across all categories. Energy usage, specifically electricity usage and fossil fuel combustion, is the cause of much of the impact from A3 except for ozone depletion, where corrugate production drives most of the impact due to background dataset choice (as older third-party datasets do not account for the continuing phase-out of ozone-depleting emissions to the same degree as current GaBi data).

The installation module (A5) includes not only the disposal of packaging from installing 1 kg of product—the declared unit—but also the environmental impact associated with producing, transporting, and disposing (either to landfill or material recovery) 0.07 kg of installation scrap. At end-of-life, 85% of the product is assumed to be recycled and the remainder landfilled.

5.2. Data Quality Assessment

Inventory data quality is judged by its precision (measured, calculated or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied) and representativeness (geographical, temporal, and technological).

To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent background LCA information from the GaBi 2019 database were used. The LCI datasets from the GaBi 2019 database are widely distributed and used with the GaBi 9.2 Software. The datasets have been used in LCA models worldwide in industrial and scientific applications in internal as well as in many critically reviewed and published studies. In the process of providing these datasets they are cross-checked with other databases and values from industry and science.

5.2.1. Precision and Completeness

- ✓ **Precision:** As the majority of the relevant foreground data are measured data or calculated based on primary information sources of the owner of the technology, precision is considered to be high. Variations across different manufacturers were balanced out by using yearly averages. All background data are sourced from GaBi databases with the documented precision.
- ✓ **Completeness:** Each foreground process was checked for mass balance and completeness of the emission inventory. No data were knowingly omitted. Completeness of foreground unit

process data is considered to be high. All background data are sourced from GaBi databases with the documented completeness.

5.2.2. Consistency and Reproducibility

- ✓ **Consistency:** To ensure data consistency, all primary data were collected with the same level of detail, while all background data were sourced from the GaBi databases.
- ✓ **Reproducibility:** Reproducibility is supported as much as possible through the disclosure of input-output data, dataset choices, and modeling approaches in this report. Based on this information, any third party should be able to approximate the results of this study using the same data and modeling approaches.

5.2.3. Representativeness

- ✓ **Temporal:** All primary data were collected for the year 2018. All secondary data come from the GaBi 2019 databases and are representative of the years 2009 – 2018, with reference years of the aluminum datasets of 2010 (RNA), 2015 (EU), and 2018 (CN). As the study intended to compare the product systems for the reference year 2018, temporal representativeness is considered to be sufficient.
- ✓ **Geographical:** All primary and secondary data were collected specific to the countries or regions under study. Where country-specific or region-specific data were unavailable, proxy data were used. Geographical representativeness is considered to be high.
- ✓ **Technological:** All primary and secondary data were modeled to be specific to the technologies or technology mixes under study. Where technology-specific data were unavailable, proxy data were used. Technological representativeness is considered to be high.

5.3. Model Completeness and Consistency

5.3.1. Completeness

All relevant process steps for each product system were considered and modeled to represent each specific situation. The process chain is considered sufficiently complete and detailed with regard to the goal and scope of this study.

5.3.2. Consistency

All assumptions, methods and data are consistent with each other and with the study's goal and scope. Differences in background data quality were minimized by exclusively using LCI data from the GaBi 2019 databases. System boundaries, allocation rules, and impact assessment methods have been applied consistently throughout the study.

5.4. Conclusions, Limitations, and Recommendations

5.4.1. Conclusions

The goal of this study was to conduct a cradle-to-gate with options LCA of aluminum specialty products so as to develop an EPD. The creation of this EPD will allow consumers and architects in the building and construction industry to make better informed decisions about the environmental impacts associated with the products they choose. Overall, the study found that environmental performance is driven primarily by metal production and manufacturing energy usage, specifically electricity usage and propane combustion.

5.4.2. Limitations

Most of the participating CISCA manufacturers produce coated metal specialty products; however, the coating is done by third-party companies that did not provide primary data for this study. As a result, a dataset for coating steel coil with polyvinylidene fluoride (PVDF) was used to proxy aluminum coil coating. The primary data from companies in the metal coating industry is considered a valid proxy for coil coating in the metal specialty products industry, and the use of this information as proxy data is further validated by the relatively low impact of coil coating relative to the metal production.

Study results are representative of the average environmental profile of aluminum specialty products manufactured by the participating CISCA members and do not necessarily reflect the profile of these products in general.

5.4.3. Recommendations

The results show that the largest opportunities for reducing each product’s environmental impact are in the raw materials and manufacturing stages. These are important areas for CISCA to focus their efforts as they represent aspects that they can influence through material panel design or energy efficiency measures.

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Appendix A. Manufacturing

Table A-1: Average manufacturing unit process. Values shown per 1 kg of product

Flow	Amount	Unit
INPUTS		
Aluminum, sheet	9.42E-01	kg
Aluminum, parts	2.49E-01	kg
Insulation, acoustic fleece	3.61E-03	kg
Insulation, cellulose	4.25E-03	kg
Insulation, glass wool	7.08E-03	kg
Insulation, other	1.15E-03	kg
Coating, laminate	6.28E-04	kg
Coating, paint	9.52E-04	kg
Coating, powder	8.86E-03	kg
Coating, veneer	4.95E-03	kg
Coating, other	1.72E-03	kg
Ancillary materials	1.02E-02	kg
Packaging, corrugate	4.53E-02	kg
Packaging, pallet	2.33E-01	kg
Packaging, other	7.84E-02	kg
Energy, other	1.34E-04	MJ
Energy, electricity	4.39E+00	MJ
Energy, natural gas	3.96E+00	MJ
Energy, propane	1.81E-01	MJ
Water	1.92E+00	kg
OUTPUTS		
Product	1.00E+00	kg
Packaging out	3.56E-01	kg
Recycled metal	1.75E-01	kg
Waste to end-of-life	1.12E+00	kg

Appendix B. Retroactive Participation

The table presented in this appendix includes the mean (i.e. baseline) results for modules A1 to A3, along with the minimum and maximum facility values and standard deviation. Both the mean and standard deviation values are weighted according to facility production mass (as described in the main body of the report).

Table B-1: Aluminum specialty products retroactive participation statistics (A1-A3)

	Mean	Min.	Max.	St. Dev.	COV
Global warming potential, GWP 100 [kg CO_2 eq]	8.83	7.77	17.3	4.33	49%
Ozone depletion potential, ODP [kg CFC-11 eq]	3.96E-08	4.08E-10	7.46E-08	4.36E-08	110%
Acidification potential, AP [kg SO_2 eq]	4.48E-02	3.96E-02	8.34E-02	2.08E-02	46%
Eutrophication potential, EP [kg N eq]	1.17E-03	1.07E-03	2.40E-03	6.04E-04	52%
Smog formation potential, SFP [kg O_3 eq]	0.421	0.365	0.929	0.255	61%
Abiotic depletion potential (fossil), ADP [MJ, surplus]	9.3	8.2	12.5	2.64	28%