Ceilings and Interior
Systems Construction
Association

# LCA Background Report for Aluminum Specialty Products

Life cycle assessment background report in support of an Environmental Product Declaration (EPD) for aluminum specialty products.

11/25/2014

PE INTERNATIONAL

**On behalf of PE INTERNATIONAL AG and its subsidiaries**

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# List of Acronyms

| | |
|---|---|
| ADP | Abiotic Depletion Potential |
| AP | Acidification Potential |
| CML | Centre of Environmental Science at Leiden |
| CISCA | Ceilings and Interior Systems Construction Association |
| EoL | End-of-Life |
| EP | Eutrophication Potential |
| EPD | Environmental Product Declaration |
| GaBi | Ganzheitliche Bilanzierung (German for holistic balancing) |
| GHG | Greenhouse Gas |
| GWP | Global Warming Potential |
| ISO | International Organization for Standardization |
| LCA | Life Cycle Assessment |
| LCI | Life Cycle Inventory |
| LCIA | Life Cycle Impact Assessment |
| LCV | Lower Calorific Value |
| NMVOC | Non-Methane Volatile Organic Compounds |
| ODP | Ozone Depletion Potential |
| PCR | Product Category Rule |
| PE | PE INTERNATIONAL |
| PED | Primary Energy Demand |
| PVDF | Polyvinylidene fluoride |

# GLOSSARY (ISO 14040/44:2006)

ISO 14040:2006, Environmental management - Life cycle assessment - Principles and framework, International Organization for Standardization (ISO), Geneva.

*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.

*Ceilings and Interior Systems Construction Association – CISCA*

The trade association responsible for organizing the participating member companies of this study.

*Close loop & open loop*

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.

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.

*Cradle to grave*

Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of life.

*Cradle to gate*

Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of the production process ("gate of the factory"). It may also include transportation until use phase.

*Declared Unit*

Quantified amount of a product system for use as a reference unit

*Environmental Product Declaration- EPD*

A disclosure of potential product environmental impacts commonly used in the building and construction industry

*Functional Unit*

Quantified performance of a product system for use as a reference unit

*Life Cycle*

A unit operations view of consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal. This includes all materials and energy input as well as waste generated 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

*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.

*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.

*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.

*Product Category Rules- PCR*

The rules that govern the required information and methodology for an environmental product declaration, as specified by the program operator—UL Environment for this study.

*UL Environment- ULE*

The program operator for metal specialty product EPDs in charge of certifying the results of the LCA study and environmental product declarations.

# 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” 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 Addendum to the IBU product category rules (PCR) for metal ceilings [ULE 2014b, IBU 2014]. While the PCR is written for metal ceilings, this study covers aluminum specialty products, which include wall panels, extruded trims, brake-formed shapes, column covers, and their suspension carriers, or runners and attachments. These 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. PE further recommends making this report available upon request to all third parties to whom the EPD is communicated. Company-specific information has been aggregated to create a production mass-weighted, industry average; 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 order to be published by a program operator, the EPD will undergo a verification for conformance to the PCR.

# 2 SCOPE OF THE STUDY

The following section describes the general scope of the project to achieve the stated goals. This includes the identification of specific product systems to be assessed, the declared unit and reference flows, the system boundary, allocation procedures, and cut-off criteria of the study.

## 2.1 PRODUCT SYSTEMS TO BE STUDIED

This declaration 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, extruded trims, brake-formed shapes, column covers, and their suspension carriers, or runners and attachments. The participating member companies for aluminum product manufacturing include:

- Accent Ceilings & Walls
- Armstrong
- Gordon Inc.
- Hunter Douglas
- Lindner
- Rockfon

- Steel Ceilings Inc.
- USG

Aluminum specialty products are manufactured from metal coil or sheet, and are perforated and bent as needed for the customer's specifications. Depending on the application, the aluminum may be coated or laminated with additional materials. For the purposes of this declaration, aluminum specialty product manufacturing also includes the suspension carriers, or runners and attachments. This study does not include the manufacturing of ceiling grid, regardless of product use or panel material type.

## 2.2 Declared Unit

The declared unit for this study is 1 kg of aluminum specialty product. Note that ceiling grid is not included in the definition of aluminum specialty product. Due to the participation of multiple manufacturers and the often-customized nature of the products, it is not meaningful to declare a reference panel that is accurate for all participating manufacturers. Therefore mass was chosen as the extensive property to normalize energy, materials, and impact assessment results. 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: Reference flows**

| Example Panel Thickness (in.) | Sheet weight per sq. ft. (lbs. / $ft^2$) | Area per 1kg of product ($ft^2$) |
|---|---|---|
| 0.020 | 0.28 | 7.9 |
| 0.032 | 0.45 | 4.9 |
| 0.040 | 0.56 | 3.9 |
| 0.063 | 0.88 | 2.5 |
| 0.090 | 1.3 | 1.7 |
| 0.125 | 1.8 | 1.3 |
| 0.188 | 2.6 | 0.83 |

## 2.3 System Boundaries

The aluminum specialty product scope includes the product stage (A1 – A3) and construction (A5), explicitly the disposal of packaging to landfill. The transportation to the site (A4), the use stage (B1-B7), the disposal stage (C1-C4) and benefits and loads beyond the system boundary (D), as well as portions of construction (A5) are 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.

**Table 2-2: System boundaries**

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

### 2.3.1 Time Coverage

The majority of primary data collected from CISCA members represents 12 continuous months of production during the 2013 calendar year, with two exceptions. First, due to data availability, one manufacturer provided data for the first six months of 2014. Second, another manufacturer provided previously collected data representing 12 continuous months of production in calendar year 2011. The data from these two manufacturers were benchmarked against the other CISCA members and deemed to be consistent. The averaging of all CISCA member companies will help to reduce any potential error introduced by time coverage inconsistent with PCR requirements. Background datasets for upstream and downstream data are representative of the years 2009 – 2014 and were obtained from the GaBi 2013 databases.

### 2.3.2 Technology Coverage

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

### 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 company manufacturing aluminum products exported to North America.

Manufacturing energy datasets were modeled with the regional energy LCIs. Proxy datasets were used in some cases for raw material inputs to address the lack of U.S. regional 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 3-2 in the *Life Cycle Inventory (LCI) Analysis* chapter.

Electricity generation for U.S. manufacturing is modeled using regional, consumption-based power mixes based upon the EPA's eGRID data, which have been adapted to account for power trade between regions. Electricity generation for manufacturing outside of the U.S. and thermal energy from natural gas are modelled using national production mixes.

## 2.4 ALLOCATION

### 2.4.1 Multi-Output Allocation

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 mass of production. The aluminum and steel raw materials were not allocated, but are tracked independently for aluminum and steel products.

One manufacturer also produces products that fall outside the scope of this study in the same facility as its aluminum specialty products. Since total production mass was not available for that subset of products, economic allocation based upon product sales price was used to determine energy and packaging material consumption. The allocated data from this manufacturer was benchmarked against the mass-allocated data from the other manufacturers and was deemed to be consistent.

For manufacturers that produce both product suspensions and aluminum panels, these are combined and inventory assessment information is reported by mass of metal. Allocation was used in the GaBi background data, as described below.

Allocation of upstream data (energy and materials):

- For all refinery products, allocation by mass and net calorific value is applied. The manufacturing route of every refinery product is modeled and so the effort of the production of these products is calculated specifically. Two allocation rules are applied: (1) the raw material (crude oil) consumption of the respective stages, which is necessary for the production of a product or an intermediate product, is allocated by energy (mass of the product * calorific value of the product); and (2) the energy consumption (thermal energy, steam, electricity) of a process, e.g., atmospheric distillation, being required by a product or an intermediate product, are charged on the product according to the share of the throughput of the stage (mass allocation).

- Materials and chemicals needed during manufacturing are modeled using the allocation rule most suitable for the respective product. For further information on a specific product see http://documentation.gabi-software.com/.

### 2.4.2 End-of-Life Allocation

Since the EPD does not cover the end-of-life of the products, end-of-life allocation is outside the scope of the study. The following paragraphs discuss the treatment of recycling and wastes during the production process.

A combination of closed-loop recycling and cut-off allocation was used to treat manufacturing wastes and end-of-life treatment for packaging. Metal scrap produced during the production module (A3) was looped back to the raw materials module (A1) as it is assumed to enter the system burden-free and is assumed to be used at the same quality it is produced. Net scrap input to A1 is then calculated. All relevant recycling operations, such as remelting 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. No credits are given for electricity or thermal energy recovered from waste in accordance with the cut-off approach; however the energy that may be recovered is reported as exported energy in Section 4.2, *Other Resources and Wastes*.

## 2.5 Cut-Off Criteria

Processes or activities that contribute no more than 1% of the total mass and 1% of the total energy, as well as less than 5% of total mass and energy usage per module, may be omitted under PCR cut-off criteria. For this project, all energy and material flows were considered, excepting the items noted in the following paragraph.

Low volume coatings, including wood- laminate materials were considered for inclusion in this study, but were determined to be below the cut-off criteria. Capital equipment production and maintenance were cut-off under the assumption that the impacts associated with these aspects are sufficiently small enough to fall below cut-off criteria when scaled down to the declared unit. Production of packaging for inbound raw materials to CISCA member companies was also excluded; however, disposal of this packaging is included in waste reported by some manufacturers. Inbound transportation for many process materials (including packaging) is not included, except for inbound transportation of the metal, which represents the bulk of the product mass.

## 2.6 Selection of LCIA Methodology and Types of Impacts

According to the *Product Category Rules for Building-Related Products and Services: Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project report* [ULE 2014a], the following inventory items shall be calculated and declared:

- Use of renewable primary energy excluding renewable primary energy resources used as raw materials
- Use of renewable primary energy resources used as raw materials
- Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)
- Use of non- renewable primary energy excluding non-renewable primary energy resources used as raw materials
- Use of non- renewable primary energy resources used as raw materials
- Total use of non- renewable primary energy resources (primary energy and primary energy resources used as raw materials)
- Use of secondary material kg
- Use of renewable secondary fuels MJ, lower calorific value
- Use of net fresh water.

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

- Hazardous waste disposed
- Non-hazardous waste disposed
- Radioactive waste disposed
- Components for re-use
- Materials for recycling
- Materials for energy recovery
- Exported energy

The PCR also requires that the following parameters of environmental impact assessment be declared:

- Global warming potential (GWP) – 100 year
- Acidification potential (AP)
- Ozone depletion potential (ODP) – Steady State / Infinite
- Smog formation potential (SFP)
- Eutrophication (EP)

In order to conform to EN 15804, the following impact assessment category indicators are also included:

- Formation potential of tropospheric ozone (POCP)
- Abiotic depletion potential for non-fossil resources (ADP-elements)
- Abiotic depletion potential for fossil resources (ADP-fossil fuels)

The results are calculated using both the CML 2001 – Apr. 2013 and TRACI 2.1 impact methodologies.

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 emitted molecules would (a) actually 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 chosen declared 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

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 given time and budget constraints.

- Measured primary data is considered to be of the highest precision, followed by calculated and estimated data.

- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. Cut-off criteria apply and were defined in Section 2.5.

- Consistency refers to modeling choices and data sources. The goal is to ensure that differences in results occur due to actual differences between product systems, and not due to inconsistencies in modeling choices, data sources, or emission factors.

- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope.

An evaluation of the data quality with regard to these requirements is provided in the interpretation chapter of this report, Section 5.2.

## 2.9 Software and Database

The LCA model was created using the GaBi 6 software system for life cycle engineering, developed by PE INTERNATIONAL AG. The GaBi 2013 LCI databases provide the life cycle inventory data for the background system, as shown in Section 3.1.

## 2.10 Critical Review

A critical review was conducted by Dr. Thomas P. Gloria on behalf of Wade Stout, EPD Project Manager for UL Environment. This review was performed against ISO 14040/44, EN15804, and the selected PCR (Requirements on the EPD for Metal Ceilings, Version 1.6).

# 3 Life Cycle Inventory (LCI) Analysis

## 3.1 Data Collection

### 3.1.1 Data Collection & Quality Assessment Procedure

All primary data 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, PE engaged with the data provider to resolve any open issues.

Product composition and manufacturing details were also collected from CISCA member companies. Installation, covered in module A5, was assumed to include only packaging disposal and all packaging was conservatively modeled as sent to landfill.

### 3.1.2 Fuels and Energy – Background Data

National and regional averages for fuel inputs and electricity grid mixes were obtained from the GaBi 2013 databases. Table 3-1 shows the key LCI datasets used in modeling energy generation and consumption for the product systems.

**Table 3-1: Key energy datasets used in inventory analysis**

| Energy | Dataset name | Primary source | Ref. year | Geography |
|---|---|---|---|---|
| Electricity | Electricity grid mix | PE | 2010 | CA |
| Electricity | Electricity grid mix | PE | 2010 | DE |
| Electricity | Electricity grid mix- CAMX | PE | 2009 | US |
| Electricity | Electricity grid mix- PJM | PE | 2009 | US |
| Electricity | Electricity grid mix- SRMV | PE | 2009 | US |
| Electricity | Electricity grid mix- SRSO | PE | 2009 | US |
| Technical heat | Thermal energy from natural gas | PE | 2010 | CA |
| Technical heat | Thermal energy from natural gas (EN 15804 B6) | PE | 2010 | DE |
| Technical heat | Thermal energy from natural gas | PE | 2010 | US |
| Technical heat | Thermal energy from propane | PE | 2010 | US |
| Diesel | Diesel mix at filling station | PE | 2010 | US |
| Fuel Oil | Heavy fuel oil at refinery (1.0 wt. %S) | PE | 2010 | DE |

### 3.1.3 Raw Materials and Processes – Background Data

Data for upstream and downstream raw materials and unit processes were obtained from the GaBi 2013 databases and industry association data. Table 3-2 shows the key LCI datasets used in modeling materials for the product system. Packaging is detailed in Table 3-3. Documentation for the majority of datasets can be found at http://www.gabi-software.com/support/gabi/gabi-6-lci-documentation/. Exceptions include the Aluminum Association data for cold rolled and extruded aluminum. These datasets are part of an upcoming release of the GaBi Professional Database by PE. The background report, *The Aluminum Association - The Environmental Footprint of Semi-Finished Aluminum Products in NA,* can be found on the Aluminum Association website and the aggregated data is freely available from the USLCI database.

**Table 3-2: Key material datasets used in inventory analysis**

| Material | Dataset name | Primary source | Ref. year | Geography |
|---|---|---|---|---|
| Acoustic Fleece | Viscose fabric | PE | 2012 | EU-27 |
| Anodized aluminum | Anodization of aluminium (EN15804 A1-A3) | PE | 2012 | DE |
| Backside paint | Coating solvent-based (industry; white) | PE | 2012 | DE |
| Cleaning Solvent | Methanol from natural gas mix | PE | 2012 | US |
| Cleaning Solvent | Ethanol (96%) (hydrogenation with nitric acid) | PE | 2012 | US |
| Cold rolled aluminum | Cold Rolled Aluminum | AA | 2010 | NA |
| Extruded aluminum | Extruded Aluminum | AA | 2010 | NA |
| Fiberglass | Fiberglass Loose Fill | NAIMA | 2007 | US |
| Hot dip galvanized steel | Steel hot dip galvanized | Worldsteel | 2007 | NA |
| Lubricants | Lubricants at refinery | PE | 2010 | US |
| Polyester coating | Polyester Resin unsaturated (UP) | PE | 2012 | DE |
| Powder coating | Clear coat powder | PE | 2012 | DE |
| Primer | Primer solvent-based | PE | 2012 | DE |
| Solvent for coating | Methyl ethyl ketone (MEK) | PE | 2012 | US |

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

| Material | Dataset name | Primary source | Ref. year | Geography |
|---|---|---|---|---|
| Steel band | Steel Finished Cold Rolled Coil | Worldsteel | 2007 | NA |
| Corrugate | Corrugated board (2012) | PE/FEFCO | 2011 | EU-27 |
| Pallets | Wooden pallets (EURO, 40% moisture) | PE | 2012 | EU-27 |
| Paper | Kraft paper (EN15804 A1-A3) | PE | 2012 | EU-27 |
| Plastic band | Polypropylene granulate (PP) | PE | 2012 | US |
| Plastic band | Plastic extrusion profile (unspecific) | PE | 2012 | GLO |
| Plastic film | Polyethylene film (LDPE/PE-LD) PE | PE | 2012 | US |
| Styrofoam | Expanded Polystyrene (EPS 30) PE | PE | 2012 | UA |

### 3.1.4 Transportation

Average transportation distances and modes of transport are included for the transport of the metal materials, which constitute the majority of the product mass. Some manufacturers also included information for the transportation of process and packaging materials; however, this information was not sought from the manufacturers who did not provide this data as the impacts of transportation for these materials was judged to be below the cut-off criteria specified in Section 2.5.

The GaBi 2013 databases were used to model transportation. Truck transportation within the United States was modeled using the US truck transportation datasets. The vehicle types, fuel usage, and emissions for these transportation processes were developed based on the last available US Census Bureau Vehicle Inventory and Use Survey (2002) and US EPA emissions standards for heavy trucks in 2007. The 2002 VIUS survey is the most current available data describing truck transportation fuel consumption and utilization ratios in the US, and the 2007 EPA emissions standards are considered by this study's authors to be the most appropriate data available for describing current US truck emissions. For a detailed discussion of heavy-duty vehicle fuel efficiency data in the US, please refer to [LANGER 2013].

One manufacturer included in this study provided data for manufacturing of aluminum specialty products in Europe. As discussed in Section 2.3.3, 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 to the East Coast of the United States. The transportation datasets used in this study are shown in Table 3-4.

**Table 3-4: Transportation datasets used in the inventory**

| Transport | Dataset name | Primary source | Ref. year | Geography |
|---|---|---|---|---|
| Container Ship | Container ship | PE | 2012 | GLO |
| Truck | Truck- Trailer, basic enclosed / 45,000 lb payload- 8b | PE | 2012 | US |

### 3.1.5 Emissions to Air, Water and Soil

All emissions reported by the CISCA manufacturers were taken into account. For gate-to-gate emissions from fuel combustion, processes that include both fuel production and combustion were chosen from the GaBi 2013 databases and are listed in Table 3-1 as technical heat. These processes include combustion emissions to air and serve as proxy data for combustion emissions not tracked by the manufacturers.

Data for all upstream materials, electricity, and energy carriers were obtained from the GaBi 2013 databases. The emissions ($CO_2$, $NO_x$, etc.) from electricity generation are accounted for with the use of the electricity datasets.

## 3.2 METAL SPECIALTY PRODUCTS MANUFACTURING

Information on the gate-to-gate manufacturing of metal specialty products is discussed in this section.

### 3.2.1 Materials

The materials for producing 1 kg of aluminum specialty product are listed in Table 3-5. Over 97% of the materials are metal, by mass, with the largest metal component being pre-coated, cold-rolled aluminum.

**Table 3-5: Aluminum Specialty Product Composition**

| Component | Material | % Mass |
|---|---|---|
| Metal | Coated, Cold-Rolled Aluminum | 50% |
| Metal | Extruded Aluminum | 27% |
| Metal | Bare, Cold-Rolled Aluminum | 17% |
| Metal | Anodized, Cold-Rolled Aluminum | 3% |
| Metal | Laminated, Cold-Rolled Aluminum | <1% |
| Acoustic Fleece | Non-woven fabric | <1% |
| Insulation | Fiberglass | <1% |

### 3.2.2 Manufacturing

There are two basic processes used by CISCA members for manufacturing metal specialty products, coil-coat 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 is shaped. The two processes are depicted in Figure 3-1.


**Figure 3-1: Metal specialty product manufacturing process, coil-coating (left) & post-paint (right)**

As Figure 3-1 shows, most manufacturers receive the metal for their products in the form of master coil or pre-slit master coil. In the case of coil-coating, as depicted on the left of Figure 3-1, the coil is often 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 is often 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 major input to the manufacturing process is the metal for the panel; however 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, which is listed as materials for recycling in Table 4-3. The scrap generated during manufacturing is assumed to be produced at the same quality it is used by the upstream metal production processes. Therefore, the scrap from manufacturing is treated using closed-loop recycling as discussed in Section 2.4.2.

# 4 Life Cycle Inventory and Impact Assessment

This chapter includes both inventory and impact assessment results for aluminum specialty products. Inventory metrics include different forms of resource use as well as environmental impact indicators; a list of these metrics is shown in Section 2.6. The impact assessment results are calculated using The US EPA's Tool for Reduction and Assessment of Chemical and Environmental Impacts (TRACI)—version 2.1. Additionally, the impact results are included as calculated based upon the US EP University of Leiden's CML 2001 – Apr 2013 for continuity with the EN 15804 standard for environmental product declarations of construction products.

Cradle-to-gate and packaging disposal results for aluminum specialty products are presented in this section. These results include the manufacturing stage (A1 – A3) and disposal of packaging material (A5). It is important to note that the results are normalized to one kilogram of aluminum specialty product, and the weight of an actual panel of aluminum specialty product can vary depending on the material and style chosen. This was previously discussed in Section 2.2.

## 4.1 Primary Energy Demand

Primary energy resource use—both renewable and non-renewable—is presented below. In addition to presenting renewable and non-renewable resources used as raw materials (Table 4-1), the results are also broken down by energy resource (Table 4-2 and Figure 4-1). No energy resources are used as raw materials for the production of aluminum specialty products; this is reflected in Table 4-1.

**Table 4-1: Primary energy demand by usage for 1 kg of aluminum product [MJ LCV]**

| | A1 | A2 | A3 | A5 | Total |
|---|---|---|---|---|---|
| **Non-Renewable** | | | | | |
| Primary energy resources used as raw materials | 0 | 0 | 0 | 0 | **0** |
| Primary energy excluding resources used as raw materials | 85.8 | 0.737 | 32.3 | 0.200 | **119** |
| Total primary energy resources | 85.8 | 0.737 | 32.3 | 0.200 | **119** |
| **Renewable** | | | | | |
| Primary energy resources used as raw materials | 0 | 0 | 0 | 0 | **0** |
| Primary energy excluding resources used as raw materials | 32.8 | 0.00459 | 6.05 | 0.00887 | **38.9** |
| Total primary energy resources | 32.8 | 0.00459 | 6.05 | 0.00887 | **38.9** |

Table 4-2: Primary energy demand by resource for 1 kg of aluminum product [MJ LCV]

| | A1 | A2 | A3 | A5 | Total |
|---|---|---|---|---|---|
| **Non-Renewable** | | | | | |
| Crude Oil | 13.6 | 0.667 | 14.8 | 0.113 | **29.1** |
| Hard Coal | 9.08 | 0.00914 | 6.05 | 0.0139 | **15.2** |
| Lignite | 23.4 | 0.000735 | 0.598 | 0.00522 | **24.0** |
| Natural Gas | 35.6 | 0.0562 | 7.05 | 0.0624 | **42.7** |
| Uranium | 4.18 | 0.00387 | 3.85 | 0.00604 | **8.04** |
| **Renewable** | | | | | |
| Geothermal | 0.0780 | 0.000130 | 0.0209 | 0.0000521 | **0.0991** |
| Hydro power | 30.8 | 0.00108 | 0.829 | 0.00119 | **31.6** |
| Solar power | 1.42 | 0.00298 | 5.01 | 0.00640 | **6.44** |
| Wind | 0.515 | 0.000404 | 0.156 | 0.00123 | **0.673** |

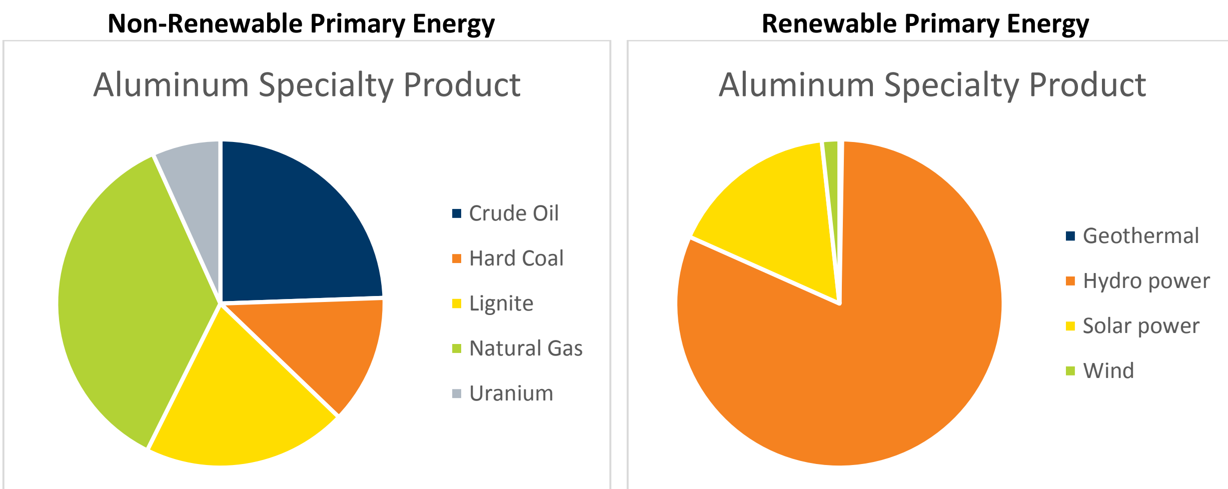


Figure 4-1: Non-renewable and renewable primary energy demand for 1 kg of aluminum product

## 4.2 Other Resources and Wastes

Secondary material and secondary fuel (fossil and renewable) consumption are presented below, along with water and waste results. Secondary material consumption represents the use of metal scrap in the upstream raw material production, while materials for recycling represents the scrap metal produced during manufacturing. Both fresh water use (as required by the PCR) and fresh water intake are provided in Table 4-3 .

**Table 4-3: Other resources and wastes for 1 kg of product aluminum product**

| | A1 | A2 | A3 | A5 | Total |
|---|---|---|---|---|---|
| **Aluminum Specialty Product** | | | | | |
| Secondary material [kg] | 0.722 | 0 | 0 | 0 | **0.722** |
| Secondary fuel (fossil) [MJ LCV] | 7.36E-02 | 1.88E-04 | 6.46E-03 | 4.83E-04 | **8.08E-02** |
| Secondary fuel (renewable) [MJ LCV] | 7.55E-03 | 1.78E-05 | 6.25E-04 | 2.11E-04 | **8.40E-03** |
| Fresh water use [L] | 141 | 0.0506 | 10.5 | -0.539 | **151** |
| Fresh water intake [L] | 3.56E+04 | 1.45 | 1.14E+03 | 5.32 | **3.67E+04** |
| Hazardous waste [kg] | 5.53E-03 | 7.32E-07 | 2.61E-04 | 4.76E-06 | **5.80E-03** |
| Non-hazardous waste [kg] | 1.91 | 1.64E-05 | 2.13E-02 | 1.51E-01 | **2.08** |
| Radioactive waste [kg] | 1.71E-03 | 1.52E-06 | 1.52E-03 | 2.39E-06 | **3.23E-03** |
| Components for re-use [kg] | 0 | 0 | 0 | 0 | **0** |
| Materials for recycling [kg] | 0 | 0 | 0.240 | 0 | **0.240** |
| Materials for energy recovery [kg] | 0 | 0 | 0 | 0 | **0** |
| Exported energy [MJ LCV] | 0 | 0 | 3.29E-03 | 0.161 | **0.164** |

## 4.3 Impact Assessment Indicator Results

Life cycle impact assessment results are summarized below in Table 4-4 and Figure 4-2.

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

| | A1 | A2 | A3 | A5 | Total |
|---|---|---|---|---|---|
| **Aluminum Specialty Product** | | | | | |
| Acidification Potential [kg $SO_2$-Equiv.] | 4.17E-02 | 2.62E-04 | 5.32E-03 | 9.05E-04 | **4.82E-02** |
| Eutrophication Potential [kg N-Equiv.] | 1.67E-03 | 1.67E-05 | 5.53E-04 | 5.37E-04 | **2.78E-03** |
| Global Warming Potential [kg $CO_2$-Equiv.] | 7.45 | 0.0518 | 2.04 | 0.276 | **9.82** |
| Ozone Depletion Potential [kg CFC 11-Equiv.] | 1.62E-09 | 4.59E-13 | 4.55E-10 | 2.74E-13 | **2.08E-09** |
| Smog Formation Potential [kg $O_3$-Equiv.] | 3.50E-01 | 7.98E-03 | 6.93E-02 | 4.49E-03 | **4.32E-01** |

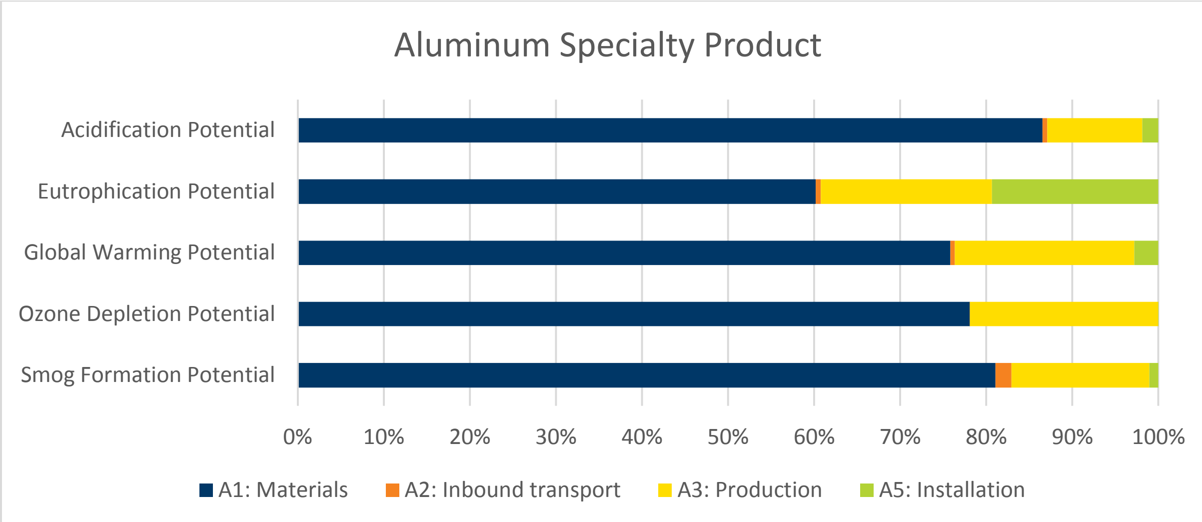


**Figure 4-2: TRACI 2.1 impact assessment results for 1 kg of aluminum product**

In an effort to be consistent with declarations written in accordance with EN 15804, the CML 2001- April 2013 impact assessment results are calculated in addition to TRACI 2.1 results (detailed above). These results are summarized in Table 4-5.

**Table 4-5: CML and TRACI impact assessment results for 1 kg of aluminum product**

| | TRACI 2.1 | | CML 2001 – April 2013 | |
|---|---|---|---|---|
| Acidification potential | 4.82E-02 | kg SO2-Equiv. | 5.10E-02 | kg SO2-Equiv. |
| Eutrophication potential | 2.78E-03 | kg N-Equiv. | 3.36E-03 | kg PO43--Equiv. |
| Global warming potential | 9.82 | kg CO2-Equiv. | 9.82 | kg CO2-Equiv. |
| Ozone depletion potential | 2.08E-09 | kg CFC 11-Equiv. | 1.93E-09 | kg R11-Equiv. |
| Photochemical ozone creation potential | — | — | 3.30E-03 | kg C2H4-Equiv. |
| Smog formation potential | 4.32E-01 | kg O3-Equiv. | — | — |
| Abiotic depletion potential, elements | — | — | 7.48E-06 | kg Sb-Equiv. |
| Abiotic depletion potential, fossil | — | — | 111 | [MJ LCV] |

# 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 just the raw material module (A1), 95-100% of the impact, in almost all assessment categories, is due to the production of aluminum. The two exceptional impact categories are eutrophication and ozone depletion, to which acoustic fleece production and fiberglass production, respectively, represent relevant contributions. Inbound transportation (A2) is almost negligible across all impact categories except for smog formation, in which it accounts for almost 2% of the product impacts.

For the production module (A3), energy usage—specifically electricity usage and propane combustion—is the cause of much of the impact. Coil coating is associated with the second largest effect on eutrophication and smog. The polyester resin and solvent production are primary contributors to eutrophication from the coil coating process. Finally, the disposal of packaging is significant to eutrophication due to the leaching of ammonia from the landfilling of treated wood pallets.

## 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, primary industry data were combined with background LCA data from the GaBi 2013 databases. The LCI data sets from the GaBi 2013 databases are widely distributed and used with the GaBi 6 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:** Foreground data was based on primary data. All background data were obtained from the GaBi 2013 databases with the documented precision**.**

**Completeness:** Each unit process was checked for mass balance and completeness of the emission inventory. Selected coatings that represented under 1% of mass were excluded under the cut-off criteria and some inbound transportation was not considered for process materials; otherwise, no data were knowingly omitted. The decision to neglect inbound transportation of most process materials, as discussed in Section 3.1.4, is validated by the impact assessment results. The results indicate that the transportation of the metal, which is the majority of the mass of materials included in this study, is only relevant to smog formation where the metal transportation contributes less than 2% of overall impact potential. Therefore, the marginal increase in transportation mass due to the much lighter mass of process materials would not have a significant impact on the overall results.

### 5.2.2 Consistency and Reproducibility

**Consistency:** To ensure consistency, all primary data were collected with the same level of detail (i.e., using consistent data collection templates), while all background data were sourced from the GaBi 2013 databases. Allocation and other methodological choices were made consistently throughout the model, with the exception of the one manufacturer who used economic allocation, which resulted in data similar to those of other participants.

**Reproducibility:** Reproducibility is not possible since disclosure of company-specific input and output data would violate confidentiality of the data providers. Information on generic formulation, dataset choices, and methodological choices can provide some limited insight into the methods and calculations used for third parties.

### 5.2.3 Representativeness

**Temporal:** As discussed in Section 2.3.1, most of the primary data is taken from 12-months of continuous operation in calendar year 2013. Two respondents provided data inconsistent with the temporal scope. The data from these two manufacturers were benchmarked against the other CISCA members and deemed to be consistent. The averaging of all CISCA member companies will help to reduce any potential error introduced by time coverage inconsistent with PCR requirements. All secondary data came from the GaBi 2013 databases and are representative of the years 2009-2012, except as noted in Table 3-2. As the study intended to represent current production of CISCA member companies, temporal representativeness is warranted.

**Geographical:** All primary and secondary data were collected specific to the location of manufacture when possible. Energy and transportation data used represents the region-specific infrastructure and emission factors. Raw material datasets were chosen for technological accuracy and are based on North American conditions or reasonable proxies. Regional differentiation for all raw material LCIs was not possible within the time and cost constraints of the study. Geographical representativeness is considered to be good.

**Technological:** All primary and secondary data were modelled to be specific to the technologies or technology mixes under study. Technological representativeness is considered to be good.

## 5.3 Conclusions, Limitations, and Recommendations

### 5.3.1 Conclusions

The goal of this study was to conduct a cradle-to-gate 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.

### 5.3.2 Limitations & Assumptions

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, primary information collected from the metal coating industry for coating steel coil with polyvinylidene fluoride (PVDF) was used to proxy aluminum coil coating. The PVDF material was replaced with polyester resin more similar to the polyester coating used by CISCA members. 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.

Another limitation of this study is that results are presented per kilogram of aluminum product rather than per square foot of panel. This is due to the variability of metal specialty products, as discussed in Section 2.2. To mitigate the effects of this limitation, sample results for common panel thicknesses listed in Table 2-1 are presented in Appendix A for aluminum products.

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

### 5.3.3 Recommendations

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

# 6 REFERENCES


| | |
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# Appendix A Results for Alternative Dimensions

While the aluminum specialty products sold by the participating CISCA member companies vary in size, three examples of impact assessment results scaled to one square foot of product are shown in Table A-1. These panels represent common thicknesses for aluminum specialty products and are scaled by mass.

**Table A-1: Impact assessment results for 1 $ft^2$ of aluminum specialty products**

| Impact Category | | Acidification Potential [kg $SO_2$-Equiv.] | Eutrophication Potential [kg N-Equiv.] | Global Warming Potential [kg $CO_2$-Equiv.] | Ozone Depletion Potential [kg CFC 11-Equiv.] | Smog Formation Potential [kg $O_3$-Equiv.] |
|---|---|---|---|---|---|---|
| Thickness [in] | Mass [lbs./$ft^2$] (kg/$ft^2$) | | | | | |
| 0.020 | 0.28 (0.13) | 6.12E-03 | 3.53E-04 | 1.25 | 2.64E-10 | 5.49E-02 |
| 0.032 | 0.45 (0.20) | 9.83E-03 | 5.67E-04 | 2.00 | 4.24E-10 | 8.81E-02 |
| 0.040 | 0.56 (0.25) | 1.23E-02 | 7.09E-04 | 2.50 | 5.30E-10 | 0.110 |
| 0.063 | 0.88 (0.40) | 1.93E-02 | 1.11E-03 | 3.94 | 8.34E-10 | 0.173 |
| 0.090 | 1.26 (0.57) | 2.76E-02 | 1.59E-03 | 5.63 | 1.19E-09 | 0.248 |
| 0.125 | 1.76 (0.80) | 3.84E-02 | 2.21E-03 | 7.82 | 1.66E-09 | 0.344 |
| 0.188 | 2.64 (1.20) | 5.79E-02 | 3.33E-03 | 11.78 | 2.50E-09 | 0.518 |