Generic Aluminum Siding

Product Selection and Description

Aluminum siding is a commonly-used exterior wall cladding that is known for its light weight and durability. Aluminum siding typically has an exterior coating to provide color and durability. Popular coatings include acrylic, polyester, and vinyl.

For the BEES system, the functional unit is one ft^2 of exterior wall area covered with horizontal aluminum siding in a thickness of 0.061 cm (0.024 in) and a width of 20 cm (8 in). The aluminum siding is assumed to be fastened with aluminum nails 41 cm (16 in) on center, requiring approximately 0.000374 kg (0.000825 lb) of aluminum nails per ft^2.

Flow Diagram

The flow diagram below shows the major elements of the production of this product, as it is currently modeled for BEES.

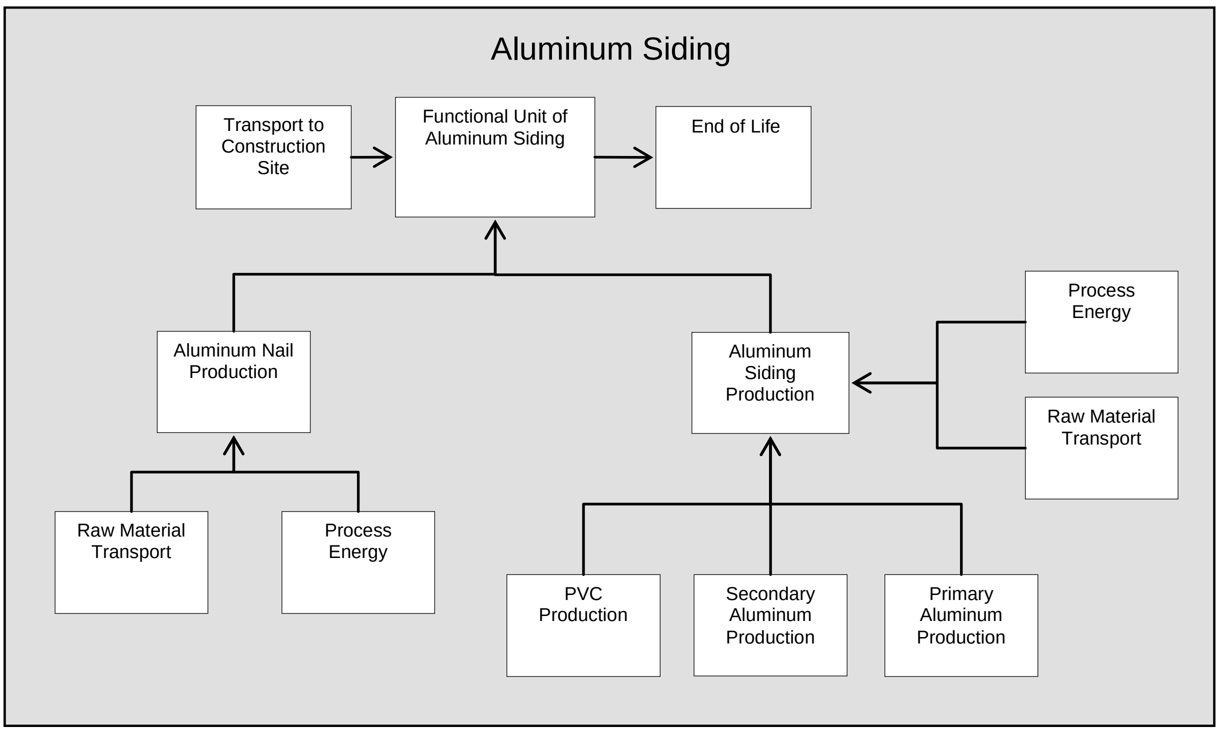

Figure 1: Aluminum Siding System Boundaries

Raw Materials

There are a number of aluminum siding products on the market, most of which are manufactured using different combinations of aluminum alloys and coating materials. Coating formulations are generally proprietary; the product studied for the BEES system is manufactured as an aluminum sheet with a polyvinyl chloride (PVC) thermoset topcoat.

The following Table presents the major constituents of aluminum siding. Life cycle data for the production of these raw materials comes from the U.S. LCI Database.

Table 1: Aluminum Siding Constituents

Constituent	***Mass*** ***kg/m^2 (lb/ft^2)***	***Mass Fraction (%)***
Aluminum Alloy Sheet	1.631 (0.3340)	99
PVC Topcoat	0.0161 (0.0033)	1

The aluminum sheet is manufactured from aluminum ingots. Since aluminum recycling is considered to be a closed loop process and aluminum siding is generally recycled at the end of the life of the building (see End of Life below), the environmental burdens from aluminum production are determined by the end-of-life recovery rate and the yield of metal from the aluminum recycling process. According to The Aluminum Association, 30 % of all aluminum used in construction is from secondary sources. Therefore, the BEES model assumes a mix of 30 % secondary and 70 % primary aluminum.

The vinyl topcoat is 0.08 mm to 0.09 mm (3.3 mils to 3.7 mils) thick; environmental burdens from the production of PVC come from the SimaPro database.

According to The Aluminum Association, the following aluminum alloys account for over 90 percent of aluminum used in siding: 3005, Alclad 3004, 3003, 1100, and 3105. Their composition is given in the Table below.

Table 2: Alloy Composition[1]

Alloy	**Al**	**Co**	**Fe**	**Pb**	**Mn**	**Mo**	**S**	**Ti**	**Zn**	**Total**
1100	99.0	-	0.1	-	-	0.1	1.0	-	0.0	100.1
3003	97.3	-	0.1	0.7	-	1.2	0.6	-	0.1	100.0
3004	96.2	-	0.3	0.7	1.0	1.2	0.3	-	0.3	99.9
3005	96.3	0.1	0.3	0.7	0.4	1.2	0.6	0.1	0.3	100.0
3105	96.6	0.2	0.3	0.7	0.5	0.6	0.6	0.1	0.4	100.0
Average	97.1	0.1	0.2	0.6	0.4	0.9	0.6	0.0	0.2	100.0
3000 series only	96.6	0.1	0.2	0.7	0.5	1.1	0.5	0.1	0.3	100.0
6061 (nails)	96.7	0.2	0.3	0.7	1.0	0.2	0.6	0.2	0.3	100.0

In all, alloys only account for 2.9 % to 3.3 % of the mass of the aluminum product. The life cycle environmental data for the alloying metals is not included in the model due to lack of available data; as a result the model assumes that the alloy is in fact made of 100 % aluminum.

Manufacturing

Energy Requirements and Emissions. Energy requirements and emissions for production of the individual siding components (rolled aluminum alloy and PVC resin) are included in the BEES data for the raw material acquisition life-cycle stage. The model, however, does not include the energy demands or emissions associated with application of PVC topcoat to the aluminum siding.

In the U.S., approximately half of rolled aluminum products are either hot or cold rolled.[2] The energy requirements for the average of the hot and cold rolling processes are presented in the Table below.

[1] Alloy composition data from http://www.capitolcamco.com/MSDS/MSDS_I_Aluminum.htm.

[2] BCS, Inc., *U.S. Requirements for Aluminum Production: Historical Prospective, Theoretical Limits, and New Opportunities* (Washington, DC: Prepared for the U.S. Department of Energy, Energy Efficiency and Renewable Energy, February 2003).

Table 3: Energy Requirements for Aluminum Rolling

Energy Carrier	***MJ/kg (Btu/lb)***
Diesel	0.00148 (0.636)
Kerosene	0.000131 (0.0565)
Gasoline	0.0372 (16.0)
Natural Gas	1.11 (479)
Propane	0.00345 (1.48)
Electricity	1.11 (475)
Total	**2.26 (972)**

Transportation. Transportation of rolled aluminum and PVC resin to aluminum siding mills is assumed to be 402 km (250 mi) by truck.

Waste. Before rolled aluminum sheet is coiled and shipped, edge trimming knives remove damaged material from the edge of the sheet. The average edge trim loss for hot and cold rolling is 17 % of unrolled aluminum.[3] Edge trim waste is returned to the cast shop for remelting.

Transportation

Transportation of manufactured aluminum siding by heavy-duty truck to the building site is modeled as a variable of the BEES system.

Installation

Aluminum siding installation is predominately a manual process--a small amount of energy may be required to operate compressors to power air guns, but this is assumed to be very small and is not included in the analysis. Installation waste with a mass fraction of 5 % is assumed, and all waste is assumed to go to landfill.

Nails are assumed to be placed 41 cm (16 in) on center; however, as it is increasingly common to find buildings with studs 61 cm (24 in) on center, manufacturers are typically providing instructions for nail spacing of 61 cm (24 in) in order for the fasteners to penetrate this framing configuration. For installation on 41 cm (16 in) centers, 0.00085 lb of aluminum nails are used per ft^2 of siding. The overall installation average is still probably close to 41 cm (16 in), but a slight reduction in the mass of the nails, taken conservatively to be 3 %, is modeled to account for some installation on 61 cm (24 in) framing.

While sheathing, weather resistive barriers, and other ancillary materials may be required to complete the exterior wall system, these materials are not included in the system boundaries for BEES exterior wall finishes.

Use

The product is assumed to have a useful life of 80 years. In some instances, siding without significant corrosion damage can be found after 100 years. However, owners may replace siding for reasons other than corrosion (e.g., to update the home's exterior appearance or change the color). It is assumed for the model that the siding remains in place over the 50- year use period.

Buildings with aluminum siding are periodically cleaned, usually for aesthetic reasons. Information on typical cleaning practices (e.g., frequency of cleaning, types and quantities of cleaning solutions used) is not available; no use phase impacts from cleaning are included.

[3] BCS, Inc. *U.S. Requirements for Aluminum Production: Historical Prospective, Theoretical Limits, and New Opportunities.*

End of Life

Aluminum scrap has a significant economic value – the market price of clean, thick-walled scrap is close to the market price of primary materials. There is therefore a financial incentive to recover aluminum siding from a building at the end of its useful life.

An EPA report, *Characterization of Building-Related Construction and Demolition Debris in the United States*, confirms that the materials most frequently recovered and recycled from construction and demolition (C&D) debris are concrete, asphalt, metals, and wood. The EPA study also estimates that from 1 % to 5 % of C&D waste consists of metals. Therefore, the model assumes that all of the aluminum siding is recovered at the end of its useful life and returned to a secondary aluminum smelter for recovery.

References

Life Cycle Data

National Renewable Energy Laboratory (NREL): *U.S. Life-Cycle Inventory Database*. 2005. Golden, CO. Found at: http://www.nrel.gov/lci/database.

PRé Consultants: *SimaPro 6.0 LCA Software*. 2005. The Netherlands.

Aluminum Association, *Life Cycle Inventory Report for the North American Aluminum Industry* (Washington, DC: Aluminum Association November 1998).

Franklin Associates, " Management of Construction and Demolition Debris in the United States", Chapter 8, *EPA530-R-98-010 - Characterization of Building-Related Construction and Demolition Debris in the United States* (Washington, DC: U.S. Environmental Protection Agency, June 1998) Found at: http://www.epa.gov/epaoswer/hazwaste/sqg/c&d-rpt.pdf.

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Industry Contacts

Paola Kistler, Director Environment, EHS FIRST, Alcan Inc. (September 2005)

Michael Skillingberg, The Aluminum Association, Inc. (January 2006)