ENVIRONMENTAL PRODUCT DECLARATION

METAL COMPOSITE MATERIAL

FOR WALL PANEL SYSTEMS

Photo: Miller-Clapperton Partnership, Inc. (left)
Photo: Mark Kempf Photography (right)
Photo: Robert R. Gigliotti (bottom)

METAL CONSTRUCTION ASSOCIATION

The Metal Construction Association (MCA), Chicago, IL, is an organization of manufacturers and suppliers whose metal products are used in structures throughout the world. Since it was formed in 1983, MCA has focused on promoting the use of metal in the building envelope through marketing, education, and action on public policies that affect metal's use.

MCA is a volunteer-led organization that works to eliminate barriers to using metal in construction through product performance testing, research, and monitoring and responding to codes and regulations that affect metal.

MCA also supports third-party metal product research and testing. MCA and its members are committed to creating a cleaner, safer environment evidenced by the association's LCA program and support of similar initiatives.

Metal Composite Material is a major product category of MCA members. This Environmental Product Declaration for Metal Composite Material is one of several different product EPDs offered by MCA.

For more information visit www.metalconstruction.org

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

Metal Composite Material Panels
Industry-Wide EPD

According to ISO 14025

This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.

PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	Metal Construction Association (MCA)
DECLARATION NUMBER	13CA56115.101.1
DECLARED PRODUCT	Metal Composite Material Panels
REFERENCE PCR	Insulated Metal Panels & Metal Composite Panels, and Metal Cladding: Roof and Wall Panels (UL, October 2012)
DATE OF ISSUE	February 14, 2014
PERIOD OF VALIDITY	5 Years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications

The PCR review was conducted by:	UL Environment Review Panel Thomas Gloria (Chairperson) 35 Bracebridge Road Newton, MA 02459-1728 t.gloria@industrial-ecology.com
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories: ☐ INTERNAL ☒ EXTERNAL	Wade Stout, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas Gloria, Life-Cycle Services, LLC

Description of organization and product

Organization Description

The Metal Construction Association (MCA), Chicago, IL, is an organization of manufacturers and suppliers whose metal products are used in structures throughout the world. Since it was formed in 1983, MCA has focused on promoting the use of metal in the building envelope through marketing, education, and action on public policies that affect metal's use. MCA is a volunteer-led organization that works to eliminate barriers to using metal in construction by supporting product performance testing, initiating research, and monitoring and responding to codes and regulations that affect metal. Visit www.metalconstruction.org for more details.

Information in this document has been prepared by MCA technical staff and members of MCA's MCM Fabricators Council and MCA's Wall Panel Council who are volunteers representing the leading manufacturers of Metal Composite Material (MCM) and companies that provide premium fabricating services for MCM. The product configurations offered herein use ranges representative of all types of MCM based on specific products from the following MCA member companies.

3A Composites employs 2,700 persons in 21 locations in Europe, the Americas and Asia. It is active in manufacturing and commercializing lightweight products for architecture, visual communication, transportation, industrial and wind energy markets. Its well-known brand, ALUCOBOND®, is the category leader in the markets served. 3A Composites is committed to making its products and production processes environmentally sustainable. By partnering with recyclers of ACM 3A Composites reduces its manufacturing carbon footprint, is a silver member of USGBC and contributes multiple points to LEED certification. Learn more at www.alucobondusa.com.

Alcoa Architectural Products is a business unit of Alcoa, Inc., the world's leading producer of aluminum products. Alcoa Architectural Products' Reynobond and Reynolux panels provide solutions for any exterior or interior cladding and corporate identity needs. Architects and specifiers find they have greater control over the finished appearance of projects when working with the Alcoa family of products, which includes the Colorweld® 500 finish with the industry's first 30-year warranty. Other innovative materials include the self-cleaning finish, Ecoclean, Reynobond Wood Grain ACM, and Reynobond with KEVLAR®. For more information on the complete line of products call 1.800.841.7774 or visit www.reynobond.com.

ALPOLIC®, a division of Mitsubishi Plastics Composites America, Inc., Chesapeake, VA creates state-of-the-art composite materials with stunning appearance and outstanding performance. Introduced to the United States in 1974, ALPOLIC Materials have been manufactured in North America since 1991. ALPOLIC's OPERATION ENCORE focuses on the return and recycling of expired ACM/MCM panels. ALPOLIC separates the panel components and returns them into industry recycling steams. MPCA is committed to managing its business and products in a sustainable and environmentally responsible manner and is an active member of the USGBC. MPCA works with its customers to support LEED certification and reduce manufacturing impacts on the environment. Visit www.alpolic-northamerica.com for more information.

Firestone Building Products is a leading manufacturer and supplier of a comprehensive "Roots to Rooftops" portfolio of products for commercial building performance solutions. By taking the entire building envelope into consideration, Firestone tailors solutions to individual customer and project needs for roofing, metal wall and landscape and lining systems. Headquartered in Indianapolis, Ind., the company also offers outstanding technical services, an international network of roofing and wall contractors, distributors and field sales representatives, and superior warranty protection. Products include metal wall panels, insulation, cavity wall construction, commercial roofing systems, roofing accessories, green roofing systems, photovoltaic and daylighting systems, vegetative roofing systems, pond liners and geomembranes, and stormwater management solutions. For more information visit www.firestonebpco.com.

The Miller-Clapperton Partnership, Inc., an MCA Certified Premium MCM Fabricator, employs over 100 people. It is one of the largest domestic fabricators and installers of MCM-tested cladding systems, producing over 1,000,000 square feet annually. Since its inception 34 years ago, the company has striven to be good stewards of its resources. Daily activities such as recycling scrap aluminum, recycling wood for building crates, and minimizing freight costs are good for the planet, and the bottom line. Accurate design and engineering assure proper component construction which eliminates 'more-is-better' waste. Embracing cutting-edge technology such as 3D Modeling from laser scanning allows Miller-Clapperton to produce highly accurate panels 'one time right' and has nearly eliminated the waste associated with remakes. Learn more by visiting www.millerclapperton.com.

Sobotec Ltd., a certified Premium MCM Fabricator, is one of North America's largest manufacturers of metal composite material panel systems. Since Sobotec's inception more than 25 years ago, the company has met the challenge to design thermally efficient and sustainable wall panel systems to withstand Canada's harsh climate conditions. As a result, Sobotec's innovative designs have played a key role in the proliferation of metal composite use in cladding applications throughout North America. The company is dedicated to the design of sustainable building envelope solutions using recyclable materials and incorporating business practices that minimize environmental impact. Learn more at www.sobotec.com.

Product Benefits

When it comes to consistency and precision, Metal Composite Material (MCM) panels are among the best metal construction products. MCM sheets stay flat after installation because the skins are bonded to the core under tension, which produces a balanced panel. As a result of MCM's unique strength-to-weight ratio, highy efficient cladding designs can reduce the overall dead load on structures, which in-turn reduces the structural mass necessary for building framing. MCM panels can also be finished in virtually any color a building owner or architect desires, or they can be installed unfinished to reap the benefits of natural metals such as zinc, copper and titanium.

The superb properties of MCM panels boost creativity and offer a broad range of solutions for all types of buildings and identities. As a result, MCM panels are now installed on a wide variety of building types and applications, ranging from major project wall panel systems to cornices and canopies. They are also frequently used to join areas between other major building materials, such as glass and precast concrete panels.

As architects, designers and building owners ask for more functional and innovative construction materials, MCM panels will continue to meet the need to fulfill structural and technical demands as well as ecological requirements.

The LEED Platinum-certified Duke Energy Center, Charlotte, NC uses MCM to offset the abundance of glass and define the building's corners and tapered crown.

Photo: Miller-Clapperton Partnership, Inc.

Photo: Mark Kempf Photography

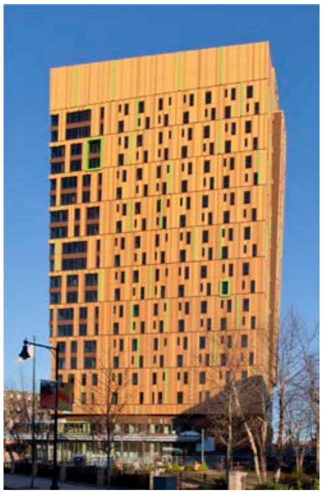
Designers of the Maryland Live! Casino in Hanover, MD chose MCM panels to meet the needs of this stylish, energy-efficient building.

Photo: Robert R. Gigliotti

MCM panels form the primary cladding on the Tower at Rush University Medical Center, Chicago.

Photo: Daniel Lunghi courtesy Alucobond®

The ever-changing color spectrum of the MCM panels on the Cullum Tower in North Bergen, NJ make the building stand out in the city's skyline.



Seven colors of ACM are used to clad the Mass Art Residence Hall, a LEED Silver-certified building in Boston, MA.

Photo: Peter Landerwarker, courtesy MassArt

Photo: Raymond Chan PhotomediaCanada

ACM Panels form the curved roof of the Visitor's Center at Van Dusen Botanical Gardens, a LEED Platinum-certified building in Vancouver, BC.

Product Description

Metal Composite Material (MCM) panels have been used in North American construction for over 30 years. They are formed by bonding two metal skins to a highly engineered plastic core. Originally known as Aluminum Composite Material (ACM), the name of the product category has evolved to Metal Composite Material to reflect the introduction of new skin metals such as zinc, copper, stainless steel, and titanium. Aluminum, however, remains the predominant skin material.

MCMs not only provide exceptional flatness, but also a broad choice of finishes. Aluminum and steel MCMs can be finished in virtually any color a building owner or architect desires. Zinc, copper and titanium panels are usually installed unfinished, utilizing the benefit of these natural materials to achieve a unique weathered look over time.

Metal composite panels are also an environmentally responsible and sustainable choice for buildings. Approximately 70 percent of an aluminum composite wall panel by weight is recycled content.

Materials

Raw materials/primary products

Component	Material	Availability	Origin	Mass (%)
Aluminum skin	Painted aluminum coil, extruded	Fossil resource, limited	North America	38%
Panel hardware	Aluminum, extruded	Fossil resource, limited	North America	24%
Polyethylene core	Polyethylene, primary and secondary	Fossil resource, limited	North America	38%

Table 1: Base material mass by percentage, MCA industry-average

Auxiliary substances/Additives

In addition to the main components declared above, adhesives may be used in the manufacturing process.

Raw Material Extraction and Origin

Aluminum coil represents aluminum that has been rolled out into 0.51mm (0.02 inches) to 0.25mm (0.01 inch) thickness depending on the building needs. The coated aluminum sheet is assumed to be 100% produced in North America. The coils are coated with protective and aesthetic paints for the surface to achieve desired characteristics. The mining location and transportation distances are not specified, as this EPD considered information from multiple organizations considered to be representative of the market. Weighted average of the upstream transportation of aluminum coil to the coil coating facilities is 128 miles. Following the coil coating process, the weighted average inbound transportation to MCM manufacturers is 1,333 miles.

Polyethylene core is comprised of virgin plastic granulate and secondary plastic. Primary and secondary plastics are assumed to be produced and sourced in North America. The specific chemistry is usually proprietary to each manufacturer. The formulation contains the additives necessary to meet the fire performance of the given product geometry and to satisfy the needs of the manufacturing process. Typical thickness of the polyethylene is 4mm. However, depending on the building needs the core thickness can be 3mm, 4mm, or 6mm.

Availability of Raw Materials

All primary raw materials are produced from fossil resources and thus of limited availability. Aluminum sheet production, however, consumes around 0.64 kg of scrap aluminum per kilogram of output. Secondary polyethylene granulate is limited by availability from recyclers.

MCM Laminating Process

MCM panels are formed by bonding two metal skins to a highly engineered plastic core placed between them. This occurs under very precise conditions of temperature, pressure and tension. The result is a strong composite sheet of metal and plastic. Properly designed and installed, these metal composite panels provide a very reliable building envelope that resists the elements and protects against air and water infiltration.

Producing the panels requires a five-stage process, as shown in Figure 1 below. The metal coils are introduced from two pay-off reels (1). Next the laminating rollers bond the aluminum to the continuously extruded thermoplastic core (2). The laminated material then enters the cooling chamber and is constantly moved at a steady rate by the pulling rollers (3). A protective masking film is then applied to the MCM to protect the surface finish (4). Finally, the MCM is trimmed to the required width, sheared to the required length, and stacked for inspection and final packaging (5).

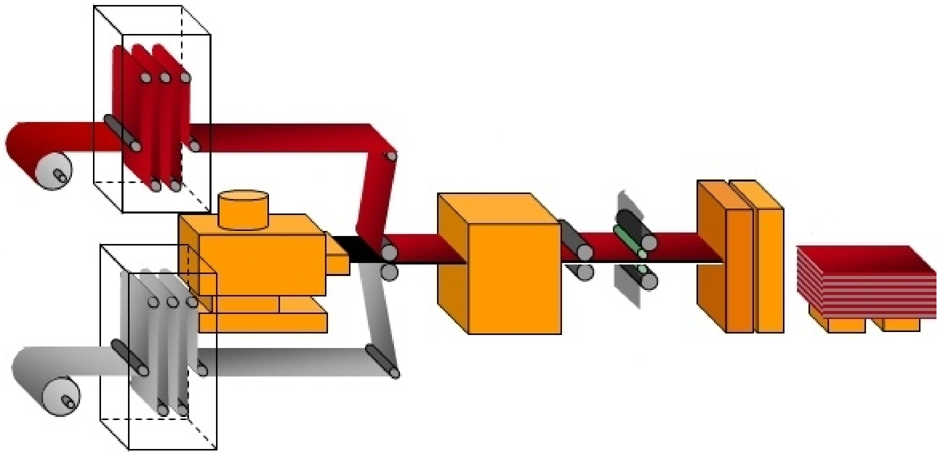


Figure 1: Schematic of MCM Laminating Process

Range of Applications

Examples of the types of structures using MCM panels for wall cladding:

- Commercial
- Government/Municipal
- Healthcare
- Hospitality
- Institutional
- Light commercial and industrial
- Public venues, such as sports complexes, museums and convention centers
- Religious
- Residential
- Retail
- Schools and Universities
- Transportation

Product Performance Data

Performance Standards - Air Tightness

ASTM E 283 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen*

Performance Standards - Fire

ASTM D1929 Standard Test Method for Determining Ignition Temperature of Plastics

E 84 Standard Test Method for Surface Burning Characteristics of Building Materials

E119 Standard Test Methods for Fire Tests of Building Construction and Materials

CAN/ULC

S101	Standard Methods of Fire Endurance Tests of Building Construction and Materials
S102	Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings, and Miscellaneous Materials and Assemblies
S134	Standard Method of Fire Test of Exterior Wall Assemblies

Materials and Assemblies

NFPA 285	Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components
ASTM D 635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in Horizontal Position
ASTM E 162	Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
UL 1715	Fire Test of Interior Finish Material

Performance Standards – Structural

ASTM C 297	Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions
C 393	Standard Test Method for Core Shear Properties of Sandwich Constructions
C 481	Standard Test Method for Laboratory Aging of Sandwich Constructions
D 1002	Standard Test Method for Apparent Shear Strength of Single-Lap -Joint Adhesively Bonded Metal Specimens
D 1781	Standard Test Method for Climbing Drum Peel Test for Adhesive Materials
E 72	Structural Test of Panels
E 228	Standard Test Method for Linear Thermal Expansion of Solid Materials
E 330	Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*

Performance Standards - Water Resistance

ASTM E 331	Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference*
AAMA 501.1	Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure

501.2 Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls and Sloped Glazing Systems

508 Voluntary Test Method and Specification for Pressure Equalized Rain Screen Wall Cladding Systems

509 Voluntary Test and Classification Method for Drained and Back Ventilated Rain Screen Wall Cladding Systems

Performance Standards - Finishes

AAMA

611 Specification for Anodized Architectural Aluminum

2604 Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels

2605 Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels

ASTM

D 822 Practice for Operating Light and Water Exposure Apparatus (Carbon-Arc Type) for Testing Paint, Varnish, Lacquer and Related Products

D 968 Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive

D 1308 Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes

D 1735 Standard Practice for Testing Water Fog Testing of Organic Coatings

D 2244 Standard Practice for Calculation of Color Tolerances and Color Differences

D 2794 Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)

D 3359 Methods for Measuring Adhesion by Tape Test

D 3363 Standard Test Method for Film Hardness by Pencil Test

D 4145 Standard Test Method for Coating Flexibility of Prepainted Sheet

D 4212 Method for Testing Chalk and Paint Delamination

D 4214 Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films

Quality Control

Metal Composite Material panels are manufactured to meet the performance and testing requirements of the model building codes and insurance listing agencies. MCM panels carry ratings for fire, structural, water leakage and air infiltration. When compared to other materials, which are field assembled or applied, fabricated MCM panels minimize the erector impact on the system performance. This results in better in-place quality, better weather integrity and appearance. To ensure compliance, individual quality control parameters will vary by individual manufacturer.

Description	Tolerance
Panel Flatness	Rises and falls across panel (local bumps and depressions) are not accepted 0.080"(2 mm) in a concave/convex direction, measured perpendicular to normal plane
Panel Alignment	Maximum deviation from vertical and horizontal alignment or erected panel: ¼" in 20' (6mm in 6m)

Table 2: Allowable Fabrication Tolerances

Delivery Conditions and Properties

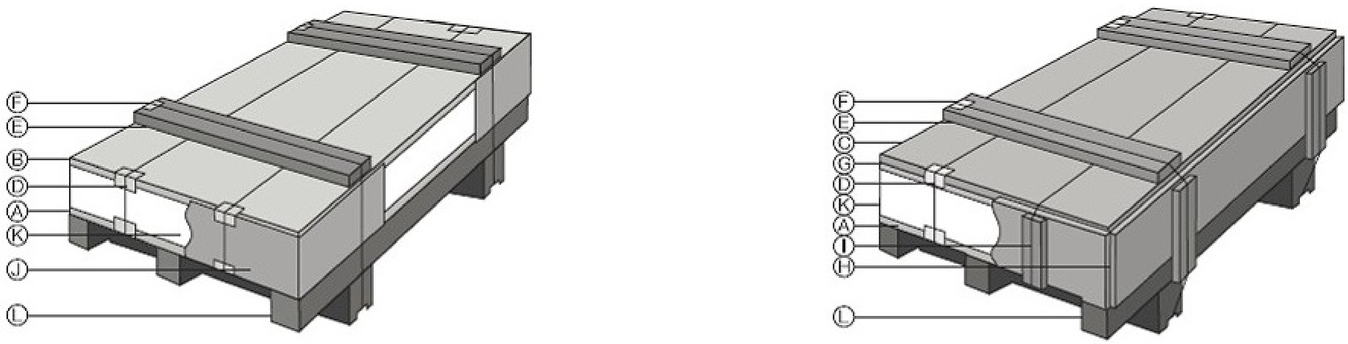
The delivery conditions can vary highly depending on the needs of the building structure and design. Panel width can range from approximately from 0.150 meters to 1.5 meters. As characteristic of continuous production methods, panels can be sheared to the required length, but can be as long as approximately 5 meters.

MCM panels can be produced with different skin metals, such as zinc, copper, stainless steel, and titanium. Aluminum, however, remains the predominant skin material. Aluminum MCM panels can be finished to any color to fit the building design.

Aluminum coil thickness can range from 0.25 mm to 0.5 mm. Moreover, the polyethylene backing can range from 3 mm to 6 mm in thickness depending on the application. Combined with the jointing structure, panels are typically 60 mm thick, approximately.

Packaging

MCM finishes show visual differences based on the direction of finish application. The finish direction is indicated on the protective film for ease of installation.



Ⓐ Cardboard placed on the pallet
Ⓑ Cardboard placed on the last panel
Ⓒ Agglomerated woodchip cover
Ⓓ Longitudinal banding + 4 cardboard corners per band
Ⓔ Stacking planks
Ⓕ Transverse banding + 4 cardboard corners per band
Ⓖ Polyethylene film (packages of over 20 panels)
Ⓗ Agglomerated woodchip sides (packages of over 20 panels)
Ⓘ Wooden blocks (packages of more than 20 panels)
Ⓙ Cardboard sides (packages of more than 20 panels)
Ⓚ Panels
Ⓛ Pallet

Figure 2: MCM Packaging

Singular Effects

Key Product Standards

Not all standards are applicable to all products. Consult specific manufacturer's information for standards compliance.

Material Standards

Aluminum Assoc. Specifications for Aluminum Structures

Aluminum Assoc. Aluminum Design Manual

ASTM	A 480	Standard Specification for General Requirements for Flat Rolled Stainless Steel and Heat Resistant Steel Plate, Sheet and Strip
	A 653	Galvanized Steel Physical and Galvanizing Requirements
	A 792	Aluminum-Zinc alloy coated steel
	B 209	Standard Specification for Aluminum Sheet and Extrusions
	B 370	Standard Specification for Copper Sheet and Strip for Building Construction

DIN EN988 Specifications for zinc and zinc alloy rolled flat products for building

DIN EN1179 Zinc and zinc alloys

Thermal Effects

Thermal expansion or contraction of MCM panels can occur in any direction on the panel and is always greatest along the longest panel dimension. MCM panels will thermally expand and contract the same as solid aluminum or galvanized steel sheet or aluminum plate. Architectural wall panel joints need to be designed to account for thermal movement of the panels, unless design calculations prove otherwise.

Requirements for the Underlying Life Cycle Assessment

The LCA study and analysis were conducted according to the Product Category Rule (PCR) created by UL Environment for insulated metal panels, metal composite panels, and metal cladding.

Functional Unit/Reference Flow

The functional unit for this study is defined as "coverage of 93 square meters (1,000 square feet) with metal product". The coverage area refers to the projected flat area covered by the product as output by the final manufacturing process step, and does not account for losses due to overlap and scrap during installation.

To achieve the functional unit of 93 square meters (1,000 square feet) coverage, a reference flow of 711 kg is required for an industry-average MCM panel.

Table 2 summarizes the key MCA primary products, substrates, and processes for which LCI data was collected from MCA member facilities.

Primary Product	Metal Substrate of Interest	MCA Primary Processes
Metal Composite Material (MCM) panel	High performance coated 0.020" aluminum cladding skins with thermoplastic core	• Continuous Coil Coating • MCM Sheet Manufacturing • MCM Panel Fabrication

Table 3: MCM Panel, Key Metal Substrates and Processing

System Boundaries

The defined system boundary is a 'cradle-to-gate' LCA, which correlates to the Product Stage modules A1 – A3 as defined by EN 15804:

– A1 - Raw material supply

- A2 - Inbound transport of raw materials to manufacturing facility and transportation between aluminujm coil coating and MCM manufacturing facilities

– A3 - Energy and water input at aluminum coating and MCM manufacturing facilities

A cradle-to-gate assessment excludes all impacts beyond the factory; thus, the reference service life (RSL) is not stated in the document. Figure 3 illustrates the system boundary for the MCM product system.

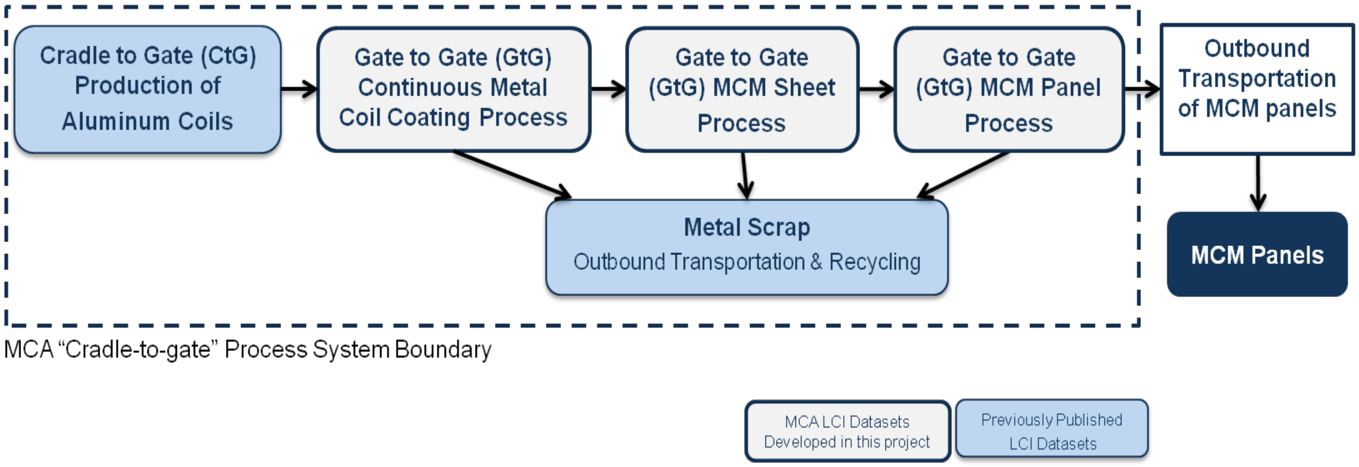


Figure 3: Cradle-to-Gate System Boundaries of MCM panels

Scope

The scoping stage considers all elements identified as contributing to the production of MCM products and then evaluated for their inclusion or exclusion from the LCA study. Table 3 summarizes the elements included and excluded from the cradle-to-gate system boundary for this study.

Included	Excluded
✓ Extraction of input raw materials, transportation and production of the metal sheet used in the product ✓ Energy supply ✓ Overhead (heating, lighting) of manufacturing facilities ✓ In-bound transportation of all materials, intermediate products and fuels ✓ Operation of primary production equipment ✓ Operation of mobile support equipment ✓ Input water (for process and cooling) ✓ Waste and on-site waste water treatment ✓ Manufacture and transport of product packaging ✓ Process ancillary materials (e.g. fasteners) ✓ Waste & emissions ✓ Transportation & recycling of metal sheet scrap	× Maintenance and manufacture of fixed capital equipment × Maintenance of mobile support equipment × Outbound transportation of the main product/process output × Hygiene related water use × Employee commuting × Human labor × Installation and disposal of product

Table 4: System Boundaries Description for Cradle-to-Gate process

Temporal Scope

Primary data collected from MCA member companies for their operational activities are representative for the year 2010. Additional data necessary to model base material production and energy use, etc. was adopted from the GaBi 2011 databases.

Geographic Scope

The geographical coverage for this study is based on North American system boundaries for all processes and products. Whenever North American background data was not readily available, European data was used as a proxy.

Background Data

The LCA model was created using the GaBi 4.4 Software system for life cycle engineering, developed by PE INTERNATIONAL AG. The GaBi 2011 LCI database provides the life cycle inventory data for several of the raw and process materials obtained from the background system. North American background data were used whenever possible; if such data were not available, European data were used as a proxy. The International Aluminum Institute data were used for aluminum sheet background data, with coil coating data obtained from the Metal Construction Association (MCA).

Life Cycle Assessment Results and Analysis

Cradle-to-gate life cycle impact assessment results are shown for both TRACI 2.0 and CML (November 2009) characterization factors. Due to the relative approach of LCA, which is based on a functional unit, these results are relative expressions only and do not predict impacts on category endpoints (such as Human Health or Ecosystem Quality), the exceeding of thresholds, safety margins, or risks.

With respect to global warming potential, no credit was given for the sequestration of biogenic carbon during the growth of biomass used in plant-derived packaging materials. Any carbon temporarily sequestered during the use of bio-based materials is assumed to be re-released to the atmosphere upon their decomposition. Since the lifetime of plant-derived packaging materials is shorter than the 100 year time horizon of this impact category (GWP 100), biogenic carbon was excluded from the global warming potential calculations.

Total Environmental Impacts

TRACI 2.0 Impact Categories	Units	MCA Industry-average
Global warming potential (GWP)	kg CO2-eq.	6.11E003
Ozone depletion potential (ODP)	kg CFC11-eq.	1.45E-4
Acidification potential (AP)	kg H+ mol-eq.	1.85E003
Eutrophication potential (EP)	kg N-eq.	0.852
Smog formation potential (SFP)	kg O3-eq.	292
CML 2001 – November 2009	**Units**	
Global warming potential (GWP)	kg CO2-eq.	6.12E003
Ozone depletion potential (ODP)	kg R11-eq.	2.43E-4
Acidification potential (AP)	kg SO2-eq.	38.6
Eutrophication potential (EP)	kg PO43--eq.	1.68
Photochemical oxidation potential (POCP)	kg Ethene-eq.	3.07
Abiotic depletion potential (ADP) – elements	kg Sb-eq.	0.00255
Abiotic depletion potential (ADP) – fossil fuels	MJ	7.77E004

Table 5: Total life cycle impacts of 93 square meters (1,000 sq ft) of MCM panel, TRACI 2.0 and CML 2001 (Nov 2009)

The following chart shows TRACI 2.0 impact categories by product stages A1 – A3. Two additional inventory metrics of primary energy demand, non-renewable (PED, non-ren.) and primary energy demand, renewable (PED, ren.) are included.

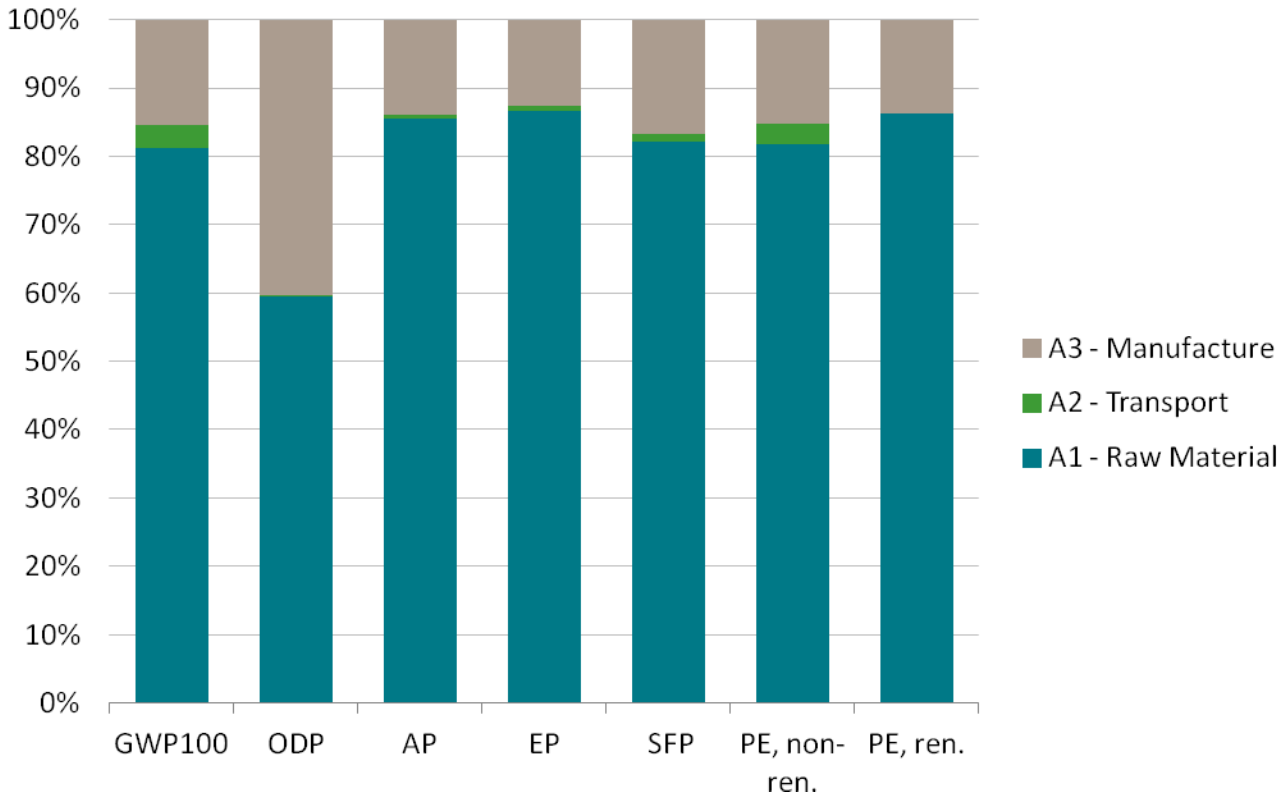


Figure 4: Total life cycle impacts of 93 square meters (1,000 sq ft) of MCM panel, TRACI 2.0 impacts and primary energy inventory

As described in the product description, aluminum sheet and polyethylene core can vary in thickness. Alulminum coil is assumed to be 0.51mm (0.02 inches) by default, however can be 0.25mm (0.01 inches). The polyethylene core is by default 4mm, but can also be 3mm or 6mm. The effect of these thickness variations on the environmental indicators are shown below.

		Aluminum thickness (0.51mm default)	
TRACI 2.0 Impact Categories	**Unit**	**0.25mm (0.01 in)**	**0.51mm (0.02 in)**
Global warming potential	kg CO_2-eq.	4,890	6,120
Ozone depletion potential	kg CFC11-eq.	1.30E-04	1.45E-04
Acidification potential	kg H^+ mol-eq.	1,570	1,850
Eutrophication potential	kg N-eq.	0.729	0.852
Smog formation potential	kg O_3-eq.	238	292

Total Resource Use and Waste Outputs			
Primary Energy, Renewable	MJ	8,560	12,600
Primary Energy, Non-renewable	MJ	75,700	88,800
Secondary Materials	kg	236	363
Water Use	m^3	1,585	1,588
Hazardous Waste	kg	187	361
Non-hazardous Waste	kg	3.16	6.26
Stockpile Goods	kg	4,650	6,110
Radioactive Waste	kg	2.13	2.42
Materials for Recovery	kg	97	121

Table 6: TRACI 2.0 impacts, resource use, and waste outputs of 93 square meters (1,000 sq ft) of MCM panel for different aluminum coil gauges

		Polyethylene core thickness (4mm default)		
TRACI 2.0 Impact Categories	**Unit**	**3mm**	**4mm**	**6mm**
Global warming potential	kg CO_2-eq.	5,950	6,120	6,430
Ozone depletion potential	kg CFC11-eq.	1.42E-04	1.45E-04	1.50E-04
Acidification potential	kg H^+ mol-eq.	1,770	1,850	2,030
Eutrophication potential	kg N-eq.	0.787	0.852	0.983
Smog formation potential	kg O_3-eq.	285	292	305
Total Resource Use and Waste Outputs				
Primary Energy, Renewable	MJ	12,500	12,600	12,600
Primary Energy, Non-renewable	MJ	83,000	88,800	100,000
Secondary Materials	kg	336	363	417
Water Use	m^3	1,587	1,588	1,588
Hazardous Waste	kg	360	361	363
Non-hazardous Waste	kg	6.16	6.26	6.45
Stockpile Goods	kg	6,040	6,110	6,260
Radioactive Waste	kg	2.36	2.42	2.54
Materials for Recovery	kg	121	121	122

Table 7: TRACI 2.0 impacts, resource use, and waste outputs of 93 square meters (1,000 sq ft) of MCM panel for different polyethylene core thicknesses

Energy and Material Resources

Primary energy resources, secondary material, and water use are presented below, subdivided by stages. Since no secondary fuels are associated with MCM panels this category is not shown.

Product Stages	Primary Energy, Renewable [MJ]	Primary Energy, Non-renewable [MJ]	Secondary Material [kg]	Water use [m^3]
Total	1.26E+04	8.88E+04	363	1.59E+03
A1 - Raw Material	1.08E+04	7.26E+04	363	5.75
A2 - Transport	3.84	2.64E+03		7.3
A3 - Manufacture	1.72E+03	1.36E+04		1.57E+03

Table 8: Energy and materials resource use of 93 square meters (1,000 sq ft) of MCM panels

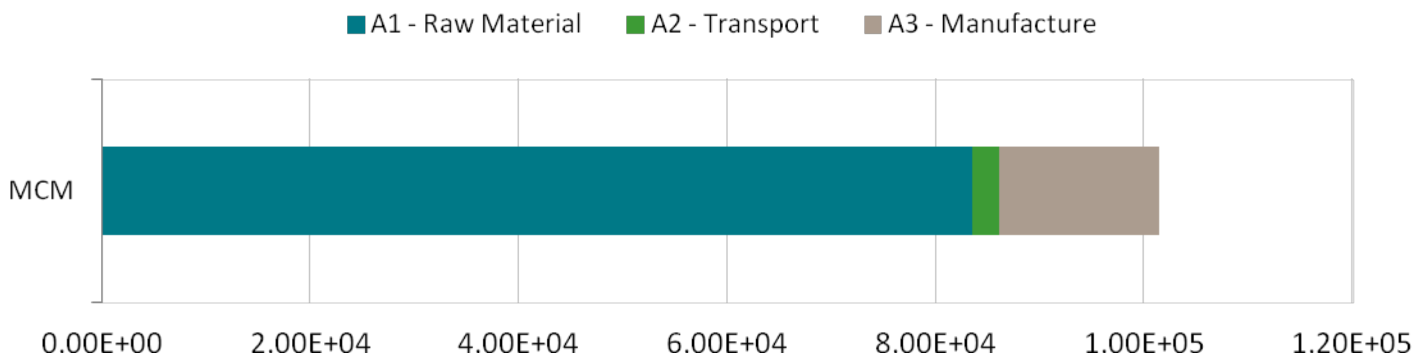


Figure 5: Primary energy demand by product stages A1 - A3

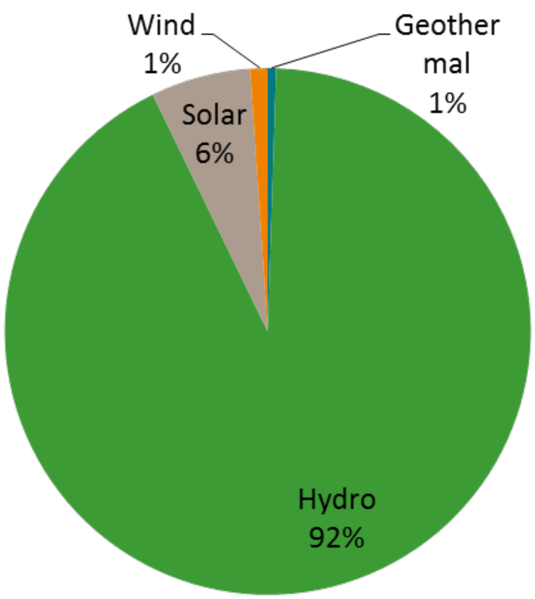


Figure 6: Renewable primary energy demand by fuel type

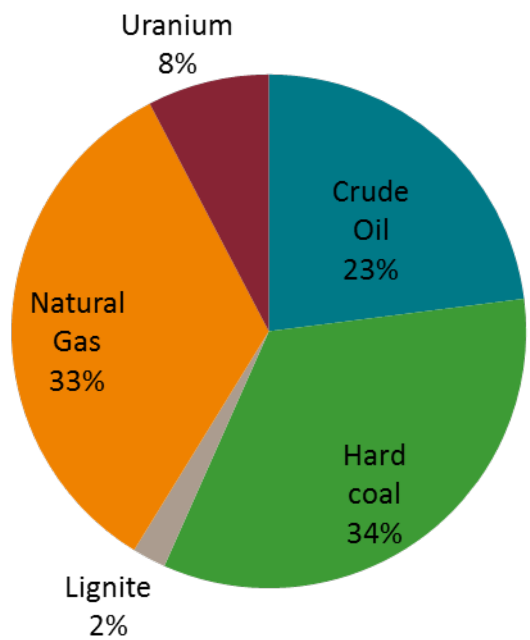


Figure 7: Non-renewable primary energy demand

Renewable primary energy is also broken down into primary energy resources used as raw materials and primary energy resources excluding resources used as raw materials. Since consumption of renewable primary energy resources used as raw materials is exclusively due to packaging materials and takes place during raw materials supply, this category is not broken down by life cycle stage.

	Renewable primary energy used as raw materials [MJ]	Renewable primary energy, excluding those used as raw materials [MJ]	Renewable primary energy, total [MJ]
MCA MCM panels	2.35E003	1.02E004	1.26E004

Table 9: Total renewable energy used as raw material and as energy source

Waste and Output Flows

Additional environmental information, including hazardous, non-hazardous, and radioactive waste disposed; materials for recycling; and materials for energy recovery are shown below.

Since no reused components or exported energy are associated with MCM panel's life cycle, these categories are excluded. Additionally, waste is assumed to be sent to landfill so no materials are available for energy recovery.

	MCA
Hazardous Waste [kg]	363
Non-Hazardous Waste [kg]	42.7
Stockpile goods [kg]	6.11E003
Radioactive Waste [kg]	2.42
Materials for Recovery [kg]	114

Table 10: Waste and output flows per functional unit

Interpretation

The above results represent a cradle-to-gate assessment of an industry-average profile of metal composite material (MCM) panels produced by Metal Construction Association (MCA) member companies. The study was conducted for the declared unit of coverage of 93 square meters (1,000 square feet) with metal panel products. Because of the cradle-to-gate system boundary (stages A1 – A3), impacts beyond manufacturing, such as delivery to construction site, installation, and disposal at the end of useful life, are not considered.

The global warming potential impact is dominated by stages A1 (materials) and A3 (manufacturing). In the raw material stage (A1), aluminum sheet production is the major contributor at approximately 69% of the global warming impact of the cradle-to-gate system. Auxiliary material inputs, manufacturing process, and transportation comprise the additional 31%. The transportation stage (A2) included all known inbound transportation as well as delivery of coated aluminum coil to MCM panel manufacturing facilities. Delivery to the construction site is excluded in this EPD. The contribution to global warming from stage A2 is marginal (3%) and originate from fuel combustion.

The manufacturing stage (A3) is a significant contributor to overall climate change impacts albeit considerably lower than aluminum (15%). Electricity generation and natural gas combustion comprise the climate change impacts that originate at the manufacturing stage.

With respect to the other environmental indicators, raw materials dominate over 80%. Of the raw materials, extruded aluminum comprise the majority of the total impacts for all selected impacts other than ozone depletion. For ozone depletion, aluminum production is not the main contributor, but is significant nonetheless with 34% of the total impacts. Upstream emissions of halogenated compounds from raw materials and electricity generation for manufacturing comprise the majority of ozone depletion impacts. Specifically, fluororpolymer, used in the coil coating process, is a significant contributor of the halogenated compound 1,1,1-Trichloroethane, which is a potent ozone-depleting substance. Electricity generation also emit a multitude of halogenated compounds which contribute to ozone depetion.

While raw materials dominate the total eutrophication potential impacts (87%), aluminum production comprise just 53% of the total eutrophication impacts. The additional 34% of eutrophication impacts originate from the processing of secondary polyethylene for incorporation into the polyethylene core of the panel. The *A3 – Manufacturing* stage is also a significant contributor at 13%. The manufacturing impacts largely originate from the energy generation required to produce the MCM panels. This is largely evident due to airborne nitrogen oxides (NOx) being a large portion of the eutrophication impacts at manufacturing.

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