ENVIRONMENTAL PRODUCT DECLARATION

PRIMARY STRUCTURAL STEEL FRAME COMPONENTS

METAL BUILDING MANUFACTURERS ASSOCIATION
INDUSTRY-WIDE EPD

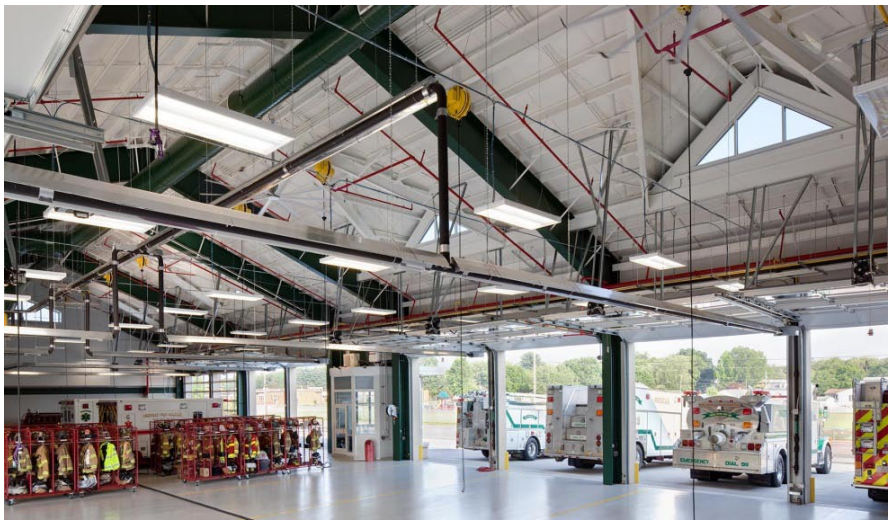

Illustration of primary structural steel framing (columns/beams) supporting secondary structural steel framing members (girts/purlins) with metal roof panel (standing seam or through fastened) and metal wall panel (through fastened) cladding.

Note: Primary structural steel framing featured in illustration above.

The Metal Building Manufacturers Association (MBMA), Cleveland, Ohio, was founded in 1956. Since that time, MBMA and its manufacturer members have worked together as partners to further its mission: to conduct research, to help advance building codes and standards, and to educate the construction community. MBMA's passion is to support a strong, sustainable metal building systems industry that meets the needs of building owners and society.

MBMA's members are deeply committed to the social, environmental and economic principles of sustainability. This pledge is aimed at improving the quality of life for everyone now without compromising the ability of future generations to meet their needs.

This industry-average EPD includes only the *Primary Structural Steel Frame Components* used in metal building systems. These components serve as the load carrying columns and beams of a metal building system.

Separate EPDs are available that address the secondary structural steel framing and the exterior metal roof and wall panel cladding used to form a complete metal building system.

This industry-average EPD is representative of the MBMA Metal Building Systems members.

A complete list of MBMA Building Systems Members is available at www.mbma.com.

ENVIRONMENTAL PRODUCT DECLARATION

METAL BUILDING MANUFACTURERS ASSOCIATION®

Primary Structural Steel Frame Components
Industry-Wide EPD

According to ISO 14025 & ISO 21930

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 Building Manufacturers Association
DECLARATION NUMBER	4786774590.101.1
DECLARED PRODUCT	Primary Structural Steel Frame Components
REFERENCE PCR	SCS Global Services. (2015). North American Product Category Rule for Designated Steel Construction Products. V1.0
DATE OF ISSUE	January 20, 2016
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:	PCR Review Panel
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Wade Stout, UL Environment
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by: The Athena Sustainable Materials Institute	
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas Gloria, Industrial Ecology Consultants

This EPD conforms with ISO 21930:2007

Environment

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Primary Structural Steel Frame Components
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Metal Building Manufacturers Association

The Metal Building Manufacturers Association (www.mbma.com) is a trade association established in 1956. The mission of the MBMA is to promote the design and construction of metal building systems in the low-rise, non-residential building marketplace. Metal building systems are commonly used to provide warehouses, manufacturing, office, retail, community, and religious buildings. The popularity of metal building systems has been driven by the design and aesthetic flexibility, consistency and speed of construction. MBMA building systems members fabricate primary rigid frames, secondary framing and component products, such as metal roof and wall panel cladding systems.

Ownership of Industry-Wide EPD

This Industry-Wide EPD was developed for use by MBMA Building Systems Member companies, a complete list of can be found here: http://www.mbma.com/System_Members.asp.

Product Description

Primary structural steel frames used in a metal building system are built-up using three welded steel plates to form an "I" section. The three plates include the uniform width of the two flanges (commonly derived from bar stock) and one tapered web section (commonly derived from hot-rolled steel plate). The flanges are welded to the tapered web to form the tapered web I-section for the beam and columns, typically by an automatic welder. End plates with bolt holes are welded to the ends of the individual frame sections by a certified welder, along with other weldments and accessories. The primary frames are often coated with a rust-inhibiting primer or painted to meet project specifications. Once the columns and roof beams have been fabricated, completed with holes in webs and flanges for attachment of secondary structural members and bracing, the products are delivered to the job site.

Flexible Design

Metal building manufacturers custom design the primary structural steel frame components in accordance with the order documents. Order documents are based on the specified building code, loading conditions and serviceability requirements. The primary frame will consist of two exterior columns and a rafter spanning the width of the building. Primary frames can also feature straight columns when the end use warrants such a design (for example, in office or retail spaces with finished drywall interiors). Primary frame rafters can span over 61 m (200 ft), with a height that can exceed 18.3 m (60 ft) with frames commonly spaced from 6.1 m (20 ft) to 12.2 m (40 ft) apart. Interior columns can be used to support rafters for buildings wider than 200 ft, or to create a more economical design where the interior building layout allows.

Certified welder adding metal accessories to primary structural steel frame.

Environment

Primary Structural Steel Frame Components
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Less Material

Most often, the weight of steel used in a metal building framing system is significantly less than hot-rolled steel frames due to the structural optimization of the tapered web design. By tapering the web, material is used where it is needed for strength and stability. Traditional hot-rolled steel frame designs and other competing materials do not take advantage of this material optimization. This weight savings inherently reduces the environmental impact of metal buildings when compared to traditional framing systems. Life cycle assessment software, such as the Athena Impact Estimator, can be used to confirm environmental and material savings.

Metal Building System - EPD Family

A complete metal building system is made up of primary structural steel frames (covered by this EPD), a secondary framing system (covered by the *Secondary Structural Steel Frame Component* EPD), and metal roof and wall panel cladding (covered by the *Rolled Formed Metal Wall and Roof Panels* EPD). All three EPDs may be found on the UL Environmental website available here: http://productguide.ulenvironment.com.

Range of Applications

Metal buildings are used for low-rise, non-residential construction end uses. This includes smaller building designs for health care, religious, office, education and retail facilities, up to larger building designs for warehouses, aircraft hangars, manufacturing and sports facilities. These and other building end uses are shown below.

Healthcare

Automotive

Recreation

Religious

Aviation

Retail

Office

Agriculture

Storage / Warehouse

Environment

METAL BUILDING MANUFACTURERS ASSOCIATION®

Primary Structural Steel Frame Components
Industry-Wide EPD

According to ISO 14025 & ISO 21930

Material Content and Fabrication

Table 1 lists the primary material inputs and the fabrication processes used in the production of primary structural steel frame components.

Hot-rolled plate or bar is commonly used for flanges, webs, end plates and base plates. The typical product thickness used in a metal building manufacturing plate is between 3 mm (0.125 in) to 50 mm (2.0 in). Steel sections, such as pipe, angles, structural channels and wide-flange beams, are pre-formed or shaped prior to arriving at the metal building manufacturing plant in order to be cut to size. Interior columns may be either pipe columns or made out of wide-flange I-beams. Bracing may utilize angles connected to the structure and structural channels may be used for spandrels.

For the production of primary structural frame components, the primary semi-finished steel inputs are hot-rolled plate (80%), bar (10%), and sections (10%). The semi-finished steel input is sourced from both Electric Arc Furnace (EAF) and Basic Oxygen Furnace (BOF) routes, 73% and 27%, respectively and varies in thickness from 1.8 mm (0.071 in) to 38.1 mm (1.5 in). For every 0.9072 metric tonne (1 short ton) of primary frame component produced, a total of 0.979 metric tonnes (1.079 short tons) of steel is required; this yields a 7.9% scrap rate for the processes leading to the production of primary structural frame components.

Table 1: Primary Material Inputs and Fabrication Processes

MBMA Product
Primary Structural Steel Frame Components
Input Materials
Hot-rolled plate, hot-rolled bar and sections of varying thicknesses
Primary Processes
Plate/bar/sections shearing, punching, splicing, tack welding, flange welding, finish welding & grinding, painting, touch-up painting (if applicable) and packaging.

Product Codes and Standards

The products considered in this EPD meet or exceed one or more of the following codes, specifications and standards:

Model Codes and Standards
International Building Code
State or Locally Adopted Code
ASCE/SEI 7 - Minimum Design Loads for Buildings and Other Structures
UL - Building Material Directory
UL - Fire Resistance Directory
Common Industry Standards
MBMA Metal Building Systems Manual
International Accreditation Service (IAS)
Accreditation Criteria 472 (AC472) - Accreditation Criteria for Inspection Programs for Manufacturers of Metal Building Systems

METAL BUILDING MANUFACTURERS ASSOCIATION®

Primary Structural Steel Frame Components
Industry-Wide EPD

According to ISO 14025 & ISO 21930

Specifications and Standards
American Institute for Steel Construction (AISC)
AISC 360 - Specification for Structural Steel Buildings
AISC 341 - Seismic Provisions for Structural Steel Buildings (when appropriate)
AISC 303 - Code of Standard Practice for Steel Buildings and Bridges
AISC Design Guide 3 - Serviceability Design Considerations for Steel Buildings
American Welding Society (AWS)
AWS D1.1 / D1.1M - Structural Welding Code - Steel
AWS D1.3 / D1.3M - Structural Welding Code - Sheet Steel
ASTM International (ASTM)
ASTM A6/A6M - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A36/A36M – Standard Specification for Carbon Structural Steel
ASTM A123/A123M – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A500/A500M – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A529/A529M - Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality
ASTM A572/A572M - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A992/A992M - Standard Specification for Structural Steel Shapes
ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength, Low-Alloy and High-Strength Low-Alloy with Improved Formability and Ultra-High Strength
ASTM A1018/A1018M - Standard Specification for Steel, Sheet and Strip, Heavy Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawings, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM F1554 – Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
ASTM F3125 – Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions
Research Council on Structural Connections (RCSC)
Specification for Structural Joints Using High-Strength Bolts
The Society for Protective Coatings (SPSC)
SSPC Paint-15 – Steel Joist Shop Primer / Metal Building Primer

Quality Control

Metal building primary structural steel frames, secondary framing and metal wall and roof cladding are all custom-fabricated in a factory following strict quality assurance standards. Quality control is a major focus for all MBMA metal building manufacturers. MBMA worked with the International Accreditation Service (IAS), a subsidiary of the International Code Council (ICC), to develop the Accreditation Criteria for Inspection Programs for Manufacturers of Metal Building Systems (AC472). This comprehensive, third-party accreditation program is based on the special inspection requirements outlined in the International Building Code (IBC) Chapter 17. This program provides code officials with a means to approve the inspection programs of manufacturers involved in the fabrication of a metal

building system. It provides building owners and specifiers with an extra level of assurance in knowing that the metal building system manufacturer's engineering, order, design and fabrication processes all conform to high standards. All MBMA member companies are committed to quality control and adhere to the strict criteria of the AC472 program.

Transportation

As noted in the MBMA LCA Final Report, both the average transportation of raw materials to production facilities by truck, rail and ocean freighter, as well as the transport of manufacturing wastes, to their end of waste state are included. The mining locations and transportation distances of raw material extraction and origin are not specified in this EPD, since this EPD considered information from multiple organizations deemed to be representative of the market.

Underlying Life Cycle Assessment

Declared Unit

The declared unit is one metric tonne (1,000 kg); optionally the results of the EPD are also reported on a short ton (2,000 lbs) basis, as shown in Table 2.

Table 2: Declared Unit

Name	Quantity	Required Unit	Quantity	Optional Unit
Declared Unit	1	metric tonne	1	short ton
Density	7,833	kg/m^3	489	lbs/ft^3

System Boundary

The underlying LCA product system boundary was limited to a cradle-to-gate analysis (as shown in Figure 1) of the production stage – Modules A1-A3 as depicted in Table 3 below. As per the scope of the PCR, construction, use and end-of-life are excluded from the product system boundary. The optional Module D is also excluded. No reference service life is specified for primary structural steel frames.

***Foreground data*:** Primary gate-to-gate LCI manufacturing and input transportation data was collected for primary structural steel frames production for the reference year 2008, which was deemed a representative production year for the industry. This data was collected from 10 MBMA member companies from three discrete regions (East, Midwest and Western U.S.), to represent the U.S. industry-average technology mix. These 10 plants produce primary structural steel frames and were deemed representative of the specific processes and the MBMA's membership. The MBMA represents 41 different production facilities; as a result, the plant sample represents about 25% of all establishments. The 10 plants were combined on a production-weighted basis to provide a weighted average profile for U.S. production.

***Background data*:** Background data to support the LCA of primary frames was obtained from 2013 North American LCI profiles of semi-finished steel products (hot-rolled plate, hot-rolled bar and sections) and various proprietary and commercial databases as documented in the project background report. This data is less than 10 years old.

***Cut-off criteria*:** All flow data reported by the participating MBMA facilities were included for the relevant process and product models. None of the reported flow data was excluded based on the cut-off criteria as specified in the PCR.

Figure 1: Cradle-to-Gate System Boundary

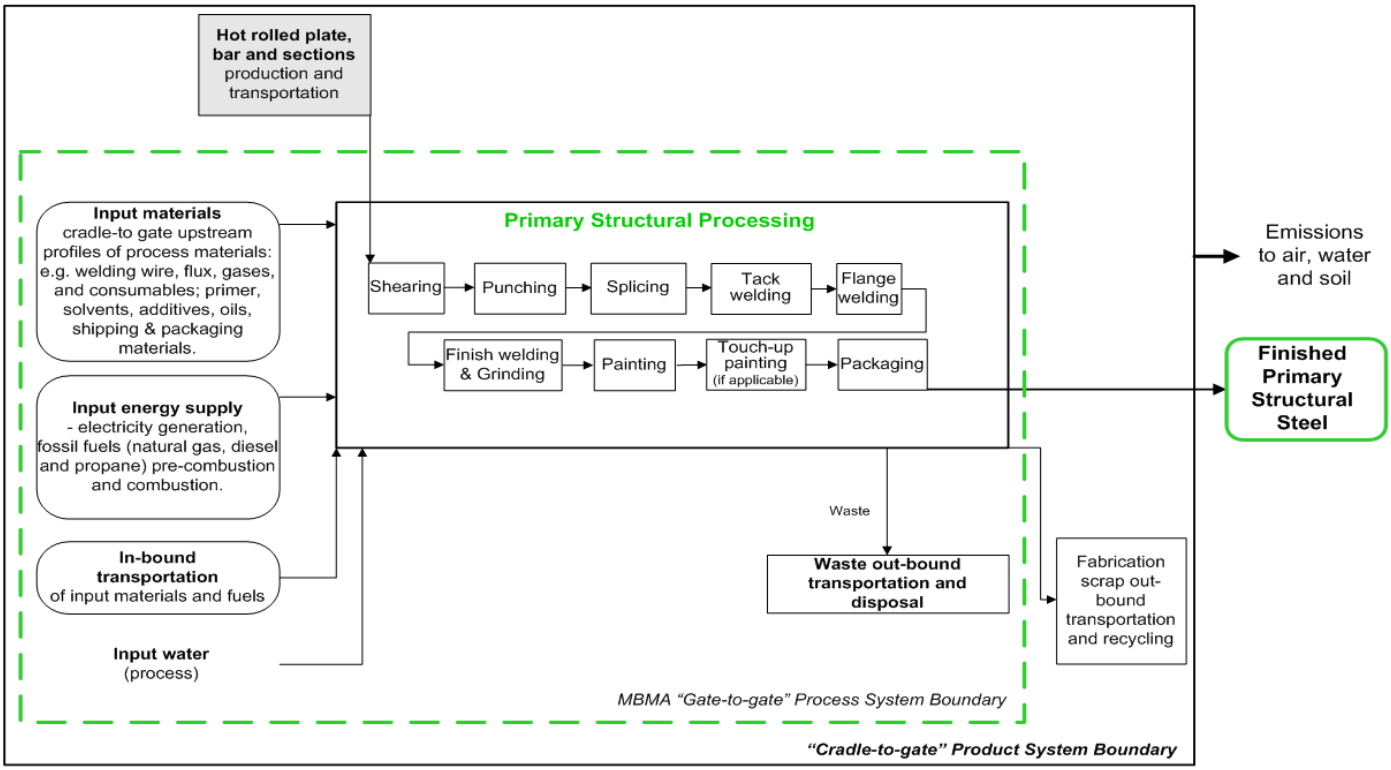

Table 3: Systems Boundaries

Product Stage			Construction Stage		Use Stage					End-of-Life Stage				Benefits and Loads Beyond System Boundary
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
RAW MATERIAL SUPPLY	TRANSPORT	MANUFACTURING	TRANSPORT	INSTALLATION	USE	MAINTENANCE	REPAIR	REPLACEMENT	REFURBISHMENT	DE-CONSTRUCTION	TRANSPORT	WASTE PROCESSING	DISPOSAL	REUSE, RECOVERY AND RECYCLING POTENTIAL
X	X	X	MND		MND					MND				MND

X = Included in LCA; **MND** = Module is not declared

Data Quality

Representativeness:

- Time related coverage of the MBMA *primary* data: 2008.
- *Secondary* data: the most appropriate LCI datasets were used as found in the U.S. LCI (adjusted) Database, U.S. adjusted ecoinvent v.2.2 database, 2011, and the World Steel Association N. American LCI database (2013, 2015) – excluding end-of-life recycling. No secondary data sources are more than 10 years old.
- Geographical coverage: the geographical coverage is the U.S.
- Technological coverage: typical or average.

The LCI data is deemed representative for the production year and the industry and adequately reflects North American conditions and prevailing technologies.

Consistency: To ensure data consistency, all primary data was collected with the same level of detail, while all background data was consistently applied.

Reproducibility: Through disclosure of input and output flow data, selected datasets and methodological approaches as described in the project background report, a third-party should be able to demonstrate results similar to this EPD using similar and consistent data sources and modeling approaches.

Uncertainty: Due to the consistency of the modeling approach and the representativeness of both primary and secondary LCI data, the uncertainty surrounding the results is considered to be low.

Allocation

Multiple product output: The MBMA plant participants produce an array of products used in the structure and envelope of metal buildings and, as such, allocation across shared processes was applied. “Mass” was deemed as the most appropriate physical parameter for allocation of the total inputs/outputs of the plant production system between primary frames, secondary frames, and roof and wall panel manufacturing lines. Data collection participants provided input and output data specific to each of four selected manufacturing processes. Then inputs/outputs were allocated over the total outputs of panel or framing on a mass basis.

Semi-finished steel products are integral commodities used in the production of upstream and are the primary MBMA metal building products. As a result, current peer-reviewed LCI data according to the ISO 14040 series for these metal products generated by the World Steel Association (WSA) was applied in this LCA study. With regard to allocation rules applied for the upstream semi-finished steel products, WSA allocation rules as described in Section 4.6, Methodological Details, “WSA 2011: Methodology Report, Life Cycle Inventory Study for Steel Products,” were deemed appropriate.

Life Cycle Assessment Results

Environmental Impacts, Resource Use, and Other Information

Life cycle impact assessment (LCIA) results are presented for the product stage for both a metric tonne and short ton of a primary structural frame, as shown in Table 4. Table 5 presents the product stage resource use consumption results for both a metric tonne and short ton of a primary structural frame. Table 6 presents the product stage waste flows by category and output flows as per the PCR for a metric tonne and short ton of a primary structural frame.

Table 4: LCIA Results Per Metric Tonne and Short Ton

Parameters Describing Environmental Impacts		Per Metric Tonne		Per Short Ton	
Abbreviation	**Product Stage**	**A1 to A3**	**Unit**	**A1 to A3**	**Unit**
GWP	Global warming potential	1489	kg CO_2 eq	1350.8	kg CO_2 eq
ODP	Depletion potential of the stratospheric ozone layer	5E-06	kg CFC-11 eq	4.5E-06	kg CFC-11 eq
AP	Acidification potential	5.8	kg SO_2 eq	5.2	kg SO_2 eq
EP	Eutrophication potential	0.259	kg N eq	0.235	kg N eq
POCP	Photochemical ozone creation potential	81.8	kg O_3 eq	74.2	kg O_3 eq
ADP-elements	Abiotic depletion potential for non-fossil resources[1]	1.96E-04	kg Sb eq	1.78E-04	kg Sb eq
ADP- fossil fuels	Abiotic depletion potential for fossil resources	19,769	MJ, LHV	1.7E+07	BTU, LHV

[1] This indicator is based on assumptions regarding current reserves estimates. Users should use caution when interpreting results because there is insufficient information on which indicator is best for assessing the depletion of abiotic resources.

Table 5: Energy and Material Resource Use Results Per Metric Tonne and Short Ton

Parameters Describing Resource Use		Per Metric Tonne		Per Short Ton	
Abbreviation	**Product Stage**	**A1 to A3**	**Unit**	**A1 to A3**	**Unit**
PERE	Renewable primary energy as energy carrier	54	MJ, LVH	4.7E+04	BTU, LHV
PERM	Renewable primary energy resources as material utilization	0	MJ, LVH	0	BTU, LHV
PERT	Total use of renewable primary energy resources	54	MJ, LVH	4.7E+04	BTU, LHV
PENRE	Non-renewable primary energy as energy carrier	19,769	MJ, LVH	1.7E+07	BTU, LHV
PENRM	Non-renewable primary energy as material utilization	0	MJ, LVH	0	BTU, LHV
PENRT	Total use of non-renewable primary energy resources	19,769	MJ, LVH	1.7E+07	BTU, LHV
SM	Use of secondary material	904	kg	0.904	short ton
RSF	Use of renewable secondary fuels	0	MJ, LVH	0	BTU, LHV
NRSF	Use of non-renewable secondary fuels	0	MJ, LVH	0	BTU, LHV
FW	Net use of fresh water	6.3	m^3	1.5E+03	gallons

Table 6: Waste Category and Output Flow Results Per Metric Tonne and Short Ton

Other environmental information describing different waste categories and output flows		Per Metric Tonne		Per Short Ton	
Abbreviation	**Product Stage**	**A1 to A3**	**Unit**	**A1 to A3**	**Unit**
HWD	Hazardous waste disposed	30.5	kg	0.031	short ton
NHWD	Non hazardous waste disposed	10.7	kg	0.011	short ton
RWD	Radioactive waste disposed	0.60	kg	0.001	short ton
WR	Waste for recovery	20.3	kg	0.020	short ton
CRU	Components for re-use	0	kg	0	short ton
MFR	Materials for recycling	79	kg	0.079	short ton
MER	Materials for energy recovery	0	kg	0	short ton
EE	Exported energy	0	MJ, per energy carrier	0	BTU per energy carrier

Contribution Summary by Information Module

Figure 2 below provides a percentage contribution summary by information module (A1 – raw material supply, A2 – transport and A3 – manufacturing) for all non-zero category indicators, resource use metrics, and waste and output flows. NOTE: the recycling of fabrication scrap results in an environmental benefit for FW, HWD and ADP-elements as it avoids the primary production of semi-finished steel products. This "avoidance" result shall not be interpreted as a "reversal" of environmental burdens elsewhere due to increased production of primary frame components.

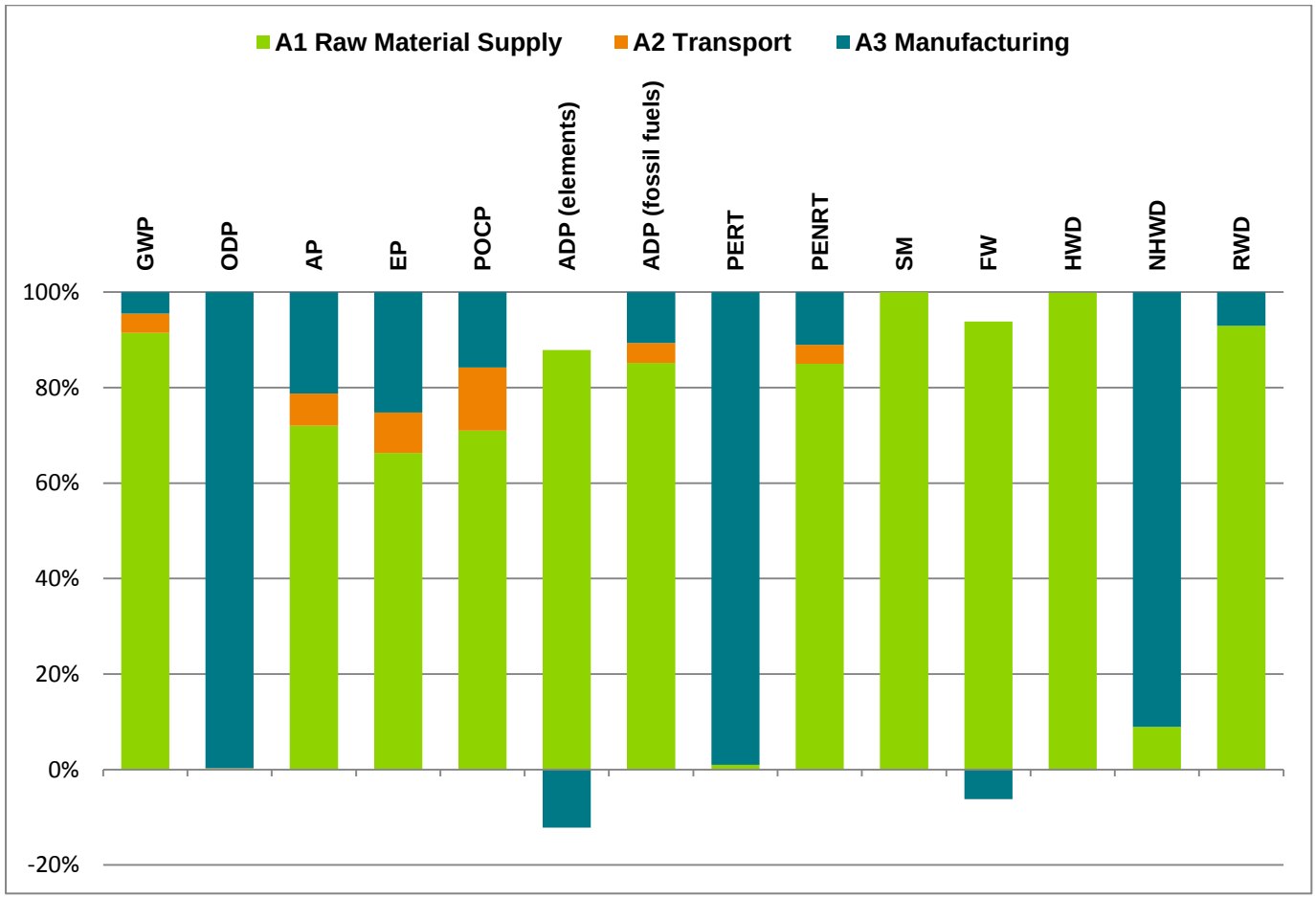

Figure 2: Percent Contribution by Product Stage Information Modules (A1, A2 and A3)

Primary Structural Steel Frame Components
Industry-Wide EPD

According to ISO 14025 & ISO 21930

Disclaimer

This Environmental Product Declaration (EPD) conforms to ISO 14025, ISO 14040, ISO 14044, and ISO 21930.

Scope of Results Reported: The PCR requires the reporting of a limited set of LCIA indicators and resource use metrics; therefore, there may be relevant environmental impacts beyond those disclosed by this EPD. This EPD does not indicate that any environmental or social performance benchmarks are met nor thresholds exceeded.

Accuracy of Results: This EPD has been developed in accordance with the PCR applicable for the identified product following the principles, requirements and guidelines of the ISO 14025, ISO 14040, ISO 14044, and ISO 21930 standards as well as ULE's general program instructions. The results in this EPD are estimations of potential impacts. The accuracy of results in different EPDs may vary as a result of value choices, background data assumptions and quality of data collected.

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. Such comparisons can be inaccurate and could lead to the erroneous selection of materials or products which are higher impact, at least in some impact categories. Any comparison of EPDs shall be subject to the requirements of ISO 21930. For comparison of EPDs that report different module scopes, such that one EPD includes Module D and the other does not, the comparison shall only be made on the basis of Modules A1, A2 and A3. Additionally, when Module D is included in the EPDs being compared, all EPDs must use the same methodology for calculation of Module D values.

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