Life Cycle Assessment of Commercial Steel Doors and Steel Frames

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Steel Door Institute

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1. Goal of the Study

This report presents the findings of the Life Cycle Assessment (LCA) conducted by SCS Global Services (SCS) for the Steel Door Institute (henceforth referred to as "SDI"). The scope includes two product systems: 1) commercial steel doors and 2) commercial steel frames, produced by five separate manufacturers.

The goals of the study include two primary objectives:

1. To assess the potential environmental impacts, use of resources, and generation of waste for the two product systems on a 'cradle-to-gate' basis – from extraction of raw materials and components, upstream transportation, through facility use – for the production of the steel doors and frames.
2. To serve as the basis for preparing two industry-wide Environmental Product Declarations (EPDs) conformant to the UL Product Category Rule for Commercial Steel Doors and/or Steel Frames[1] (henceforth referred to as "the PCR"), which is consistent and complies with the UL PCR Part A[2], ISO-21930[3], ISO-14025[4], ISO-14040[5], and ISO-14044[6].

Life Cycle Impact Assessment (LCIA) results are reported using the indicators prescribed by the PCR and based on the IPCC AR5 and TRACI 2.1 characterization methodologies. It should be noted that the PCR does not require reporting of all environmentally relevant impacts, such as impacts to ecosystems, key species habitats, or water resources. The LCA study scope, methodology, data sources, assumptions, and limitations, used to calculate final indicator results developed for the EPD are described in this report. The following life cycle stages are included: raw material extraction and processing, transport to Steelmaking and steel coil production (A1); transportation to the Steel Door Institute facilities (A2); and product manufacture at the Steel Door Institute facilities (A3).

The intended audience for this technical LCA report includes Steel Door Institute, the participating members of the study, the critical reviewer, the EPD verifier, and other LCA practitioners or technical audiences with which SDI chooses to share the report. Results presented are not intended for use in

[1] Product Category Rule for Building-Related Products and Services. Part B: Commercial Steel Doors and Steel Frames. UL 10010-27, version 2.0.
[2] PCR for Building-Related Products and Services - Part A: LCA Calculation Rules and Report Requirements, UL v.4.0, 2022
[3] ISO-21930: 2017 Sustainability in building construction – Environmental declaration of building products
[4] ISO-14025:2006 Environmental labels and declarations – Type III environmental declarations – Principles and procedures
[5] ISO-14040: 2006 Environmental management – Life cycle assessment – Principles and framework
[6] ISO-14044: 2006 Environmental management – Life Cycle Assessment – Requirements and guidelines

comparative assertions. This report has been critically reviewed by an external LCA practitioner independent of the project for conformance to the PCR, ISO 14044 and ISO 21930:2017.

2. Study Parameters

2.1 Functions of the Product System and Function Unit

In conformance with the requirements of the PCR, the products in this LCA study represent a production-weighted average of steel door and frame, respectively, each produced at the plants of the five participating companies. The steel door and steel frame in this LCA study are designed and intended to be used for commercial applications. An example image of each product in this LCA study are provided below.

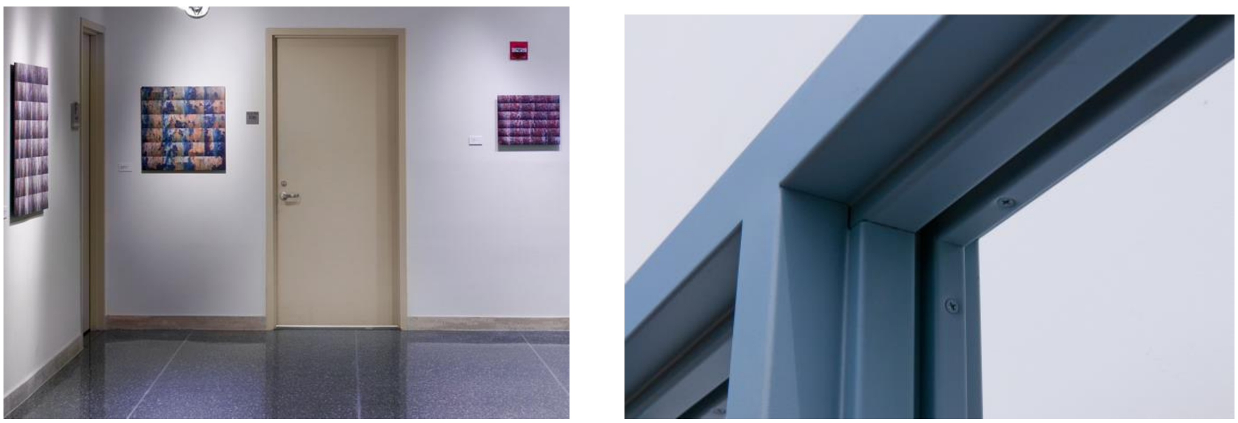

Figure 1. Example image of an installed commercial steel door (left) and steel frame (right).

2.2 System Boundary

The system under study includes the extraction of raw materials and processing, including all activities and transport necessary for the production and fabrication of the Steel Products. Capital goods and infrastructure are excluded from the product system boundary.

The cradle-to-gate system boundary includes all unit processes contributing measurably to the category indicator results and is represented by the product stage, which is comprised of three information modules (A1, A2, A3) in accordance with the PCR. In accordance with ISO 21930, the polluter-pays principle is applied in which processes relevant to waste processing are assigned to the product system that generates the waste until the system boundary between product systems is reached.

The information module approach (described in ISO 21930:2017) has been adopted by the PCR to define the product life cycle stages and is described relative to the LCA study in Table 1. The deletion of life cycle stages, processes, inputs, or outputs is permitted since it is not expected to significantly change the overall conclusions of the study.

Table 1. Life cycle stages included in the system boundary. MND = Module Not Declared.

Module	Module description from the PCR	Included in System Boundary
A1	Raw material extraction and processing, including but not limited to the recovery or extraction and processing of feedstock materials and including all activities necessary for the reprocessing steel scrap. Transportation to the melt shop. Steelmaking, casting, cold rolling, and coating. Raw material and processing of all other product components and ancillary materials.	✓
A2	Transportation of upstream materials, including steel, polystyrene, paint, and adhesives to the Steel Door Institute facilities	✓
A3	Steel door and frame manufacture at the participant manufacturing facilities	✓
A4	Transport (to the building site)	MND
A5	Construction-installation process	MND
B1-B5	Use stage, including maintenance, repair, replacement, and refurbishment	MND
B6	Operational energy use	MND
B7	Operational water use	MND
C1	Deconstruction, demolition	MND
C2	Transport (to waste processing)	MND
C3	Waste processing	MND
C4	Disposal	MND
D	Reuse-recovery-recycling potential	MND

The major individual unit processes that make up each module of the product stage shown in Figure 2.

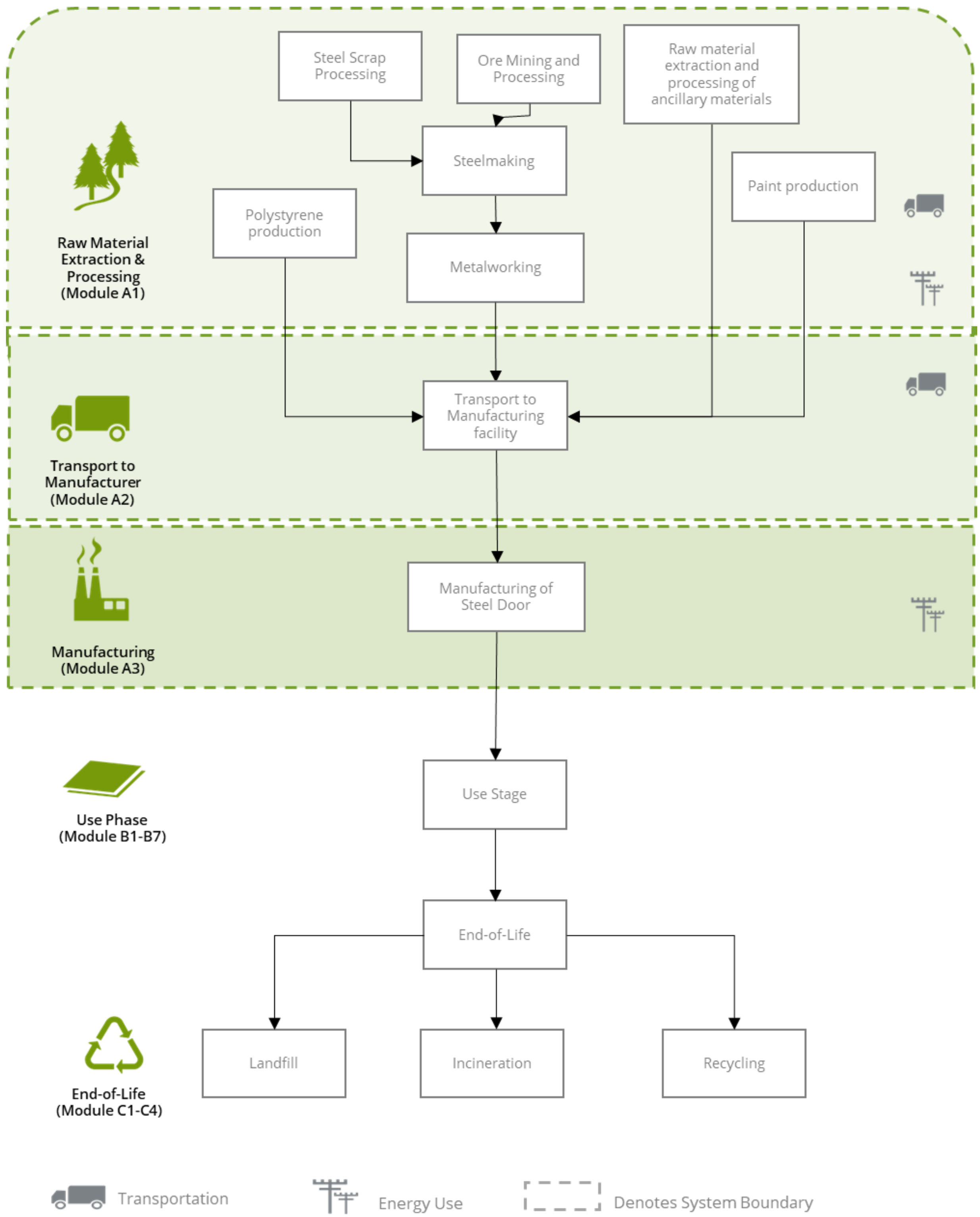

Figure 2. Flow diagram representing the major processes in the product stages of the steel door and frame.

2.3 Product Descriptions

The technical specifications for the representative industry wide products in this LCA study are listed below. The technical information and the corresponding documents can be found on the Steel Door Institute website[7].

- ANSI/SDI A250.8-2023
- Includes a prime-painted finish, conforming to ANSI/SDI A250.10-2020
- Steady-state thermal transmittance and performance rating based on SDI-113-13 Standard Practice for Determining the Steady-State Thermal Transmittance of Steel Door and Frame Assemblies
- Air Leakage rate based on ANSI/UL 1784-2001 Air Leakage Test of Door Assemblies
- Indoor-outdoor sound attenuation according to ASTM E1332 Standard Classification for Rating Outdoor-Indoor Sound Attenuation
- Deflection/loading based on ASTM E330 Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Uniform Static Air Pressure Difference

The average material composition and average recycled content of each product and its packaging in this LCA study are presented in Table 2 and Table 3 below. The material composition values represent an average, described in Section 3.1, and are rounded to three significant figures.

EPDs produced from the LCA report do not contain hazardous substances, as classified by the Resource Conservation and Recovery Act (RCRA).

2.3.1 Commercial Steel Door

The representative industry wide commercial steel door in this LCA study is based on a 3’ x 7’ (0.91 m x 2.1 m) flush panel 18-gauge Heavy Duty (level 2) steel door with a polystyrene core conforming to ANSI/SDI A250.8-2023. Additionally, the final commercial steel door includes a prime painted finish conforming to ANSI A250.10-2020. Closer reinforcement, 4.5” hinge preps, and 161 mortise hardware reinforcement are included, however, the hardware itself (e.g., hinges or exit devices) are not include. The applicable UNSPSC codes for the steel doors is 30171505 Metal doors.

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[7] https://steeldoor.org/

Table 2. Material composition of the average steel door and its packaging.

Material	Value (kg)	Value (lbs)	Percent of total
Steel	38.9	85.6	92%
Polystyrene	2.20	4.84	5%
Adhesive	0.37	0.82	1%
Primer (Paint)	0.66	1.46	2%
Total	**42.1**	**92.7**	**100%**
Packaging			
Cardboard	0.320	0.705	40%
Strapping	0.0142	0.0314	2%
Pallet	0.457	1.01	58%
Total	**0.792**	**1.74**	**100%**

2.3.2 Commercial Steel Frame

The representative industry wide commercial steel frame in this LCA study is based on a 5-3/4” (146 mm) 16-gauge steel frame conforming to ANSI/SDI A250.8-2023. The final commercial steel frame includes a prime painted finish conforming to ANSI A250.10-2020. Hardware, such as hinges, are not included. The applicable UNSPSC codes for the steel frames is 30171507 Door frames.

Table 3. Material composition of the average steel frame and its packaging.

Material	Value (kg)	Value (lb)	Percent of total
Steel	20.4	44.9	96%
Prime Paint	0.93	2.05	4%
Total	**21.3**	**46.9**	**100%**
Packaging			
Strapping	0.139	0.306	100%
Total	**0.139**	**0.306**	**100%**

The steel door and frame products under normal conditions do not present inhalation, ingestion, or contact health hazards. These products are used inside the building envelope, or other structures, and do not include materials or substances which have potential route of exposure to humans or flora/fauna in the environment.

2.5 The Product System Under Study

The commercial steel doors and frames in this study are manufactured primarily from coated steel, sourced from various suppliers, and a paint primer. The commercial steel door also includes a polystyrene core with an adhesive. The raw materials are transported to each of the five facilities, the locations for which are included in Table 5. Once at the manufacturing facilities, the doors and frames are assembled, painted and packaged.

Primary data were collected from the Steel Door Institute participants. Electricity and resource use at the facilities are allocated to the steel doors and frames based on product mass. Packaging for the steel doors included corrugated cardboard, plastic banding/strapping, and pallets. Packaging for the steel frame consists of strapping.

While outside the scope of the system boundary, of the packaging waste produced during installation is reported in Table 4[8].

Table 4. Disposal pathways for steel door packaging and steel frame packaging during installation (A5).

Material	*Steel door packaging* Recycled (kg)	Incinerated (kg)	Landfilled (kg)	*Steel frame packaging* Recycled (kg)	Incinerated (kg)	Landfilled (kg)
Cardboard	0.26	0.01	0.05	--	--	--
Strapping	0.0019	0.0024	0.0099	0.0189	0.0235	0.0965
Pallet	0.123	0.065	0.27			
Total	**0.38**	**0.080**	**0.33**	**0.0189**	**0.0235**	**0.0965**

The eGRID subregions applicable to the location of the manufacturing facilities are documented in Table 5. The electricity supply mix for each of the Steel Door Institute facilities are modeled using ecoinvent electricity grid for the applicabe NERC region and modifed to reflect the electricity mix of the subregion.

Table 5. Steel Door Institute industry-wide EPD participants, facility locations, and the relevant eGRID region.

Manufacturer	Location	eGRID region
Deansteel Manufacturing, Inc.	931 S. Flores St., San Antonio, TX	ERCT
Door Components, Inc. d.b.a. DCI Hollow Metal	7980 Redwood Avenue, Fontana, CA	CAMX
HMX	1140 N 47th Ave, Phoenix, AZ	AZNM
Mesker Door	3440 Stanwood Blvd, Huntsville, AL	SRTV
MPI KY, LLC	319 N. Hills Road, Corbin, KY 40701	SRTV

The year of data supplied by each manufacturer represents an entire year of operations, either January 1, 2022 through December 31, 2022 or July 1, 2022 through June 30, 2023.

- Dean Steel 01/01/2022 through 12/31/2022
- DCI Hollow 01/01/2022 through 12/31/2022
- HMX 7/01/2022 thru 6/30/2023
- Mesker 7/01/2022 thru 6/30/2023
- MPI 1/1/2022 to 12/31/2022

[8] US EPA 2018 Facts and Figures Report, December 2020.

2.6 Data Requirements

The LCA study included several key data requests:

- Primary data, including resource use (e.g., electricity, natural gas, water, etc.), waste generation, and emissions released during steel door and frame manufacturing,
- Materials purchased, suppliers, and upstream transport for materials purchased,
- Representative inventory data for several unit processes with a preference for data from the Ecoinvent 3.9.1[9] life cycle database,
- Product material composition.[10]

2.7 Allocation Procedures

This study follows the allocation guidelines of ISO 14044 and allocation rules specified in the PCR and minimized the use of allocation wherever possible.

Mass allocation was deemed the most accurate and reproducible way of calculating the energy and material requirements for the manufacture of the steel doors and frames. Primary data for resource use (e.g., electricity, natural gas, water), waste/byproducts, and emissions released, are allocated on a mass-basis as a fraction of total annual production.

The transportation from primary producer of material components to the facilities are based on primary data provided by each of the participants, including modes, distances, and amount of material transported. Transportation was allocated on the basis of the mass and distance the material was transported.

2.8 LCIA Methodology and Interpretation Used

LCIA methodologies are used to relate the LCI results to the associated environmental impacts, where the LCI results are classified within impact categories, each with a category indicator. The choice of methods and indicators used in the assessment are based on the requirements of ISO 14044 and the relevant PCR. It should be noted that the LCIA results presented below are relative expressions and do not predict impacts on category endpoints, exceedance of thresholds, safety margins, or risks associated

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[9] Ecoinvent v3.9.1. Weidema, B.P.; Bauer, Ch.; Hischier, R.; Mutel, Ch.; Nemecek, T.; Reinhard, J.; Vadenbo, C.O.; Wernet, G, 2022, The ecoinvent database: Overview and methodology, Data quality guideline for the ecoinvent database version 3, www.ecoinvent.org
[10] Confirmed with client

with the product system. Additionally, the environmental relevance of LCIA results is not affected by LCI declared unit calculation, system wide averaging, aggregation and allocation.

Within LCIA, two approaches of characterization may occur along the environmental pathway of an impact indicator: midpoint approach and endpoint approach. Characterization at the midpoint level models the impact using an indicator located somewhere along the methodology mechanism prior to the endpoint categories; while characterization at the endpoint level requires modeling through to the endpoint categories described by the areas of protection (primarily ecosystem quality, human health and resources). In addition to differences according to environmental modeling approach (midpoint and endpoint), other differences among LCIA methodologies include the number of impact categories, and substances, covered by each methodology, as well as temporal and geographic variations in characterization data used. In the current study, impact category indicators are estimated using the TRACI 2.1[11] characterization methodologies.

TRACI (Tool for the Reduction and Assessment of Chemical and other environmental Impacts) is a midpoint-oriented methodology developed by the US Environmental Protection Agency (US EPA), with aim of assisting in the impact assessment of process designs and achieving pollution prevention. The midpoint impact categories considered in the methodology include: Ozone depletion, global warming, smog formation, acidification, eutrophication, human health cancer, human health non cancer, human health criteria pollutants, eco-toxicity, and abiotic resources depletion potential for fossil resources. The impact categories were selected and characterized based on the data and information from the U.S. EPA. The normalization factors are based on annual emissions and resources for the US. No weighting method is embedded in the methodology. The regional validity for the methodology impact categories is appropriate to US, although global impact categories. such as ozone layer depletion and global warming, are also considered.

The LCA conforms to ISO 14040/44 and the UL Product Category Rule for the category of Commercial Steel Doors and Steel Frames. Impact category indicators, with the exception of global warming potential, are estimated using TRACI 2.1 characterization factors. The impact indicators considered for the assessment include:

- Potential for Global Warming,
- Acidification Potential,
- Eutrophication Potential,
- Smog Formation Potential,
- Ozone Depletion Potential, and
- Fossil Fuel Depletion Potential

[11] Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI). Dr. Bare, J., http://www.epa.gov/nrmrl/std/traci/traci.html

For global warming calculations, the TRACI 2.1 global warming characterization factors are based on IPCC 2007, whereas the PCR requires the updated IPCC AR5 factors from 2013. For this reason, the climate change potential is calculated using IPCC AR5 GWP100 factors rather than using TRACI 2.1. Note also that the characterization method does not include biogenic carbon uptake or biomass CO_2 emissions. Based on the component materials of the product and production processes, there are no impacts associated with land-use changes, nor are environmental impacts associated with carbonation relevant for the product system. Biogenic carbon uptake and biomass CO_2 emissions are relevant for the wood-based packaging only as described in section 2.5 and quantified in Table 7.

The impact category indicators included in the assessment are described below in Table 6.

Table 6. Impact Categories and description of Environmental Mechanisms.

Category Indicator	Units	Impact Category and Environmental Mechanism
Global Warming Potential of GHGs over 100 years (GWP)	kg CO_2 eq.	Anthropogenic emissions of greenhouse gases and short-lived climate forcers have led to increased radiative forcing, which has in turn increased the global mean temperature by above 0.99°C since pre-industrial times. All IPCC scenarios project an increase to 1.5°C in the near term, occurring between 2021 to 2040. The projection for the SSP2-4.5 scenario estimates an increase of 2.0°C occurring between 2043-2062, with 3°C occurring between 2061-2080[12]. As global mean temperatures continue to climb, global climate change will result. Some of the predicted impacts include reductions in food and food supplies, water supplies, and sea level rise.[13]
Ozone Layer Depletion (ODP Steady State) (ODP)	kg CFC-11 eq.	Emissions of ozone depleting substances such as chlorofluorocarbons contribute to a thinning of the stratospheric ozone layer. This can lead to increased cases of skin cancer, and effects on crops, other plants, marine life, and human-built materials. All chlorinated and brominated compounds stable enough to reach the stratosphere can have an effect. CFCs, halons and HCFCs are the major causes of ozone depletion. Damage to the ozone layer reduces its ability to prevent ultraviolet (UV) light entering the earth's atmosphere, increasing the amount of carcinogenic UVB light reaching the earth's surface. Due to the international ban on ozone depleting chemicals, the stratospheric ozone layer has begun to recover; U.S. EPA projects that the ozone layer will recover within about 50 years.
Smog Formation Potential (SFP)	kg O_3 eq	Photochemical ozone, also called "ground level ozone", is formed by the reaction of volatile organic compounds and nitrogen oxides in the presence of heat and sunlight. If ozone concentrations reach above certain critical thresholds, health effects in humans can result, including bronchitis, asthma, and emphysema. The impact category depends

[12] Technical Summary. IPCC AR6 WGI. Box TS.1
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_TS.pdf
[13] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf

Category Indicator	Units	Impact Category and Environmental Mechanism
		largely on the amounts of carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxide (NO), ammonium and NMVOC (non-methane volatile organic compounds).
Acidification (AP)	kg SO_2 eq	Acidification is the increasing concentration of hydrogen ion (H^+) within the local environment and occurs as a result of adding acids such as nitric acid and sulphuric acids into the environment. Acid precursor emissions transport in the atmosphere and deposit as acids. These acids may deposit in soils which are sensitive, or insensitive, to the increased acid burden; sensitivity can depend on a number of factors. In acid-sensitive soils, the deposition can decrease the soil pH (acidification) and increase the mobility of heavy metals in the environment, such as aluminum. This acidification can affect the pH of local soils and freshwater bodies, by increasing local hydrogen ion concentrations, causing endpoints such as tree die-offs and dead lakes. Emissions of sulphur dioxide and nitrogen oxides from the combustion of fossil fuels have been the greatest contributor to acid rain.
Eutrophication (EP)	kg N eq	Eutrophication is the build-up of a concentration of chemical nutrients in an ecosystem which leads to abnormal productivity. In some regions, emissions of excess nutrients (including phosphorus and nitrogen) into water can lead to increased algal blooms. These blooms can reach such a severity that waterways become choked, with no other plant life able to establish itself. If algal blooms are intense enough, the decaying algae consumes dissolved oxygen in the water column starving other organisms of needed oxygen. Whereas phosphorous is mainly responsible for eutrophication in freshwater systems, nitrogen is mainly responsible for eutrophication in ocean water bodies. Emissions of ammonia, nitrates, nitrogen oxides and phosphorous to air or water all have an impact on eutrophication.
Fossil Fuel Depletion (FFD)	MJ surplus	This impact category reflects the relative abundance and depletion of feedstock reserves resulting from the net consumption of fossil energy resources used for electric power generation, operations and transport, and for incorporation into materials such as plastics. This indicator takes into account the amount of resources used for the function under study, the availability of economically recoverable reserves, the degree to which such resources may be replenished, the relative efficiency of power generation systems and fuel systems, and whether the resource is available for reuse at end of life (e.g., recycling). All fossil fuel resources which are consumed in a non-renewable fashion are included.

The PCR requires that several other parameters be reported in the EPD, including resource use, waste categories and output flows, and other environmental information. Many of these resource and waste parameters are calculated in conformance with guidance provided by the American Center for Life Cycle Assessment (ACLCA)[14]. In light of the above discussion, the additional parameters were assessed using the following methods:

- *Use of renewable primary energy resources used as raw materials (RPR_M).* No classification scheme is available in openLCA 2.0 for energy resources used as raw materials, and there are no

[14] ACLCA (May 2019). ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017.

renewable primary energy resources used as raw materials in the product. This parameter is estimated manually based on the amount of wood-based packaging.

- *Use of renewable primary energy excluding renewable primary energy resources used as raw materials (RPR_E).* Since there is no classification scheme available in openLCA 2.0 to account for this parameter, it is estimated using the Cumulative Energy Demand, Lower Heating Value (CED LHV) methodology available in openLCA, which accounts for renewable energy resources in background and foreground processes, minus the amount used as materials, namely RPR_M.
- *Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials ($NRPR_M$).* No classification scheme is available in openLCA 2.0 for energy resources used as raw materials in the product. This parameter is calculated manually based on the energy content of the product materials (adhesive, and paint) and packaging materials (plastic strapping).
- *Use of non-renewable primary energy resources used as raw materials ($NRPR_E$).* Since there is no classification scheme available in openLCA 2.0 to account for this parameter, it is estimated using the Cumulative Energy Demand, Lower Heating Value (CED LHV) methodology available in openLCA, which accounts for nonrenewable primary energy resources in background and foreground processes.
- *Use of secondary material (SM).* The products contains steel scrap, and as such this is a measure of the use of scrap in the product, as provided by the participants.
- *Use of renewable and nonrenewable secondary fuels (RSF/NRSF).* The main consumption of any secondary fuel in the product system is the combustion of municipal solid waste, used to generate electricity in some regions. In the U.S., municipal solid waste incineration accounts for less than 2% of total electricity generation. This parameter is reported as N/A, per ACLCA guidance.
- *Net use of fresh water (FW).* Net use of fresh water (consumption) is included in the ecoinvent datasets used for the modeling and are reported for all modules. Water consumption evaporation, transpiration, product integration and discharge into a different drainage basin or the sea. Use of FW is calculated from life cycle inventory flows using the freshwater parameter within “Selected Indicators, Additional” provided by openLCA 2.0.
- *Hazardous waste disposed (HWD).* All flows of hazardous waste classified by the Resource Conservation and Recovery Act (RCRA) are included in the full LCI and other data sources were aggregated into a single result for total hazardous waste disposal. This parameter is calculated using primary data provided by participants on the hazardous waste generated within their facility, per the ACLCA guidance.

- *Non-hazardous waste disposed (NHWD).* This includes all wastes produced across all life cycle stages included in the study scope. This parameter is calculated using primary data provided by the participants on the hazardous waste generated within their facility, per the ACLCA guidance.
- *Radioactive wastes disposed (HLRW/ILLRW).* This parameter includes flows of radioactive wastes in the primary data reported as low-level and high-level radioactive wastes, per the ACLCA guidance.
- *Components for re-use (CRU).* There are no components of the product which can be re-used at end of life.
- *Materials for recycling (MR).* This indicator consists of the materials for recycling generated during manufacturing.
- *Materials for energy recovery (MER).* The production of materials for energy recovery crossing the system boundaries is negligible and reported as N/A.
- *Recovered energy (RE).* The recovered energy crossing the system boundaries is negligible and reported as N/A.

Additionally, the PCR requires the calculation of carbon emissions and removals. Biogenic carbon removals are included in the packaging for the steel door, while emissions are not included in the A1-A3 modules as no biogenic materials are used in the product and packaging end of life is outside the scope. These parameters are reported in Table 7. Wood-based packaging is *not* used for the steel frames and thus all biogenic carbon parameters are 0.0 kg.

Table 7. Biogenic carbon inventory parameters for the average steel *door*

	Module		
Additional Inventory Parameters	**A1**	**A2**	**A3**
Biogenic Carbon Removal from Product	0.0	0.0	0.0
Biogenic Carbon Emission from Product	0.0	0.0	0.0
Biogenic Carbon Removal from Packaging	0.0	0.0	1.43 kg CO_2/ton steel door
Biogenic Carbon Emission from Packaging	0.0	0.0	0.0
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production	0.0	0.0	Neg.

All results are calculated with the openLCA 2.0 model using primary and secondary inventory data as described above.

The GWP emissions associated with the biogenic carbon content for packaging waste produced during installation would be 0.202 kg CO2e, calculated using average pulp-based packaging disposal rates in North America from the UL Part A PCR, the emissions factor for wood-based packaging from the ACLCA guidance document, and assuming complete combustion of incinerated packaging materials.

The interpretation phase conforms to ISO 14044 with further guidance from the ILCD General Guide for Life Cycle Assessment[15]. The interpretation included the use of evaluation and sensitivity checks to steer the iterative process during the assessment, and a final evaluation including completeness, sensitivity, and consistency checks, at the end of the study.

2.9 Value Choices and Optional Elements

The study avoids the use of value choices in the assessment, as described in ISO-14044, such as normalization, weighting, or grouping of indicator results. The study includes a data quality assessment, considered optional under ISO-14044 and required by the PCR.

2.10 Cut-off Criteria

The cut-off criteria for including or excluding materials, energy, and emissions data from the study are in accordance with the PCR and are listed below.

- All inputs and outputs to a unit process are included in the LCA calculation for which data are available. Any data gaps are filled with representative data. Assumptions used for filling data gaps are documented in the LCA report.
- Where there is a data gap or insufficient data, criteria for exclusion of inputs and outputs is 1% of primary energy usage (renewable and non-renewable energy) and 1% on a mass basis for the specific unit process. The maximum criteria for exclusion of inputs and outputs is 5% of primary energy usage and mass across all modules included in the LCA.
- If a flow meets the above criteria for exclusion but is considered to have a significant potential environmental impact, it is included.

2.11 Limitations

As a result of the choice of study scope and LCIA methodologies used, there are several important study limitations which should be understood to ensure an appropriate interpretation of results, as described below.

[15] European Joint Research Commission. International Reference Life Cycle Data System handbook. *General guide for Life Cycle Assessment – Detailed Guidance.* © European Union, 2010.

Limitations in the Study Scope

Primary data of material components could not be modeled with actual process information. Secondary data consists of ecoinvent datasets and impact results taken from the supplier EPDs.

Comparison of the environmental performance of construction products should be based on the product's use in a building, considering the complete life cycle. Results that do not consider the complete building context are inappropriate for comparing construction products. Comparability of EPDs is limited to those applying a functional unit. As the scope of this LCA is the production of steel construction products, and does not include impacts on the building, indicator results presented in this LCA cannot be compared directly to another material type, unless these products have equivalent use phase impacts and identical effects on the whole building.

The results presented should be considered in the context of operational impacts from the function of the integrated whole building system. When the building lifetime is taken into account, the impacts resulting from the production of these steel products can range from small, to significant, due to the nearly limitless number of building designs possible. These impacts from the operational phase of a whole building are not the subject of this study but should be considered when interpreting results.

Limitations in Life Cycle Impact Assessment Phase

It should also be noted that LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Limitations in Results for Other Parameters

The PCR requires that results for several inventory flows related to construction products are to be reported as “other parameters”. These are aggregated inventory flows, and do not characterize any potential impact; results should be interpreted taking into account this limitation.

2.12 Data Quality Requirements

One of the primary goals of the study is to produce an EPD for the commercial steel doors and steel frames; the overarching data quality requirements are to enable a reliable assessment of the indicator results for all reported impact categories, with data quality sufficient as to identify the key unit processes, differentiated by overall contribution to final results.

No data gaps were allowed which were expected to significantly affect the outcome of the indicator results.

2.13 Type of Critical Review

This LCA report has been critically reviewed by an independent external LCA expert not involved with the execution of this study, in conformance with ISO 14044. This critical review is considered an 'external' critical review.

3. Life Cycle Modeling

The life cycle inventory (LCI) of each unit process comprises material and energy inputs, emissions, co-products, and wastes. Data sources for these inventories include primary data as well as secondary data from the Ecoinvent database. Environmental flows from the LCI modeling are used to calculate environmental impacts in the LCIA phase. Where necessary, the lower heating value is used for energy flow calculations.

In the present study, except as noted, all known materials and processes were included in the inventory.

3.1 Assumptions

The assessment relied on several assumptions, described below.

- Life cycle inventory for hot dipped galvanized (HDG) and cold rolled steel were modeled based on data in the 2021 AISI LCA report[16]. Galvannealed steel were modeled using the AISI report for HDG production with an increased zinc concentration.
- Each steel door and frame manufacturer supplied the names of their steel suppliers and recycled content thereof. Steel purchased from distributors were modeled using the US average. Steel purchased from mills were modeled using the appropriate EAF or BOF datasets in ecoinvent with the electricity dataset tailored to the appropriate egrid NERC subregion, RFCW and SRTV.
- Representative inventory data for other raw materials were modeled with unit process data taken from Ecoinvent.
- Representative inventory data for electricity use at the participating facilities were modified to reflect the eGRID subregion electricity supply mixes at the each of the manufacturing facilities.
- Transportation for manufacturing wastes were modeled using the EPA WARM model assumption of 20 miles (~32 km), from the point of product use to a landfill, material recovery center, or waste incinerator. Ecoinvent datasets are used to model the impacts associated with incineration and landfilling, which does not include energy recovery from landfill gas.

[16] sphera on behalf of AISI. 2020. Life Cycle Inventories of North American Steel Products.

3.2 Transportation

The transportation of materials from supplier of raw materials to the manufacturing facilities are based on primary data provided by each of the participants and includes truck transportation.

3.3 Data Sources

Unit processes were developed within openLCA v2.0 software. The principal source of secondary LCI data is Ecoinvent v3.9.1[17] database. Detailed descriptions of unit processes can be found in the accompanying documentation. The LCI datasets used in the LCA model to represent unit processes in the cradle-to-gate LCA are provided in Table 8 below.

[17] Ecoinvent Centre (2022) Ecoinvent data from v3.9.1. Swiss Center for Life Cycle Inventories, Dübendorf, 2022. http://www.Ecoinvent.org

Table 8. LCI datasets and associated databases used to model the product systems for Steel Door Institute.

Flow	Dataset	Data Source	Publication Date
Steel Door Materials			
HDG Steel	LCI for HDG taken from AISI report	AISI report	2021
	Ecoinvent datasets to build LCI of steel: steel production, electric, low-alloyed | Cutoff, U - Europe without Switzerland and Austria * modified for egrid subregion (RFCW, SRTV, CAMX) steel production, converter, low-alloyed | Cutoff, U – RER* modified for egrid subregion (RFCW) hot rolling, steel | Cutoff, U - Europe without Austria market group for electricity, medium voltage | Cutoff, U – US market for natural gas, high pressure | Cutoff, U – US market for hydrochloric acid, without water, in 30% solution state | Cutoff, U - RER market for nitrogen, liquid | Cutoff, U – RER market for zinc | Cutoff, U – GLO process-specific burdens, hazardous waste incineration plant |Cutoff, U - RoW	Ecoinvent 3.9.1	2022
Galvannealed Steel	See above	Ecoinvent 3.9.1	2022
Polystyrene core	polystyrene foam slab production | Cutoff, U - RER	Ecoinvent 3.9.1	2022
Primer	Modeled based upon SDS sheets provided by manufacturer	Ecoinvent 3.9.1	2022
Adhesive	polyurethane adhesive production | Cutoff, U - GLO	Ecoinvent 3.9.1	2022
Packaging Materials			
Corrugated	market for corrugated board box | Cutoff, U - US	Ecoinvent 3.9.1	2022
Strapping	polyethylene production, low density, granulate | Cutoff, U - RER	Ecoinvent 3.9.1	2022
Pallet	EUR-flat pallet production | Cutoff, U – RER	Ecoinvent 3.9.1	2022
Resource Use			
Electricity	market for electricity, medium voltage | Cutoff, U	Ecoinvent 3.9.1	2022
	modified for respective eGRID subregions	eGRID 2021	2023
Propane	propane, burned in building machine | Cutoff, U - GLO	Ecoinvent 3.9.1	2022
Water	market for tap water | Cutoff, U - Europe without Switzerland	Ecoinvent 3.9.1	2022
	market for argon, liquid | Cutoff, U – RER market for carbon dioxide, liquid | Cutoff, U – RER market for oxygen, liquid | Cutoff, U - RER		
Manufacturing wastes	treatment of waste paint, hazardous waste incineration | Cutoff, U - Europe without Switzerland process-specific burdens, municipal waste incineration | Cutoff, U - Europe without Switzerland process-specific burdens, inert material landfill | Cutoff, U – RoW treatment of spent solvent mixture, hazardous waste incineration | Cutoff, U - Europe without Switzerland	Ecoinvent 3.9.1	2022
Transportation			
Truck transport	transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U - RER	Ecoinvent 3.9.1	2022

3.4 Data Quality Assessment

The data quality assessment is discussed in the table below for each of the data quality parameters in Table 9.

Table 9. Data Quality Assessment

Data Quality Parameter	Parameter Description	Data Quality Discussion
Time-Related Coverage	Age of data and the minimum length of time over which data is collected	The most recent available data are used, based on other considerations such as data quality and similarity to the actual operations. Typically, these data are less than 10 years old. All of the data used represented an average of at least one year's worth of data collection. Manufacturer-supplied data (primary data) are based on a full year of operations at each of the manufacturing facilities.
Geographical Coverage	Geographical area from which data for unit processes is collected to satisfy the goal of the study	The data used in the analysis provide the best possible representation available with current data. Actual processes for upstream operations are primarily North American. Surrogate data used in the assessment are representative of North American operations. Data representative of European operations are considered sufficiently similar to actual processes. Data representing disposal practices are based on regional statistics.
Technology Coverage	Specific technology or technology mix	For the most part, data are representative of the actual technologies used for processing, transportation, and manufacturing operations.
Precision	Measure of the variability of the data values for each data expressed (e.g. variance)	Precision of results are not quantified due to a lack of data. Data collected for operations were typically averaged for one or more years and over multiple operations, which is expected to reduce the variability of results.
Completeness	Percentage of flow that is measured or estimated	The LCA model included all known mass and energy flows for production of the steel doors and frames. In some instances, surrogate data used to represent upstream and downstream operations may be missing some data which is propagated in the model. No known processes or activities contributing to more than 1% of the total environmental impact for each indicator are excluded.
Representativeness	Qualitative assessment of the degree to which the data set reflects the true population of interest (i.e. geographical coverage, time period and technology coverage)	Data used in the assessment represent typical or average processes as currently reported from multiple data sources and are therefore generally representative of the range of actual processes and technologies for production of these materials. Considerable deviation may exist among actual processes on a site-specific basis; however, such a determination would require detailed data collection throughout the supply chain back to resource extraction. For supplier information, the most representative source of data possible was chosen or modeled.
Consistency	Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis	The consistency of the assessment is considered to be high. Data sources of similar quality and age are used with a bias towards Ecoinvent v3.9.1 data. Different portions of the product life cycle are equally considered; however, it must be noted that final disposition of the product is based on assumptions of current average practices in Europe and North America.
Reproducibility	Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study	Based on the description of data and assumptions used, this assessment would be reproducible by other practitioners with access to the primary data. All assumptions, models, and data sources are documented.

Data Quality Parameter	Parameter Description	Data Quality Discussion
Sources of the Data	Description of all primary and secondary data sources	Data representing energy use at the manufacturing facilities represent an annual average and are considered of high quality due to the length of time over which these data are collected, as compared to a snapshot that may not accurately reflect fluctuations in production. The Ecoinvent database is used for secondary LCI datasets.
Uncertainty of the Information	Uncertainty related to data, models, and assumptions	Uncertainty related to materials in the steel doors and frames is low. Actual supplier data for upstream operations was not available for all suppliers and the study relied upon the use of existing representative datasets. These datasets contained relatively recent data (<10 years) but lacked geographical representativeness. Uncertainty related to the impact assessment methods used in the study are high. The impact assessment method required by the PCR includes impact potentials, which lack characterization of providing and receiving environments or tipping points.

3.5 LCI Results

The resource use and emissions from each step of the product life cycle are summed to obtain the life cycle inventory results. Table 10 summarizes the results for additional parameters (energy and waste flows) as specified in the PCR (see Section 2.8) for the North American market. The LCIA and inventory flow results were calculated using the openLCA 2.0 model and summarized for one steel door or frame. Where necessary, the lower heating value is used for energy flow calculations.

Life cycle inventory results were reviewed for completeness, consistency and representativeness. Overall, with respect to those impact categories assessed, the inventory was considered consistent and generally representative of the system processes as the same types of data sources are used throughout, primarily from the manufacturer, as well as the Ecoinvent life cycle inventory database. As noted previously, all known processes and materials of the product system are included in the inventory.

Table 10. Resource use and wastes results for the declared unit. All values are rounded to three significant digits. Results representing energy flows are calculated using lower heating (i.e., net calorific) values.

Parameter	Unit	Value	
Resource use		**Steel Door**	**Steel Frame**
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (RPR_E)	MJ	182	140
Use of renewable primary energy resources used as raw materials (RPR_M)	MJ	4.39	0.00
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials ($NRPR_E$)	MJ	1,200	584
Use of non-renewable primary energy resources used as raw materials ($NRPR_M$)	MJ	190	12.1
Use of secondary material (SM)	kg	23.5	15.7
Use of renewable secondary fuels (RSF)	MJ	0.00	0.00
Use of non-renewable secondary fuels (NRSF)	MJ	0.00	0.00
Recovered Energy (RE)	MJ	0.00	0.00
Use of net fresh water (FW)	m^3	1.44	0.746
Waste and outflows			
Non-hazardous waste disposed (NHWD)	kg	0.303	0.124
Hazardous waste disposed (HWD)	kg	$4.39x10^{-7}$	$1.14x10^{-7}$
High-level Radioactive waste disposed (HLRW)	kg	0.00	0.00
Radioactive waste disposed (ILLRW)	kg	0.00	0.00
Components for re-use (CRU)	kg	0.00	0.00
Materials for recycling (MR)	kg	3.68	3.00
Materials for energy recovery (MER)	kg	0.00	0.00
Exported energy (EE)	MJ	0.00	0.00

3.6 Contribution Analysis

Life cycle modeling of the steel doors and frames was divided into distinct life cycle phases, including raw material extraction and processing including steelmaking and hot rolling, transportation to the Steel Door Institute member manufacturing facility, and manufacture of the steel products. A detailed examination of the potential environmental impacts provides some insight into the relative contributions from each of the product's life cycle phases.

The following life cycle phases were included in the contribution analysis:

- *Raw Materials and Processing (Sourcing/Extraction) stage (A1)* **–** This stage includes extraction of virgin materials and reclamation of non-virgin feedstock. This includes the extraction of all raw materials, including the transport to the manufacturing site. Resource use and emissions associated with both extraction of the raw materials and product components manufacturing are included. The impacts associated with the transport of the processed raw materials to the steelmaking and rolling mills.
- *Transport stage (A2)* –The impacts associated with the transport of the steel coil and other raw materials to the manufacturing facilities.

- *Manufacturing stage (A3)* **–** This stage includes all the relevant manufacturing processes and flows for manufacturing the steel doors and frames, including the impacts from energy use and emissions at the manufacturing facilities.

  The life cycle stages included in the system boundary for the steel doors and frames are summarized in the table below.

Product			Construction Process		Use							End-of-life				Benefits and loads beyond the system boundary
A1	A2	A3	A4	A5	B1	B1	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material extraction and processing	Transport to manufacturer	Manufacturing	Transport	Construction - installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction demolition	Transport	Waste processing	Disposal	Reuse, recovery and/or recycling potential
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

X = Included in system boundary
MND = Module not declared

Table 11. Resource use and waste flows for one commercial steel door, production-weighted average across manufacturers, including percent contribution by life cycle stage. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.

Parameter	A1	A2	A3	Total (A1-A3)
Resources				
RPRE (MJ)	166	0.234	16.0	182
	91%	0%	9%	100%
RPRM (MJ)	0.00	0.00	4.39	4.39
	0%	0%	100%	100%
NRPRE (MJ)	1,040	15.1	149	1,200
	86%	1%	12%	100%
NRPRM (MJ)	189	0.00	0.388	190
	100%	0%	0%	100%
SM (kg)	23.5	0.00	0.00	23.5
	100%	0%	0%	100%
RSF/NRSF (MJ)	n/a	n/a	n/a	n/a
RE (MJ)	n/a	n/a	n/a	n/a
FW (m^3)	1.38	1.87×10^{-3}	0.0541	1.44
	96%	0.13%	3.8%	100%
Wastes				
NHWD (kg)	n/a	n/a	0.303	0.303
	n/a	n/a	100%	100%
HWD (kg)	n/a	n/a	4.39×10^{-7}	4.39×10^{-7}
	n/a	n/a	100%	100%
HLRW (kg)	n/a	n/a	0.00	0.00
	n/a	n/a	n/a	n/a
ILLRW (kg)	n/a	n/a	0.00	0.00
	n/a	n/a	n/a	n/a
CRU (kg)	n/a	n/a	0.00	0.00
MR (kg)	n/a	n/a	3.68	3.68
	n/a	n/a	100%	100%
MER (kg)	n/a	n/a	n/a	n/a
EE (MJ)	n/a	n/a	n/a	n/a

Table 12. Resource use and waste flows per commercial steel frame, production-weighted average across manufacturers including percent contribution by life cycle stage. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.

Parameter	A1	A2	A3	Total (A1-A3)
Resources				
RPRE (MJ)	132	0.0892	8.29	140
	94%	0%	6%	100%
RPRM (MJ)	0.00	0.00	0.00	0.00
	n/a	n/a	n/a	n/a
NRPRE (MJ)	498	5.74	80.5	585
	85%	1%	14%	100%
NRPRM (MJ)	10.4	0.00	1.75	12.1
	86%	0%	14%	100%
SM (kg)	15.7	0.0	0.0	15.7
	100%	0%	0%	100%
RSF/NRSF (MJ)	0.00	0.00	0.00	0.00
RE (MJ)	0.00	0.00	0.00	0.00
FW (m3)	0.719	7.14×10^{-4}	0.0264	0.746
	96%	0.1%	3.5%	100%
Wastes				
NHWD (kg)	n/a	n/a	0.124	0.124
	n/a	n/a	100%	100%
HWD (kg)	n/a	n/a	1.14×10^{-7}	1.14×10^{-7}
	n/a	n/a	100%	100%
HLRW (kg)	n/a	n/a	0.00	0.00
	n/a	n/a	n/a	n/a
ILLRW (kg)	n/a	n/a	0.00	0.00
	n/a	n/a	n/a	n/a
CRU (kg)	n/a	n/a	0.00	0.00
MR (kg)	n/a	n/a	3.00	3.00
	n/a	n/a	100%	100%
MER (kg)	n/a	n/a	n/a	n/a
EE (MJ)	n/a	n/a	n/a	n/a

4. Life Cycle Impact Assessment

4.1 Overview

Category impact indicator results are presented in Tables 13 and 14 below using the CML-IA and TRACI 2.1 characterization methodologies required in the PCR, discussed in Section 2.8.

It should be noted that the indicators prescribed by the PCR do not represent all categories of potential environmental and human health impact associated with the life cycle of the product, and this represents a general limitation of the LCA study. Additionally, these indicators have no "environmental relevance," as defined in the ISO-14044 §4.4.2.2.2, 4.4.2.2.4, and 4.4.5, with the exception of the "Potential for Global Warming" indicator, which has low environmental relevance. That is, these "potential" results may or may not have any relationship to actual impacts occurring.

The potential environmental impacts are presented by information module (A1-A3), described in Section 2.2, providing some insight into the relative contributions for the product systems under study.

4.2 Contribution Analysis

Life cycle impact category indicator results for the production-weighted average steel door are summarized by life cycle phase in Table 13 and Figure 3. The primary contributor to indicator results for the steel door is from the Upstream Raw Material Production (A1) stage, primarily from the steelmaking.

Table 13. LCIA results for the declared unit of one commercial steel door, production-weighted average across participating manufacturers. All values are rounded to three significant digits. Values below indicator results show the percent contribution of each life cycle module to the result for each impact category.

Impact Category	Life cycle stage			
	A1	A2	A3	Total
CML-IA				
GWP (kg CO_2 eq)	87.5	1.05	8.10	96.6
	91%	1%	8%	100%
ODP (kg CFC-11 eq)	1.57×10^{-6}	1.89×10^{-8}	5.75×10^{-8}	1.65×10^{-6}
	95%	1%	3%	100%
AP (kg SO_2 eq)	0.261	3.11×10^{-3}	1.72×10^{-2}	0.282
	93%	1%	6%	100%
EP (kg $(PO_4)^{3-}$ eq)	0.141	8.18×10^{-4}	1.43×10^{-2}	0.156
	90%	1%	9%	100%
POCP (kg C_2H_4 eq)	5.16×10^{-2}	1.61×10^{-4}	9.27×10^{-4}	5.27×10^{-2}
	98%	0%	2%	100%
ADPE (kg Sb eq)	1.70×10^{-3}	3.41×10^{-6}	1.16×10^{-5}	1.72×10^{-3}
	99%	0%	1%	100%
ADPF (MJ)	1,060	14.7	101	1,170
	90%	1%	9%	100%
TRACI 2.1				
GWP (kg CO_2 eq)	86.6	1.04	8.05	95.6
	90%	1%	8%	100%
ODP (kg CFC-11 eq)	1.80×10^{-6}	2.49×10^{-8}	1.21×10^{-7}	1.94×10^{-6}
	92%	1%	6%	100%
AP (kg SO_2 eq)	0.271	3.78×10^{-3}	1.82×10^{-2}	0.292
	93%	1%	6%	100%
EP (kg N eq)	0.292	8.77×10^{-4}	3.11×10^{-2}	0.324
	90%	0%	10%	100%
SFP (kg O_3 eq)	3.96	0.101	0.373	4.44
	89%	2%	8%	100%
FFD (MJ eq)	116	2.14	10.8	129
	90%	2%	8%	100%

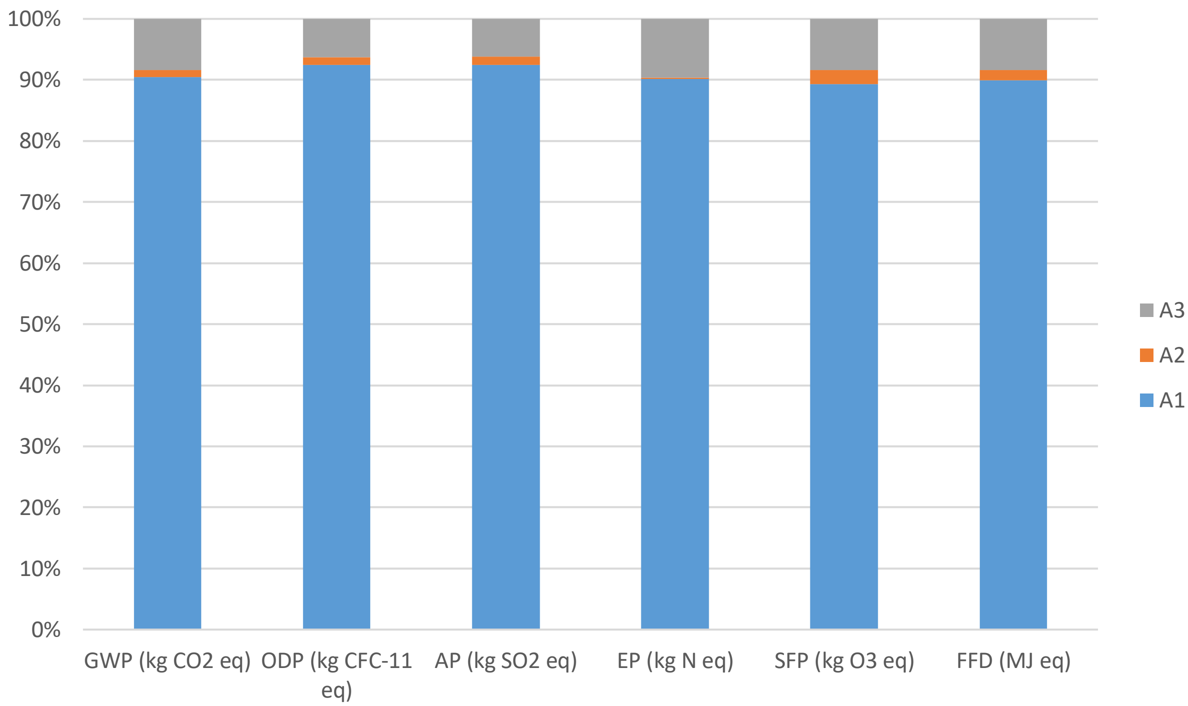

Figure 3. Cradle to gate contribution analysis of life cycle modules for the average commercial steel door, assessed using IPCC AR5 and TRACI 2.1

Category indicator results for the production-weighted average steel frame are summarized by life cycle phase in Table 14 and Figure 4. The primary contributor to indicator results for the steel frame is from the Upstream Raw Material Production (A1) stage, primarily from the steelmaking.

Table 14. LCIA results for the declared unit of one commercial steel frame, production-weighted average across participating manufacturers. All values are rounded to three significant digits. Values below indicator results show the percent contribution of each life cycle module to the result for each impact category.

Impact Category	Life cycle stage			
	A1	A2	A3	Total
CML-IA				
GWP (kg CO_2 eq)	46.1	0.410	4.57	51.1
	90%	1%	9%	100%
ODP (kg CFC-11 eq)	$7.82x10^{-7}$	$7.41x10^{-9}$	$3.42x10^{-8}$	$8.23x10^{-7}$
	95%	1%	4%	100%
AP (kg SO_2 eq)	0.137	$1.22x10^{-3}$	$9.44x10^{-3}$	0.147
	93%	1%	6%	100%
EP (kg $(PO_4)^{3-}$ eq)	$8.66x10^{-2}$	$3.20x10^{-4}$	$7.67x10^{-3}$	$9.46x10^{-2}$
	92%	0%	8%	100%
POCP (kg C_2H_4 eq)	$1.58x10^{-2}$	$6.31x10^{-5}$	$4.95x10^{-4}$	$1.63x10^{-2}$
	97%	0%	3%	100%
ADPE (kg Sb eq)	$1.14x10^{-3}$	$1.33x10^{-6}$	$6.29x10^{-6}$	$1.14x10^{-3}$
	99%	0%	1%	100%
ADPF (MJ)	421	5.76	56.8	484
	87%	1%	12%	100%
TRACI 2.1				
GWP (kg CO_2 eq)	45.9	0.407	4.54	50.8
	90%	1%	9%	100%
ODP (kg CFC-11 eq)	$9.21x10^{-7}$	$9.74x10^{-9}$	$6.97x10^{-8}$	$1.00x10^{-6}$
	92%	1%	7%	100%
AP (kg SO_2 eq)	0.143	$1.48x10^{-3}$	$9.94x10^{-3}$	0.155
	93%	1%	6%	100%
EP (kg N eq)	0.181	$3.43x10^{-4}$	$1.66x10^{-2}$	0.198
	91%	0%	8%	100%
SFP (kg O_3 eq)	2.06	$3.96x10^{-2}$	0.197	2.29
	90%	2%	9%	100%
FFD (MJ eq)	36.0	0.837	6.13	43.0
	84%	2%	14%	100%

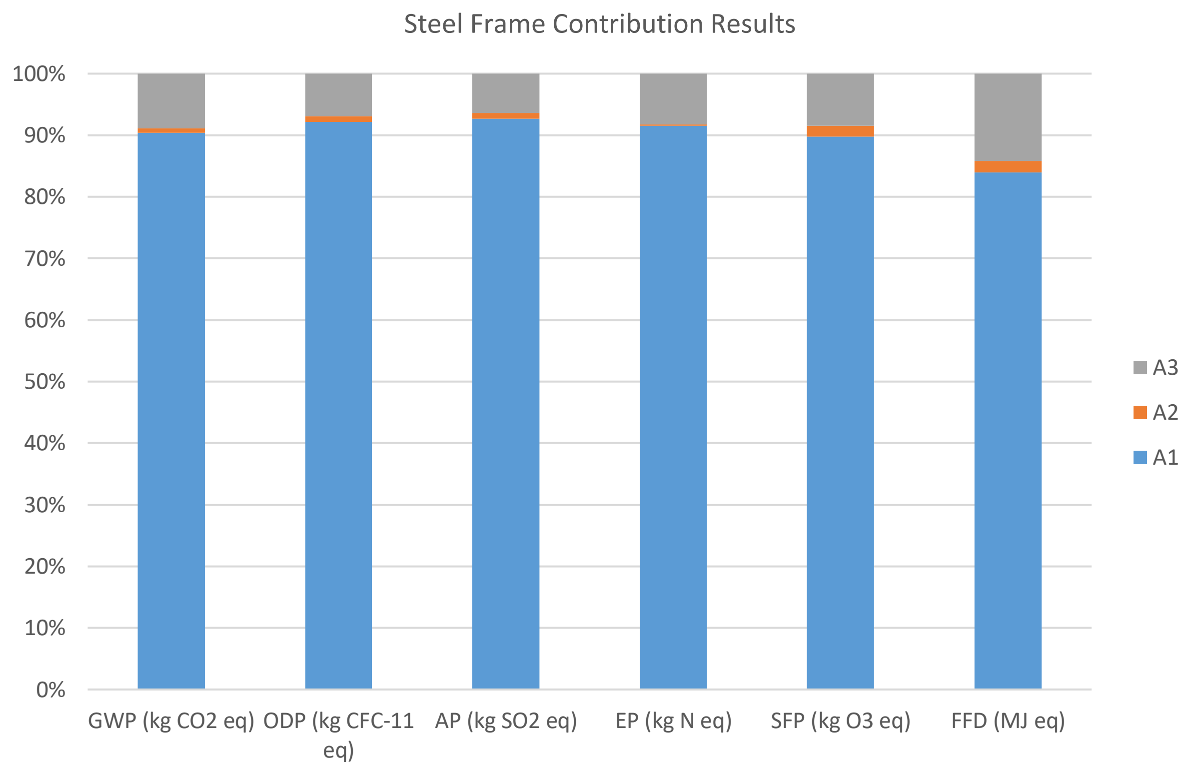

Figure 4. Cradle to gate contribution analysis of life cycle modules for the average commercial steel frame, assessed using IPCC AR5 and TRACI 2.1.

5. Life Cycle Interpretation

Generally speaking, for the steel doors and frames across indicators included in this study, the contribution to impacts is largely from the upstream production of raw materials (A1); in most cases due primarily to energy use during the steelmaking processes.

Significant Issues

Per ISO 14044, one of the steps in the Interpretation phase is the identification of significant issues. The purpose of this step is to identify the assumptions, methodological decisions, unit processes, and other aspects, which influence the results of the assessment.

Completeness Check

The completeness of the assessment is high. In the case where data were unavailable, gaps were filled based on activity data provided by the manufacturer (i.e. waste disposal based on oil usage rather than actual waste oil disposed, etc.) and not expected to have a significant impact on results.

Sensitivity Analysis

As part of an iterative process, sensitivity checks to the key assumptions, methodological choices, data uncertainties, parameters, inventory data, and characterization data were performed.

The key aspects of the study, to which final results are sensitive, include:

- As discussed in the above section, Module A1 is the most significant contributor to results, primarily due to the significance of the steelmaking on the final result. Changes to the supply chain could have a significant impact on the final results.
- The results are a production-weighted average, per the PCR requirements. As such, the results are sensitive to the relative production volumes of doors and frames by facility.
- The LCIA methodology used, considering both the impact categories included and characterization factors used.

Consistency Check

Throughout all stages of this LCA, methodological choices and practices were consistent with ISO 14044 and the PCR.

6. Conclusions

A life cycle assessment of Commercial Steel Doors and Steel Frames was conducted to support the preparation of two industry wide Environmental Product Declarations (EPD) for Steel Door Institute based on the PCR. The LCIA results were assessed relative to the production of one (1) Steel Door and one Steel Frame. and the impact category indicator results are presented in Section 5.

The indicator results for the steel products, when considered across all life cycle stages, indicate that the upstream materials production is the most significant contributor to results (Module A1) across impact indicators.

Recommendations

Collecting primary data for upstream steelmaking and coating processes would improve the accuracy of these results.

ISO 14044 Critical Review

Industrial Ecology Consultants

April 30, 2024

Keith Killpack
Manager, LCA Services | SCS Global Services
2000 Powell St., Ste. 600 | Emeryville, CA 94608

Verification Report: Commercial Steel Doors and Steel Frames

The LCA Practitioner, SCS Global Services, commissioned Industrial Ecology Consultants to perform an external independent verification of the **Life Cycle Assessment of Commercial Steel Doors and Steel Frames. SCS Global Services** completed the Life Cycle Assessment (LCA) study and respective Environment Product Declarations (EPDs) on behalf of the commissioning organization, the **Steel Door Institute (SDI)** and **MPI KY LLC (MPI KY).**

The review of the study was performed to demonstrate conformance with the following standards, general program instructions, and product category rules:

- International Organization for Standardization. (2000). *Environmental labels and declarations -- General principles* (ISO 14020:2000).
- International Organization for Standardization. (2006). *Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures* (ISO 14025:2006).
- International Organization for Standardization. (2020). *Environmental management -- Life cycle assessment – Principles and framework* (ISO 14040:2006/Amd 1:2020).
- International Organization for Standardization. (2020). *Environmental management -- Life cycle assessment -- Requirements and guidelines* (ISO 14044:2006/Amd 2:2020).
- International Organization for Standardization. (2014). *Environmental management -- Life cycle assessment -- Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006*. (ISO/TS 14071:2014).
- International Organization for Standardization. (2017). *Sustainability in buildings and civil engineering works — Core rules for environmental product declaration of construction products and services* (ISO 21920:2017).
- SCS Global Services. (2023). *Program Operator Manual: Type III Environmental Declaration Program.* Version 12-0, revised December 2023.
- UL Environment. (2022). *Product Category Rules for Building-Related Products and Services in: Brazil, China, Europe, India, Japan, Korea, North America, and South East Asia – Part A: Life Cycle Assessment Calculation Rules and Report Requirements*. UL Environment Standard 10010 v4.0, March.
- UL Environment. (2020). *Product Category Rule (PCR) Guidance for Building-Related Products and Services – Part B: Designated Steel Construction Product EPD Requirements*. UL Environment Standard 10010-34 v2.0, August.

The independent third-party verification was conducted by an external expert per ISO 14044:2006 Section 6.2: Critical review by internal or external expert:

Industrial Ecology Consultants

Thomas P. Gloria, Ph.D.
Founder, Chief Sustainability Engineer
Industrial Ecology Consultants

REVIEW SCOPE

The intent of this review was to provide an external independent third-party critical review of a completed LCA study project report and verification of the respective EPDs. The EPDs generated from this LCA study were the following:

Steel Door Institute:

- Product Group – Doors: 3 feet x 7 feet (0.91 m x 2.1 m) flush panel 18 gauge Heavy Duty (level 2) steel door with a polystyrene core conforming to ANSI/SDI A250.8- 2023. The product includes a prime painted finish conforming to ANSI A250.10.
- Product Group – Frames: 5-3/4" (146 mm) 16-gauge steel door frame conforming to ANSI/SDI A250.8-2023. The product includes a prime painted finish conforming to ANSI A250.10.

MPI KY, LLC:

- Product Group – Doors: 3 feet x 7 feet (0.91 m x 2.1 m) flush panel 18 gauge Heavy Duty (level 2) steel door with a polystyrene core conforming to ANSI/SDI A250.8- 2023. The product includes a prime painted finish conforming to ANSI A250.10.
- Product Group – Frames: 5-3/4" (146 mm) 16-gauge steel door frame conforming to ANSI/SDI A250.8-2023. The product includes a prime painted finish conforming to ANSI A250.10.

REVIEW PROCESS

The review and verification involved developing review matrices based on the requirements set forth by the applicable ISO standards, UL Environment Part A and Part B product category rules, and SCS Global Services General Program Instructions (GPIs). The LCA report and review of the EPD covered identified requirements specified by the PCR, GPIs, and applicable ISO standards.

The LCA study report was reviewed and deemed by this ***independent*** and ***external*** reviewer to conform to the applicable ISO standards, PCRs, and General Program Instructions. This review did not include an assessment of the Life Cycle Inventory (LCI) model, however, it did include a detailed analysis of the individual datasets used to complete the study.

VERIFICATION STATEMENT

Based on the independent verification objectives, the **Life Cycle Assessment of Commercial Steel Doors and Steel Frames**, April 19, 2024, and respective EPDs prepared by SCS Global Services on behalf of SDI and MPI KY, were reviewed and verified to be ***in conformance*** with the applicable ISO standards referenced above, the UL Environment PCRs, and SCS Global Services General Program Instructions. The plausibility, quality, and accuracy of the LCA-based data and supporting information are confirmed.

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As the External Independent Third-Party Reviewer, I confirm that I have sufficient knowledge and experience of steel building and construction products, the relevant PCR, ISO standards and the geographical areas intended to generate EPDs to carry out this verification.

Sincerely,

Thomas P. Gloria, Ph.D.
Founder, Chief Sustainability Engineer
Industrial Ecology Consultants