Global Warming Potential Impacts of Domestic Steel Construction Products

Methodologies, Assumptions, and Results, for Use by and in Support of the Federal Highway Administration's Low Carbon Transportation Materials Program

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Table of Contents

I. Introduction

A. Purpose

The purpose of this report is to fulfill a request from the Federal Highway Administration (FHWA) for the domestic steel industry to provide a methodology for selecting steel construction products "that have substantially lower levels of embodied greenhouse-gas emissions". This report provides a robust and up-to-date status of the up-front (modules A1-A3) embodied Global Warming Potential (*GWP**) impacts of American steel construction products. The steel industry leads the construction material sector in environmental transparency and disclosure, and it is expected that this report will be used as a resource by policy-makers to set performance benchmarks.

*References to GWP in this report refer to a GWP-100 metric.

B. Basis of the Report

The Inflation Reduction Act of 2022, Section 60506, appropriated funds to FHWA to incentivize eligible recipients to use materials and products "that have substantially lower levels of embodied greenhouse-gas emissions associated with all relevant stages of production, use and disposal as compared to estimated industry averages of similar materials or products, as determined by the Administrator of the U.S. Environmental Protection Agency (EPA)."

On December 22, 2022, EPA issued an Interim Determination[1] to provide FHWA and the General Services Administration (GSA) with a framework for selecting materials and products that meet the intent of the law. As established in the EPA Interim Determination, FHWA must identify the industry data for each eligible construction material (i.e., steel, concrete, asphalt, and glass) upon which to base industry averages and respective 20% and 40% quintiles. The determination also requires that eligible materials are determined using GWP as reported via environmental product declarations (EPDs).

[1] https://www.epa.gov/system/files/documents/2023-01/2022.12.22%20Interim%20Determination%20on%20Low%20Carbon%20Materials%20under%20IRA%2060503%20and%2060506_508.pdf

On August 28, 2023, the FHWA requested a formal collaboration with domestic steel industry associations with the intent of supporting their Low Carbon Transportation Materials Program[2] (LCTM). A letter of intent to collaborate with FHWA was sent on September 29, 2023 by leading steel organizations, among them:

- American Institute of Steel Construction
- Concrete Reinforcing Steel Institute
- Steel Manufacturers Association
- Steel Tube Institute

C. Scope

1. Conformance with LCA Standards

The life cycle assessment (LCA) methodology and assumptions in this report are consistent with requirements in the following standards:

- ISO 21930, *Sustainability in buildings and civil engineering works: Core rules for environmental product declarations of construction products and services*
- ISO 21678,* *Sustainability in buildings and civil engineering works: Indicators and benchmarks—Principles, requirements and guidelines*

*ISO 21678 addresses indicators and benchmarks including means, medians and quintiles for buildings and civil engineering works. It is not specifically applicable to construction materials and products. The description of indicators for buildings assumes the availability of a significant number of data points required for a meaningful determination of medians and quintiles. This is not the case for most domestically produced steel construction products where there are a limited number of production facilities. To address this situation the methodology proposed in this document is based on the discrete values reported in publicly available, facility-specific EPDs, weighted by relative production volume.

2. Conformance with the Relevant North American PCR

This report will reference data from EPDs developed by domestic steel manufacturers in accordance with the North American Product Category Rule (PCR) for Steel Construction Products, as applicable at the time of EPD publication. The current PCR is Part B: Designated Steel Construction Product EPD Requirements of the Product Category Rule (PCR) Guidance for Building-Related Products and Services[3] V2.0, published by UL Environment (ULE) in 2020 (UL 2020 (version 2)).

[2] https://www.fhwa.dot.gov/inflation-reduction-act/fact_sheets/lctm_grants.cfm

[3] https://www.shopulstandards.com/ProductDetail.aspx?productId=ULE10010-34_2_S_20200826

The steel construction products industry is currently updating the PCR, an effort which began formally on June 6, 2023 under the direction of program operator Smart EPD. The work is underway with a 33 person committee representing 23 organizations including a broad range of industry, government, NGO, consultant, and end-user stakeholders. The publication of the new version of the PCR is expected in late 2024, at which time the steel industry will no longer recognize the applicability of the UL 2020 (version 2) of the PCR for the development of new EPDs, despite its formal expiration in 2025.

3. Focus on Global Warming Potential

Construction products require material and energy resources from various sources for their production, which can lead to variation among potential environmental impacts that are typically quantified and disclosed in EPDs (such as acidification potential, eutrophication potential, ozone depletion potential, and smog formation potential). However, to meet the needs of the LCTM and to inform the key focus of sustainability policy-makers at present, only the environmental impact of GWP, will be addressed in this report. While current attention is appropriately focused on GWP and the resultant climate change impacts, it is critical that a broader range of environmental impacts continue to be transparently reported in EPDs and considered by policy-makers to gain a true sense of the environmental impacts of any material or product. This also allows decision makers to understand trade-offs among potential impacts to the environment (choosing a material with the lowest GWP may greatly increase the potential for eutrophication, as a hypothetical example).

4. LCA Scope and EPD Modules

The North American Steel Construction Products PCR recognizes that the A1, A2, and A3 definitions are fluid based upon the EPD owner's product and corresponding scope of control. For example, an EPD owner may be a steel mill representing their steel mill products and define A1-A3 as cradle-to-mill-gate, or they may be a downstream manufacturer who uses mill products as their primary input to create manufactured steel products, in which case they define A1-A3 as cradle-to-manufacturer-gate. Therefore, the LCA scope of this report is defined as cradle-to-mill gate (for steel mill products) or cradle-to-manufacturer gate* (for downstream-of-mill products), commonly reported in modules A1-A3 in construction sector EPDs. The aggregated value reported in these modules typically accounts for nearly 90% of a steel construction product's product-stage, A1-A5, embodied GWP.

> *Note: The current draft of V3 of the PCR Part B: or designated Steel Construction Products defines a mill product as "Products produced at steel mills using iron ore, steel scrap, or semi-finished steel (billets, blooms, slabs). Common examples: unfabricated rebar, unfabricated hot-rolled sections, unfabricated plate, coil, rods, wire, light sections." and manufactured product as "A mill product(s) transformed into a new product through a manufacturing process. Common examples: unfabricated HSS, open-web joists, steel deck, PC strand."

Many downstream processes that occur prior to A4 (transportation to the project site) are not included in the scope of this report. Such processes are case-specific, and their impacts (often measured on a per labor-hour basis) do not adequately correspond to the declared unit of the mill or manufactured product (mass basis). Additionally, GWP related to other life-cycle stages—transportation (A4), construction (A5), use (B), and end-of-life (C)—as well as benefits outside the system boundary (D) are not included.
Examples of scenario-specific downstream processes are:

- Bending & Rolling
- Magnetic Induction
- Abrasive (shot) Blasting
- Cambering (hot or cold)
- Castellation
- General Fabrication (building, bridge and ornamental)
- Fireproofing (shop or field)
- Galvanizing
- Metalizing
- Complex Coatings

5. Treatment of Fabrication Impacts

The environmental impacts of structural steel and reinforcing bar fabrication are quantified in the respective industry-wide EPDs of the AISC and CRSI, as shown in Table I.C.5.

Table I.C.5. Industry-Average Fabrication GWP (kg CO_2e / kg steel)

	Transport to Fabricator	Fabrication	Waste Rate[3] (%)
Structural Steel[1]	0.0446	0.0967	7.71
Reinforcing Bar[2]	0.0490	0.0270	3.10

[1] *Fabricated Hot-Rolled Structural Sections* 2021, *Fabricated Steel Plate* 2021, and *Fabricated Hollow Structural Sections* 2022, all published by the American Institute of Steel Construction, and based on *EPD Background Report: Fabricated hot-rolled sections, plates and hollow-structural sections*, American Institute of Steel Construction, 2021

[2] *Environmental Product Declaration: Fabricated Steel Reinforcement*, Concrete Reinforcing Steel Institute, 2022

[3]Waste rates represent the industry-average loss of primary material during fabrication

Table I.C.5 should be used to determine the aggregated impacts for fabricated products (A2 - transport to fabricator, A3 - fabrication) when conducting a whole building LCA when based on industry-average values, as fabrication is a common downstream process for structural steel and reinforcing bar. However, for the purposes of material thresholds for product-level procurement, such as Buy Clean policies, it is not meaningful or effective to include downstream processes such as fabrication in the determination and publication of product thresholds. This is the case for several reasons:

1. Steel mills and manufacturers do not perform fabrication. The only instances of fabrication impacts (sometimes) included in mill and manufacturer specific steel EPDs are in the form of the industry average values from Table I.C.5. Therefore, it is not meaningful to add a static value to both "the measurement standard" and "the thing being measured".
2. Fabrication is often cited as approximately 10% of the cradle-to-fabricator-gate GWP impacts of fabricated steel, as reflected in the respective industry-wide EPDs, leading some policy-makers to assert the importance of its inclusion as a matter of scale and completeness. However, fabrication is only one of many possible downstream, pre-installation, scenario-specific processes that exist in reality, and it's the only one currently included in industry-wide EPDs. That inclusion was a choice of the industry-wide EPD authors based upon the feasibility of gathering that particular data from their members, and it does not represent the full range of possible downstream processes.

   Actual proportions:
   a. Rebar fabrication is reported as 3% of cradle-to-fabricator-gate GWP per *Fabricated Steel Reinforcement*, Concrete Reinforcing Steel Institute, 2022.
   b. Structural fabrication is reported as 8% of cradle-to-fabricator-gate GWP per *Fabricated Hot-Rolled Structural Sections*, American Institute of Steel Construction, 2021. If all downstream processes were included in the cradle to pre-A4 scope, it would demonstrate that fabrication is notably less than 8% of the total.
3. Creating a future where fabrication-specific EPDs are commonplace will be challenging. Nearly 90% of fabrication impacts occur due to energy use, and the majority of those are from electricity. This determines two policy problems:
   a. First, judging small businesses' operations based upon the cleanliness of the electrical grid they are attached to clearly isn't a good national policy.
   b. Second, fabricator's impacts are not a function of the weight of material, but rather by the labor-hours required to perform fabrication services. Fabricators do not have control over the nature of the fabrication services, which are instead determined by a project's engineers and designers. A fabricator's labor-hours per weight of material produced can therefore vary widely from project to project, making potential data collection and EPD reporting quite unrepresentative of future performance.
4. Further, fabrication is a highly case-specific activity based on a wide variety of different scenarios such as building fabrication, bridge fabrication, ornamental fabrication, specification of welding or bolting, and design decisions outside the control of the fabricator. Scenarios are not allowed in A1-A3 per ISO 21930. Fabrication exists in a gray area between those actions that occur prior to delivery to a jobsite, yet are still fully customizable as preparation for installation. In fact, it is worth noting that significant discussion occurred among the v3 PCR redevelopment committee as to whether fabrication should remain in A3 or be better categorized as A5. All this to say, including fabrication in the scope of a procurement policy is a highly problematic idea with extremely little benefit. Fabricators should be expected to provide the

mill-specific EPD of the procured material for a particular project, as that procurement decision represents the overwhelming majority of the cradle-to pre-A4 impacts under their control.

5. For policy-makers wishing to address structural fabrication in their low-carbon materials programs, we suggest requiring participation in AISC's fabricator-focused sustainability program, which sets the standard for sustainable steel fabrication. The program is free and available to all of AISC's nearly 1000 full-member fabricators. Learn more at www.aisc.org/partnerprogram, where a list of all program participants are also dynamically published.

In conclusion, threshold values in this report shall only be compared to GWP values from individual EPDs on a cradle-to-mill-gate or cradle-to-manufacturer-gate basis.

D. Use by FHWA and Others

This report is intended to be used by FHWA in support of their LCTM.

This report and the values included within are not intended to be used as a basis for LCA studies of FHWA projects.

As FHWA and other agencies are commonly subject to Buy America and/or Buy American statutes, the methodology and included results of this report are based on domestically-produced steel construction products. However, this is not an accurate representation of the actual domestic market for steel construction products where imports represent as much as 30% of the market for some products.

> Note: This report does not make any assertions as to which products are compliant with any particular Buy America(n) policies or requirements. It is the responsibility of others to verify compliance, such as with "melted and poured" standards.

Inclusion of the GWP impacts of imported products would significantly increase average and quintile industry values, thereby preferencing domestic production, and this inclusion should be considered in any future green procurement program not subject to Buy America requirements. The Buy America(n) statutes largely ensure that steel products purchased in the United States are better than the global average GWP, as illustrated in the next section.

1. Influence of the Global Market

Steel produced in the United States has the lowest carbon intensity of all the major steel-producing countries. Table I.D.1 illustrates the significant global differences in average GWP values for four common steel product types included in this report.

Table I.D.1. Comparison of North American and Global GWP (kg CO_2e / kg steel)

Steel Product	North American Average	Global Average[4]
Hot-Rolled Structural Sections	1.00[1]	1.66
Plate	1.47[1]	2.47
Hollow Structural Sections	1.71[2]	2.62
Reinforcing Bar	0.778[3]	1.77

[1] *Life Cycle Inventories of North American Steel Products*, American Iron and Steel Institute, 2021

[2] *Hollow Structural Sections,* Steel Tube Institute*, 2021*

[3] *Environmental Product Declaration: Fabricated Steel Reinforcement*, Concrete Reinforcing Steel Institute, 2022

[4] *Worldsteel LCA eco-profile Global - Sections, Plate, Rebar, Hot-rolled Coil, and Welded Pipe*, June 2023 , Worldsteel Association

A comprehensive discussion comparing domestic and global steel production can be found in Hasanbeigi, A. 2022, *Steel Climate Impact - An International Benchmarking of Energy and CO2 Intensities*, Global Efficiency Intelligence, Florida, United States

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Therefore, the methodology and resultant thresholds presented in this document are not suitable for any steel construction market not subject to Buy America and/or Buy American provisions.

E. Continual Maintenance

It is the intention of the steel construction products industry to reconvene in April of each year to identify potential changes to this report in consultation with FHWA and update this report on July 1 of each year, beginning in 2025.

These updates will benefit from the increased availability of even more robust and timely EPDs, as are expected in the future.

II. Products Included in this Report

The methodology proposed in this report is applicable for all steel construction products. However, average and quintile values will only be provided for those products for which an industry-average EPD and an adequate number of facility-specific EPDs have been published. Those products are listed below and fully described in the subsections of the report:

- Reinforcing Bar
- Steel Plate
- Hot-rolled Structural Sections
- Hollow Structural Sections
- Steel Deck

In the estimation of the steel industry, these products also represent the most common steel construction products used on federally-supported transportation projects.

Reinforcing bars, steel plate, and hot-rolled sections are finished steel products that can be transported from the producing mill to the project site without further manufacturing processes other than the fabrication processes required to prepare the product to the requirements of the specific project. Products such as hollow structural sections or steel decking are manufactured to standard sizes using a mill product, such as hot-rolled coil or cold-rolled coil, at a manufacturing facility and then may be shipped directly to a project site or to a fabrication facility for final preparation.

III. Availability of Industry Data

As of the date of this report, Table III summarizes the count of applicable facility- and product-specific EPDs for each product category included in this report which is an approximation of the percentage of overall market production. Note that these current counts are not necessarily the same as the number of participants who contributed to the development of industry-wide EPDs at the time of their publishing.

Table III. Summary of EPD Representation

Product Category	Product- and Facility-specific EPDs	Share of US Market Production Represented[1]	Industry-Wide EPD published by Applicable Trade Association?
Reinforcing Bar	26	High	Y
Steel Plate	9	High	Y
Hot-rolled Structural Sections	6	High	Y
Hollow Structural Sections	23	High	Y
Steel Deck	23	High	Y

[1]Key (Coverage of EPDs as estimate of market production represented):
High 67% to 100%
Medium 34% to 66%
Low 0% to 33%

As noted in Section I.C.2, current work is being undertaken to update the existing North American Steel Construction Products PCR, and it is anticipated that some of these EPDs will be updated, and new facility- and product-specific EPDs will be published, at the time of publication of the updated PCR. Any subsequent data published after the proposed annual update of this methodology document will be reflected in the subsequent annual update.

IV. Methodology for Determination of FHWA Requested Information

A. Overview

In accordance with the definition of "substantially lower" embodied carbon, as specified in the EPA's Interim Determination, the methodology for establishing 20%/40%/Better Than Average quintiles for steel products is provided below. In all the methodologies in this section, the following principles have been included:

- Production or capacity weighting is appropriate for establishing representative results
- For products with a small number of EPDs, leniency should be included when applying a strict 20th and 40th percentile calculation.
- Results are based on cradle-to-mill-gate or cradle-to-manufacture-gate scopes and do not include downstream, scenario-specific impacts, which are possible variations outside the control of steel mills or manufacturers.

B. Calculation of Average GWP

Primary Approach

The "Average GWP" for each product shall be established by referencing a currently valid industry-average Type III (third-party verified) EPD for the product that conforms to the applicable North American PCR for Steel Construction Products, published by an industry trade association representing the product. The "Average GWP" is the production-weighted average GWP impact for the product as reported in the respective industry-average EPD. The reported GWP used in industry data calculations is currently declared using IPCC AR5 (IPCC 2013) methodology.

Alternative Approach

For products not represented by an EPD described in the Primary Approach, an alternative approach to establishing the "Average GWP" may be used, which would consist of a calculated weighted average of available valid Type III (third-party verified) EPDs based on the applicable North American PCR for Steel Construction Products for the product. GWP values used should be weighted either by production or capacity.

At the time of publishing this report, all steel construction products included in this report have a currently valid Type III (third party verified) EPD, and the primary approach has been utilized.

C. Calculation of 20% and 40% Quintiles

Below is a hierarchy of approaches for determining GWP quintiles. The product-specific subsections of this report indicate which approach is used in each subsection.

Primary Approach (preferred)

GWP quintiles for a steel construction product shall be established by referencing the quintiles reported in a valid industry-average Type III (third-party verified) EPD for the product that conforms to the applicable North American PCR for Steel Construction Products, published by an industry trade association representing the product.

> Note: Currently, a valid industry-average Type III EPD that *includes quintile information* does not exist for any steel product. However, this inclusion may become a standard practice, and the requirement is currently being considered in the upcoming steel PCR revision.

Alternative Approach #1

For steel construction products not represented by an industry-average EPD that identifies quintiles described in the Primary Approach, alternative approach #1 is preferred when production or capacity values are available for all product EPDs.

20% and 40% quintiles shall be established by calculating the 20^{th} and 40^{th} percentiles of GWP values as reported among available product-specific EPDs (and/or LCA data points, such as from an industry-wide EPD's LCA model). GWP values used shall be weighted, either by production or capacity.

Alternative Approach #2

For steel construction products not represented by an industry average EPD that identifies quintiles described in the Primary Approach, no weighting data is available, and represented by 10 or more product specific EPDs, alternative approach #2 is preferred.

In this case, the process of weighting is neglected, and the 20% and 40% quintiles are determined by the GWP value of the EPD representing the highest GWP of the lowest 20% and 40% of reported EPD values.

Alternative Approach #3

For steel construction products not represented by an industry average EPD that identifies quintiles described in the Primary Approach; no weighting data is available; and due to a small number of EPDs, following alternative approach #2 without weighting would result in either single-sourcing or quintile data points corresponding to an unrepresentative market supply; then the alternative approach #3 shall be used.

Table IV.C determines the applicable quintiles by EPD count.

Table IV.C. Quintile Determinations for Alternative Approach #2

Product and Facility-Specific EPDs Available	20% Quintile	40% Quintile
0-5	Default to Average GWP	Default to Average GWP
6-8	2nd Lowest Reported GWP Value	3rd Lowest Reported GWP Value
9	2nd Lowest Reported GWP Value	4th Lowest Reported GWP Value

Summary of the Quintile Calculation Approaches

Approach	Industry Average EPD w/ Quintiles Exists?	Weighting Data Available?	>= 10 EPDs Available?	< 10 EPDs Available?	Source of Quintiles
Primary	Yes	-	-	-	From Industry Average EPD
Alternative #1	No	Yes	-	-	Weighted Average of EPDs
Alternative #2	No	No	Yes	-	Unweighted Average of EPDs
Alternative #3	No	No	No	Yes	From EPD based on Table Table IV.C

V. Results by Product

A. Reinforcing Bar

1. Product Description

Steel reinforcing bars, which are also known as steel reinforcement or rebar, are used within reinforced concrete for building, bridge, and industrial projects. Rebar produced in the mill is either transported directly to a contractor (no further fabrication needed), a distribution house, or a fabrication facility. Fabrication is where the rebar is bent, cut, or otherwise manufactured into the shapes needed for a given project.

Reinforcing bars are a family of steel products of varying strength, performance, physical, metallurgical, and chemical characteristics meeting the requirements of various standards. The GWP values included in this report are only for reinforcing bars conforming to *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement* (ASTM A615/A615M) or *Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement* (ASTM A706/A706M) and grade specific standards referenced therein.

Because reinforcing bars are used within concrete, and not as a standalone product, the GWP of reinforcing bars should be considered in conjunction with the GWP of concrete. Regardless of the application, reinforcing bars typically constitute only a small fraction of reinforced concrete, by mass. Thus, greater GWP reductions are usually possible by optimizing the design of the entire reinforced concrete member compared to optimizing the GWP of the reinforcing bars alone. Refer to the concrete industry's FHWA LCTM report for more information on appropriate GWP quintiles for concrete.

2. Industry Average

The primary approach of Section IV.B is followed. Table V.A.2 specifies the Industry Average for this product.

Table V.A.2. Industry Average Cradle-to-Mill-Gate GWP of Reinforcing Bar (kg CO_2e / kg steel)

Domestic	0.755[1]
Global	1.77[2]

[1] *Environmental Product Declaration: Fabricated Steel Reinforcement*, Concrete Reinforcing Steel Institute, 2022. The unfabricated value is back-calculated from the report.
[2] LCA Eco-Profile Global, Rebar, Worldsteel 2023
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.

This industry average is based on data collection from 19 CRSI-member mills producing reinforcing bars. Primary data for steel production was collected by the CRSI and represents the 2019-2020 production year. Weighting was based on production data. See also section 4.b) Representativeness & Market Coverage.

a) Comparison to Global Values

The industry average GWP-100 for domestically produced unfabricated reinforcing bars is 0.778 kg CO_2e / kg of steel. The global average is 1.77 kg CO_2e / kg of steel. The global average includes reinforcing bars produced in the United States, which means that the average GWP for reinforcing bars produced outside the United States is even higher than 1.77.

Clearly the most important decision a specifier can make to lower the GWP impact of a project using reinforcing bars is to specify domestic products.

3. Quintiles

As quintiles are not provided in either the background LCA or published industry-wide EPD, alternative approach #1 of Section IV.C was followed. Twenty-six facilities domestically produce reinforcing bars, meet the product description, and qualify for inclusion in this section. Table V.A.3 specifies the quintiles for this product. Weighting has been included and is based on proprietary market production capacity data kept by CRSI.

Table V.A.3. Quintile Cradle-to-Mill-Gate GWP of Steel Reinforcing Bars (kg CO_2e / kg steel)

	20%	40%
Domestic	0.614	0.678

Note: Inclusion of the GWP impacts of imported products would significantly increase quintile industry data. Therefore, the thresholds presented in this table are not suitable for any steel construction market not subject to Buy America or Buy American provisions.
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.

4. Variations, Limitations, and Interpretation

a) Methodology Consistency

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review. Likewise, it met a formal standard of methodological requirements.

20% and 40% Quintiles
The alternative approach of referencing a set of relevant facility-specific EPDs is less consistent. Those EPDs, and their accompanying LCAs, were done by different LCA consultants and at different times. Variations include differences in the software packages, differences in the background datasets referenced, and even differing versions of the same background datasets. Even methodological differences such as coproduct allocation and treatment of renewable energy sources may exist.

b) Representativeness & Market Coverage

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review, and data from 19 steel manufacturing facilities that produce reinforcing bars. The industry-wide EPD also met a formal standard of representativeness.

20% and 40% Quintiles
Approximately 92% of domestic reinforcing bar steel mill facilities are represented in the currently available producer and facility specific EPDs. The primary output of these facilities are straight and coil reinforcing bars intended for subsequent fabrication and installation in reinforced concrete for buildings, bridges, and other structural applications.

c) Geography

The twenty-six mills producing ASTM A615 or A706 reinforcing bars are located in Alabama, Arizona, Colorado, Connecticut, Florida, Illinois, Indiana, Missouri, Mississippi, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, South Carolina, Tennessee, Texas, Utah, and Washington, and serve markets throughout the United States. There is no variation in a particular product based on where the product was produced, as it must meet the functional requirements of the specified ASTM grade.

The only geographic variation between products would be the impact of the varying intensity of embodied carbon associated with the regional Egrid, as electricity is a major contributor to the average GWP-100 impact of the final product.

Each mill's capacity is closely matched to local or regional demand. Selecting products outside of a typical market may increase the GWP of the product due to increased

transportation-related GWP (A4) impacts. Overall, this burden shifting may result in an increase in the product's total A1-A4 GWP. Additionally, scrap sourcing is typically aligned to the market in which it is used. Mills that must increase capacity may need to source scrap from farther distances, which will increase the transportation-related GWP of the scrap, affecting the A2 impact.

d) Time Period

Industry Average
All primary data for mill operations is based on the 2019-2020 production year.

20% and 40% Quintiles
The facility-specific EPDs used to calculate quintiles are based on primary data either from production years 2019 through 2021.

e) Production Method & Technology

The production process for all domestic reinforcing bars begins when scrap steel is melted down in an electric-arc furnace (EAF) in a steel mill. Depending on the composition of the scrap, minor amounts (3% or less) of virgin materials may be added to meet the ASTM standard specification requirements for the given grade of steel. Thus, reinforcing bars conforming to ASTM A615 or A706 contain 97% recycled content or more.

f) Data Sources & Limitations

Primary data was used for modeling all mill processes. Background data was sourced from then current databases specific to the software including GaBi and Ecoinvent being used by the LCA practitioner performing the LCA study.

The establishment of thresholds and quintiles based on limited number of production facilities, the inherent variability and uncertainty associated with data collection, the variability in the time periods of collection, the use of constantly evolving background datasets, and 5-year EPD validity periods create the greatest limitations on the veracity of those values. Some of these limitations can be addressed through modifications to the PCR covering these products – such an update is currently underway, but the greatest limitation, a small number of domestic mill facilities producing this product, will not change.

g) Variability in Stages A1, A2 and A3

The North American Steel Construction Products PCR recognizes that the A1, A2, and A3 definitions are fluid based upon the EPD publisher's product and corresponding scope of control. Therefore, variability in the individual A1, A2 and A3 modules is not representative of the industry and only the aggregated A1, A2 and A3 should be considered. Below is a description of how those decisions were made and reported for this product.

Industry Average
As the Primary Approach was used to determine Average GWP from one source, the industry-wide EPD, no variability exists.

20% and 40% Quintiles
Among the 26 facility-specific EPDs used to determine the quintiles, they all utilize secondary tables to explicitly report their cradle-to-mill-gate GWP. A summary is shown in Table V.A.4g.

Table V.A.4g. References to Cradle-to-Mill-Gate GWP in Domestic Reinforcing Bar EPDs

EPD Owner	Date of Issue	Declaration Number	Reference
Cascade Steel – McMinnville, OR	01/01/2022	UL-EPD-4790066131	Table 6
CMC Steel Arizona – Mesa	02/25/2021	ASTM-EPD-151	Table 17
CMC Steel Florida – Jacksonville	02/25/2021	ASTM-EPD-151	Table 17
CMC Steel New Jersey – Sayreville	02/25/2021	ASTM-EPD-151	Table 17
CMC Steel Oklahoma – Durant	02/25/2021	ASTM-EPD-151	Table 17
CMC Steel South Carolina – Cayce	02/25/2021	ASTM-EPD-151	Table 17
CMC Steel Tennessee – Knoxville	02/25/2021	ASTM-EPD-151	Table 17
CMC Steel Texas – Seguin	02/25/2021	ASTM-EPD-151	Table 17
Evraz NA – Pueblo, CO	01/07/2021	SCS-EPD-06643	Table 5
Gerdau – Charlotte, NC	08/30/2021	SCS-EPD-07287	Table 5
Gerdau – Jackson, TN	08/30/2021	SCS-EPD-07288	Table 5
Gerdau – Midlothian, TX	08/30/2021	SCS-EPD-07289	Table 5
Nucor – Jewett, TX	06/24/2022	UL-EPD-4790372675	Table 11
Nucor – Plymouth, UT	06/24/2022	UL-EPD-4790372675	Table 11
Nucor – Auburn, NY	06/24/2022	UL-EPD-4790372675	Table 11
Nucor – Birmingham, AL	06/24/2022	UL-EPD-4790372675	Table 11
Nucor – Wallingford, CT	06/24/2022	UL-EPD-4790372675	Table 11
Nucor – Frostproof, FL	03/10/2023	ASTM-EPD-439	Table 2
Nucor – Jackson, MS	06/24/2022	UL-EPD-4790372675	Table 11
Nucor – Kankakee, IL	06/24/2022	UL-EPD-4790372675	Table 11
Nucor – Kingman, AZ	06/24/2022	UL-EPD-4790372675	Table 11
Nucor – Marion, OH	06/24/2022	UL-EPD-4790372675	Table 11
Nucor – Seattle, WA	06/10/2022	UL-EPD-4790291557	Table 2
Nucor – Sedalia, MO	10/13/2022	ASTM-EPD-378	Table 2

Steel Dynamics – Columbia City, IN	09/27/2022	ASTM-EPD-367	Table 4
Vinton Steel – Vinton, TX	06/23/2023	SCS-EPD-09168	Table 6

5. Future Activity

CRSI anticipates publishing an industry average EPD based on a new LCA study in advance of the expiration of the current industry-average EPD on September 19, 2027.

In 2024, work will begin on the SteelEPD project which will include both an LCI and EPD generator which will allow the use of significantly more consistent background datasets and a standardized methodology resulting in shorter EPD update cycles. It is anticipated that such a tool will be available within 3 years.

B. Steel Plate

1. Product Description

Steel plates are used in building, bridge, and industrial projects. Plates are typically detailed, cut, drilled bolted, welded, and otherwise processed at the fabricator to prepare them for installation. They consist of a family of steel products of varying strength, performance, physical, metallurgical, and chemical characteristics meeting the requirements of the *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling* (ASTM A6-19) and grade specific standards referenced therein.

Structural Steel is defined in the Code of Standard Practice for Steel Buildings and Bridges (ANSI/AISC 303-22).

2. Industry Average

The primary approach of Section IV.B is followed. Table V.B.2. specifies the Industry Average for this product.

Table V.B.2. Industry Average Cradle-to-Mill-Gate GWP of Steel Plate
(kg CO_2e / kg steel)

Domestic	1.47[1]
Global	2.47[2]

[1] *Life Cycle Inventories of North American Steel Products*, American Iron and Steel Institute, 2021.
[2] *Worldsteel LCA eco-profile Global - Plate,* June 2023, Worldsteel Association
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.

Primary data for steel production was collected by the AISI and represents the 2017 production year. Weighting was based on production data. See also section 4.b) Representativeness & Market Coverage.

a) Comparison to Global Values

The industry average GWP-100 for domestically produced steel plate is 1.47 kg CO_2e / kg of steel. The global average is 2.47 kg CO_2e / kg of steel. The global average includes hot-rolled sections produced in the United States which means that the average GWP for sections produced outside the United States is even higher than 2.47.

Clearly the most important decision a specifier can make to lower the GWP impact of a project using steel plate is to specify domestic products.

3. Quintiles

As quintiles are not provided in either the background LCA or published industry-wide EPD, no comprehensive weighting data is available, and the alternative approach #2 without weighting would produce single-sourcing results and quintile data points not corresponding to a representative market supply, the alternative approach #3 of Section IV.C was followed. Nine facilities domestically produce steel plate, meet the product description, and qualify for inclusion in this section. Table V.B.3. specifies the quintiles for this product.

Table V.B.3. Quintile Cradle-to-Mill-Gate GWP of Steel Plate
(kg CO_2e / kg steel)

	20%	40%
Domestic	0.987	1.16

Note: Inclusion of the GWP impacts of imported products would significantly increase quintile industry data. Therefore, the thresholds presented in this table are not suitable for any steel construction market not subject to Buy America or Buy American provisions.
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.

Note: it is expected that future versions of the industry-average steel plate EPD, or its background report, will contain information necessary to determine weighted quintile values.

4. Variations, Limitations, and Interpretation

a) Methodology Consistency

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review. Likewise, it met a formal standard of methodological requirements.

20% and 40% Quintiles
The alternative approach of referencing a set of relevant facility-specific EPDs is less consistent. Those EPDs, and their accompanying LCAs, were done by different LCA consultants and at different times. Variations include differences in the software packages, differences in the background datasets referenced, and even differing versions of the same background datasets. Methodological differences such as coproduct allocation and treatment of renewable energy sources may also exist.

b) Representativeness & Market Coverage

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review, and it met a formal standard of representativeness. Six major facilities, of both EAF and BOF steelmaking, are represented.

20% and 40% Quintiles
All but one domestic plate facilities in operation in 2022 are represented in currently available producer and facility specific EPDs. A new plate mill began operation in Kentucky in 2023 for which a full year of normal operating and production data is not yet available. When that information is available, it is anticipated that a facility specific EPD will be readily published.

c) Geography

Plate mills are located in Alabama, Indiana, Iowa, Kentucky, North Carolina, Oregon, Pennsylvania, and Texas and serve markets throughout the United States. There is no variation in a particular product based on where the product was produced, as it must meet the functional requirements of the specified ASTM grade.

The only geographic variation between products would be the impact of the varying intensity of embodied carbon associated with the regional electricity grid, as roughly 45% of the average GWP-100 impact of the final product is attributed to electricity.

d) Time Period

Industry Average
All primary data for mill operations is based on the 2017 production year per *Life Cycle Inventories of North American Steel Products*, American Iron and Steel Institute, 2021.

20% and 40% Quintiles
The facility-specific EPDs used to calculate quintiles are based on primary data from production years spanning 2018-2022.

e) Production Method & Technology

Plate products can be produced via electric arc furnace (EAF) or integrated blast furnace/basic oxygen furnace (BF/BOF) steel production technologies. Regardless of production method or technology, plate products are required to meet the same ASTM specifications and are functionally equivalent in the marketplace.

f) Data Sources & Limitations

Primary data was used in existing EPDs for modeling all mill and fabrication processes. Background data was sourced from then current databases specific to the software including GaBi and Ecoinvent being used by the LCA practitioner performing the LCA study.

The establishment of thresholds and quintiles based on limited number of production facilities, the inherent variability and uncertainty associated with data collection, the variability in the time periods of collection, the use of constantly evolving background datasets and 5-year EPD validity periods create the greatest limitations on the accuracy of those values. Some of these limitations can be addressed through modifications to the PCR covering these products – such an update is currently underway, but the greatest limitation (a small number of domestic mill facilities producing this product) will not change.

g) Variability in Stages A1, A2 and A3

The North American Steel Construction Products PCR recognizes that the A1, A2, and A3 definitions are fluid based upon the EPD author's product and corresponding scope of control. Therefore, variability in the individual A1, A2 and A3 modules is not representative of the industry and only the aggregated A1, A2 and A3 should be considered. Below is a description of how those decisions were made and reported for this product.

Industry Average
As the Primary Approach was used to determine Average GWP from one source, the industry-wide EPD, no variability exists.

20% and 40% Quintiles
Among the nine facility-specific EPDs used to determine the quintiles, many utilize secondary tables to explicitly report their cradle-to-mill-gate GWP. A summary is shown in Table V.B.4g.

Table V.B.4g. References to Cradle-to-Mill-Gate GWP in Domestic Steel Plate EPDs

EPD Owner	Date of Issue	Declaration Number	Reference
Cleveland Cliffs - Burns Harbor, IN	06/20/24	SCS-EPD-10190	Table 5
Cleveland Cliffs - Coatesville, PA	06/06/23	SCS-EPD-09058	Table 5
JSW - Baytown, TX	05/04/23	SmartEPD-2023-001-0002-01	Page 10
JSW - Baytown, TX	05/04/23	SmartEPD-2023-001-0003-01	Page 10
Nucor - Hertford County, NC	07/27/23	SCS-EPD-09262	Table 3
Nucor - Tuscaloosa, AL	07/27/23	SCS-EPD-09263	Table 3
SSAB - Muscatine, IA	08/24/22	4790146803.102.1	Table 5
SSAB - Axis, AL	08/24/22	4790146803.102.1	Table 4
EVRAZ Portland, OR	02/10/22	SCS-EPD-07593	Table 5

5. Future Activity

In 2024, work will begin on the SteelEPD project which will include both an LCI and EPD generator which will allow the use of significantly more consistent background datasets and a standardized methodology resulting in shorter EPD update cycles. It is anticipated that such a tool will be available within 3 years.

It is expected that future versions of the industry-average steel plate EPD, or its background report, whether created by SteelEPD or by other means, will contain information necessary to determine weighted quintile values.

C. Hot-rolled Structural Sections

1. Product Description

Hot-rolled structural steel sections are used in building, bridge, and industrial projects. These products are rolled shapes such as parallel flange sections, angles, channels, and tees that are detailed, cut drilled, bolted, welded, and otherwise processed at the fabricator in order to prepare them for installation. They consist of a family of steel products of varying strength, performance, physical, metallurgical, and chemical characteristics meeting the requirements of the *Standard Specification for General Requirements of Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling* (ASTM A6-22) and grade specific standards referenced therein.

Structural Steel is defined in the *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303-22). They differ from Merchant Bar Quality (MBQ) products in that the latter are produced at bar mills as "junior products", whose applications include ancillary reinforcement and non-structural purposes such as frames, brackets, fencing, gates, doors, windows, and railings.

2. Industry Average

The primary approach of Section IV.B is followed. Table V.C.2 specifies the Industry Average for this product.

Table V.C.2. Industry Average Cradle-to-Mill-Gate GWP of Hot-rolled Structural Sections (kg CO_2e / kg steel)

Domestic	1.00[1]
Global	1.66[2]

[1] *Life Cycle Inventories of North American Steel Products*, American Iron and Steel Institute, 2021
[2] *Worldsteel LCA eco-profile Global - Sections,* June 2023, worldsteel Association
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.

This industry average is based on data collection from 100% of all heavy structural mills rolling hot-rolled sections. Primary data for steel production was collected by the AISI and represents the 2017 production year. Weighting was based on production data. See also section 4.b) Representativeness & Market Coverage.

> Note: redevelopment of AISC's industry-wide EPD is underway and expected to be completed by the end of 2024. This update will reflect 2023 production year data.

a) Comparison to Global Values

The industry average GWP-100 for domestically produced hot-rolled sections is 1.00 kg CO_2e / kg of steel. The global average is 1.66 kg CO_2e / kg of steel. The global average includes hot-rolled sections produced in the United States which means that the average GWP for sections produced outside the United States is even higher than 1.66.

Clearly the most important decision a specifier can make to lower the GWP impact of a project using hot-rolled structural steel is to specify domestic products.

3. Quintiles

As quintiles are not provided in either the background LCA or published industry-wide EPD, but reliable weighting data is available, the alternative approach #1 of Section IV.C was followed. Six facilities domestically produce hot-rolled structural sections, meet the product description, and qualify for inclusion in this section. Table V.C.3 specifies the quintiles for this product. Weighting has been included and is based on proprietary production data kept by AISC.

Table V.C.3. Quintile Cradle-to-Mill-Gate GWP of Hot-rolled Structural Sections (kg CO_2e / kg steel)

	20%	40%
Domestic	0.713	0.816

Note: Inclusion of the GWP impacts of imported products would significantly increase quintile industry data. Therefore, the thresholds presented in this table are not suitable for any steel construction market not subject to Buy America or Buy American provisions.
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.

4. Variations, Limitations, and Interpretation

a) Methodology Consistency

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review. Likewise, it met a formal standard of methodological requirements.

20% and 40% Quintiles
The alternative approach of referencing a set of relevant facility-specific EPDs is less consistent. Those EPDs, and their accompanying LCAs, were done by different LCA consultants and at different times. Variations include differences in the software packages, differences in the background datasets referenced, and even differing versions of the same background datasets. Methodological differences such as coproduct allocation and treatment of renewable energy sources may also exist.

b) Representativeness & Market Coverage

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review. Likewise, it met a formal standard of representativeness.

20% and 40% Quintiles
100% of domestic hot-rolled structural section facilities are represented in the currently available producer and facility specific EPDs. The primary output of these facilities are heavy structural sections intended for subsequent fabrication and installation in buildings, bridges, and other structural applications.

A limited number of junior structural shapes are produced at bar mills whose primary products are merchant bar quality (MBQ), special bar quality (SBQ), rod, and wire material. Common applications include ancillary reinforcement and non-structural purposes such as frames, brackets, fencing, gates, doors, windows, and railings.

c) Geography

The six heavy structural mills are located in Arkansas, Texas, Indiana, Georgia, Virginia, and South Carolina and serve markets throughout the United States. There is no variation in a particular product based on where the product was produced, as it must meet the functional requirements of the specified ASTM grade.

The only geographic variation between products would be the impact of the varying intensity of embodied carbon associated with the regional electricity grid, as electricity is a major contributor to the average GWP-100 impact of the final product.

d) Time-period

Industry Average
All primary data for mill operations is based on the 2017 production year per *Life Cycle Inventories of North American Steel Products*, American Iron and Steel Institute, 2021.

20% and 40% Quintiles
The facility-specific EPDs used to calculate quintiles are based on primary data either from production years 2017 or 2020.

e) Production Method & Technology

All six heavy structural mills use EAF technology for the process of melting scrap. As such, their technology is essentially identical and their products are functionally equivalent.

f) Data sources & Limitations

Primary data was used for modeling all mill and fabrication processes. Background data was sourced from then current databases specific to the software including GaBi and Ecoinvent being used by the LCA practitioner performing the LCA study.

The establishment of thresholds and quintiles based on limited number of production facilities, the inherent variability and uncertainty associated with data collection, the variability in the time periods of collection, the use of constantly evolving background datasets and 5-year EPD validity periods create the greatest limitations on the veracity of those values. Some of these limitations can be addressed through modifications to the PCR covering these products – such an update is currently underway, but the greatest limitation (a small number of domestic mill facilities producing this product) will not change.

g) Variability in Stages A1, A2, and A3

The North American Steel Construction Products PCR recognizes that the A1, A2, and A3 definitions are fluid based upon the EPD author's product and corresponding scope of control. Therefore, variability in the individual A1, A2 and A3 modules is not representative of the industry and only the aggregated A1, A2 and A3 should be considered. Below is a description of how those decisions were made and reported for this product.

Industry Average
As the Primary Approach was used to determine Average GWP from one source, the industry-wide EPD, no variability exists.

20% and 40% Quintiles
Among the six facility-specific EPDs used to determine the quintiles, they all utilize secondary tables to explicitly report their cradle-to-mill-gate GWP. A summary is shown in Table V.C.4g.

Table V.C.4g. References to Cradle-to-Mill-Gate GWP in Domestic Hot-rolled Structural Sections EPDs

EPD Owner	Date of Issue	Declaration Number	Reference
Gerdau - Cartersville, GA	04/11/22 (v2)	SCS-EPD-07505	Table 7
Gerdau - Midlothian, TX	12/10/21	SCS-EPD-07506	Table 7
Gerdau - Petersburg, VA	04/11/22 (v2)	SCS-EPD-07508	Table 7
Nucor - Berkeley (Huger, SC)	01/01/21	UL 4789793365.102.1	Table 8
Nucor - NYS (Blytheville, AR)	01/01/21	UL 4789793365.102.1	Table 8
Steel Dynamics Inc - Columbia City, IN	06/30/22	ASTM-EPD341	Table 8

5. Future Activity

AISC is currently redeveloping a new industry-average LCA for hot-rolled heavy structural sections based on 2023 production data. The industry-average EPDs based on this LCA study will include both the industry average and 20% and 40% quintiles.

The SteelEPD project will include both an LCI and EPD generator which will allow the use of significantly more consistent background datasets and a standardized methodology, resulting in shorter EPD update cycles. It is anticipated that such a tool would be available within 3 years.

D. Hollow Structural Sections

1. Product Description

Hollow Structural Sections (HSS) included in this report are cold-formed, welded steel tubes produced in round, square, and rectangular shapes in a broad range of dimensions, thicknesses, and lengths. HSS are used as structural elements in buildings, bridges, and other structures as well as a variety of manufactured products. The scope of this report includes HSS produced according to ASTM Specifications A500, A1085, and A847. Although this report specifically focuses on HSS, the Steel Tube Institute's industry-wide Environmental Product Declaration for HSS also encompasses other welded tube products, such as steel pipe and piling, produced to ASTM Specifications A513, A53, A135, A252, A795, as well as the Canadian equivalent of A500, CSA G40.21. These other welded tube products are manufactured at the same facilities as HSS, using similar materials and processes.

2. Industry Average

The primary approach of Section IV.B is followed. Table V.D.2 specifies the Industry Average for this product.

Table V.D.2. Industry Average Cradle-to-Mill-Gate GWP of Hollow Structural Sections (kg CO_2e / kg steel)

Domestic	1.71[1]
Global	2.62[2]

[1] *Environmental Product Declaration, Hollow Structural Sections*, Steel Tube Institute, 2021
[2] See "Comparison to global values" below for commentary
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.

This industry average data collected represents HSS production in 2019 and 2020 by participating STI members located at 18 welded tube facilities across North America. 17 facilities are located in the United States, while 1 facility is located in Canada. Results are weighted according to production totals at participating facilities. See also section 4.b) Representativeness & Market Coverage.

> Note: redevelopment of STI's industry-wide EPD will begin in 2025 and is expected to be completed by the end of 2025. The 2025 update will reflect 2024 production year data.

a) Comparison to global values

While there is no known industry average for "Hollow Structural Sections" published on a global basis, the global average for welded pipe is a reasonable proxy. The global average GWP-100 for welded pipe is 2.62 kg CO_2e / kg of steel, per *Worldsteel LCA Eco-Profile, Global*

Welded Pipe, 2023. The industry average GWP-100 for domestically produced hollow structural sections is 1.71 CO_2e / kg of steel.

Clearly the most important decision a specifier can make to lower the GWP impact of a project using steel Hollow Structural Sections is to specify domestic products.

3. Quintiles

As quintiles are not provided in either the original background LCA or published industry-wide EPD, a subsequent analysis was done by the original LCA consultant utilizing the LCA model created for the industry-wide EPD in order to follow alternative approach #1 of Section IV.C. The data from facilities which domestically produce Hollow Structural Sections, meet the product description, and qualify for inclusion in this section were included in the industry-wide EPD, and subsequently included in the determination of these quintiles. Table V.D.3 specifies the quintiles for this product. The data collected represents HSS production in 2019 and 2020 by participating STI members. Results are weighted according to production totals at participating facilities.

Table V.D.3. Quintile Cradle-to-Mill-Gate GWP of Hollow Structural Sections (kg CO_2e / kg steel)

	20%	40%
Domestic[1]	1.62	1.63

Note: Inclusion of the GWP impacts of imported products would significantly increase quintile industry data. Therefore, the thresholds presented in this table are not suitable for any steel construction market not subject to Buy America or Buy American provisions.
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.
[1]See section 4.g below for commentary on the minimal difference between the 20% and 40% quintiles

4. Variations, Limitations, and Interpretation

a) Methodology Consistency

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review. Likewise, it met a formal standard of methodological requirements.

20% and 40% Quintiles
The same LCA model used for the industry-wide EPD was also employed to develop the 20% and 40% quintiles. These quintiles are derived by production-weighting the facility-specific results from the industry-wide LCA model.

b) Representativeness & Market Coverage

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review. Likewise, it met a formal standard of representativeness. HSS manufactured from both EAF and BOF coil sources are represented.

20% and 40% Quintiles
18 welded tube facilities in the United States and Canada were included in the development of the industry average EPD and LCA model, and subsequently the development of the 20% and 40% quintiles. The primary output of these facilities are steel tube sections of varying types, including Hollow Structural Sections. 16 of the facilities produce HSS, along with other welded tube products, while 2 of the facilities produce non-HSS welded tube products, using a similar manufacturing process. Although this approach doesn't include all 23 facility-specific EPDs available in the marketplace as of the date of this report, it is deemed sufficient, as it incorporates weighting data available at the time of the creation of the industry-wide EPD's LCA model. Likewise, it meets a formal standard of representativeness.

c) Geography

The HSS production facilities are located across the United States, from Portland, Oregon to Birmingham, Alabama and serve markets throughout the United States. There is no significant variation in a particular HSS product based on where the product was manufactured, as it must meet the functional requirements of the specified ASTM grade.

The primary geographic variation in environmental impact is due to varying intensity of embodied carbon associated with the regional Egrid, as electricity is a major contributor to the average GWP-100 impact of the final product. Most of this impact occurs during the upstream steel coil production (A1), rather than during the HSS manufacturing process.

d) Time Period

Primary data was collected for HSS production during the years 2019 and 2020. Background data for steel coil production was taken from the AISI and worldsteel and represents steel production during 2017 and 2019 respectively.

e) Production Method & Technology

Hollow structural sections covered by this report are manufactured by cold-forming steel coil into tubes. Hot-rolled coil is first slit into sections of appropriate width. The narrower coils are then uncoiled and passed through a series of rollers that form the continuous sheet into rectangular, square, or round tubes. The two edges of the coil are welded together via an electric resistance welding process and the product is then cut to length. Once manufactured, HSS can be powder coated or primed—or left uncoated. The tubes are subsequently packaged

for shipment. The primary input to HSS production is the steel itself, although small amounts of process and coating materials are needed. Electricity is used for manufacturing and to move the materials.

Steel coil can be produced via electric arc furnace (EAF) or integrated blast furnace/basic oxygen furnace (BOF) steel production technologies. Regardless of production method or technology of the coil feedstock, HSS products are required to meet the same ASTM specifications and are functionally equivalent in the marketplace.

f) Data Sources & Limitations

The Steel Tube Institute industry average LCA model was created using the GaBi 10 software system for life cycle engineering. Background life cycle inventory data for raw materials (coil) and processes were obtained from the GaBi 2021 database (CUP 2021.1). Primary manufacturing data was provided by the participating STI member companies.

The data limitations include the absence of upstream mill-specific coil data, necessitating reliance on industry averages for upstream processes. Additionally, the limited number of HSS manufacturing facilities providing primary data further constrains the comprehensiveness of the model.

g) Variability in Stages A1, A2 and A3

The North American Steel Construction Products PCR recognizes that the A1, A2, and A3 definitions are fluid based upon the EPD author's product and corresponding scope of control. Therefore, variability in the individual A1, A2 and A3 modules is not representative of the industry and only the aggregated A1, A2 and A3 should be considered. Below is a description of how those decisions were made and reported for this product.

Industry Average
As the Primary Approach was used to determine Average GWP from one source, the industry-wide EPD, no variability exists in the methodology.

20% and 40% Quintiles
The same LCA model used for the industry-wide EPD was employed to develop the 20% and 40% quintiles. These quintiles are derived by production-weighting the facility-specific results from the industry-wide LCA model. As the same model was utilized for all facilities, no variability exists in the methodology.

The cradle-to-gate potential environmental impacts of HSS products are primarily driven by the upstream steel coil production (A1). Inbound transport to manufacturing (A2) and HSS manufacturing (A3) contribute to potential environmental impacts on a much smaller scale. Due to the reliance on publicly available industry average data for upstream coil production (A1),

and the relatively minimal A2 and A3 impacts, there is little variability in the total GWP results for HSS products. Consequently, the 20% and 40% quintile thresholds show very little difference.

The industry-wide LCA model, developed in 2021, includes facility-specific data from 18 welded tube facilities in the United States and Canada, and was used to determine the quintiles. At this time, there are 23 known HSS facility-specific EPDs in the United States and Canada, with many using secondary tables to explicitly report their cradle-to-manufacturer-gate GWP. A summary of the available EPDs is shown in Table V.D.4g.

Table V.D.4g. References to Cradle-to-Manufacturer-Gate GWP in Domestic HSS EPDs

EPD Owner	Date of Issue	Declaration Number	Reference
Atlas Tube – Birmingham, AL	03/22/2022	4790050508.101.1	Table 6
Atlas Tube – Blytheville, AR	03/22/2022	4790050508.101.1	Table 6
Atlas Tube – Chicago, IL	03/22/2022	4790050508.101.1	Table 6
Atlas Tube – Harrow, ON	03/22/2022	4790050508.101.1	Table 6
Atlas Tube – Plymouth, MI	03/22/2022	4790050508.101.1	Table 6
Bull Moose Tube - Burlington, ON	09/28/2023	SCS-EPD-07425	Table 1
Bull Moose Tube - Casa Granda, AZ	09/28/2023	SCS-EPD-07425	Table 1
Bull Moose Tube - Chicago Heights, IL	09/28/2023	SCS-EPD-07425	Table 1
Bull Moose Tube - Elkhart, IN	09/28/2023	SCS-EPD-07425	Table 1
Bull Moose Tube - Gerald, MO	09/28/2023	SCS-EPD-07425	Table 1
Bull Moose Tube - Masury, OH	09/28/2023	SCS-EPD-07425	Table 1
Bull Moose Tube - Sinton, TX	*	*	*
Bull Moose Tube - Trenton, GA	09/28/2023	SCS-EPD-07425	Table 1
Nucor Tubular Products – Birmingham, AL	04/01/2021	4789971302.101.1	Table 10
Nucor Tubular Products – Chicago, IL	04/01/2021	4789971302.101.1	Table 10
Nucor Tubular Products – Decatur, AL	04/01/2021	4789971302.101.1	Table 10
Nucor Tubular Products - Ghent, KY	**	**	**
Nucor Tubular Products – Marseilles, IL	04/01/2021	4789971302.101.1	Table 10
Nucor Tubular Products – Trinity, AL	04/01/2021	4789971302.101.1	Table 10
Maruichi American Corporation, Santa Fe Springs, CA	02/03/2022	4790026863.101.1	See note below Table 3
Maruichi Leavitt Pipe & Tube, Chicago, IL	04/01/2022	4790146752.101.1	***

Maruichi Oregon Steel Tube, Portland, OR	02/03/2022	4790026916.101.1	See note below Table 4
Searing Industries, Rancho Cucamonga, CA	03/02/2022	4790324337.101.1	Table 5
Searing Industries, Cheyenne, WY	03/02/2022	4790324337.101.1	Table 5
Vest, Inc., Vernon, CA	07/01/2022	4790434237.101.1	See note below Table 3

*Bull Moose Tube, Sinton, TX facility is anticipated to be included in declaration number SCS-EPD-07425 by September 2024.
**Nucor Tubular Products, Ghent, KY facility is anticipated to be included in declaration number 4789971302.101.1 in 2025.
***Declaration number 4790146752.101.1 does not show the GWP-100 for HSS prior to fabrication. The GWP-100 for HSS can be determined by dividing the A1 value in Table 2 by 1.08.

5. Future Activity

STI will begin redeveloping a new industry-average LCA and resultant EPD for Hollow Structural Sections in 2025, based on 2024 production data.

STI will also work with AISC on the inclusion of Hollow Structural Sections in the SteelEPD project which will include both an LCI and EPD generator which will allow the use of significantly more consistent background datasets and a standardized methodology resulting in shorter EPD update cycles. It is anticipated that such a tool would be available within 3 years.

E. Steel Deck

1. Product Description

Steel Deck functions as the primary supporting surface for form and/or positive reinforcement for concrete bridge decks and concrete floor slabs in buildings and the primary supporting surface for roofing materials for buildings.

Steel deck is typically manufactured by rolling or otherwise forming coated or galvanized steel coils into specific shapes. The coils are either galvanized or uncoated steel to which a coating of paint may be applied. Typical steel roof or floor deck panels are 0.5 to 6 inches in depth and are manufactured from 28 to 16 gauge material. Steel deck products are defined by the following standards:

- ANSI/SDI SD-2022
- ANSI/SDI QA/QC-2022
- ANSI/SDI T-CD-2022
- ANSI/SDI SDI-COSP-2023

Steel deck is typically sold based on "squares" which are 100 square feet of deck. The weight of the square will vary with the gauge of the steel used, requiring conversion from squares to the declared unit for steel construction products of metric tons.

Steel deck is delivered from the manufacturer or a regional warehouse to the project site for installation without additional fabrication.

2. Industry Average

The primary approach of Section IV.B is followed. Table V.E.2 specifies the Industry Average for this product.

Table V.E.2. Industry Average Cradle-to-Mill-Gate GWP of Steel Deck
(kg CO_2e / kg steel)

Domestic	2.32[1]
Global	2.70[2]

[1] *Steel Roof and Floor Deck*, Steel Deck Institute, 2022
[2] See "Comparison to global values" below for commentary
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.

This industry average is based on data collection from a subset of Steel Deck Institute's (SDI) members, representing approximately 90% of domestic deck production. Primary data for steel production was collected by SDI and represents 2019 and 2020 production years. Primary data for coated or galvanized steel coil was collected by AISI and represents the 2017 production year. Weighting was based on production data. AISI galvanized coil data represents the

weighted average of coil produced by the BOF and EAF methods of crude steel production. See also section 4.b) Representativeness & Market Coverage.

a) Comparison to Global Values

Greater than 95% of the GWP-100 impact associated with steel deck originates with the steel coil being formed into the steel deck by the manufacturing of steel deck. The domestic average for hot-dipped galvanized cold-rolled steel coil used in the production of steel deck used in the industry-average EPD published by the Steel Deck Institute was 2.32 kg of CO_2e / kg of steel. Since the publication of the industry-average EPD in early 2022, EPDs for steel deck have documented an increasing trend to use lower GWP steel coil in their manufacturing processes which would lower the industry-average GWP. The global average for hot-dip galvanized cold rolled coil is 2.70 kg of CO_2e / kg of steel. The global average includes hot-dipped galvanized coil produced in the United States which means that the average GWP for coil produced outside the United States is even higher than 2.70.

Clearly the most important decision a specifier can make to lower the GWP impact of a project using steel deck is to specify steel deck manufactured from domestically produced coil.

3. Quintiles

As quintiles are not provided in either the background LCA or published industry-wide EPD, alternative approach #2 of Section IV.C was followed. 23 facility published EPDs meet the product description, and qualify for inclusion in this section. Table V.E.3 specifies the quintiles for this product. Weighting has not been included as facility specific production and capacity data are not available for steel deck production due to existing confidentiality agreements. Despite this limitation, the author of this section believes that alternative approach #2 still provides reasonable results that do not create single-sourcing or quintile data points corresponding to an unrepresentative market supply.

Table V.E.3. Quintile Cradle-to-Mill-Gate GWP of Steel Deck
(kg CO_2e / kg steel)

	20%	40%
Domestic	1.63	1.85

Note: Inclusion of the GWP impacts of imported products would significantly increase quintile industry data. Therefore, the thresholds presented in this table are not suitable for any steel construction market not subject to Buy America or Buy American provisions.
Note: see Section I.C.4. for a discussion on the exclusion of downstream processes.

4. Variations, Limitations, and Interpretation

a) Methodology Consistency

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review. Likewise, it met a formal standard of methodological requirements.

20% and 40% Quintiles
The alternative approach of referencing a set of relevant facility-specific EPDs is less consistent. Those EPDs, and their accompanying LCAs, were done by different LCA consultants and at different times. Variations include differences in the software packages, differences in the background datasets referenced, and even differing versions of the same background datasets. Methodological differences such as coproduct allocation and treatment of renewable energy sources may also exist.

b) Representativeness & Market Coverage

Industry Average
The industry-wide EPD was developed in accordance with industry standards, including a third-party review. Likewise, it met a formal standard of representativeness.

20% and 40% Quintiles
Approximately 70% of domestic steel deck facilities are represented in the currently available producer and facility specific EPDs. The primary output of these facilities is steel deck intended for installation in buildings and bridges without subsequent fabrication.

c) Geography

The steel deck manufacturers included in the industry average EPD are located in Alabama, Arizona, Arkansas, Florida, Indiana, Nebraska, New York, South Carolina, Tennessee, Texas, Virginia, and Washington and serve markets throughout the United States. There is no variation in a particular product based on where the product was manufactured, as it must meet the functional requirements of the applicable standards.

The only geographic variation between products would be the impact of the varying intensity of embodied carbon associated with the regional Egrid, as the majority of the GWP-100 impact of the manufacturing stage (A3) is attributed to electricity.

d) Time-period

Industry Average
All primary data for steel deck manufacturing operations is based on 2019 and 2020 production years.
All primary data for coated or galvanized coil feedstock is based on the 2017 production year.

20% and 40% Quintiles
The facility-specific EPDs used to calculate quintiles are based on primary data either from production years 2019, 2020 and 2021.

e) Production Method & Technology

All steel deck manufacturers use similar technology to produce steel deck products from hot-dipped galvanized coil. Coil products may be produced via electric arc furnace (EAF) or integrated blast furnace/basic oxygen furnace (BOF) steel production technologies. Regardless of production method or technology of the coil feedstock, steel deck products are required to meet the same ASTM specifications and are functionally equivalent in the marketplace.

f) Data Sources & Limitations

Primary data was used for modeling of all mill production of coated or galvanized coil (AISI) and steel deck manufacturing processes. Background data was sourced from then current databases specific to the software including GaBi and Ecoinvent being used by the LCA practitioner performing the LCA study.

The establishment of thresholds and quintiles based on limited number of production facilities, the inherent variability and uncertainty associated with data collection, the variability in the time periods of collection, the use of constantly evolving background datasets and 5-year EPD validity periods create the greatest limitations on the veracity of those values. Some of these limitations can be addressed through modifications to the PCR covering these products – such an update is currently underway, but the greatest imitation of a small number of domestic mill facilities producing this product will not change.

g) Variability in Stages A1, A2, and A3

The North American Steel Construction Products PCR recognizes that the A1, A2, and A3 definitions are fluid based upon the EPD publisher's product and corresponding scope of control. Therefore, variability in the individual A1, A2 and A3 modules is not representative of the industry and only the aggregated A1, A2 and A3 should be considered. Below is a description of how those decisions were made and reported for this product.

Industry Average
As the Primary Approach was used to determine Average GWP from one source, the industry-wide EPD, no variability exists.

20% and 40% Quintiles

Among the 23 facility-specific EPDs used to determine the quintiles, they all utilize secondary tables to explicitly report their cradle-to-mill-gate GWP. A summary is shown in Table V.E.4g.

Table V.E.4g. References to Cradle-to-Manufacturer-Gate GWP in Domestic Steel Deck EPDs

EPD Owner	Date of Issue	Declaration Number	Reference
ASC Steel Deck – Kakama, WA (BOF)	02/04/2022	SCS-EPD-07580	Table 5
ASC Steel Deck – Kakama, WA (EAF)	02/04/2024	SCS-EPD-07581	Table 5
New Millennium – Butler, IN	08/18/2023	ASTM-EPD-504	Table 5-1
CSC	06/21/2024	4791294272.101.1	Table 1
CSC	06/21/2024	4791294272.102.1	Table 1
CSC	06/21/2024	4791294272.103.1	Table 1
CSC	06/21/2024	4791294272.104.1	Table 1
New Millennium – Hope, AR	08/18/2023	ASTM-EPD-504	Table 5-2
New Millennium – Salem, WA	08/18/2023	ASTM-EPD-504	Table 5-3
New Millennium – Lake City, FL	08/18/2023	ASTM-EPD-504	Table 5-4
New Millennium – Memphis, TN	08/18/2023	ASTM-EPD-504	Table 5-5
Verco – Phoenix, AZ (EAF)	06/29/2023	SCS-EPD-09143	Table 11
Verco – Fontana, CA (EAF)	06/29/2023	SCS-EPD-09143	Table 11
Verco – Antioch, CA (EAF)	06/29/2023	SCS-EPD-09143	Table 11
Verco – Phoenix, AZ (BOF)	06/29/2023	SCS-EPD-09143	Table 12
Verco – Fontana, CA (BOF)	06/29/2023	SCS-EPD-09143	Table 12
Verco – Antioch, CA (BOF)	06/29/2023	SCS-EPD-09143	Table 12
Vulcraft-Nucor – Chemung, NY	06/29/2023	SCS-EPD-09144	Table 7
Vulcraft-Nucor – Florence, SC	06/29/2023	SCS-EPD-09144	Table 7
Vulcraft-Nucor – Fort Payne, AL	06/29/2023	SCS-EPD-09144	Table 7
Vulcraft-Nucor – Grapeland, TX	06/29/2023	SCS-EPD-09144	Table 7
Vulcraft-Nucor – Norfolk, NE	06/29/2023	SCS-EPD-09144	Table 7
Vulcraft-Nucor – Saint Joe, IN	06/29/2023	SCS-EPD-09144	Table 7

5. Future Activity

As additional steel deck producers publish EPDs, industry coverage will increase to greater than 95%.

SDI anticipates publishing an industry average EPD based on a new LCA study in advance of the expiration of the current industry-average EPD on January 1, 2027. The industry-average EPDs based on this LCA study will include both the industry average and 20% and 40% quintiles.

In 2024, work will begin on the SteelEPD project which will include both an LCI and EPD generator which will allow the use of significantly more consistent background datasets and a standardized methodology resulting in shorter EPD update cycles. It is anticipated that such a tool will be available within 3 years.