United States
International Trade Commission

# Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level

February 2025
Publication Number: 5584
Investigation Number: 332-598

United States International Trade Commission

## Commissioners

Amy A. Karpel, Chair

David S. Johanson

Rhonda K. Schmidtlein

Jason E. Kearns

Catherine DeFilippo
**Director, Office of Operations**

Jeremy E. Wise
**Director, Office of Industry and Competitiveness Analysis**

**Address all communications to**
Office of External Relations
(externalrelations@usitc.gov)
United States International Trade Commission
Washington, DC 20436

United States International Trade Commission

# Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level

February 2025
Publication Number: 5584
Investigation Number: 332-598

*This report was prepared principally by:*

***Project Leader***
Caroline Peters

***Deputy Project Leaders***
Shova KC, Alexander Melton, Kristin Smyth

***Office of Industry and Competitiveness Analysis***
Mark Brininstool, Dylan Carlson, Diana Friedman, David Guberman, Anna Perry, Meagan Reid, Karl Tsuji, Kelsi Van Veen

***Office of Analysis and Research Services***
Ann Marie Carton, Conor Hargrove, Maureen Letostak, David Oppenlander, Samantha Sanfelice, David Taylor, Laura Thayn

***Office of Tariff Affairs and Trade Agreements***
Janet Freas and Janis Summers

***Office of the General Counsel***
Brian Allen and William Gearhart

***Content Reviewers***
Samantha DeCarlo and Peter Herman

***Editorial Reviewers***
Ronald Docksai, Judy Edelhoff, Brian Rose

***Statistical Reviewers***
Cynthia Payne, Aaron Woodward

***Special Assistance***
Tristen Best, Dixie Downing, Eric Forden, Robert Stark, Rishab Sardana, Johnathan Stefanick, Brennan Taylor

***Document Preparation and Support***
David Lahrmer and Fara Ndiaye

***Under the direction of***
Robert Carr, Chief, Natural Resources and Energy Division

# Table of Contents

# Tables

# Figures

## Boxes

# Abbreviations and Acronyms

| Item | Definition |
|---|---|
| AA | Aluminum Association |
| AEC | Aluminum Extruders Council |
| AIST | Association for Iron and Steel Technology |
| AOD | argon-oxygen decarburization |
| BF | blast furnace |
| BOF | basic oxygen furnace; also known as a basic oxygen process furnace (BOPF) |
| $C_2F_6$ | perfluoroethane |
| $CaCO_3$ | calcium carbonate |
| CBAM | Carbon Border Adjustment Mechanism (EU) |
| CBI | confidential business information |
| CEMS | continuous emissions monitoring system |
| $CF_4$ | perfluoromethane |
| $CH_4$ | methane |
| CO | carbon monoxide |
| $CO_2$ | carbon dioxide |
| $CO_2e$ | carbon dioxide equivalent |
| CPTI | Committee on Pipe and Tube Imports |
| CSRD | Corporate Sustainability Reporting Directive |
| DRI | direct reduced iron including hot briquetted iron |
| EAC | energy attribute certificate |
| EAF | electric arc furnace |
| EEA | European Environment Agency |
| EF | emissions factor |
| eGRID | Emissions and Generation Resource Integrated Database (EPA) |
| EC | European Commission |
| EIA | U.S. Energy Information Administration |
| EPA | U.S. Environmental Protection Agency |
| EPD | environmental product declaration |
| ETS | Emissions Trading System (EU) |
| EU | European Union |
| f-gas | fluorinated gas |
| GHG | greenhouse gas |
| GHG Protocol | Greenhouse Gas Protocol (World Resources Institute and World Business Council for Sustainable Development) |
| GHGRP | Greenhouse Gas Reporting Program (EPA) |
| GJ | gigajoule = one billion joules |
| GREET | Greenhouse gases, Regulated Emissions, and Energy use in Technologies (USDOE) |
| GSA | U.S. General Services Administration |
| GWh | gigawatt-hour(s) |
| GWP | global warming potential |
| HBI | hot briquetted iron |
| HFCs | hydrofluorocarbons |
| HHV | high(er) heating value |
| HTS | *Harmonized Tariff Schedule of the United States* |
| IAI | International Aluminium Institute |
| IPCC | Intergovernmental Panel on Climate Change (UN) |
| IRA | Inflation Reduction Act |
| ISO | International Organization for Standardization |

| Item | Definition |
|---|---|
| JRC | Joint Research Centre (EU) |
| LCI | life cycle inventory |
| LCIA | life cycle impact assessment |
| LEED | Leadership in Energy and Environmental Design (U.S. Green Building Council) |
| Mcf | thousand cubic feet |
| MMBtu | million British thermal unit(s) = 10 therms |
| mmt | million metric ton(s) |
| mt | metric ton(s) |
| MWh | megawatt-hour(s) |
| $N_2O$ | nitrous oxide |
| $NF_3$ | nitrogen trifluoride |
| NLA | National Lime Association |
| OBMs | ore-based metallics |
| OCTG | oil country tubular goods |
| PFCs | Perfluorocarbons |
| REC | renewable energy certificate |
| scf | standard cubic feet |
| SEC | U.S. Securities and Exchange Commission |
| $SF_6$ | sulfur hexafluoride |
| SMA | Steel Manufacturers Association |
| SSINA | Specialty Steel Industry of North America |
| therm | therm = 0.1 million British thermal units |
| U. S. Steel | United States Steel Corporation |
| TJ | terajoule = 1 trillion joules |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USDOE | U.S. Department of Energy |
| UTO | useful thermal output |
| VIM | vacuum induction melting |
| WBCSD | World Business Council for Sustainable Development |
| WRI | World Resources Institute |
| worldsteel | World Steel Association |

# Glossary

**Activity data**—quantitative measures of an action or function used to calculate the greenhouse gas (GHG) emissions associated with a process. In this investigation, activity data are mainly information about quantities of material received for use in production of covered steel and aluminum products.

**Aggregate product category**—a type of product category that incorporates multiple other product categories. Aggregate product categories for which emissions intensity estimates are produced in this report include wrought aluminum, unwrought aluminum, carbon and alloy flat steel, carbon and alloy long steel, carbon and alloy tubular steel, and stainless steel. These categories are noted in Attachment A of the U.S. Trade Representative's request letter.

**Air pollution control residue**—the waste material left behind after air pollution control technologies have removed pollutants from the gases from an industrial plant. These waste materials may contain carbon. The mass-balance equations under the U.S. Environmental Protection Agency's (EPA's) mandatory Greenhouse Gas Reporting Program (GHGRP) Subpart Q account for the mass and carbon content of air pollution control residue from processes associated with iron and steelmaking.

**Alloying elements**—metallic elements added during the melting of aluminum for the purpose of increasing corrosion resistance, hardness, or strength. Alloying elements used in steel are referred to as "ferroalloys and other alloying metals" (see "Ferroalloys and other alloying metals").

**Alumina**—aluminum oxide ($Al_2O_3$). Alumina is a required input for the production of primary unwrought aluminum.

**Aluminum**—aluminum products covered under this investigation include unwrought aluminum, whether alloyed or unalloyed; wrought aluminum bars, rods, and profiles; wire; plates, sheets, and strip; foil; tubes, pipes, and tube or pipe fittings; forgings; and castings. In general terms, a product is made of aluminum if it is composed of metallic substances in which aluminum predominates by weight over other elements per the definition of aluminum in the *Harmonized Tariff Schedule of the United States* (HTS) Chapter 76, Aluminum and Articles Thereof, subheading note 1. Note: For a full list of products covered in this investigation, see attachment B to the U.S. Trade Representative's letter requesting this investigation, which is in appendix A in this report.

**Aluminum bars, rods, and profiles**—wrought aluminum products with a solid cross section, typically produced via extrusion. Aluminum rods have a solid circular cross section; bars can have a number of flat sides. Profiles, also referred to as "shapes" or "sections," have various cross-sectional shapes that differ from those of other wrought products. Aluminum bars, rods, and profiles are those products classified under HTS heading 7604.

**Aluminum castings**—the solid, rough, finished, or near-finished (near-net) aluminum shapes resulting from the foundry or die-casting processes. Aluminum castings are defined in this investigation as those products classified under HTS statistical reporting number 7616.99.5160.

**Aluminum foil**—flat-rolled wrought aluminum of thickness not exceeding 0.20 millimeters. Aluminum foil products are those classified under HTS heading 7607.

**Aluminum forgings**—wrought aluminum products formed by applying pressure to shape unwrought aluminum using either open or closed dies. Aluminum forgings are defined in this investigation as those products classified under HTS statistical reporting number 7616.99.5170.

**Aluminum plates, sheets, and strip**—flat-rolled wrought aluminum products. Plates are at least 6.0 millimeters thick (6.3 millimeters in the United States) and are cut to length. Sheets range in thickness from 0.20 millimeters to under 6.0 millimeters (0.15 millimeters to under 6.3 millimeters in the United States). Strip is slit from coiled aluminum into narrower widths than the original coil. Aluminum plates, sheets, and strip are those products corresponding to HTS heading 7606.

**Aluminum tube or pipe fittings**—wrought aluminum products such as couplings, elbows, and sleeves. Aluminum tube or pipe fittings are those products classified under HTS heading 7609.

**Aluminum tubes and pipes**—hollow wrought aluminum products. Tubes have uniform wall thicknesses along their length. Pipes are a type of tube with standardized outside diameter and wall thicknesses. Aluminum tubes and pipes are those products classified under HTS heading 7608.

**Aluminum wire**—wire produced by drawing an unwrought aluminum wire rod through one or more steel dies to attain the desired final outside dimensions. Wires do not exceed 10.0 millimeters in diameter. Aluminum wire products are those classified under HTS heading 7605.

**Aluminum, primary unwrought**—unwrought aluminum produced directly from the electrolytic smelting of alumina (aluminum oxide), typically at a primary smelter. Primary unwrought aluminum can be either pure or alloyed. For the purposes of this investigation, the primary unwrought aluminum production processes include all activities related to production occurring at the smelter, as well as on-site anode baking, casting (if applicable), and, after casting, any finishing steps that occur, such as heat treatments (if applicable). The primary unwrought aluminum production processes also include heating of any other inputs, such as alloys or aluminum scrap, which are introduced into the production process.

**Aluminum, secondary unwrought**— unwrought aluminum, produced by melting down aluminum scrap, usually along with some primary aluminum and alloying metals. It may also be produced from dross. For the purposes of this investigation, the secondary unwrought aluminum production process includes any preheating or delacquering of aluminum scrap, heating of inputs such as primary unwrought aluminum or alloys, melting, casting (if applicable), and any finishing steps that may occur after casting, such as heat treatments (if applicable).

**Aluminum, unwrought**—ingots, slabs, blocks, billets, sows, etc. produced by casting molten aluminum of either primary or secondary origin, but not further machined or processed, other than by simple trimming, scalping, or descaling. Unwrought aluminum products are defined in this investigation as those classified under HTS heading 7601.

**Aluminum, wrought**—rolled, drawn, extruded, forged, or otherwise mechanically worked (formed) aluminum products. For the purposes of this investigation, wrought aluminum includes aluminum bars, rods, profiles, plates, sheets, strip, foil, wire, pipe, tube, pipe or tube fittings, castings (such as die castings or sand castings), and forgings. Wrought aluminum products are defined in this investigation as those classified under HTS headings 7604, 7605, 7606, 7607, 7608, 7609, and HTS statistical reporting numbers 7616.99.5160 and 7616.99.5170. For the purposes of this investigation, wrought aluminum production includes the rolling, drawing, extruding, forging, die casting, or foundry casting of any unwrought aluminum product into one or more of the product groups included in this definition. Such production also includes the transformation of a wrought product into another wrought product (e.g., sheet to foil). Wrought aluminum production additionally includes any preheating of unwrought aluminum inputs that is required before the rolling, drawing, extruding, forging, die casting, or foundry casting processes. Lastly, after the wrought product is shaped, production may include finishing steps such as precipitation heat treatment or aging.

**Ambient heating, cooling, ventilation, and lighting**—a subprocess that uses energy to provide environmental control for the facility (i.e., building-related energy) rather than support a specific production subprocess. In the Commission's calculations, emissions from this building-related energy subprocess are reallocated to the production unit processes based on the relative production quantities that facilities report.

**Annealing**—a form of heat treatment designed to soften steel or aluminum and make it more formable. The annealing process involves heating the material to a set temperature and then cooling the material.

**Basic oxygen furnace (BOF)**—any refractory-lined vessel into which high-purity oxygen is blown under pressure through a bath of molten iron, scrap metal, and fluxes to remove impurities and convert the mixture to steel. BOFs are generally located at integrated iron and steel plants, where molten iron is produced in a blast furnace before being fed into the BOF. A BOF is also known as a basic oxygen process furnace (BOPF).

**Bauxite**–a naturally occurring ore containing alumina (aluminum oxide). Bauxite is refined into alumina using the Bayer process.

**Bayer process**—an industrial process for refining bauxite into alumina (aluminum oxide). During this process, bauxite is dissolved with caustic soda (sodium hydroxide) in a digester and then filtered to remove impurities. This produces a solution of sodium aluminate and metal oxides, sometimes referred to as "red mud." The solution is moved next into a precipitator where aluminum hydroxide is separated from the rest of the mixture and removed. The aluminum hydroxide is then heated in a calciner (or rotary kiln) to remove the water and produce dry alumina.

**Biomass**—renewable organic material from plants and animals, such as wood and wood processing wastes, agricultural crops, and manure.

**Blast furnace (BF)**—a furnace used to produce molten iron from iron ore pellets and other iron-bearing materials. Blast furnaces are generally located at integrated iron and steel plants, with molten iron being fed directly into a basic oxygen furnace (BOF).

**Blast furnace gas**—the combustible waste gas generated in a blast furnace when iron ore is being reduced with coke to metallic iron. This gas is commonly used as a fuel within steel facilities or is flared.

**Boiler**—a device for generating steam, hot water, or both by transmitting heat from an external source to a fluid. Boilers may use fuel combustion or electricity for their heat source. For this investigation's questionnaire, boiler-specific data were requested only for boilers that use fuel combustion as their energy source (nonelectric boilers) and that support multiple subprocesses specified in the questionnaire (multipurpose boilers).

**British thermal unit**—a unit to measure heat energy, commonly used to refer to the amount of energy released from fuel combustion. One British thermal unit is the amount of heat energy required to raise the temperature of one pound of liquid water by one degree Fahrenheit. 100,000 British thermal units (Btu) = 1 therm; 10 therms = 1 million British thermal units (MMBtu).

**Calcined petroleum coke**—a high-purity carbon material created by heating green petroleum coke (a by-product of petroleum refining) to remove impurities and volatiles. Calcined petroleum coke is used by the aluminum industry to produce carbon anodes.

**Calcining**—a process by which material is heated in a controlled environment below its melting point to drive out impurities and volatiles. Flux materials like limestone and dolomite as well as petroleum coke often require calcining before use in steel or aluminum production.

**Carbon and other alloy steel**—all steels other than stainless steel. Carbon and other alloy steel include nonalloy steel, low-alloy steel, silicon electrical steel, high-speed steel, silicomanganese steel, tool steel, chipper-knife steel, heat-resisting steel, ball bearing steel, etc. Carbon and other alloy steel is also referred to in this report as "carbon and alloy steel."

**Carbon anode**—a carbon block used to conduct electricity. Carbon anodes are inserted into an aluminum pot during the primary aluminum smelting process. Prebake carbon anodes are produced before the smelting process begins, whereas Søderberg anodes are baked in the smelting pot during the smelting process. In the United States, all producers use prebake carbon anodes.

**Carbon Border Adjustment Mechanism (CBAM)**—an instrument of the European Union (EU). According to the EU, CBAM was adopted to support reducing greenhouse gas emissions in the production of certain emissions-intensive goods imported into the EU. CBAM was established under Regulation (EU) 2023/956.

**Carbon content**—the mass of carbon as a share of the total mass of a material.

**Carbon dioxide equivalent ($CO_2e$)**—the number of metric tons of carbon dioxide ($CO_2$) emissions with the same global warming potential (GWP) as emissions of a different greenhouse gas or emissions consisting of different quantities of multiple greenhouse gases.

**Carbon electrodes**—comprised of graphite columns positioned on the electric arc furnace (EAF) lid, carbon electrodes are the main heating element used in the EAF steelmaking process. Electricity passes through the electrodes, forming a discharge of electric current between the columns which produces intense heat that melts the scrap steel. Carbon electrodes can also be used in a ladle metallurgy furnace and specialty furnace applications.

**Casting**—the process by which hot liquid steel or aluminum is poured into a mold and cooled to produce its first solid form. For the purposes of this investigation, aluminum casting processes include any heat treatment of products occurring after casting, such as homogenizing of aluminum billets.

**Coal and coal-based carbon additives**—coal and other sources of carbon derived from coal (other than coke) that are primarily used as feedstock, not fuel. Examples of coal and coal-based carbon additives include coal used to produce metallurgical coke or high-purity carbon products that are charged or injected into steelmaking furnaces.

**Coal tar pitch**—a by-product of coal distilling, used in the aluminum industry to produce carbon anodes.

**Coated flat steel products**—includes carbon and alloy steel sheets, strips, and plates that have been clad, plated, or coated with metal, in either coils or cut lengths. Examples include corrosion-resistant flat steel products that are hot-dipped; other flat steel products that are hot-dipped or electrolytically galvanized; or those coated with Galvalume (a coating of 55 percent aluminum as well as zinc and silicon, sold under several different trademarked names), tin, chromium (tin-free), or other metals. Carbon and alloy coated flat steel products are those classified under HTS headings 7210 (other than HTS subheading 7210.70.30) and 7212 (other than HTS subheading 7212.40), HTS subheadings 7225.91 and 7225.92, and HTS statistical reporting numbers 7226.99.0110 and 7226.99.0130.

**Coating, cladding, or plating flat steel products**—all processes occurring at a facility that are used to coat, clad, or plate flat steel products with metal. These processes may include hot-dip or electrolytic galvanize lines, Galvalume coating, tin coating, or any finishing operations that further process these goods (e.g., annealing, cutting).

**Cogeneration**—also known as combined heat and power (CHP), an integrated approach to generating multiple output streams—electric power and thermal energy—from a single fuel source. For industrial facilities, cogeneration is typically located on-site and captures heat and off-gases that would otherwise go unused to provide thermal energy such as steam or hot water and generate electricity. For the purposes of this investigation, on-site cogeneration refers only to units that are operated by the reporting facility.

**Coke**—a residue high in carbon content, commonly derived from either coal (metallurgical coke) or petroleum (petroleum coke). All unspecified references to “coke” in this report refer to metallurgical coke.

**Coke breeze**—fine sizes of metallurgical coke, usually less than one-half inch in diameter, that are recovered from coke plants. It is commonly used for sintering (combining smaller particles into a larger solid mass using heat and pressure without melting) iron ore.

**Coke oven gas**—the combustible waste gas produced by the carbonization of coal in a coke oven at temperatures in excess of 1,000 °C (1,832 °F). This gas is commonly used as fuel within coke-producing facilities or is flared.

**Cold-formed long steel products**—includes cold-formed or cold-drawn bars, whether or not coated with metallic or nonmetallic materials (e.g., plastics, paint, etc.). Also includes all steel wire. Stainless cold-formed long steel products are those classified under HTS subheadings 7222.20 and 7222.30, and HTS heading 7223. Carbon and alloy cold-formed long steel products are those classified under HTS headings 7215, 7217, and 7229; HTS subheadings 7228.50, 7228.60, and 7228.20.50; and HTS statistical reporting numbers 7228.10.0030 and 7228.10.0060.

**Cold-forming or cold-finishing long steel products**—all processes occurring at a facility that are used to cold form, cold finish, or cold draw long steel products, including any finishing operations that further process these goods (e.g., annealing, pickling, cutting). Also includes any process used to draw or roll wire.

**Cold-rolled flat steel products**—includes cold-rolled sheets, strips, and plates, whether or not annealed, pickled, tempered, or cold-reduced, in either coils or cut lengths. Stainless cold-rolled flat steel products may be clad, plated, or coated with metallic or nonmetallic materials. If carbon and alloy steel is clad, plated, or coated with metal, these are included in the “coated flat steel products” category. Stainless cold-rolled flat steel products include those classified under HTS subheadings 7219.31, 7219.32, 7219.33, 7219.34, 7219.35, 7219.90, 7220.20, and 7220.90. Carbon and alloy cold-rolled flat steel products include those classified under HTS heading 7209, HTS subheadings 7211.23, 7211.29, 7211.90, 7212.40, 7225.50, 7225.99, and 7226.92, and HTS statistical reporting numbers 7210.70.3000 and 7226.99.0180.

**Cold-rolling flat steel products**—all processes occurring at a facility that are used to transform hot-rolled flat steel into cold-rolled flat steel products. Such processes include the cold-rolling mill itself as well as any post-cold-rolling operations that further finish cold-rolled flat steel products (e.g., annealing, pickling, cutting, painting). For carbon and alloy steel, cold-rolling does not include coating, cladding, or plating of steel with metal or any process occurring in a facility downstream from those processes. For stainless steel, such processes are included within the definition of cold-rolling flat steel products.

**Combined heat and power (CHP)**—see "Cogeneration."

**Combustion emissions**—emissions released from the intentional reaction of a fuel (often natural gas, a petroleum product, coal, or biomass) with oxygen to release energy.

**Consuming facility**—a surveyed facility that receives upstream materials from external sources.

**Continuous emissions monitoring system (CEMS)**—a set of equipment used to directly measure a gas or particulate matter concentration or emission rate. Some EPA regulations require a CEMS for either continual compliance determinations or determination of exceedances of standards.

**Cooling agent**—refers to natural gas or another input used to provide cooling directly around a piece of equipment within a furnace that would otherwise be subject to degradation due to the high heat inside the furnace.

**Country of melt and pour (steel)**—as defined by the U.S. Department of Commerce, the location where the raw steel is (1) first produced in a steelmaking furnace in a liquid state and (2) poured into its first solid shape. The first solid state can take the form of either a semifinished steel product (e.g., ingot, bloom, slab, billet, beam blank, etc.) or a finished steel mill product. The location of melt and pour is customarily specified on mill test certificates that are commonplace in verifying steel production.

**Country of smelt (aluminum)**—as defined by the U.S. Department of Commerce, the country where new aluminum metal is produced from alumina (aluminum oxide) by the electrolytic Hall-Héroult Process. The country of smelt is customarily identified on import licenses, which are required for U.S. imports of aluminum products containing primary aluminum. The country of smelt may be different from the country of origin and the country of exportation.

**Covered steel and aluminum products**—products specified in Attachment B of the U.S. Trade Representative's letter requesting that the U.S. International Trade Commission conduct an investigation and prepare a report to assess the GHG emissions intensity of steel and aluminum produced in the United States. These items are included in the *Harmonized Tariff Schedule of the United States* (HTS) and are categorized in headings, subheadings, or as statistical reporting numbers. For the list of products, see the U.S. Trade Representative's request letter in appendix A of this report.

**Cradle-to-gate**—describes the bounds of a product life cycle analysis accounting for the environmental impact of inputs and processes in the creation of the product, from resource extraction (cradle) to the factory gate (i.e., before it leaves the factory to be transported to the consumer). Cradle-to-gate life cycle analyses are sometimes used to measure the greenhouse gas emissions of a product. Cradle-to-gate life cycle analyses are also referred to as "partial life cycle analyses" and are differentiated from cradle-to-grave or full life cycle analyses that include consideration of product use and end of life impacts.

**Decarburization**—also known as argon oxygen decarburization (AOD), a process used to further refine the steel outside the electric arc furnace (EAF) during the production of certain stainless and specialty steels. In the AOD process, steel from the EAF is transferred into a specific AOD vessel, and gaseous mixtures containing argon and either oxygen or nitrogen are blown into the vessel to reduce the carbon content of the steel.

**Delacquering**—a process of heating aluminum scrap to remove coatings such as paints, inks, plastics, and oils. Also sometimes referred to as "decoating."

**Descaling**—a cleaning process that removes mineral deposits (scales) from metal surfaces. These deposits may form during the production process when the metal is heated or exposed to oxygen or water. Descaling steel and aluminum products can be performed chemically (by applying an acidic solution to the metal surface) or mechanically (by blasting the metal with particles).

**Die casting**—a type of aluminum casting in which pressure or force is used to inject aluminum into a mold to create a finished or near-finished shape.

**Direct emissions**—greenhouse gas emissions generated from on-site activities at the reporting facility.

**Direct line connection**—a purchase of electricity by an organization through an electricity connection outside of the distribution grid. Examples of electricity generation sources for direct line connections include generation facilities located at a central plant of a campus or other nearby building, or on-site generation facilities that are owned or operated by another organization.

**Direct reduced iron (DRI)**—iron made from the chemical removal of oxygen from iron ore in its solid form, without melting in a furnace, using hydrogen and carbon monoxide (generally derived from natural gas, synthetic gas, or coal) as reducing agents. Direct reduced iron can be used in electric arc furnaces, basic oxygen furnaces, or blast furnaces.

**Dolime**—a mix of lime (CaO) and magnesia (MgO) produced from the heating (calcining) of non-calcined dolomite. Dolime is also referred to as "calcined dolomite", "calcined dolomitic limestone", or "calcium magnesium oxide ($CaMgO_2$)".

**Drawing (e.g., wire drawing)**—a metal shaping process in which the metal is pulled through the opening of a die (usually a steel die) to create its shape.

**Dross**—a by-product of the aluminum melting and casting process made up of oxidized aluminum and other waste material. The aluminum within dross is often recovered and reused in production.

**Ductility**—the ability of a material (e.g., steel or aluminum) to be bent, stretched, or worked without breaking.

**Electric arc furnace (EAF)**—a furnace that produces molten steel by heating the charge materials (primarily ferrous scrap) with electric arcs from carbon electrodes.

**Electrolysis**—a process that uses an electric current to instigate a chemical reaction. During aluminum production, electrolysis is used to convert alumina (aluminum oxide) into aluminum. In this process, carbon anodes are inserted into a carbon cathode-lined steel pot. Alumina is then dissolved in a molten cryolite bath within the pot. A large quantity of electricity is passed through the bath and the anodes, separating the oxygen from the alumina. The oxygen reacts to the carbon in the anode, producing carbon dioxide, and leaving molten aluminum at the bottom of the pot. This is also known as the Hall-Héroult electrolytic process.

**Emissions factor (EF)**—a factor that is multiplied by activity data to calculate greenhouse gas emissions estimates. EFs are typically expressed as metric tons of carbon dioxide equivalent per unit of activity data. This investigation uses multiple types of EFs to measure direct and indirect emissions.

**Emissions factor, default**—an emissions factor derived from average, typical, or otherwise representative characteristics of a good made or used by a global, national, or subnational industry. For scope 1 emissions, this investigation used default emissions factors that are based on the average emissions from combusting a given type of fuel. For scope 2 emissions, default emissions factors are derived from the average emissions associated with electricity generation across a wide geographical area. This investigation also uses default emissions factors covering the emissions intensities of materials to measure facilities' scope 3 emissions associated with externally sourced materials where no specific supplier facility is identified or available.

**Emissions factor, direct**—an emissions factor that measures the direct emissions associated with use of a specific fuel or material input or output. Facilities may use direct emissions factors in their reporting of emissions under the Greenhouse Gas Reporting Program. This investigation also uses direct emissions factors for a variety of additional calculations related to the use of fuels and material inputs.

**Emissions factor, indirect—**an emissions factor that measures the indirect emissions associated with use of energy or material inputs received from other sources. For scope 2 emissions, these factors capture the emissions associated with generating the electricity, steam, heat, or hot water the facility purchased. All facility-level scope 3 emissions are calculated using indirect emissions factors covering the emissions intensities of materials received by facilities.

**Emissions factor, site-specific**—a direct emissions factor that measures the process emissions that occur during a specific activity at a specific facility. These are determined either by measuring the carbon content of feedstocks or by performing periodic emissions stack tests. Facilities may use site-specific emissions factors in their reporting of direct emissions under the Greenhouse Gas Reporting Program.

**Emissions factor, supplier-specific**—an indirect emissions factor that measures the emissions intensity of a good produced by an identified single supplier. This can apply to energy produced at a particular generation plant or delivered by a specific utility. This investigation also measured facilities' scope 3 emissions associated with the receipts of material from listed U.S. suppliers using supplier-specific emissions factors covering the emissions intensities of materials made by those suppliers.

**Emissions Trading System (ETS)**—the ETS is a market-based approach of the European Union to reducing pollution from facilities located in the EU that sets a limit on emissions and permits trading of the allowances to emit pollutants. The two key components to this policy are a limit (or cap) on pollution and tradable allowances (or credits) equal to the limit that authorize allowance holders to emit a specific quantity of the pollutant.

**Energy attribute certificate (EAC)**—a category of contractual instrument that represents certain information (or attributes) about the energy generated but does not represent the energy itself. This category includes a variety of instruments with different names, including certificates, tags, credits, or generator declarations.

**Environmental product declaration (EPD)**—a voluntary report of a full life cycle impact assessment for a product, which allows for product-level emissions comparisons within and across companies and facilities. Within the steel and aluminum industry, an EPD is generally developed according to the International Organization for Standardization (ISO) Standard 14025, Environmental Labels and Declarations.

**External source**—either a supplier facility or source country providing production inputs to consuming facilities.

**Facility**—a manufacturing site located on one or more contiguous or adjacent properties under common operational control.

**Feedstock**—a raw material used directly in the creation of an intermediate or finished product. In semifinished steelmaking, feedstocks are added directly to the electric arc furnaces (EAFs), basic oxygen furnaces (BOFs), or ladle metallurgy furnaces where steel is in its liquid form. In unwrought aluminum production, feedstocks are added directly to the potlines or furnaces where aluminum is in its liquid form.

**Ferroalloys and other alloying metals**—elements added during the melting of steel for the purpose of controlling inclusions, deoxidation, or increasing corrosion resistance, hardness, or strength. Examples include, but are not limited to, ferronickel, nickel metal, ferrochromium, and silicon.

**Ferrous**—refers to a material containing or consisting primarily of iron (including steel).

**Flare**—a high-temperature oxidation process used to burn waste gases, including blast furnace gas and coke oven gas, that contain volatile organic compounds or other combustible components.

**Flux materials**—materials such as lime derived from limestone or dolomite that are used to separate sulfur, phosphorus, silica, and other impurities in the ironmaking and steelmaking processes.

**Forging, aluminum**—a process of applying pressure to shape unwrought aluminum using either open or closed dies.

**Fugitive emissions**—intentional or unintentional release of greenhouse gases that may occur during the extraction, processing, transformation, storage, and delivery of fossil fuels to the point of final use. Examples of sources of fugitive emissions are methane and carbon dioxide releases from ventilation and degasification in coal mining; from processing and storing coal after mining; and from leaks, venting, and flaring in natural gas systems.

**Galvanizing**—the process of coating steel with a thin layer of zinc to provide corrosion resistance. Sheet steel normally must be cold-rolled prior to the galvanizing stage. Two methods are commonly used in galvanizing steel: hot dipping coats steel by running it through a molten zinc bath, and electrogalvanizing uses an electric charge to apply a zinc coating to the steel.

**Global warming potential (GWP)**—a comparative measurement of the potential impacts of greenhouse gases (GHGs) on global warming over a GHG's lifetime. In essence, this measure conveys the energy absorption of one unit of GHG over a certain time period relative to one unit of $CO_2$, the reference gas. This investigation uses GWP definitions and ratios from the GHGRP, which are evaluated on a 100-year time horizon and are listed in Table A-1 to 40 C.F.R. § 98.

**Greenhouse gas (GHG)**—gases, both naturally occurring and generated from human-related activities such as household, commercial, and industrial applications and processes, that trap heat in the atmosphere. This investigation uses the definition of GHG as defined by the Greenhouse Gas Reporting Program in 40 C.F.R. § 98.6, which is carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), sulfur hexafluoride ($SF_6$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and other fluorinated greenhouse gases.

**Greenhouse Gas Reporting Program (GHGRP)**—the EPA's mandatory program established under 40 C.F.R. § 98. This program requires annual reporting of greenhouse gas (GHG) data and other relevant information from large GHG-emitting facilities, fuel and industrial gas suppliers, and carbon dioxide injection sites in the United States. Emissions data collected under this program from facilities are limited to select scope 1 emissions as defined in the regulation. Only U.S. facilities annually emitting over 25,000 metric tons (mt) of these emissions are required to report their emissions to the EPA under the Greenhouse Gas Reporting Program (40 C.F.R. §§ 98.2(a), 98.3(b)).

***Harmonized Tariff Schedule of the United States* (HTS)—**sets out the tariff rates and statistical categories for all merchandise imported into the United States. The HTS is based on the international *Harmonized System*, which is the global system of nomenclature applied to most world trade in goods.

**Hall-Héroult process**—see "Electrolysis."

**Heat treating**—a process of heating metal to optimize or enhance certain characteristics such as uniformity, strength, and flexibility. For steel and aluminum, common heat treating processes include homogenization, annealing, precipitation hardening, quenching (a process of using fluids to rapidly cool steel to achieve certain material properties like strength and hardness), tempering, and aging.

**Heavy structural shapes and sheet piling**—includes angles, shapes, and sections of carbon and alloy steel with a height of 80 millimeters or more; and sheet piling, which are steel sheets with interlocking edges that are driven into the ground to construct retaining walls. Heavy structural shapes and sheet piling correspond with HTS subheadings 7216.31, 7216.32, 7216.33, 7216.40, 7216.50, 7216.99, 7228.70, and 7301.10.

**Hot briquetted iron**—a premium form of direct reduced iron (DRI) that has been compacted at a temperature greater than 650 °C (1202 °F) and has a density greater than 5,000 kilograms per cubic meter ($kg/m^3$). Because of its compaction, hot briquetted iron is less porous and, therefore, less reactive than other forms of direct reduced iron and does not suffer from the risk of self-heating associated with other forms of direct reduced iron. Hot briquetted iron can be used in electric arc furnaces, basic oxygen furnaces, or blast furnaces.

**Hot-rolled plate**—hot-rolled flat steel products that have a thickness of 4.75 millimeters or more, whether in coils or cut to length. Carbon and alloy hot-rolled plate products are those classified under HTS subheadings 7208.10.15, 7208.10.30, 7208.25.30, 7208.25.60, 7208.36, 7208.37, 7208.40.30, 7208.51, 7208.52, 7211.13, 7211.14, 7225.30.11, 7225.30.30, 7225.40.11, 7225.40.30, and 7226.91.50. In this report, stainless hot-rolled plate is not distinguished from other stainless hot-rolled flat steel products.

**Hot-rolled flat steel products**—includes hot-rolled sheets, strips, and plates, whether or not annealed, pickled, or tempered, in either coils or cut lengths, not cold-rolled nor clad, plated, or coated with metal.

Stainless hot-rolled flat steel products include those classified under HTS subheadings 7219.11, 7219.12, 7219.13, 7219.14, 7219.21, 7219.22, 7219.23, 7219.24, 7220.11, and 7220.12. Carbon and alloy hot-rolled flat steel products include those classified under HTS heading 7208 and HTS subheadings 7211.13, 7211.14, 7211.19, 7225.11, 7225.19, 7225.30, 7225.40, 7226.11, 7226.19, 7226.20, and 7226.91. (Note: Painted or other non-metallically coated flat steel products that are not otherwise cold-rolled or coated, plated, or clad with metal are considered hot-rolled flat steel products).

**Hot-rolling flat steel products**—all processes occurring at a facility that are used to transform semifinished steel into hot-rolled flat steel products. Such processes include the operation of tunnel furnaces, shuttle furnaces, and reheat furnaces to prepare steel for hot-rolling; hot-rolling mills; and any post-hot-rolling operations that further finish hot-rolled flat steel products (e.g., annealing, pickling, cutting, and painting). Does not include cold-rolling; coating, cladding, or plating of steel with metal; or any process occurring in a facility downstream from those processes.

**Hot-worked long steel products**—includes hot-rolled, hot-drawn, hot-extruded, or hot-forged bars, concrete reinforcing bars, structural shapes (angles, shapes, sections, and sheet pilings), rails, and wire rods, not cold-formed, or cold-drawn. Stainless hot-worked long steel products include those classified under HTS heading 7221 and HTS subheadings 7222.11, 7222.19, and 7222.40. Carbon and alloy hot-worked long steel products include those classified under HTS headings 7213, 7214, 7227, and 7302; HTS subheadings 7216.10, 7216.21, 7216.22, 7216.31, 7216.32, 7216.33, 7216.40, 7216.50, 7216.99, 7228.20.10, 7228.30, 7228.70, 7228.80, and 7301.10; and HTS statistical reporting number 7228.10.0010.

**Hot-working long steel products**—all processes occurring at a facility that are used to transform semifinished steel into hot-worked long steel products. Such processes include the operation of tunnel furnaces, shuttle furnaces, and reheat furnaces to prepare steel for hot-working; mills for hot-rolling, hot drawing, hot extrusion, or hot forging long steel products; and any post-hot-working operations that further finish hot-worked long steel products (e.g., annealing, pickling, and cutting). Does not include cold-forming, cold finishing, and cold drawing processes; any wire drawing or rolling; or any process occurring in a facility downstream from those processes.

**Hydroelectric power**— a form of renewable energy that uses the power of moving water to generate electricity. In general, there are three types of hydroelectric power facilities: impoundment (building a dam to create a reservoir), diversion (sometimes known as run-of-the-river), and pumped storage.

**Indirect emissions**—greenhouse gas emissions that are a consequence of a reporting facility's activities but occur at sources owned or controlled by other entities.

**Ingots and steel in other primary forms**—steel in ingots or other primary forms, such as blocks, lumps, and puddled bars. Carbon and alloy ingots and steel in other primary forms are those classified under HTS heading 7206 and HTS subheading 7224.10. Stainless ingots and steel in other primary forms are those classified under HTS subheading 7218.10.

**Integrated mill—a** steel mill that heats primary iron ore and other materials (e.g., coke and a flux material) in a blast furnace to produce pig iron, and then melts the pig iron in a basic oxygen furnace to produce liquid steel. The process is also commonly called the blast furnace-basic oxygen furnace method.

**Intensity**—refers to the rate of input use or output generation associated with specific processes or product life cycles. In this investigation, material, energy, and fuel input intensities are used in the calculation of facility- and product-level emissions estimates. Emissions intensity estimates are calculated for all steel and aluminum product categories and are also used as supplier-specific and default emissions factors.

**Intermediate steel and aluminum inputs—**material inputs (both upstream inputs and semifinished substrate) used to produce steel and aluminum covered products. This term is specified in the U.S. Trade Representative's letter requesting this investigation, which is in appendix A in this report. In the letter, intermediate steel and aluminum inputs are noted as including, for example, iron ore, coke, ore-based metallics, semifinished steel and other steel substrate suitable for further processing, carbon anodes, unwrought aluminum, and wrought aluminum suitable for further processing.

**Inventory**—see "Life cycle inventory (LCI)."

**Iron fines**—small granular pieces of iron ore that are produced from the process of crushing and grinding iron ore. Iron ore fines are used as an input in iron sinter.

**Iron pellets**—also known as iron ore pellets, iron ore particles that have been rolled into little balls (typically 9–16 millimeters) in a balling drum and hardened by heat. Iron pellets are the primary iron ore input the U.S. steel industry uses to produce pig iron in blast furnace operations. For purposes of this investigation, iron pellets also include any fines (smaller particles) that iron pellet plants produce.

**Iron sinter**—a fused aggregate of fine iron-bearing materials suited for use in a blast furnace. Sinter is composed of ore fines, other finely divided iron-bearing material, and fuel (typically coke breeze), and is typically 15–25 millimeters in size. To be considered iron sinter, sinter must contain more than 65 percent iron content. For purposes of this investigation, iron sinter also includes any smaller particles that iron sinter plants produce.

**Joule—**a unit to measure energy or work. One joule is equivalent to one watt-second (i.e., one watt of power sustained for one second). In terms of unit conversion, 1,000,000,000 joules (J) = 1 gigajoule (GJ) and 1,000 gigajoules (GJ) = 1 terajoule (TJ).

**Ladle station**—sometimes called a "ladle metallurgy furnace" or "ladle." The ladle station is an intermediate steel processing unit that further refines the chemistry and temperature of molten steel. The ladle metallurgy step comes after the steel is melted and refined in the electric arc furnace or the basic oxygen furnace, but before the steel is cast.

**Life cycle**—consecutive and interlinked stages of a product's production, use, and final disposal. This investigation generally focuses on the "cradle-to-gate" or "partial" life cycle of steel and aluminum products covering the value chain processes that contribute to the production of these goods and excluding any consideration of use or disposal.

**Life cycle impact assessment (LCIA)**—analysis of a life cycle inventory to determine the environmental impact of that value chain. In this investigation, the only environmental impact of interest is the quantity of greenhouse gas emissions occurring during the value chains used to produce steel and aluminum product categories.

**Life cycle inventory (LCI)**—sometimes called an "inventory" or "emissions inventory." An LCI is an accounting of the inputs and outputs within all processes along a value chain that produces a product. In this investigation, LCIs account for all greenhouse gas emissions that occur during processes that produce—or supply energy to produce—steel, aluminum, and upstream material inputs within the system boundary. LCIs within this investigation do not take into account emissions that occur after steel or aluminum is produced (e.g., during the product's use or end of life).

**Lime**—the high-temperature product of heating (calcining) limestone. Lime—also referred to as "calcined lime" or "calcium oxide (CaO)"—is used to help remove impurities such as sulfur, phosphorus, and silica in the ironmaking and steelmaking processes.

**Location-based method**—a method for measurement of scope 2 emissions associated with an organization's purchased energy. The location-based method only considers direct sources of energy supplied to a facility and estimates scope 2 emissions using emissions factors derived from the fuel mix of a direct energy supplier and the fuel mix of the facility's regional grid.

**Market-based method**—a method for measuring scope 2 emissions associated with an organization's purchased energy that considers contractual arrangements, such as power purchase agreements and energy attribute certificates (EACs), in addition to the emissions factors used in the location-based method.

**Mass-balance approach**—calculating carbon dioxide ($CO_2$) emissions using mass-balance equations. Mass-balance equations generally measure (1) the carbon entering a process through inputs and feedstocks (the carbon content of inputs multiplied by the quantity of those inputs used in the process) and (2) the carbon exiting the same process through products and by-products. Under this approach, the difference between carbon inputs and carbon outputs is assumed to either be directly released or oxidized and then released as carbon dioxide ($CO_2$).

**Material flow analysis**—an analysis that quantifies flows and materials in a defined system. In this investigation, material flow analysis is used to measure the use of material inputs within processes used to make steel and aluminum products as a means of quantifying the emissions embedded in those inputs toward product-level emissions inventories.

**Metallurgical coke**—a form of coke used predominantly in blast furnaces to reduce iron ore to iron. Metallurgical coke is produced by the distillation of coal in coke ovens, where the prepared coal is heated in an oxygen-free atmosphere (coked) until most volatile components in the coal are removed, leaving a carbon mass. Metallurgical coke includes coke breeze.

**Minimills**—smaller-scale steel mills that use electric arc furnaces to melt ferrous scrap and, in some instances, pig iron or ore-based metallics to produce liquid steel.

**Non-calcined dolomite**—a mix of calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$), also referred to as "dolomitic limestone" or "calcium-magnesium carbonate ($CaMg(CO_3)_2$)". It can be heated (calcined) to form dolime, a mix of lime (CaO) and magnesia (MgO), or calcium-magnesium oxide ($CaMgO_2$).

**Non-calcined limestone**—calcium carbonate ($CaCO_3$). It can be heated (calcined) to form lime (CaO).

**Non-seamless steel tubular products**—includes pipes, hollow profiles, and non-seamless tubes, but not fittings and other attachments. Stainless non-seamless steel tubular products include those classified under HTS subheadings 7306.11, 7306.21, 7306.40, and HTS statistical reporting numbers 7306.61.7030 and 7306.69.7030. Carbon and alloy non-seamless steel tubular products include those classified under

HTS heading 7305; subheadings 7306.19, 7306.29, 7306.30, 7306.50, 7306.61.10, 7306.61.30, 7306.69.10, 7306.69.30, 7306.69.50, 7306.90; and statistical reporting numbers 7306.61.7060 and 7306.69.7060.

**Oil country tubular goods (OCTG)**—casing, tubing, and drill pipe, used in drilling for oil and gas. OCTG can include seamless or non-seamless tubular products. Carbon and alloy seamless OCTG correspond to HTS subheadings 7304.23 and 7304.29. Carbon and alloy non-seamless OCTG correspond to HTS subheadings 7305.20 and 7306.29. In this report, stainless OCTG are not distinguished from other stainless tubular products.

**On-site combustion**—the consumption of fuel in stationary units operated by the facility on-site to release thermal energy or generate electricity. Fuel use in on-site combustion consists of four categories: fuel consumed for on-site power generation, fuel consumed for on-site cogeneration, fuel consumed for on-site multipurpose boilers, and fuel consumed for all other on-site combustion.

**Operational control, operated by**—a company's operational control over a facility or process. If the facility or process is operated by the company or one of its subsidiaries, the company has the full authority to introduce and implement its operating policies to the facility or process. A toll producer has operational control of a facility if it controls production, even if it does not own the inputs or outputs of that production.

**Ore-based metallics**—produced mainly by the reduction of iron ore in blast furnaces and direct reduction plants. Ore-based metallics include direct reduced iron, hot briquetted iron, and pig iron.

**Other carbonaceous materials**—materials containing carbon used in electric arc furnaces as a source of charge or injection carbon, other than coal and coal-based carbon additives. Other carbonaceous materials include biomass, charcoal, used tires, petroleum coke, and other coal alternatives.

**Parent company**—a single company that has a controlling interest in another company or joint venture. A parent company can also be the ultimate owner.

**Petroleum coke**—a residue high in carbon content, created as a by-product of petroleum refining. See also calcined petroleum coke.

**Physical allocation—**a process that uses some physical attribute—in this investigation, mass of production—to divide emissions associated with broader processes into narrower processes.

**Pickling—**a process that cleans steel of rust, dirt, and oil so that further work can be done to the metal. During the pickling process, steel is sent through a series of hydrochloric acid baths that remove the oxides (rust). The pickled steel is then rinsed and dried.

**Pig iron**—the product of smelting iron ore, generally in a blast furnace. Pig iron can either be in liquid or solid form when consumed in steelmaking. The liquid form of pig iron is often referred to as "hot metal."

**Potline**—at an aluminum smelter, a potline is a row of carbon cathode-lined steel pots in which aluminum is being produced via electrolysis.

**Power purchase agreement**—a long-term agreement to buy electricity from a specific power project, commonly used by the purchaser to secure access to zero-carbon electricity at a fixed price and by the supplier to ensure stable long-term revenues for new renewable energy projects. These agreements may be between an industrial facility and a utility or independent power producer. They are one example of a contractual arrangement that can affect the emissions rate associated with a facility's electricity purchases (particularly under the market-based method).

**Process**—includes production lines, equipment, material preparation, or other aspects that carry a product through its life cycle.

**Process emissions**—emissions from physical processes or the chemical transformation of raw materials (e.g., through reduction of iron or aluminum smelting).

**Process subdivision—**dividing inputs and outputs associated with a common process into subprocesses. In this investigation, process subdivision entails splitting facility-level emissions into subprocesses using information from the Greenhouse Gas Reporting Program (GHGRP) and the questionnaire (see "Subprocess").

**Processor**—a facility that solely engages in light manufacturing processes that do not transform one category of covered products into another. Examples of processors are service centers that solely cut or slit steel or aluminum, facilities that solely thread tubular products, or facilities that process steel or aluminum prior to use in the production of downstream goods.

**Produce, production**—in this investigation, production includes manufacturing processes that transform inputs and covered products into different categories of inputs and covered products. Production can also include certain specific manufacturing processes that do not result in transformation of covered products into different categories: (1) the manufacturing of secondary unwrought aluminum from other forms of secondary unwrought aluminum and (2) heat treatment of steel products in a stand-alone facility. Any facility producing covered products was required to complete the Commission's questionnaire in this investigation. In questionnaire responses, other processing that occur in facilities where the above transformations occur were also considered production, and reporting of these activities was requested.

**Production pathway**—a specific technology or production method used to manufacture a product. The production pathway of a steel or aluminum product usually determines the intensity of material, fuel, and energy inputs into production processes, as well as the emissions intensities associated with manufacturing these products.

**Product category**—any of the steel and aluminum product groupings at which level the Commission conducted its analysis for this investigation. Product category is used to refer both to those categories listed in attachment A in the U.S. Trade Representative's request letter as well as additional product categories for steel listed in tables ES.2 and ES.3 of this report and for aluminum listed in table ES.4 of this report.

**Product subcategory**—for steel, any of the discrete product groupings at which level the Commission conducted analyses for this investigation, listed in table E.12 of this report. Product subcategories are more granular subsets of particular product categories listed in tables 2.1 and 2.2 of this report.

**Purchased electricity**—the electricity that facilities purchase through the grid (e.g., from a utility service provider) and through direct-line connections (including from on-site units operated by a third party).

**Reducing agent, reductant**—materials (reductants) added into a furnace to deoxidize (reduce) the iron ore to form metallic iron.

**Rebar**—steel concrete reinforcing bars and rods of carbon and alloy steel, whether or not wound in irregular coils. Rebar corresponds to HTS subheadings 7213.10, 7214.20, and HTS statistical reporting number 7228.30.8010.

**Reference product—**any product for which a product-level emissions inventory was calculated using allocation and material flow analysis techniques. Most product categories covered in this investigation are also reference products, with the exception of aggregate product categories. Reference products also include upstream materials produced at facilities producing covered products.

**Renewable energy certificate (REC)**—a type of energy attribute certificate. A REC is a market-based instrument that represents the property rights to the environmental, social, and other non-power attributes of renewable electricity generation. A REC is issued when 1 megawatt-hour (MWh) of electricity is generated and delivered to the electricity grid from a renewable energy resource. The term “unbundled REC” means the nonphysical REC has been separated from the physical electricity. The term “bundled REC” means the REC is sold with its associated physical electricity. REC retirement is registered in the tracking system that issued the REC and ensures that the REC cannot be sold to another entity.

**Retail energy supplier (electric)**—an entity that sells electricity in deregulated retail electricity markets. Retail energy suppliers set the rates and contract terms for their electricity customers and are responsible for sourcing the electricity from the wholesale market. Unlike a utility, retail energy suppliers do not control and maintain the distribution network that delivers the electricity.

**Rolling mill**—a facility specializing in producing rolled products. For steel, covered products produced at rolling mills include sheet, plate, and strip in hot-rolled, cold-rolled, and coated varieties. For aluminum, covered products produced at rolling mills include plate, sheet, and strip, foil, and some pipe and tube.

**Rotary hearth furnace**—a direct-reduction device that recovers metals from iron fines and dust produced during the ironmaking and steelmaking process to produce direct reduced iron or liquid pig iron from those recovered materials.

**Sand casting**—a type of aluminum casting in which aluminum is poured into a mold made of sand to create a finished or near-finished shape.

**Scalping**—the process of shaving (usually with a rotating blade) an outer layer from the surface of aluminum ingots to remove impurities or irregularities.

**Scope 1 emissions**—direct greenhouse gas (GHG) emissions that occur from sources that a facility controls, including process emissions and combustion emissions.

**Scope 2 emissions**—indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling. Although scope 2 emissions physically occur at the energy-generating plant where they are emitted, they are included in a facility’s emissions inventory because they are a result of the facility’s energy use.

**Scope 3 emissions**—indirect GHG gas emissions resulting from activities of assets that the reporting facility does not control, but that the facility indirectly affects in its value chain. For the purposes of the Commission’s investigation, scope 3 emissions are associated with the embedded emissions of upstream material inputs received by a surveyed facility from a supplier facility. A portion of the scope 3 emissions for one surveyed facility may be scope 1 and 2 emissions of another surveyed facility.

**Scrap, externally sourced**—includes fabrication scrap (pre-consumer scrap from manufacturing processes), postconsumer scrap that has been recovered from end-of-life steel or aluminum containing products (e.g., recycling of steel from cars), and blended scrap (e.g., scrap produced by scrap processors through shredding, followed by chemical analysis and sort by alloy content and then blended to a customer's preferred alloy specifications). Externally sourced scrap can be sourced from other steel and aluminum producing facilities (regardless of common ownership) as well as downstream facilities.

**Scrap, home**—see "Scrap, runaround."

**Scrap, postconsumer**—scrap recovered from end-of-life steel- or aluminum-containing products (e.g., cars, used beverage containers).

**Scrap, runaround**—scrap generated within a facility and reused as an input into the production processes at the same facility. Runaround scrap is also known as home scrap, internally generated scrap, internal scrap, turnaround scrap, or in-house scrap. The quantity of runaround scrap does not usually affect the material balance sheet (raw material in and product out) of a facility.

**Seamless steel tubular products**—includes seamless tubes, pipes, and hollow profiles, but not fittings or other attachments. Stainless seamless steel tubular products include those classified under HTS subheadings 7304.11, 7304.22, 7304.24, 7304.41, and 7304.49. Carbon and alloy seamless steel tubular products include those classified under HTS subheadings 7304.19, 7304.23, 7304.29, 7304.31, 7304.39, 7304.51, 7304.59, and 7304.90.

**Semifinished steel**—includes ingots, blooms, slabs, billets, and beam blanks (whether batch or continuously cast), as well as liquid steel not cast into a form on-site. Stainless semifinished steel includes products classified under HTS heading 7218. Carbon and alloy semifinished steel include products classified under HTS headings 7206, 7207, and 7224.

**Sequestration (as in carbon)**—the use of biological or physical processes to capture and store carbon dioxide, such as in an underground geologic formation.

**Sinter**—see "Iron sinter."

**Slab**—semifinished steel of rectangular cross section having a width measuring at least four times the thickness. Carbon and alloy steel slabs are those classified under HTS statistical reporting numbers 7207.12.0050, 7207.20.0045, 7224.90.0025, and 7224.90.0055. Stainless steel slabs are those classified under HTS statistical reporting number 7218.91.0060.

**Slag**—the by-product of iron and steel production in a blast furnace, basic oxygen furnace, or electric arc furnace. Slag contains flux materials like lime and the impurities drawn from the iron ore through the fluxing process.

**Smelting (of primary unwrought aluminum)**—the process by which alumina (aluminum oxide) is extracted from its oxide to produce aluminum, by the Hall-Héroult electrolytic process.

**Source country**—the country where production of an input—steel, aluminum, or other material—occurred.

**Stainless steel**—any alloy steel that contains, by weight, 1.2 percent or less of carbon and 10.5 percent or more of chromium, with or without other elements.

**Steel**—steel products that are covered under this investigation include carbon, stainless, and other alloy semifinished steel and downstream steel products, including flat and long steel products and steel tubular products. In general terms, a product is made of steel if iron predominates by weight over any other base metals; if it is usefully malleable; and if it contains by weight 2 percent or less of carbon, per the definition provided in the *Harmonized Tariff Schedule of the United States* (HTS) for steel in Chapter 72, Iron and Steel, notes 1(d), 1(e), and 1(f). Ferrous materials under HTS heading 7203 (direct reduced iron, hot briquetted iron, and iron pellets)—which may have low amounts of carbon—are not considered steel and are one exception to these criteria. Also, certain chromium steels may contain higher proportions of carbon but are still considered steel. Note: For a full list of products covered in this investigation, see attachment B to the Trade Representative's letter requesting this investigation, which is appendix A in this report.

**Steelmaking**—the processes that convert pig iron, scrap, direct reduced iron, or mixtures of these into semifinished steel by a refining process that lowers the carbon content and removes impurities, mainly nonferrous metals, phosphorus, and sulfur. Steel is primarily produced using one of two methods: basic oxygen furnace or electric arc furnace.

**Subprocess**—specific processes for which facilities provided input and output data as defined by the facility-level questionnaire and that were reported as emissions data under the Greenhouse Gas Reporting Program. Some subprocesses produce only a single product category (i.e., they are also a "unit process"); other subprocesses produce two or more product categories (i.e., they incorporate multiple unit processes).

**Subpart C of Title 40 of the Code of Federal Regulations, Part 98 (Subpart C of the regulation for the EPA's Greenhouse Gas Reporting Program)**—refers to 40 C.F.R. §§ 98.30–98.38, which covers reporting requirements and calculation methodologies for emissions associated with general stationary combustion for fuel sources as defined in the regulation.

**Subpart D of Title 40 of the Code of Federal Regulations, Part 98 (Subpart D of the regulation for the EPA's Greenhouse Gas Reporting Program)**—refers to 40 C.F.R. §§ 98.40–98.48, which covers reporting requirements and calculation methodologies for emissions associated with electricity generation as defined in the regulation.

**Subpart F of Title 40 of the Code of Federal Regulations, Part 98 (Subpart F of the regulation for the EPA's Greenhouse Gas Reporting Program)**—refers to 40 C.F.R. §§ 98.60–98.68, which covers reporting requirements and calculation methodologies for emissions associated with primary aluminum production as defined in the regulation.

**Subpart Q of Title 40 of the Code of Federal Regulations, Part 98 (Subpart Q of the regulation for the EPA's Greenhouse Gas Reporting Program)**—refers to 40 C.F.R. §§ 98.170–98.178, which covers reporting requirements and calculation methodologies for emissions associated with iron and steel production as defined in the regulation.

**Subregion, eGRID**—a geographic division created by the EPA to provide useful electricity emissions rate data. The United States is divided into 27 Emissions and Generation Resource Integrated Database (eGRID) subregions.

**Substrate**—raw material used as an input for the production of steel and aluminum products. For example, hot-rolled steel is the substrate for cold-rolling operations, and unwrought aluminum is the substrate for wrought aluminum products.

**Supplier facility (or supplier)**— any facility other than the consuming facility that produces materials and products used in the consuming facility's production of covered steel and aluminum products. Supplier facilities include off-site facilities under separate ownership, off-site facilities that share common ownership to the reporting facility, and facilities on-site that are not under the operational control of the reporting facility. Consuming facilities may receive materials from supplier facilities through various arrangements, including purchases, transfers, or toll processing arrangements.

**Surveyed facility**—a U.S. facility that responded to the Commission's questionnaire under this investigation and confirmed their on-site production of covered steel or aluminum products in 2022.

**System boundary**—a clearly defined scope of the greenhouse gas (GHG) emissions meant to be covered when accounting for all GHG emissions associated with a specific product, facility, or company. A system boundary generally includes contiguous processes as well as pertinent product inputs along a value chain for which all associated GHG emissions should be captured—and excludes all others.

**Therm**—a unit to measure heat energy, commonly used to refer to the amount of energy that would be released from combusting natural gas. In terms of unit conversion, 1 therm = 100,000 British thermal units (Btu) and 1 therm = 0.1 million British thermal units (MMBtu).

**Toll producer (toll production)**—a facility that engages in the production of a product on behalf of another facility that owns the product before, during, and after production. A toll producer has operational control of a facility if it controls production, even if it does not own the inputs or outputs of that production.

**Unit process—**the most narrowly defined processes for which input and output data are quantified within the calculation of emissions intensity estimates of products. In this investigation, each unit process corresponds directly with the production of an individual reference product.

**Unit process emissions**—the output of greenhouse gas emissions from a unit process. In this investigation's calculation of emissions intensity estimates for steel and aluminum facilities, unit process emissions may be direct or indirect. Direct unit process emissions occur during the unit process itself and indirect unit process emissions are associated with energy and material inputs used during the unit process.

**Used oil**—petroleum-derived or synthetically derived oil whose physical properties have changed as a result of handling or use, such that the oil cannot be used for its original purpose. Used oil consists primarily of industrial oils (e.g., industrial engine oils, metalworking oils, process oils, industrial grease, etc.) and automotive oils (e.g., used motor oil, transmission oil, hydraulic fluids, brake fluid, etc.).

**Useful thermal output**—the thermal energy (e.g., steam, heat, hot water) for use in any industrial or commercial process, heating or cooling application, or delivered to other end users. Useful thermal output is made available in a cogeneration process, a combined heat and power system, or a boiler. Useful thermal output includes only the thermal energy that is available for processes and applications other than electrical generation.

**Utility (electric)**—a corporation, person, agency, authority, or other legal entity aligned with distribution facilities to deliver electric energy for use primarily by the public. Utilities include investor-owned electric utilities, municipal and state utilities, federal electric utilities, and rural electric cooperatives. In a traditional regulated electricity market, utilities own and operate all aspects of the electric system, including power plants, transmission, and distribution systems. In an electricity market where the retail segment has been deregulated, customers may instead purchase electricity from a retail energy supplier.

**Watt-hour**—a unit to measure energy, commonly used for electricity generation or consumption. One watt-hour represents one watt of power sustained for one hour. In terms of unit conversion, 1,000,000 watt-hours (Wh) = 1 megawatt-hour (MWh).

**Wire, steel**—steel wire, whether or not plated, coated, or polished, of any cross-sectional dimension and shape. Carbon and alloy steel wire corresponds with HTS headings 7217 and 7229. Stainless steel wire corresponds with the HTS heading 7223.

**Wire rod**—a hot-rolled intermediate steel product of circular or approximately circular cross section that typically is produced in nominal fractional diameters up to 19 millimeters and sold in irregularly wound coils, primarily for subsequent drawing and finishing by wire drawers. Carbon and alloy wire rod corresponds to HTS subheading 7213.91 and HTS statistical reporting numbers 7213.99.0030, 7213.99.0090, 7227.20.0030, 7227.90.6020, 7227.90.6030, and 7227.90.6035. In this report, stainless wire rod is not distinguished from other stainless hot-worked long steel products.

# Executive Summary

This report assesses the greenhouse gas (GHG) emissions intensities (referred to as “emissions intensities” in this report) of steel and aluminum products produced in the United States in 2022. This analysis was sought by the U.S. Trade Representative (Trade Representative) to inform negotiations on the Global Arrangement on Sustainable Steel and Aluminum, which seeks to address emissions intensities and global nonmarket excess capacity in these sectors. The U.S. International Trade Commission (Commission) received the request to prepare this report in a letter from the Trade Representative dated June 5, 2023. This letter is available in appendix A of this report.

Emissions intensity estimates are calculated in terms of metric tons of carbon dioxide equivalent ($CO_2e$) GHG emitted per metric ton of steel or aluminum produced in the United States in 2022, per the Trade Representative’s letter. As requested in the letter, the Commission’s analysis estimates the average and highest emissions intensities of steel and aluminum produced in the United States by product category covering the domestically produced goods that correspond with the scope of imported goods listed in Presidential Proclamations 9704 and 9705 of March 8, 2018 (83 Fed. Reg. 11619 and 83 Fed. Reg. 11625, March 15, 2018). These goods are listed by *Harmonized Tariff Schedule of the United States* subheading in Attachment B of the Trade Representative’s letter and are referred to as “covered steel and aluminum products” or “covered products” throughout this report. As further requested in the letter, this report describes the methodologies the Commission used to collect relevant information and calculate the emissions intensity estimates, as well as identifies where emissions occur during the manufacture of these products, with respect to the production stages and sourcing location of inputs.

## Scope and Approach

As requested, the emissions intensity estimates of the covered products are shown in this report for the broad categories laid out in Attachment A of the Trade Representative’s letter. In some instances where production processes and resulting emissions intensity estimates were expected to vary within these product categories, the Commission calculated emissions intensity estimates for additional subsets of the product categories listed in Attachment A. The Commission estimated emission intensities for 30 product categories (tables E.S. 2, 3 and 4) and 20 additional steel subcategories.

In this investigation, the Commission analyzed various external data sources and conducted a survey of firms with facilities producing steel and aluminum in the United States in 2022 (this effort is explained later in this executive summary). As requested, the Commission used these data to calculate direct GHG emissions associated with the production of covered steel and aluminum products and indirect GHG emissions associated with the material and resource inputs into this production. These emissions are grouped into different “scopes” in the Trade Representative’s letter (table ES.1).

**Table ES.1** Scopes of emissions included in the Commission's emissions intensity estimates

| Scope of emissions | Types of emissions represented by these scopes in this report |
|---|---|
| Scope 1 | Direct emissions from sources a facility owns or controls that are used in the production of covered steel and aluminum products. Includes fuel combustion emissions and process emissions (i.e., emissions from industrial processes involving chemical or physical transformations other than fuel combustion). |
| Scope 2 | Indirect emissions from purchased energy used at a facility in the production of covered steel and aluminum products. |
| Scope 3 | Indirect emissions embedded in the material inputs used at a facility in the production of covered steel and aluminum products. |

Source: Compiled by the USITC from the U.S. Trade Representative's letter.

Note: Scope distinctions are determined on a facility basis. A facility's scope 2 and 3 emissions occur at sources outside of its operational control. If a facility produces upstream materials and uses them in the production of downstream products in the same facility, the scope designations for emissions embedded in those inputs (which may be scope 1, 2, or 3 emissions) are carried through to those downstream products.

In terms of GHGs, the Commission collected emissions-related data covering carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane ($CH_4$), and perfluorocarbons (PFCs). For reporting purposes, the latter three GHGs are normalized in terms of their global warming potential relative to $CO_2$, as described in this report, and the corresponding emissions of all four GHGs are aggregated and reported in units of carbon dioxide equivalent ($CO_2e$).

## Emissions Intensities

The average emissions intensity measure used in the Commission's estimates is a production-weighted national average of the associated emissions and production tonnages reported by all facilities responding to the Commission's questionnaire for particular covered product categories. The highest emissions intensity measure is the same calculation across the facilities with the highest emissions intensities for a particular product category, that combined, represent at least 10 percent of national production of that product category. The Commission presents the highest emissions intensity estimates across larger percentile ranges (20 percent of production, 30 percent of production, etc.) when results cannot be reported at the 10 percent production grouping because of data suppression to protect confidential business information. The Commission's average and highest emissions intensity estimates are presented in tables ES.2, for carbon and alloy steel product categories; ES.3, for stainless steel product categories; and ES.4, for aluminum product categories. Carbon and alloy steel and stainless steel product categories are presented in separate tables to allow for clearer comparisons because all the downstream categories in each table are derived from semifinished substrate of that particular steel type. Production-weighted averages also have been calculated for the 50–100th, 60–100th, 70–100th, and 80–100th percentile ranges (i.e., the most emissions-intensive facilities representing 50 percent, 40 percent, 30 percent, and 20 percent of production, respectively) for each product category and are presented in appendix I.

**Table ES.2** Carbon and alloy steel products: average and highest emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production within each respective product category presented.

| Product category | Average emissions intensity | Highest emissions intensity |
|---|---:|---:|
| Semifinished | 1.02 | 2.15 |
| Flat | 1.83 | 3.06 |
| Hot-rolled flat | 1.59 | 2.62 |
| Cold-rolled flat | 1.91 | 3.08 |
| Coated flat | 2.17 | 3.82 |
| Long | 0.75 | 1.89 |
| Hot-worked long | 0.67 | 1.43 |
| Cold-formed long | 1.25 | 2.62 |
| Tubular | 1.50 | 2.50 |
| Seamless tubular | 1.09 | 1.43 |
| Non-seamless tubular | 1.71 | 2.60 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table ES.3** Stainless steel products: average and highest emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production within each respective product category presented.

| Product category | Average emissions intensity | Highest emissions intensity |
|---|---:|---:|
| Stainless | 2.78 | 4.21 |
| Semifinished | 2.23 | 3.79 |
| Hot-rolled flat | 2.31 | 3.26 |
| Cold-rolled flat | 3.08 | 3.76 |
| Hot-worked long | 2.93 | 6.27 |
| Cold-formed long | 3.55 | 5.52 |
| Seamless tubular | 4.07 | 7.85 |
| Non-seamless tubular | 3.16 | 4.49 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table ES.4** Aluminum products: average and highest emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2e$/mt aluminum). ^ indicates the highest estimate is an average of the top emissions-intensive facilities with 20 percent of production and * indicates the highest estimate is an average of the top emissions-intensive facilities with 30 percent of production. The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production within each respective product category presented.

| Product category | Average emissions intensity | Highest emissions intensity |
|---|---|---|
| Unwrought | 3.46 | 14.82 |
| Primary unwrought | 14.52 | 22.22* |
| Secondary unwrought | 2.46 | 9.62 |
| Wrought | 6.23 | 17.18 |
| Bars, rods, and profiles | 8.35 | 19.76 |
| Wire | 8.35 | 16.11^ |
| Plates, sheets, and strip | 4.97 | 13.22 |
| Foil | 8.66 | 11.80^ |
| Tubes, pipes, and tube or pipe fittings | 8.21 | 15.08 |
| Castings | 6.00 | 20.24 |
| Forgings | 5.00 | 10.19 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

# Data Collection

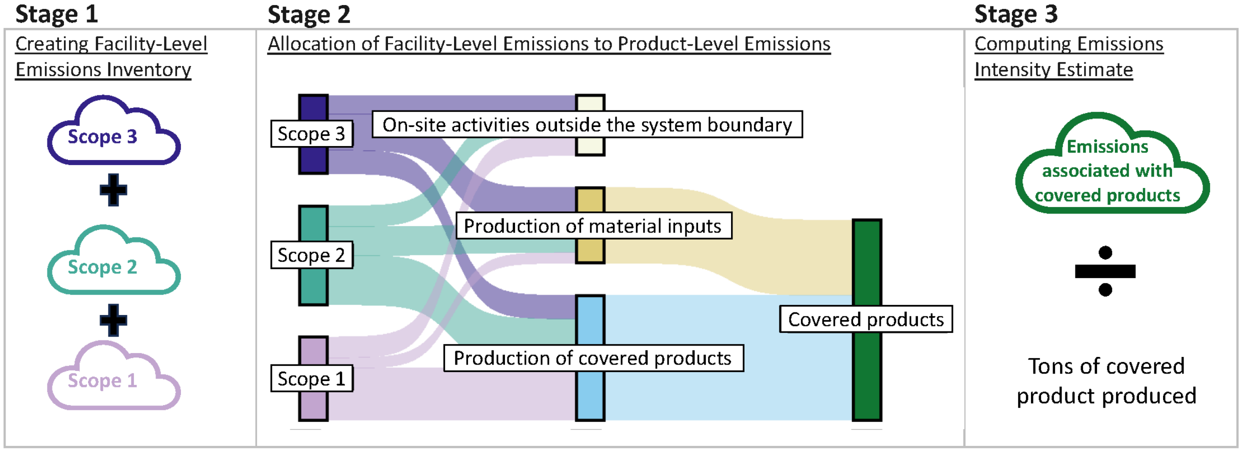
To collect pertinent data on production of covered steel and aluminum products and its associated emissions, the Trade Representative’s letter requested the Commission conduct a survey by issuing questionnaires to firms with U.S. facilities producing these products. As requested, these data were to be collected from firms to the extent that such information was not already reported through the U.S. Environmental Protection Agency GHG Reporting Program (GHGRP) or other public sources.

To fulfill this request, the Commission consulted various steel and aluminum association membership directories and public databases and worked with industry associations to develop a list of companies and their associated facilities that likely produced covered steel and aluminum products in 2022. Companies from this list were sent a company-level questionnaire to identify facilities they owned that produced covered products in 2022 and gather contact information for these facilities. After these responses were received, the Commission sent a facility-level questionnaire to all facilities identified in the relevant company-level responses. The overall response rate for the company-level questionnaire was 82.5 percent, and the response rate for the facility-level questionnaire was 93.5 percent of the total number of facilities that the companies identified as producing covered products in their company-level questionnaire responses. The production output of facility-level respondents to the questionnaire comprises the vast majority of U.S. production in covered steel and aluminum product categories in 2022. When comparing the 2022 total production data collected in responses to the Commission’s questionnaire to that from external data sources, the survey captured nearly 100 percent of production for almost all product categories.

# Overview of Calculation Methodology

To calculate emissions intensities for product categories, the Commission developed an approach drawing on data collected from the responses to its facility-level questionnaire, as well as data from the GHGRP, and data from external sources. The Commission's calculation approach was conducted in three stages, as illustrated in figure ES.1. In the first stage, the Commission compiled a facility-level emissions inventory. To generate total emissions by scope for the inventory, the Commission used data sourced directly from facility-level public reporting to the GHGRP or generated using questionnaire responses in combination with external data sources. In the second stage, the Commission allocated emissions within that inventory to product categories using information primarily provided in the questionnaire responses. In the final stage, using those product category-level emissions and production data from questionnaire responses, the Commission calculated production-weighted emissions intensity estimates for each product category.

**Figure ES.1** Illustration of three stages of the Commission's calculation approach



Source: Compiled by the USITC.

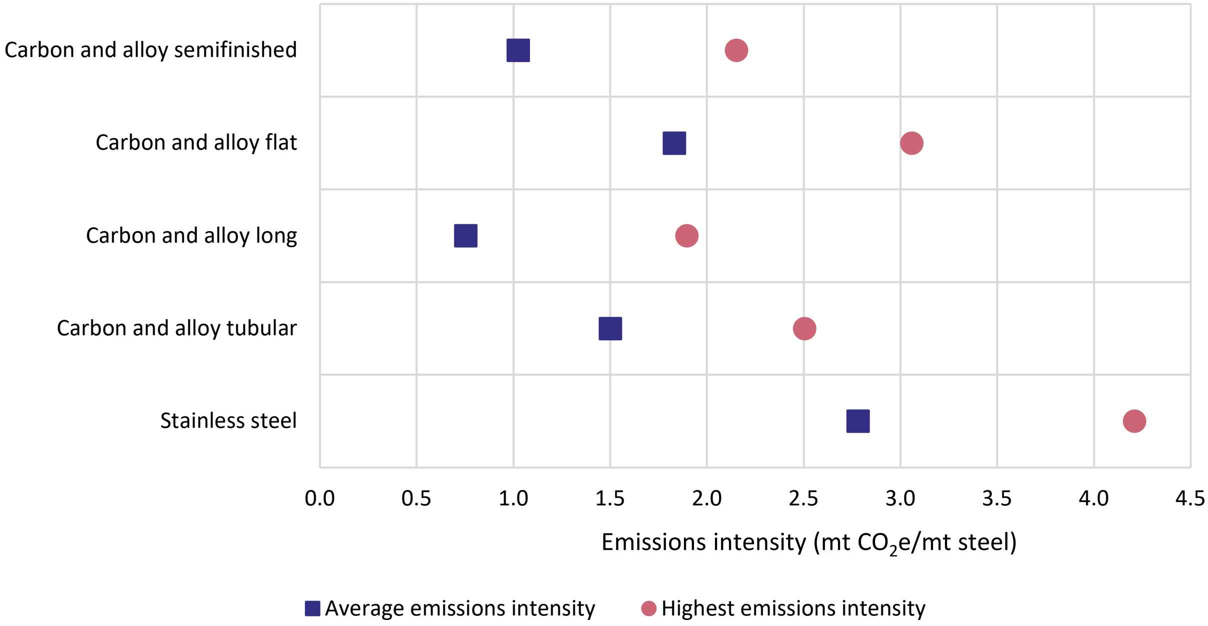
The Commission's calculation methodology was developed based upon review of various emissions accounting standards and frameworks used by government and industry and in conjunction with the design of the Commission's survey questionnaire. The Commission's approach did not adhere to any single existing standard or framework for calculating product-level GHG emissions but broadly reflects commonly accepted emissions accounting practices. Consistent with other emissions accounting methodologies, the Commission did not assign embedded emissions to scrap used in steel or aluminum production in this investigation.

# Assessment of Steel Emissions Intensities

Steel emissions intensity estimates are presented in the figures below. Average emissions intensity as well as estimates of the highest emissions intensity are presented at increasing levels of disaggregation. Figure ES.2 displays the intensity estimates for the five steel product categories outlined in Attachment A of the request letter, which include all stainless as well as carbon and other alloy ("carbon and alloy") semifinished products, the two broad categories made from carbon and alloy semifinished steel—flat products and long products—and tubular products, which are made from flat steel or from semifinished steel. Intensity estimates are then disaggregated into 15 product categories (figure ES.3).

**Figure ES.2** Average and highest emissions intensities, for semifinished and aggregate steel product categories

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). The highest estimate is the production-weighted average of those facilities with the highest emissions intensities that represent 10 percent of production within each respective product category presented. Underlying data for this figure can be found in appendix J, table J.1.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

As shown in figure ES.2 above, carbon and alloy semifinished steel (e.g., slabs, billets, and ingots) had an average emissions intensity of 1.02 metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel) and a highest emissions intensity of 2.15 mt $CO_2e$/mt steel. Variation in facility-level emissions intensity is driven in large part by the production pathway under which semifinished steel is produced. In the United States, semifinished steel is made either using large-scale, integrated blast furnace (BF)-basic oxygen furnaces (BOFs) (about one-third of all U.S. semifinished steel production) or smaller electric arc furnaces (EAFs) (about two-thirds of all U.S. semifinished steel production). These production pathways have varying levels of associated emissions, driven by the different processes and inputs they use. Typically, steel produced (or containing steel inputs produced) using the blast furnace and basic oxygen furnace (BF-BOF) production pathway results in higher emissions intensities than steel produced (or containing steel inputs produced) using the EAF production pathway, given the associated inputs and processes used in these production pathways as described below.

Blast furnaces generate blast furnace gas as a by-product of the use of coke, iron, and other materials. Blast furnace gas that is not flared is typically used along with other fuels in stoves used to preheat blast furnaces and in other integrated facility processes, producing scope 1 fuel combustion emissions. Scope 1 emissions are also released during the transformation of pig iron into steel when the carbon in the iron and other materials are oxidized and released as $CO_2$. Further emissions associated with the BF-BOF production pathway come from the embedded scope 3 emissions in material inputs like iron ore, metallurgical coke, and flux materials, as well as some scope 2 emissions from purchased electricity and other types of energy.

Facilities with EAFs rely primarily on steel scrap as the main metallic input used in steelmaking and generally do not produce other metallic inputs on-site. Because the Commission did not assign embedded emissions to scrap in this investigation, EAF facilities' reliance on scrap reduces the overall emissions associated with EAF steelmaking. EAF facilities have proportionally large scope 2 emissions associated with the purchased electricity necessary to melt ferrous inputs in EAFs. Scope 1 fuel combustion emissions can also occur within facilities producing steel using an EAF in separate furnaces designed to preheat scrap or to keep the steel hot enough for casting and finishing, and scope 1 process emissions occur from the consumption and melting of carbon electrodes, scrap, pig iron, direct reduced iron, flux materials, and feedstocks like coal, coke, and natural gas. Emissions also occur from the embedded scope 3 emissions of material inputs used like pig iron and direct reduced iron that supplement scrap use.

The emission intensities of carbon and alloy flat, long, and tubular steel products downstream from semifinished steel products are also affected by processes and inputs used in production. The production pathway of the semifinished substrate used and the energy intensity of finishing steps undertaken in production are drivers of the emissions intensities of downstream carbon and alloy steel products. In addition, foreign emissions are embedded in U.S. steel products when domestic producers use imported materials in their production, which can be more emissions intensive than those of U.S.-produced materials.

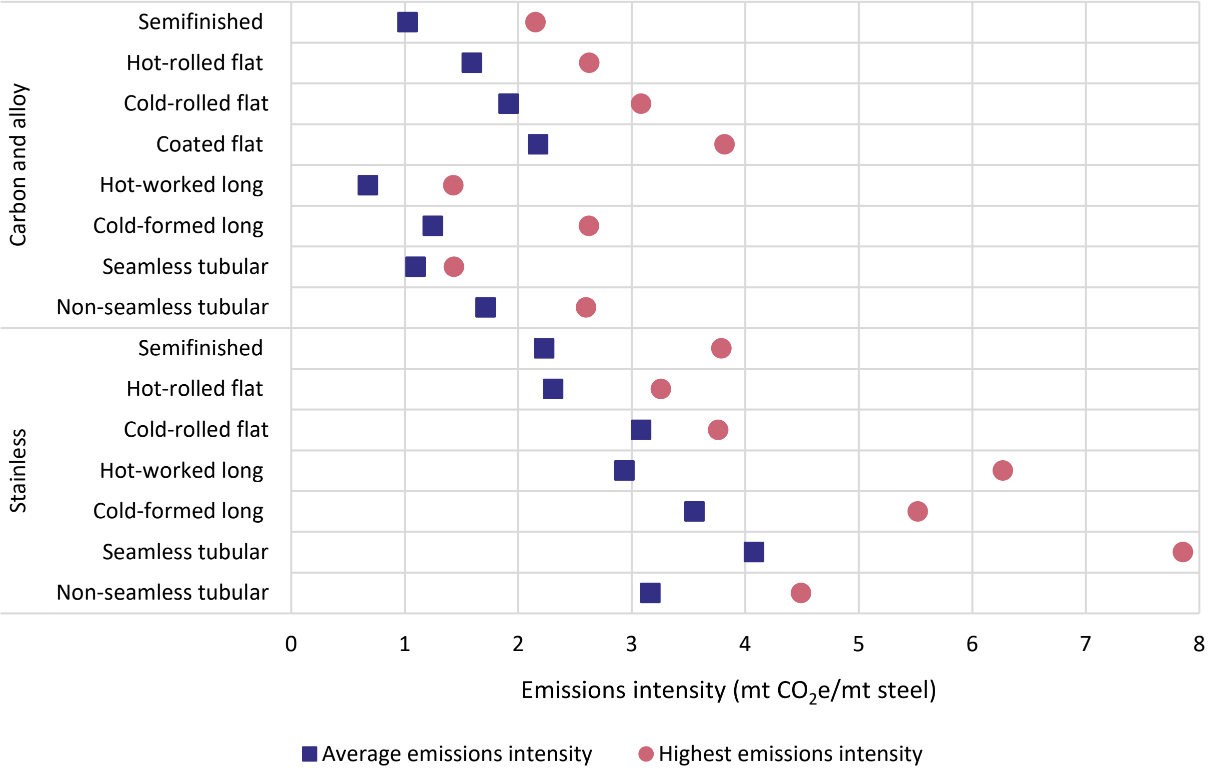
The average emissions intensity was 1.83 mt $CO_2e$/mt steel for carbon and alloy flat steel products and 0.75 mt $CO_2e$/mt steel for carbon or alloy long products. The average emissions intensities for these aggregate product categories are in part explained by the production pathways used at the facilities where they (and the semifinished steel substrate used to make them) are produced. Facilities using the BF-BOF and EAF production methods both reported production of flat steel products. Only facilities using the lower-emitting EAF production pathway reported production of long steel products.

The variety of products within the product categories may result in corresponding variations in emissions intensities when product categories are further disaggregated. The average emissions intensity of carbon and alloy tubular steel products (1.50 mt $CO_2e$/mt steel) reflects a mix between the higher emissions intensities of non-seamless tubular steel (which is made using flat steel products) and lower intensity for seamless tubular steel products (which are generally made from long products). Stainless steel had an average emissions intensity of 2.78 mt $CO_2e$/mt steel. Because this broad category covers all forms of stainless steel, however, emissions intensities vary depending on how these different forms of stainless steel are disaggregated.

Figure ES.3 shows the average and highest emissions intensities for the more disaggregated steel product categories in mt $CO_2e$/mt steel. Compared to the production of semifinished steel using the BF-BOF and EAF production pathways, the various processes (e.g., hot-rolling or hot-working, cold-rolling or cold-forming) that transform semifinished steel into finished steel mill products individually emit lower amounts of GHGs, but still collectively represent a meaningful share of overall product-level emissions across product categories. The emissions intensity of these finished steel mill products is largely determined by the embedded emissions of upstream material inputs—more specifically, by the scope 3 emissions associated with their semifinished steel substrate inputs. The majority of surveyed facilities' externally sourced semifinished steel used in the production of covered products was sourced from the United States, 57.7 percent, compared with 42.3 percent from imported sources. The largest sources of imported semifinished steel included Brazil (48.3 percent), Mexico (29.8 percent), and Canada (8.5 percent). In overall terms, imports of semifinished steel inputs increased average embedded emissions for downstream steel mill products, relative to domestically sourced inputs.

**Figure ES.3** Average and highest emissions intensities of steel, by steel product category

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). The highest estimate is the production-weighted average of those facilities with the highest emissions intensities that represent 10 percent of production within each respective product category presented. Underlying data for this figure can be found in appendix J, table J.2.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

As with the aggregate flat and long categories, disaggregated carbon and alloy flat and long categories also reflect that flat products (e.g., hot-rolled, cold-rolled, coated) are more emissions intensive than long products (e.g., hot-worked, cold-formed). The average emissions intensity of carbon and alloy hot-worked long steel products was the lowest of all product categories, including semifinished steel, reflective of the fact that no long products were made using semifinished steel produced in a BF-BOF. The emissions intensity estimates for carbon and alloy flat products were 1.59 mt $CO_2e$/mt steel for hot-rolled flat steel, 1.91 mt $CO_2e$/mt steel for cold-rolled flat steel, and 2.17 mt $CO_2e$/mt steel for coated flat steel. These figures reflect the additional finishing work done after hot-rolling, such as cold-rolling, annealing, or the application of coating materials. Each of these additional processes contributes to the overall emissions embedded in the product, increasing its emissions intensity. For example, the higher emissions intensity of cold-formed long steel relative to hot-worked is the result of the additional finishing steps employed to produce cold-formed long steel after hot-working. Emissions from non-seamless tubular products are mostly the result of the embedded scope 3 emissions of the hot-rolled flat steel used to form the tube, whereas seamless tube is produced directly from long products made via the EAF pathway, which carry lower embedded scope 3 emissions.

The majority of hot-rolled flat steel and hot-worked long steel used as inputs into the production of further downstream products like cold-rolled or coated flat products or cold-formed long products were sourced from the United States. Of all hot-rolled flat steel received by surveyed facilities from external sources, 92.6 percent was sourced domestically, 4.3 percent was imported, and 3.2 percent came from unknown sources. The largest country sources for hot-rolled flat imports were Canada (45.3 percent), the Netherlands (12.1 percent), and Mexico (11.9 percent). Similarly, 77.1 percent of externally sourced hot-worked long products used in downstream production came from domestic sources, 21.3 percent came from imports, and 1.6 percent was unknown. The sourcing of hot-worked long products was more dispersed globally with the largest sources being Canada (14.8 percent), Brazil (9.7 percent), and Algeria (8.9 percent). Since hot-rolled flat and hot-worked long products were primarily sourced domestically, the emissions intensities of individual country import sources have a lower impact on the Commission's average emissions intensity estimate. Downstream products using imported hot-rolled flat or hot-worked long products had higher average embedded emissions than those made with domestically sourced inputs.

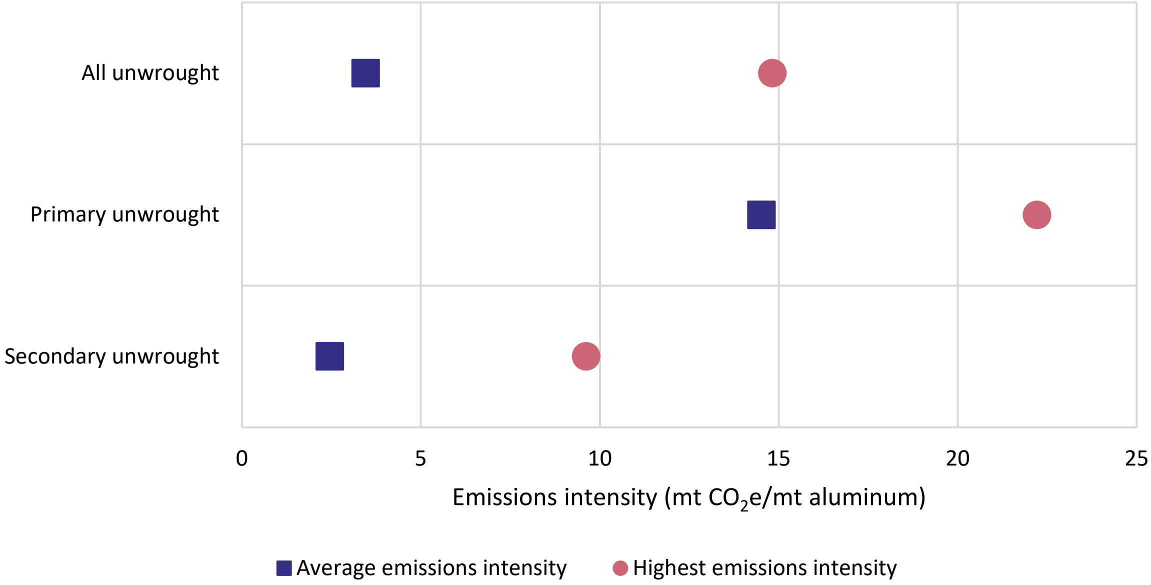
The stainless steel market in the United States is smaller than the carbon and alloy steel market, representing only 3 percent of U.S. steel production in 2022. The average emissions intensity of stainless semifinished steel was 2.23 mt $CO_2e$/mt steel. Unlike carbon and alloy semifinished steel, no surveyed facilities producing stainless semifinished steel reported use of the BF-BOF method. Therefore, the primary determinants for the emissions intensity for stainless semifinished steel were not tied to differences in production pathway. Instead, the amounts and types of ferroalloys used to make stainless semifinished steel drove the emissions intensity of these products, because ferroalloys are used in greater proportions in stainless than in carbon and alloy steel. In addition to the impact of ferroalloys and other upstream inputs which carry embedded scope 3 emissions, stainless steel production was also more energy intensive than carbon and alloy steel production for all processes, resulting in higher relative scope 1 emissions and scope 2 emissions.

# Assessment of Aluminum Emissions Intensities

The aluminum emissions intensity estimates shown in table ES.4 are presented in figures below. Estimates of the average emissions intensity as well as a measure of the highest emissions intensity are presented for the aluminum product categories outlined in Attachment A of the request letter. These product categories are unwrought products (which include primary and secondary unwrought, shown in figure ES.4) and wrought products with additional breakouts for bars, rods, and profiles; wire; plates, sheets, and strip; foil; tubes, pipes, and tube or pipe fittings; and to the extent practicable, castings and forgings (shown in figure ES.5).

**Figure ES.4** Average and highest emissions intensities of unwrought aluminum, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2e$/mt aluminum). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production within each respective product category presented, except for primary aluminum, where the highest emissions intensities represent 30 percent of production because of confidentiality considerations. Underlying data for this figure can be found in appendix J, table J.3.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

The average emissions intensity for primary unwrought aluminum is 14.52 mt $CO_2e$/mt aluminum, higher than the average emissions intensity of secondary unwrought aluminum of 2.46 mt $CO_2e$/mt aluminum. This is a result of the electricity-intensive manufacturing process (electrolysis) for primary unwrought aluminum (which converts aluminum oxide to molten aluminum metal), as well as the source of the generation of that electricity in the United States. Electrolysis contributes most of the emissions associated with primary aluminum production, with some sources finding that about three-fourths of emissions in primary aluminum production result from the electrolysis process. The main factor determining a primary unwrought aluminum smelter's emissions intensity is its electricity source. Smelters powered by nuclear power or by renewable power sources such as hydroelectricity typically yield little to no emissions attributable to the electricity sourcing. Smelters powered by fossil fuel-based electricity, such as from coal and natural gas, result in much higher electricity-related emissions.

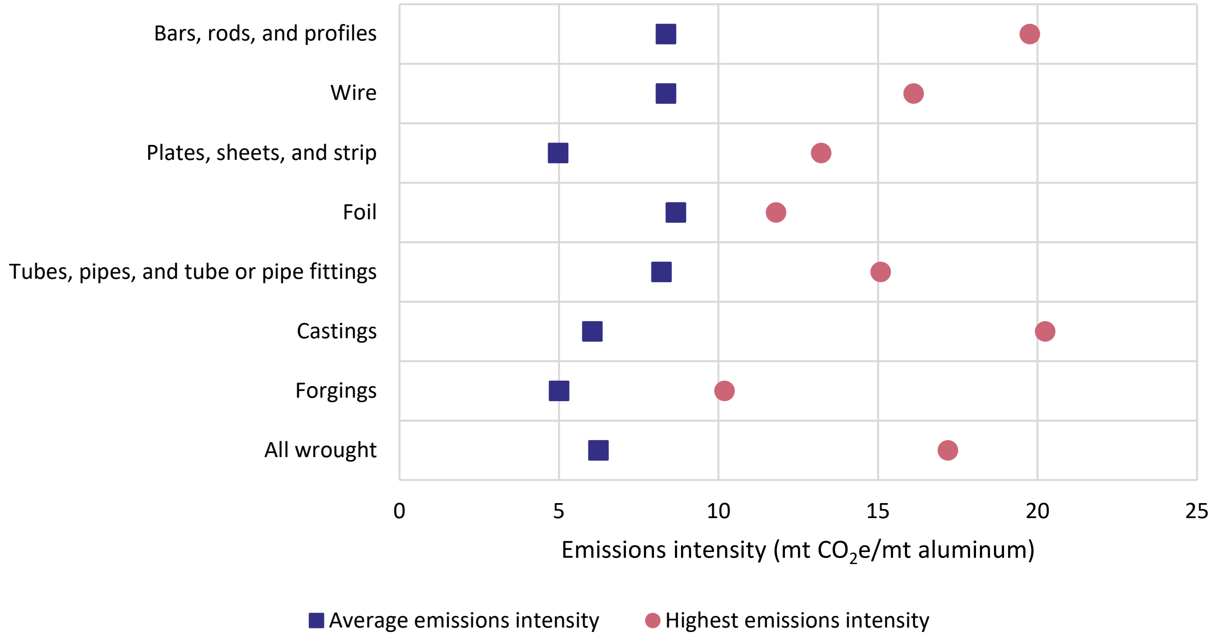
The amount of electricity used to make primary unwrought aluminum in the United States was estimated at over 150 times the amount used to make secondary unwrought aluminum. Moreover, secondary unwrought aluminum production (which primarily consists of remelting aluminum scrap in a furnace) consumes 90–95 percent less energy overall than primary unwrought aluminum production, resulting in much lower emissions in the secondary process compared to primary production. In addition, although secondary unwrought aluminum has scope 3 emissions from inputs such as primary unwrought aluminum and alloying elements, the largest input is scrap, which has no embedded emissions according to the Commission's methodology. The average unwrought emissions intensity (3.46 mt of $CO_2e$/mt aluminum) includes both primary and secondary unwrought aluminum. Because the

Commission's emissions intensity estimates are weighted by production, the unwrought aluminum emissions intensity is therefore influenced by the much higher production volume of secondary unwrought aluminum in the United States.

The average emissions intensities among wrought aluminum products ranged from that of plates, sheets, and strip, at 4.97 mt $CO_2$e/mt aluminum product, to foil, at 8.66 mt $CO_2$e/mt aluminum product. The two main drivers of the differences in emissions intensities between wrought product categories are the amount of primary aluminum used and the energy intensity of the various manufacturing processes. In wrought aluminum production, scope 1 fuel combustion emissions are emitted from furnaces when aluminum is heated before being further worked or heat treated as a finishing step. When electricity is used to operate machinery that shapes wrought products, such as rolling lines or extrusion presses, those electricity purchases contribute a small amount of scope 2 emissions. In addition, inputs such as primary aluminum and alloying elements contain embedded scope 3 emissions, which contribute to the emissions intensities of the wrought products derived from them. The amount of primary aluminum used in wrought products can vary greatly, even within a product category, depending on the intended end use of the product. The amount of fuel combustion needed to heat or heat treat the aluminum also varies by product, but the variation of fuel use rates within a product category is fairly small and depends on the necessary finishing steps and energy efficiency.

**Figure ES.5** Average and highest emissions intensity of wrought aluminum, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2$e/mt aluminum). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production within each respective product category presented, except for wire and foil products, where the highest emissions intensities represent 20 percent of production because of confidentiality considerations. Underlying data for this figure can be found in appendix J, table J.4.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

All wrought aluminum product categories had average emissions intensity estimates that fell within 4 mt $CO_2e$/mt aluminum of one another. As a product known for its high primary aluminum content, aluminum wire (8.35 mt $CO_2e$/mt aluminum product) had a high share of scope 3 emissions and was toward the upper end of the product-level average emissions intensity range. Especially for wrought products with high levels of primary aluminum content, sourcing primary unwrought aluminum inputs from producers using hydroelectric power can result in lower emissions compared to producers using coal-powered electricity.

About two-thirds of primary aluminum used by facilities was imported. Canada was the largest source of these imports, accounting for about 70.6 percent. Primary unwrought aluminum smelted in Canada has a lower emissions intensity because nearly all Canada's smelters use hydroelectric power. Primary unwrought aluminum smelted in Canada also made up large shares of the metal content in imports of secondary unwrought aluminum and wrought aluminum inputs used by facilities, accounting for 56.2 percent and 35.6 percent, respectively. This helped to drive down scope 3 emissions for those products.

# Chapter 1
# Introduction

This report responds to the request by the U.S. Trade Representative (Trade Representative) to assess the greenhouse gas (GHG) emissions intensities of steel and aluminum produced in the United States. The report was prepared in response to a letter from the Trade Representative dated June 5, 2023, under authority delegated by the President under section 332(g) of the Tariff Act of 1930.[1]

The letter requested that the U.S. International Trade Commission (Commission) conduct an investigation and prepare a report to inform negotiations with the European Union regarding the Global Arrangement on Sustainable Steel and Aluminum. In its report, the Commission was asked to assess emissions intensity estimates at the product level in terms of GHGs (expressed in metric tons of carbon dioxide ($CO_2$) equivalent) emitted per metric ton of steel or aluminum produced in the United States in 2022. ("Steel and aluminum produced in the United States" refers to the domestically produced goods that correspond with the scope of imported goods listed in Presidential Proclamations 9704 and 9705 of March 8, 2018 (83 Fed. Reg. 11619 and 83 Fed. Reg. 11625, March 15, 2018) as listed in Attachment B of the Trade Representative's letter.) The letter also requested that the Commission describe the methodologies that were used to collect relevant information and analyze product-specific GHG emissions intensities. Further the Commission was asked to identify, to the extent practicable, where GHG emissions occur within steel and aluminum production processes, with respect to the manufacturing stages and the sourcing location of inputs.

As detailed in the letter, GHG emissions intensity estimates presented in the report should cover the following types of emissions:

- *Scope 1*—direct GHG emissions related to the production of steel and aluminum from the facility's owned or controlled sources. These include the facility's fuel combustion emissions, process emissions (emissions from industrial processes involving chemical or physical transformations other than fuel combustion), and emissions from the facility's own electricity generation.
- *Scope 2*—indirect GHG emissions related to the production of steel and aluminum associated with a facility's purchased energy—including electricity, steam, heat, or cooling.
- *Certain scope 3*—indirect GHG emissions associated with material and resource inputs for the production of steel and aluminum.[2]

---

[1] 19 U.S.C. § 1332(g). The Trade Representative's letter is appendix A of this report.

[2] Under some accounting methodologies, scope 3 GHG emissions are all indirect emissions not included in scope 2 that occur in the value chain of the reporting company. The Trade Representative's letter stated that for purposes of this investigation, the Commission should analyze only a specific subset of upstream scope 3 GHG emissions. This subset comprises the material inputs and resources purchased by a facility from other sources and used in the production of steel and aluminum, what the request letter refers to as "intermediate steel and aluminum inputs" (e.g., iron ore, coke, ore-based metallics, semifinished steel and other steel substrate suitable for further processing, carbon anodes, unwrought aluminum, and wrought aluminum suitable for further processing).

To collect data needed to generate emissions intensity estimates for the report, the Trade Representative's letter requested that the Commission conduct a survey by issuing questionnaires to firms with facilities producing steel and aluminum in the United States. It requested that the Commission's questionnaire should collect information on production and the associated emissions from these goods to the extent such information is not already reported through the U.S. Environmental Protection Agency (EPA) Greenhouse Gas Reporting Program (GHGRP) or other public sources. To the extent practicable, the letter requested that the Commission use information obtained through the questionnaires and external data sources to develop estimates of the highest (e.g., the 50th through the 90th percentiles) and the average GHG emissions intensities for each steel and aluminum product category produced in the United States in 2022.

In terms of presentation of results, the letter requested that, to the extent practicable, these highest and average estimates be weighted by metric ton of steel or aluminum production associated with each emissions intensity data point. It also requested that the Commission produce, to the extent practicable, emissions intensity estimates for the broad categories of steel and aluminum products laid out in Attachment A to the letter. It also stated that the Commission may consider producing estimates for additional product categories, including at the subcategory level laid out in Attachment B, as needed.

# Investigation Scope

The products covered by the Commission's report are listed by U.S. Harmonized Tariff Schedule (HTS) headings, subheadings, and statistical reporting number in Attachment B of the Trade Representative's letter and correspond with the scope of imported goods for which section 232 tariffs were imposed in March 2018.[3] These products are referred to as "covered steel and aluminum products" or "covered products" throughout this report. The Commission endeavored to capture all pertinent scope 1, 2, and 3 GHG emissions associated with the U.S. production of these products. The Commission collected data on emissions of carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and perfluorocarbons (PFCs).[4] To gather information related to these emissions, the Commission issued a questionnaire to companies with U.S. facilities that the Commission identified as likely producers of any amount of covered products

---

[3] Section 232 of the Trade Expansion Act of 1962, 19 U.S.C. 1862. As specified in the letter, the headings, subheadings, and statistical reporting numbers listed reflect the HTS as of June 5, 2023, and were subject to change throughout the investigation period with modifications of the HTS.

[4] Perfluorocarbons (PFCs) in this investigation include perfluoromethane ($CF_4$), and perfluoroethane ($C_2F_6$). All the GHGs correspond with those for which information is collected under the GHGRP from facilities producing covered products, and with those gases recommended for assessment by the Intergovernmental Panel on Climate Change when developing emissions inventories for fuel combustion, iron and steel production, and aluminum production. 40 C.F.R. § 98.32 (reporting for fuel combustion from stationary sources), § 98.62 (reporting for aluminum production), § 98.172 (reporting for iron and steel production); IPCC "Chapter 4: Methodological Choice and Identification of Key Categories," 2006, 4.8, 4.9. More information on these gases is presented later in this chapter.

during 2022.[5] Production quantities included volumes of external shipments outside a facility as well as for internal consumption within a facility.

In this report, emissions intensities of covered products are presented by product category. Product categories include the aggregate steel and aluminum categories in Attachment A of the Trade Representative's letter, as well as several other more granular groupings of the covered products within these aggregate categories (see tables 2.1, 2.2, and 2.4 for a full list).[6] For steel products, product categories are semifinished steel, hot-rolled flat steel, cold-rolled flat steel, coated flat steel, seamless pipe and tube, non-seamless pipe and tube, hot-worked long steel, and cold-formed long steel. Each of these steel product categories was divided into two separate overarching steel types: (1) carbon and other alloy (called "carbon and alloy" throughout this report) steel and (2) stainless steel.[7] The exception is coated flat steel, for which information was collected only for carbon and alloy products. For aluminum products, these product categories are primary unwrought aluminum; secondary unwrought aluminum; bars, rods, and profiles; wire; plates, sheets, and strip; foil; tubes, pipes, and tube or pipe fittings; castings; and forgings. For steel, some data were collected at a further disaggregated level (referred to as the "product subcategory" level); estimates generated from these subcategories are presented when possible.

The definition of "production" for these product categories was restricted to activities that transformed inputs into covered products or transformed a covered product in one product category into a covered product in a different product category with some exceptions. Those exceptions are that facilities engaged in the manufacture of secondary aluminum from other secondary aluminum and in certain heat-treating activities for steel were also considered to have engaged in production for purposes of this investigation.[8] Any facility meeting this definition of production of covered products in 2022 was required to complete the Commission's questionnaire in this investigation. If a facility required to report also engaged in processing activities outside this definition of production, the questionnaire required the

---

[5] More information on how the Commission identified facilities producing steel and aluminum is available in the "Primary Data Collection" section of this chapter and in the "Survey Population Development" section in appendix H. The analysis presented in this report reflects the structure of steel and aluminum industry in 2022. Changes to this structure since this time—such as changes to plant capacity and operating status, or changes in production technology—may impact the overall U.S. emissions intensities in subsequent years. For a summary of changes to the structure of U.S. steel and aluminum industries, see box 1.3 in this chapter. More information on new technologies being tested in the United States and globally to reduce the emissions embedded in steel production is available in chapter 2.

[6] In creating these product categories, the Commission considered consistency with the *Harmonized Tariff Schedule of the United States* (HTS) (as the scope of covered products was defined by the HTS and the purpose of this investigation is to inform trade negotiations), and how best to reflect a common set of vertically linked processes (to aid data collection and product allocation approaches). For more detail on these product categories and the criteria used in their selection, see chapter 2.

[7] For example, the Commission analyzed carbon and alloy semifinished steel and stainless semifinished steel, carbon and alloy hot-rolled steel and stainless hot-rolled steel, and so on for all steel categories.

[8] These production activities were included in the data collection given their prevalence in industry and the non-negligible emissions associated with these transformations. See chapter 2, "Finished Steel Production" for more information on heat treating steel, and "Secondary Unwrought Aluminum Production," for more information on secondary aluminum produced from other secondary aluminum.

facility to report that activity and that activity was included in the facility's production.[9] Processors (i.e., facilities that only processed but did not produce covered products as defined above) were not asked to provide questionnaire responses.

# Report Organization

Chapter 1 provides information on the scope of this report, as well as an overview of the GHG emissions sources and the various GHG accounting methods that the Commission reviewed to inform the methodology that it used in this investigation; a description of how the Commission defines scope 1, 2, and 3 emissions for this investigation; a summary of the data and information sources used in the report; and a list of the Commission's guiding principles regarding its methodological and primary data collection approach decisions made throughout the investigation. Chapter 2 provides background on the industry and production processes of the U.S. steel and aluminum sectors, as well as a presentation of the covered products and the Commission's system boundaries for each sector in this investigation. Chapter 3 gives an overview of the Commission's calculation approach to estimating product category-level GHG emissions intensities for the U.S. steel and aluminum industries. Chapters 4 and 5 provide the results of the Commission's calculations for the U.S. steel and aluminum sectors, respectively, presenting the product category-level emissions intensity estimates and supporting analyses.

# Introduction to GHG Emissions

Greenhouse gases (GHGs) are gases that trap heat in the Earth's atmosphere by absorbing energy from sunlight near the surface of the Earth. Presence of these gases keeps the Earth's atmosphere warm enough to support life on Earth, known as the greenhouse effect. As noted by the EPA and others, anthropogenic (human-related) activities have led to higher concentrations of GHGs in the atmosphere, resulting in a stronger greenhouse effect, or global warming.[10]

The primary GHGs emitted are, by order of prevalence and overall contribution to global warming, carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and fluorinated gases.[11] Major anthropogenic sources of $CO_2$ emissions are from the combustion of fossil fuels (coal, natural gas, and petroleum) used for energy and transportation.[12] Methane is often released in fossil fuel production and industrial agricultural activities, such as leaks from natural gas systems and from livestock production. Nitrous oxide is mostly emitted through industrial agricultural activities, including nitrogen-based fertilizer

---

[9] Emissions associated with most processing activities are minimal; the questionnaire asked that these activities be reported for completeness and to reduce the burden on the reporting facilities for which the energy and resources used for these activities may be hard to isolated from production operations. Note that he output totals requested in the questionnaire included all covered products produced on-site, whether for internal consumption in the production of other covered and noncovered products or for external shipment to other facilities.

[10] EPA, "Basics of Climate Change, November 1, 2024; NASA, What is the Greenhouse Effect?" accessed April 22, 2024; MIT Climate Portal,"Greenhouse Gases," May 22, 2023; IPCC, *Climate Change 2013*, 2013; Marvel et. al., "Ch. 2 Climate Trends," 2023, 2-4; IPCC, *Climate Change 2021*, 2021, SPM-5; NAS, "Climate Change: Evidence and Causes," 2020, 5, 6; USGCRP, *Climate Science Special Report,* 2017, 14.

[11] Fluorinated gases include perfluorocarbons (PFCs). EPA, "Overview of Greenhouse Gases," October 10, 2023.

[12] EPA, "Basics of Climate Change," November 1, 2024; NASA, "What Is the Greenhouse Effect?," accessed April 22, 2024; MIT Climate Portal, "Greenhouse Gases," May 22, 2023.

applications for crop growth.[13] Fluorinated gases are used and released in refrigeration, air conditioning, and various industrial processes, including aluminum production.[14]

The warming effect of GHGs varies in part according to their atmospheric lifetimes (i.e., the amount of time a GHG stays in the atmosphere). Atmospheric lifetimes for GHGs range from roughly ten years for methane to thousands of years for fluorinated gases.[15] To compare the potential impacts of GHGs on global warming over their lifetimes, gases are considered in terms of their global warming potential (GWP). Global warming potential is a measure that conveys the energy absorption of one unit of GHG over a certain period relative to one unit of $CO_2$, the reference gas. For example, nitrous oxide has a global warming potential of 298 over a 100-year time period, meaning 1 metric ton (mt) of nitrous oxide warms the planet 298 times more than one mt of $CO_2$ over 100 years.[16] Reporting of GHG emissions is typically normalized in units of carbon dioxide equivalent ($CO_2e$), which measures quantities of each gas multiplied by its respective global warming potential.[17] In the United States and globally, $CO_2$ is the primary GHG emitted both in terms of volume and total warming effect when compared to other gases. In 2022, $CO_2$ comprised almost 80 percent of the more than 6.3 billion mt of GHGs (as measured in $CO_2e$) emitted in the United States (figure 1.1).

---

[13] EPA, "Basics of Climate Change," November 1, 2024; MIT Climate Portal, "Greenhouse Gases," May 22, 2023.

[14] Fluorinated gases are released almost exclusively from man-made sources. Although fluorinated gases are only a small volume of total GHGs, they have the highest potency and per-unit warming effect. The four main categories of fluorinated gases are: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride ($SF_6$), and nitrogen trifluoride ($NF_3$). HFCs were developed to replace ozone-depleting chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which were gases used in refrigerants, aerosol propellants, foam blowing agents, solvents, and fire retardants. Ozone-depleting gases are set to be phased out under the terms of the Montreal Protocol for all countries party to the agreement, including the United States, by 2030. EPA, "Overview of Greenhouse Gases," October 10, 2023; MIT Climate Portal, "Greenhouse Gases," May 22, 2023; UNEP, "About Montreal Protocol," accessed November 18, 2024.

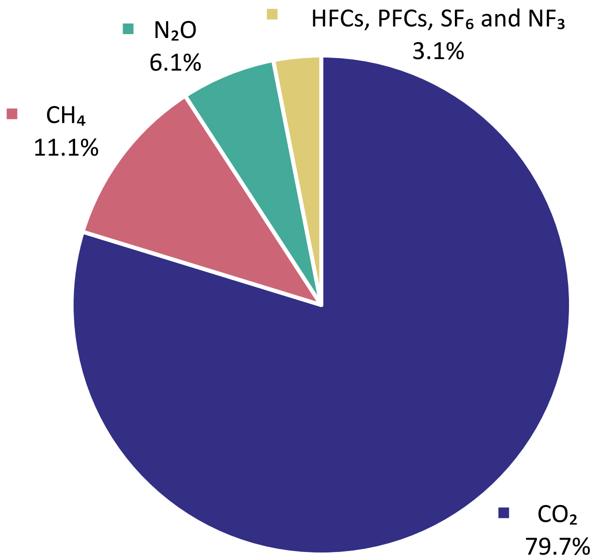
[15] EPA, "Understanding Global Warming Potentials," August 8, 2024; MIT Climate Portal, "Greenhouse Gases," May 22, 2023.

[16] In its main approach, the Commission employed the global warming potentials (GWPs) used by the GHGRP and derived by the IPCC Fourth Assessment Report. IPCC, "2.10.2 Direct Global Warming Potentials," 2007. 40 C.F.R. 98 Table A-1 to Subpart A. GWPs can be measured across different time horizons. Carbon dioxide has a GWP of 1, regardless of the timespan, with the warming potentials of other gases benchmarked to this value. A 100-year time period is most common and is used throughout the EPA's GHGRP reporting of non-$CO_2$ GHGs. However, shorter time horizons (e.g., 20-year time horizon) are sometimes used in analyses to highlight the near-term impact of GHGs, like methane, whose impacts relative to $CO_2$ are more potent in the short term but whose volumes relative to $CO_2$ dissipate more quickly. See box E.2 in appendix E for more information on the GWPs used in this report and see appendix F for an analysis that includes estimates of fugitive methane emissions under a 100-year and 20-year time horizon. EPA, "Understanding Global Warming Potentials," August 8, 2024.

[17] EPA, "Overview of Greenhouse Gases," October 10, 2023.

**Figure 1.1** Share of U.S. greenhouse gas emissions measured in carbon dioxide equivalent ($CO_2e$), by gas, 2022

In percentages. $CH_4$ = methane; $N_2O$ = nitrous oxide; $CO_2$ = carbon dioxide; HFCs = hydrofluorocarbons; PFCs = perfluorocarbons, $SF_6$, and $NF_3$ = sulfur hexafluoride and nitrogen trifluoride (both fluorinated gases). Underlying data for this figure can be found in appendix J, table J.5



Source: EPA, OAR, “Greenhouse Gas Inventory Data Explorer,” accessed April 11, 2024.

# GHG Emissions Measurement and Accounting Frameworks

Emissions accounting frameworks provide guidelines for public and private entities to measure and report emissions to voluntary or regulatory programs. Emissions reporting objectives under these frameworks may include developing complete and consistent records of annual GHG emissions, increasing public knowledge on emissions, or informing the development of regulatory incentives and reduction targets.[18] Organizations use emissions accounting frameworks at various accounting levels—national, corporate, facility, and product—based on the emissions reporting objectives and type of reporter. To standardize the emissions measured and captured by framework users, accounting frameworks typically specify a system boundary. A system boundary is a clearly defined scope of the GHG emissions meant to be covered when accounting for all GHG emissions associated with a specific product, facility, or company.[19] The Commission reviewed frameworks across accounting levels to inform the development of the system boundary and product-level emissions intensity estimates in this investigation. Certain aspects of prominent accounting frameworks at the national, corporate, facility,

---

[18] Berg, “Why Report Your Greenhouse Gas Emissions,” July 18, 2023; McGrath and Jonker, “What Is Greenhouse Gas Reporting?,” January 17, 2024.

[19] The system boundaries delimiting the emissions accounted for in the emissions intensity estimates are explained in greater detail in chapter 2.

and product levels are relevant to the development of the Commission's methodology and described further below. [20]

## National Accounting Frameworks

Governments use national emissions accounting frameworks to produce national emissions inventories, which include estimates of GHGs from all man-made sources within their borders.[21] Multilateral agreements and international organizations have advanced the development of national emissions accounting, providing a common structure to measure and monitor each nation's contributions to global warming. One such multilateral agreement is the United Nations Framework Convention on Climate Change (UNFCCC), to which the United States is a party.[22] Parties to the UNFCCC publish national inventories of their emissions as one of their commitments under the agreement.[23] A decision made within the UNFCCC framework obligates certain parties to use guidelines developed by the Intergovernmental Panel on Climate Change (IPCC), an intergovernmental body of the United Nations.[24] The 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the 2019 refinement to those guidelines standardize emissions accounting for nations across major inventory sectors.[25] Importantly, these guidelines enumerate methods and good practices by which countries can measure or calculate emissions data—many of these methods have been adopted in other accounting frameworks, such as the U.S. Environmental Protection Agency's (EPA's) Greenhouse Gas Reporting Program (GHGRP).[26]

In the United States, the EPA develops the annual national inventory for submission to the UNFCCC, known as the Inventory of U.S. Greenhouse Gas Emissions and Sinks. Inventory categories of major

---

[20] For a list of the main accounting standards that the Commission consulted in preparing its own calculation methodology, see section "IV. Standards Informing the Commission's Methodology Development" in appendix E.

[21] For example, the U.S. inventory is published by the EPA. EPA, OAR, "Inventory of U.S. Greenhouse Gas Emissions and Sinks," October 22, 2024.

[22] The United States ratified the UNFCCC in October 1992, following the convention's 1992 adoption in Rio de Janeiro, Brazil. Treaty Doc. 102-38, S. Exec. Rept. 102-55. UNFCCC (May 9, 1992).

[23] The United States is an annex I party to the UNFCCC. Annex I parties accepted specific commitments, including the submission of inventories of their emissions and sinks (carbon storage). The United Nations Framework Convention on Climate Change (UNFCCC) is a framework convention without an obligatory enforcement mechanism to address noncompliance with obligations under the agreement. UNFCCC, May 9, 1992.

[24] A 2014 UNFCCC decision determined that annex 1 parties' national GHG inventory submissions would follow IPCC inventory guidelines. UNFCCC, *Decision 24/CP.19*, January 31, 2014, 7. The World Meteorological Organization and the United Nations Environment Programme established the IPCC in 1988 to provide governments with scientific information from which to develop climate policies. IPCC, "Intergovernmental Panel on Climate Change," accessed August 21, 2024. The IPCC guidelines were updated in 2019 to reflect scientific and technical advances that have occurred since 2006. IPCC, TFI, "2019 Refinement to the 2006 IPCC Guidelines," accessed April 29, 2024; IPCC, "Decision IPCC/XLIV-5," April 13, 2016; IPCC, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," July 2023.

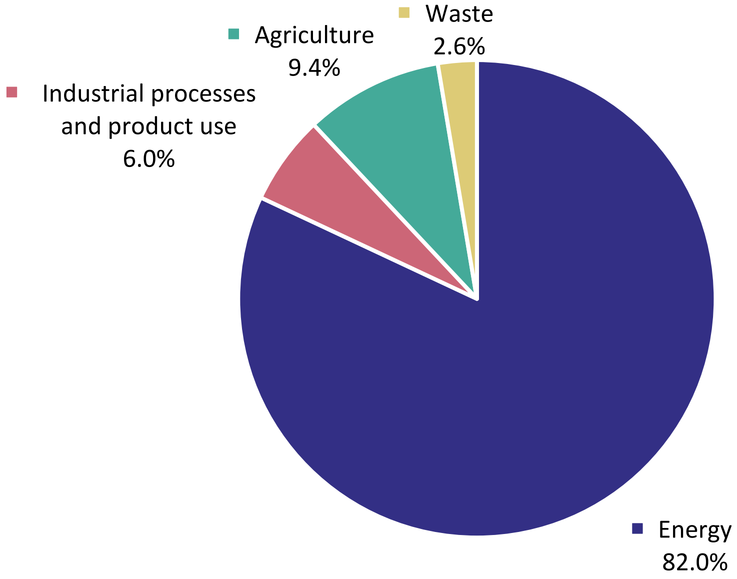
[25] In 2023, 44 parties published national inventories detailing GHG emissions associated with their 2022 activities by type of GHG, sector, and fuel source. UNFCCC, "National Inventory Submissions 2023," accessed April 28, 2024; IPCC, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," July 2023.

[26] Chapters 1 and 2 in volume 1 of the IPCC guidelines contain a broad description of method types and good data collection practices. Volume 3 describes the IPCC's application of these concepts to the different inventory sectors. IPCC, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," July 2023. EPA's GHGRP tiered calculation methodology guidance at the facility level was one such accounting framework adapted from the IPCC's guidance at the national level. For more information on the GHGRP tiered methods of emissions calculation, see "Facility Accounting Frameworks" later in this section.

emissions sources are land use, land-use change, and forestry (LULUCF); energy; industrial processes and product use; agriculture; and waste, with energy being the largest source of emissions (figure 1.2).[27] Industrial processes and product use contains GHGs emitted by industries in non-energy-related activities, including chemical and physical transformations in production processes.[28]

**Figure 1.2** Share of U.S. greenhouse gas emissions measured in carbon dioxide equivalent ($CO_2e$), by UNFCCC/IPCC sector, 2022

In percentages. UNFCCC = United Nations Framework Convention on Climate Change; IPCC = Intergovernmental Panel on Climate Change. Underlying data for this figure can be found in appendix J, table J.6.



Source: EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2022, 2024, ES-16.
Note: The land use, land-use change, and forestry (LULUCF) inventory category is not included in the figure because it was a net carbon sink in 2022 (negative 854.2 million mt $CO_2e$).

Figure 1.3 further distinguishes by sector the emissions attributed to industrial processes and product use in figure 1.2 by industry. Emissions within this category include non-energy GHG emissions by domestic steel and aluminum industries.[29] In 2022, U.S. emissions from industrial processes and product use totaled 383.2 million metric tons (mmt) of $CO_2e$, of which 46.8 mmt (12.2 percent) were from the metals industry (figure 1.3).[30] Iron, steel, and metallurgical coke production (40.7 mmt $CO_2e$) and primary aluminum production (2.2 mmt $CO_2e$) accounted for 91.7 percent of reported emissions in the broader metals industry.[31]

---

[27] The energy inventory category contains all GHGs from stationary and mobile energy-related activities—primarily fossil fuel combustion. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2022*, 2024, ES-16.

[28] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2022*, 2024, ES-17.

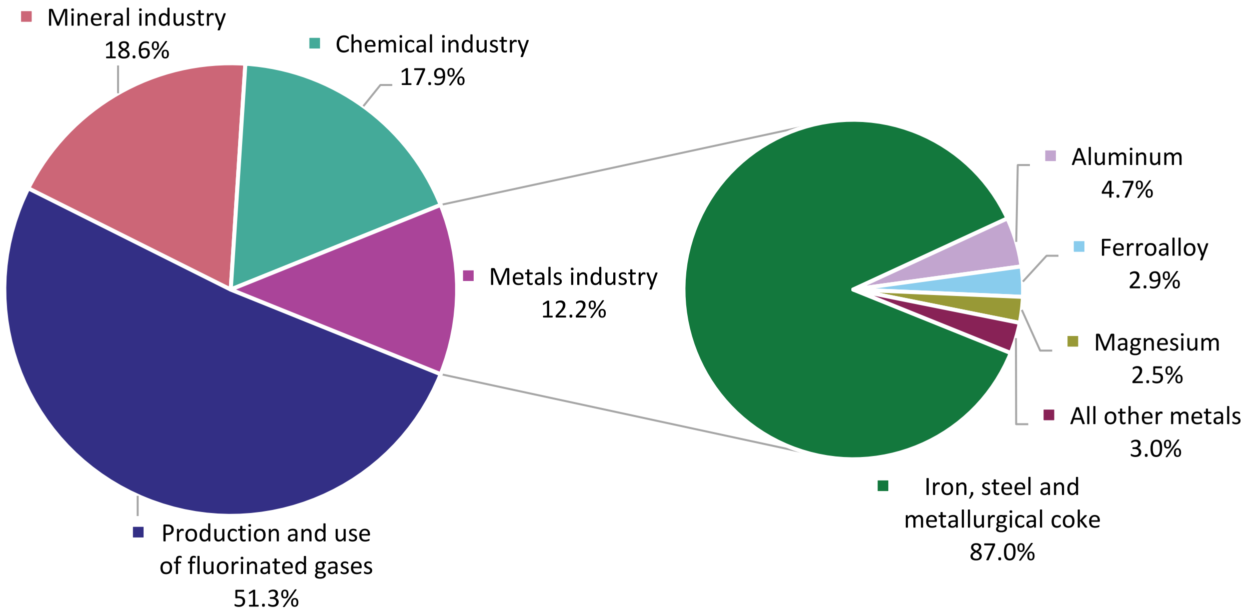
[29] Described further in chapter 2 and chapter 3, these GHGs correspond with the scope 1 process emissions in this investigation.

[30] EPA, “Greenhouse Gas Inventory Data Explorer,” August 18, 2023.

[31] Primary aluminum production as described in this source corresponds with primary unwrought aluminum in this report. EPA, OAR, “Greenhouse Gas Inventory Data Explorer,” accessed April 11, 2024.

**Figure 1.3** Share of U.S. direct emissions measured in carbon dioxide equivalent ($CO_2e$), by industrial processes and product use, 2022

In percentages. Underlying data for this figure can be found in appendix J, table J.7.



Source: EPA, OAR, "Greenhouse Gas Inventory Data Explorer," accessed April 11, 2024.
Note: The category "production and use of fluorinated gases" encompasses emissions from industries involved in the production of hydrofluorocarbons (HFCs), the primary replacement for ozone-depleting substances, among other manmade compounds. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2022*, 2024, 4–1.

## Corporate Accounting Frameworks

Emissions from the activities of corporations are measured using corporate emissions accounting. The GHG Protocol Corporate Accounting and Reporting Standard (Corporate Standard) is one of the more widely used frameworks within the steel and aluminum industry.[32] It provides guidance for corporations to define inventory boundaries, identify sources of emissions, and create strategies to monitor and reduce those emissions.[33] The Corporate Standard categorizes emissions under "scopes" according to the corporation's level of control over the emissions-generating activities.[34] The emissions that should be included in the Commission's emissions intensity estimates were characterized in the Trade Representative's request letter using the "scope" framework (explained in greater detail under the "Overview of Scope 1, 2, and 3 Emissions" section below in this chapter).

---

[32] U. S. Steel, written submission to the USITC, December 21, 2023, 12–13. The first edition of the Corporate Standard was published in 2001. It has since been updated with guidance to companies on how to calculate indirect emissions from energy purchases and throughout the value chain. As an organization, the GHG Protocol is a partnership between the World Resource Institute and the World Business Council for Sustainable Development. It regularly convenes environmental groups and industry as part of its multistakeholder standard development process for the Corporate Standard and other standards. WRI and WBCSD, *The Greenhouse Gas Protocol*, March 2004; GHG Protocol, "About Us," accessed November 15, 2023.
[33] WRI and WBCSD, *The Greenhouse Gas Protocol*, March 2004, 3–4.
[34] WRI and WBCSD, *The Greenhouse Gas Protocol*, March 2004, 25–26.

The Corporate Standard provides guidance for voluntary corporate reporting. Mandatory corporate reporting standards are becoming increasingly common because governments and international organizations are introducing reporting requirements for companies with emissions exceeding a certain threshold.[35]

## Facility Accounting Frameworks

Facility emissions accounting frameworks are designed to capture the emissions generated from a single facility within a corporate body, rather than accounting for an entire corporation. Multiple programs are set up as facility level frameworks including the GHGRP and the EU Emissions Trading System (ETS).

The GHGRP is an annual reporting requirement for U.S.-based facilities generating large amounts of GHG emissions.[36] The EPA's GHGRP rule applies to over 30 categories of reporters, ranging from producers of chemicals, metals, and minerals to emitters of gases from wastes.[37] Facilities are mandated to report their direct emissions to the GHGRP if their operations fall within these categories and emit over 25,000 mt of $CO_2e$ annually, or if those facilities are conducting certain types of industrial activities with any level of associated emissions.[38] The coverage of the GHGRP is limited to direct emissions which are all reported at the facility level.[39] Data reported by facilities to the GHGRP are one of the main sources of emissions data used in this investigation.[40] For information on the types of methods by which facilities calculate their emissions to report to the GHGRP, see box 1.1.

---

[35] McGrath and Jonker, "What Is Greenhouse Gas Reporting?," January 17, 2024. For example, the U.S. Securities and Exchange Commission (SEC) issued a rule in March 2024 that public companies with revenue exceeding $100 million are to report certain emissions using the scope framework outlined in the Corporate Standard. 17 C.F.R §§ 210, 229–230, 232, 239, 249; SEC, "SEC Adopts Rules to Standardize Climate-Related Disclosures," March 6, 2024; Deloitte, "SEC's Landmark Climate Disclosure Rule," April 8, 2024. The European Union (EU) Corporate Sustainability Reporting Directive entered into force in January 2023, requiring EU-based companies to report emissions under the Corporate Standard by 2025. The Corporate Sustainability Reporting Directive applies to public companies and large private companies based in the EU. Feldman et al., "Calculating and Reporting Greenhouse Gas Emissions," November 8, 2023.

[36] The regulations that implemented the GHGRP (40 C.F.R. § 98) were published on October 30, 2009. In the previous year, the EPA was directed by the United States Congress to use its authority under the Clean Air Act to develop and publish a draft of mandatory greenhouse gas reporting thresholds for all sectors of the U.S. economy. P.L. 110-161, 121 Stat. 1844, 2128 (2008); U.S. House Appropriations Committee, *Conference Report on the Consolidated Appropriations Act*, 2008, 1254.

[37] EPA, "Learn About the Greenhouse Gas Reporting Program (GHGRP)," September 22, 2014.

[38] The 25,000 mt $CO_2e$ threshold for reporting GHG emissions under specific categories is based on the facility's total emissions, not their emissions within those individual categories. Facilities that have activities under some industrial categories need to report their emissions whether they hit the 25,000 $CO_2e$ emissions threshold or not. For more information on the GHGRP reporting requirements, see chapter 3.

[39] The emissions required to be reported under the GHGRP do not include those generated from mobile equipment operated at the facility site. Mobile equipment emissions are a category of emissions for which reporting is encouraged in other frameworks, like the GHG Protocol. WRI and WBCSD, *The Greenhouse Gas Protocol*, March 2004, 27.

[40] In this investigation, the Commission used directly measured emissions data (for facilities reporting emissions using a continuous emissions monitoring system) or emissions data calculated using more complex methodologies when possible. It also relied on emissions data calculated using less complex methods where directly measured data were not available, particularly in its calculations of indirect emissions. For an overview of the Commission's sourcing of emissions data, see "Overall Approach and Data Used" in chapter 3.

**Box 1.1** Methodological Tiers of Emissions Calculation and Measurement under the U.S. Environmental Protection Agency's Greenhouse Gas Reporting Program

Under the Greenhouse Gas Reporting Program (GHGRP) regulation, facilities may choose from multiple methodologies for calculating their emissions. These methodologies vary in terms of their complexity and presumed accuracy.[a] For example, in subpart C (fuel combustion), the methodologies are organized into tiers from least complex to most: the **tier 1** methodology uses default emissions factors and fuel use quantities to calculate emissions, **tier 2** methodology uses a mix of default emissions factors and site-specific data on the fuel combusted, **tier 3** methodology uses more detailed site-specific data on the fuel combusted, and **tier 4** methodology uses a continuous emission monitoring system.[b] When certain types of fuels are combusted and when fuel is combusted in units with high heat input capacities, the GHGRP requires reporting under higher tiers.[c] Subpart Q (iron and steel production) also allows facilities to apply different methodologies for reporting those emissions, including a carbon mass-balance method, site-specific emissions factor method, or use of a continuous emission monitoring system.[d]

[a] EPA, "Greenhouse Gas Reporting Program: Subpart C Methodologies," December 2017.
[b] 40 C.F.R. § 98.33.
[c] 40 C.F.R. § 98.33(b).
[d] 40 C.F.R. § 98.173. The calculation methodologies listed in subpart Q of the GHGRP regulation are not labeled by tier number. GHGRP tiers are also distinct from the tiers that the International Panel on Climate Change (IPCC) uses for emissions methodology. For more context on how the GHGRP methodology for reporting emissions from steel and aluminum production compares to the IPCC tiers, see Mandatory Reporting of Greenhouse Gases, Proposed Rule, 74 Fed. Reg. 16490, 16517 (April 10, 2009).

The EU ETS is a facility-level emissions accounting framework that has companies monitor and report their facilities' emissions on a yearly basis.[41] Established on a "cap and trade" principle, the ETS requires companies to surrender purchased allowances to fully cover their facilities' annual emissions.[42] Like the GHGRP, the ETS provides tiered options for methodologies to calculate emissions from fuel combustion.[43] The ETS methodology for calculating emissions is also used in the EU's Carbon Border Adjustment Mechanism (CBAM) (explained in the next section).[44]

## Product Accounting Frameworks

Product emissions accounting measures some or all of a product's embedded emissions related to its raw material inputs, processing and production, transportation, use, and end-of-life disposal.[45] Many product accounting frameworks characterize their system boundaries in terms of the life cycle analysis of the product, specifying which emissions are collected in relation to a product's "cradle," "gate," or

---

[41] Facilities are called "installations" under EU ETS language. EC, "What Is the EU ETS?," accessed November 15, 2023.

[42] The EU ETS sets a cap on the amount of GHG emissions that can be released from around 10,000 installations in the EU. The EU ETS works on the "cap and trade" principle. A limit is set on the installations covered by the system. Within the cap, companies can buy and trade ETS allowances. The cap is reduced annually in line with the EU's climate target, ensuring that emissions decrease overtime. European Commission, written submission to the USITC, November 27, 2023; EC, "What Is the EU ETS?," accessed November 15, 2023.

[43] EU, "Commission Implementing Regulation (EU) 2018/2066," Article 21, 26, December 19, 2018.

[44] EC, "Guidance Document on CBAM Implementation for Installation Operators Outside the EU," December 8, 2023, 87.

[45] Embedded emissions refer to the estimated emissions generated throughout the value chain associated with a product in the market. EPD International, "Environmental Product Declarations," accessed November 6, 2024; Aslam and Aisbett, "Why Embedded Emissions Accounting Is Key," September 11, 2023.

"grave."[46] The system boundaries for steel and aluminum products in this investigation generally follow a "cradle-to-gate" scope which accounts for all upstream emissions from extraction of raw materials ("cradle") to final production ("gate").[47] For more information on the Commission's system boundaries used in this investigation, see "Steel System Boundary" and "Aluminum System Boundary" in chapter 2.

The International Organization for Standardization (ISO), an international standards development organization, established a series of technical standards for product emissions accounting. ISO 14025 provides guidance to develop environmental product declarations (EPDs), which companies submit to reporting programs.[48] An EPD is a voluntary report of a full life cycle impact assessment for a product, which can allow for product-level emissions comparisons within and across companies.[49] Steel and aluminum producers in the United States use EPDs to report the embedded emissions associated with their products to their customers and the general public.[50] The Commission reviewed EPDs for steel and aluminum products in its research on the emissions-generating production processes within U.S. facilities.

The EU Carbon Border Adjustment Mechanism (CBAM) has also established a method of attributing emissions to products covered under its regulation. CBAM is an instrument that applies with respect to imports of carbon-intensive goods—including steel and aluminum—which enter the EU market from non-EU countries.[51] Under the CBAM regulation, EU importers declare the annual quantity of covered steel and aluminum goods imported into the EU and the direct emissions of those goods for each facility that the importer is sourcing from.[52] The method of calculating those emissions is borrowed from the EU ETS, while the method for calculating the assignment of facility-level emissions to covered

---

[46] A gate is considered a start or end point of a core process in the life of a product. A cradle-to-grave assessment considers the full life cycle of a product, from the point of resource extraction until disposal of the product. A gate-to-gate assessment accounts for emissions only in a value-adding unit process in production. EEA, "Term: Cradle to Grave," accessed September 20, 2024; Latimer, "What Is LCA?," accessed November 15, 2024.

[47] Latimer, "What Is LCA?," accessed November 15, 2024. The Commission's methodology takes a cradle-to-gate approach, as requested by the Trade Representative, but some processes (e.g., transportation) fall outside the system boundaries defined for this report and therefore are not covered in the Commission's analysis.

[48] Other ISO standards offer guidance more specific to GHG emissions accounting, such as ISO 14067, which is product-specific. However, companies participating in this investigation often shared product-specific GHG emissions data through broader environmental product declarations. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 7.1; ISO, *ISO 14025:2006*, July 2006; ISO, *ISO 14067*, April 22, 2022; EPD Australasia, "What's the Difference? EPDs vs ISO 14067 Carbon Footprint," March 14, 2023.

[49] EPD International, "Environmental Product Declarations," accessed November 6, 2024.

[50] U.S. industry representative, interview by USITC staff, July 20, 2023; U.S. industry representative, interview by USITC staff, August 3, 2023; U.S. industry representative, interview by USITC staff, August 16, 2023. The Federal Buy Clean Initiative set forth in the Inflation Reduction Act (IRA) signals that environmental product declaration reporting will become a requirement in federal procurement and federally funded projects. On December 12, 2023, the U.S. General Services Administration (GSA) announced low-embodied carbon requirements for construction materials in its IRA-funded projects. Office of the Federal Chief Sustainability Officer, "Federal Buy Clean Initiative," accessed August 27, 2024; GSA, "GSA Pilots Buy Clean Inflation Reduction Act Requirements," May 16, 2023.

[51] USITC, hearing transcript, December 7, 2023, 14 (testimony of Vicente Hurtado Roa, EC); EU, "Commission Implementing Regulation (EU) 2023/1773," Annex II, Section 2, Table 1, August 17, 2023.

[52] EU, "Commission Implementing Regulation (EU) 2023/1773," Article 35, August 17, 2023.

goods is outlined in the implementing regulation.[53] The Commission used prominent product accounting frameworks like CBAM and other industry-specific product accounting frameworks to inform its own data collection and emissions calculation approaches, particularly the development of the steel and aluminum system boundaries used in this investigation.[54]

## Overview of Scope 1, 2, and 3 Emissions

As specified in the request letter, the Commission uses the scope emissions framework to categorize facility-level emissions for companies producing covered steel and aluminum in the United States in 2022. As described within the GHG Protocol Corporate Standard, this framework categorizes a corporation's emissions by scope as direct or indirect emissions.[55] Scope 1 emissions are direct emissions from activities that a corporation owns or controls. Scope 2 emissions are indirect emissions related to the energy consumption of a corporation from purchased electricity, heat, steam, and hot water.[56] Scope 3 emissions are additional indirect emissions related to a corporation's value chain.[57]

The system boundaries for scope 1, 2, and 3 emissions data collected in this investigation are slightly narrower than the full definition provided under the GHG Protocol.[58] The Commission's definitions of scope 1, 2, and 3 are stated in the sections that follow. In keeping with the specification in the request letter, the Commission's system boundary contains scope 1 and 2 emissions associated with the production of steel and aluminum products, as well as scope 3 emissions associated with the upstream material resources and inputs received from other sources and used for the production of steel and aluminum. These are the only emissions included in the emissions intensity estimates presented in this investigation (see figure 1.4).[59] As a result, the system boundaries for this investigation generally follow

---

[53] EU, "Commission Implementing Regulation (EU) 2023/1773," Annex III, Section F, August 17, 2023. A mapping of the groups of Combined Nomenclature codes to their aggregated goods categories is available in table 1 of EU, "Commission Implementing Regulation (EU) 2023/1773," Annex II, Section 2, August 17, 2023. Under CBAM reporting, when a facility "produces several different products, the emissions must be appropriately attributed to the individual products." European Commission, written submission to the USITC, November 27, 2023, 4.

[54] IAI, "Guidelines on Transparency – Aluminum Scrap," September 2022; AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022; ResponsibleSteel, *ResponsibleSteel International Standard Version 2.0*, September 14, 2022; worldsteel, *Life Cycle Inventory Methodology Report*, 2017; WRI and WBCSD, *GHG Protocol Product Life Cycle Accounting and Reporting Standard*, September 2011. For a comparison of many of these standards to the Commission's emissions calculation methodology, see "IV. Standards Informing the Commission's Methodology Development" in appendix E.

[55] A difference between the GHG Protocol's scopes and the Commission's is that the GHG Protocol refers to scope of emissions in terms of corporate reporting. This investigation refers to scopes in terms of facility reporting. WRI and WBCSD, *The Greenhouse Gas Protocol*, March 2004, 25.

[56] WRI and WBCSD, *The Greenhouse Gas Protocol*, March 2004.

[57] EPA, "Scope 3 Inventory Guidance," December 15, 2023; WRI and WBCSD, *The Greenhouse Gas Protocol*, March 2004.

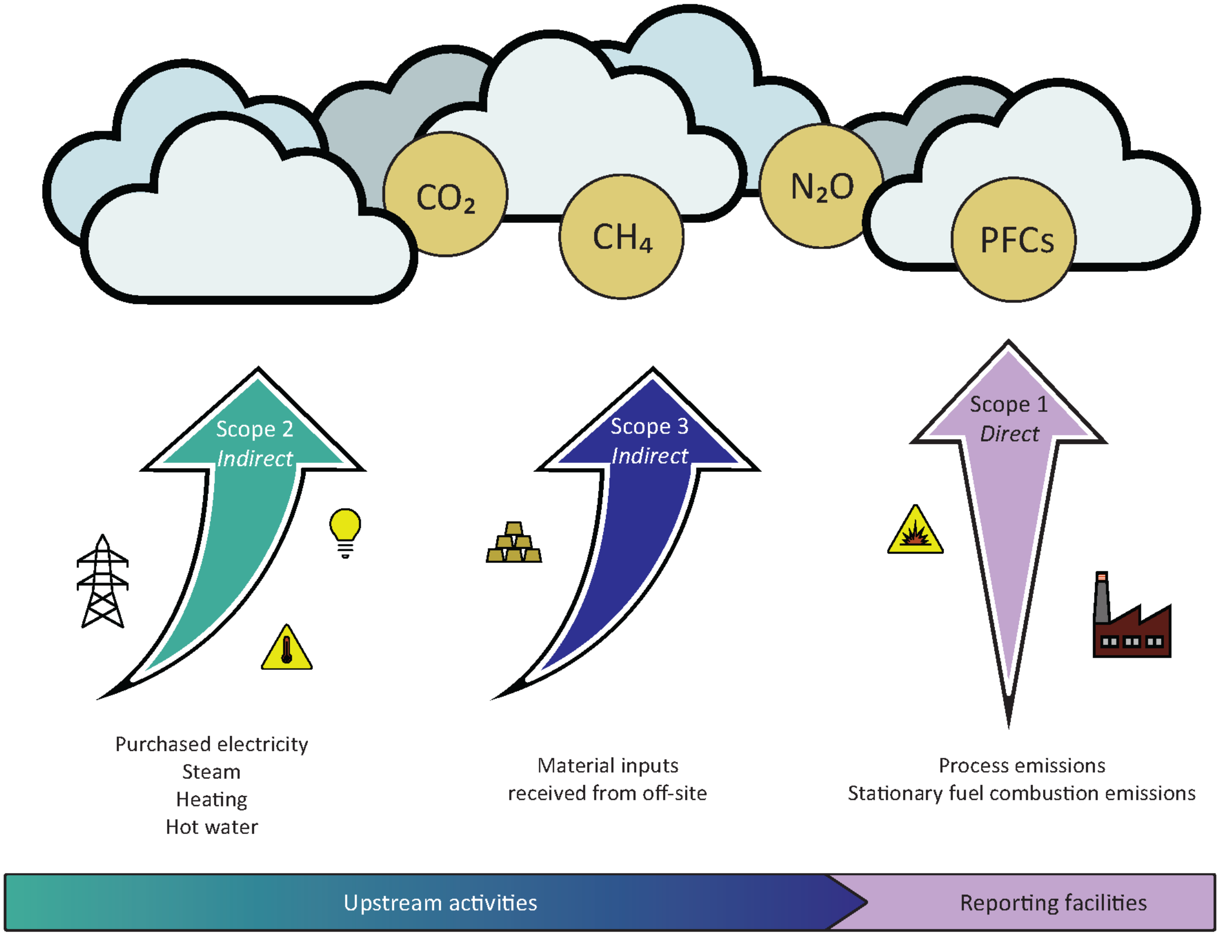
[58] See the "Steel System Boundary" and "Aluminum System Boundary" sections of chapter 2 for further information on what is included in the system boundaries for this investigation.

[59] The definition of scope 3 emissions used in this investigation includes emissions that resulted from the operations of supplier facilities under common ownership, which differs from the definition of scope 3 used by the GHG Protocol's Corporate Value Chain (Scope 3) Accounting and Reporting Standard (the "*Scope 3 Standard*"). Because the *Scope 3 Standard* covers corporate-level accounting of GHG emissions, scope 3 emissions determined under that standard consider whether the value chain activities occurred outside of the operational control of the

the GHG Protocol's scope framework but exclude transportation emissions and scope 3 emissions in the downstream value chain by comparison.[60] The sections that follow highlight common sources of scope 1, 2, and 3 emissions in the U.S. steel and aluminum industries that occur at the facility level.

**Figure 1.4** Scope 1, 2, and 3 emissions accounting specific to the Commission's investigation

$CO_2$ = carbon dioxide; $CH_4$ = methane; $N_2O$ = nitrous oxide; PFCs = perfluorocarbons.



Source: This graphic was adapted by the USITC from GHG Protocol's Corporate Accounting and Reporting Standard.
Note: Under the Commission's system boundaries for this investigation, all GHGs shown in the figure may be directly or indirectly emitted in the production of steel and aluminum in the United States, except for perfluorocarbons, which are only directly emitted in the production of primary unwrought aluminum.

---

company, rather than the operational control of individual facilities owned by that company. Given the objectives of this investigation, measurement of product-level emissions for each U.S. facility producing steel and aluminum was necessary, requiring an adaptation of the *Scope 3 Standard* definition. WRI and WBCSD, *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*, 2013.

[60] Public data sources may not specify all that is included within the emissions factors they report. Therefore, some public scope 3 emissions factors in the report may include transportation emissions (which are not included within the Commission's system boundaries) associated with externally sourced materials and inputs.

## Scope 1: Direct Process and Fuel Combustion Emissions

Scope 1 emissions encompass both on-site process emissions and fuel combustion emissions resulting from activities and operations owned or directly controlled by aluminum and steel facilities.[61] Fuel combustion emissions occur when a fuel is burned to release energy, including for the purposes of electricity generation. Process emissions are created by the physical or chemical transformation of raw material inputs.[62] In steel and aluminum facilities, sources of scope 1 emissions include electric arc furnaces, basic oxygen furnaces, potlines, on-site power plants and cogeneration plants, heaters, boilers, and flares of waste gases.

## Scope 2: Indirect Emissions from Purchased Energy

Scope 2 emissions are emissions associated with a facility's purchased energy, including electricity, heat, steam, and hot water.[63] Purchased electricity is the primary source of scope 2 emissions for most facilities.[64] Facility location (the regional grid) and contractual arrangements such as purchases of renewable energy certificates can affect the emissions intensity of a facility's purchased electricity.[65] For example, electricity purchases made by a facility located in a region that sources electricity mainly from coal will have higher relative scope 2 emissions than purchases made by a facility within a region that sources electricity mainly from hydropower. Therefore, total scope 2 GHG emissions can vary between two facilities that otherwise have the same production output and energy usage. The GHG Protocol's guidance on scope 2 emissions provides two distinct approaches for scope 2 emissions accounting: the location-based method and the market-based method. Box 1.2 provides an overview of the accounting approaches and industry preferences for each method. In this investigation, the Commission uses the location-based method in its main analysis.[66] The Commission chose the location-based method because it is better suited to demonstrating the aggregate GHG performance of a sector, can be applied to all electricity grids, and has more consistent data quality.[67]

---

[61] The Commission's investigation defines scopes 1, 2, and 3 from the perspective of the producing facility and not the corporation. Therefore, the Commission defined scopes 1, 2, and 3 differently than how the GHG Protocol defined them.

[62] EPA, "Greenhouse Gas Reporting Program: Emission Calculation Methodologies," July 2015.

[63] Unlike purchases of steam, heat, and hot water, cooling was not reported in the Commission's outreach to steel and aluminum industries. Industry representatives, interviews by USITC staff, September 7, November 29, December 11, and December 12, 2023.

[64] WRI, *GHG Protocol Scope 2 Guidance*, 2015.

[65] EPA, OAR, "Power Profiler," accessed various dates.

[66] Appendix F contains a sensitivity analysis using the market-based method. For more information on how the Commission calculated scope 2 emissions using these two methods, please refer to appendix E.

[67] This choice is consistent with this investigation's guiding principles of interoperability and precision, discussed later in this chapter. The use of the location-based method is also consistent with how scope 3 emissions from electricity use in imported materials were typically estimated (see for example "Development of Default Emissions Factors for Materials Used by Steel Facilities" in appendix F). For more on data quality considerations, see appendix F. WRI, *GHG Protocol Scope 2 Guidance*, 2015, 26.

**Box 1.2** Location-Based Method Versus Market-Based Method in Industry Accounting

**The location-based method** only considers the average emissions intensity of grids on which energy consumption occurs because the emissions considered are defined by geographic boundaries where the energy is generated and consumed.[a] Under the location-based method, the emissions factors informing scope 2 emission estimates are derived from the fuel mix and generation type of the facility's regional grid.[b]

**The market-based method** considers contractual arrangements, such as power purchase agreements and energy attribute certificates, in addition to the emissions factors used in the location-based method.[c] Companies often purchase energy attribute certificates to increase their low-carbon and renewable energy sourcing. Power purchase agreements and other contractual arrangements to source electricity from specific plants may be associated with a higher or lower emissions intensity than the regional grid, depending on the plants and the grid mix.[d]

[a] WRI, *GHG Protocol Scope 2 Guidance*, 2015, 26
[b] WRI, *GHG Protocol Scope 2 Guidance*, 2015, 4.
[c] WRI, *GHG Protocol Scope 2 Guidance*, 2015, 4. See "Market-Based Method" in appendix F for more information on how the methodology considers each of these elements.
[d] WRI, *GHG Protocol Scope 2 Guidance*, 2015.

## Scope 3: Indirect Value Chain Emissions

Scope 3 emissions result from activities from assets in a reporter's value chain and include all production inputs not within the reporter's scope 1 and 2 boundaries.[68] As requested by the Trade Representative, the Commission collected information to calculate a specific subset of scope 3 emissions, specifically those associated with the upstream material resources and inputs received from other sources and used in the production of steel and aluminum.[69] Therefore, in the context of the steel and aluminum value chains for covered products under this investigation, the scope 3 emissions associated with the received inputs for a facility include the scope 1, 2, and 3 emissions of the producer of those inputs.[70]

The Commission considered upstream inputs to include the output of any production process within the system boundaries of this investigation. For steel covered products, common upstream inputs include pig iron, direct reduced iron, ferroalloys and other alloying metals, iron pellets, coke, and lime. For aluminum covered products, common upstream inputs include other alloying metals, alumina, and carbon anode inputs. Upstream inputs can also include externally sourced steel or aluminum products used in further downstream manufacturing. Depending on the fuel, energy, and material intensity of the inputs used for production, the scope 3 emissions can make up a significant portion of the overall emissions intensity of a product.[71]

---

[68] EPA, "Scope 3 Inventory Guidance," December 15, 2023.
[69] The report, in accordance with the Trade Representative's request, does not include scope 3 emissions from downstream activities and assets.
[70] For more information on the scope 3 emissions methodology used in this investigation, please see chapter 3. Note that a facility's scope 3 emissions occur at sources outside its operational control. If a facility produces upstream materials and uses them in the production of downstream products in the same facility, the scope designations for emissions embedded in those inputs (which may be scope 1, 2, or 3 emissions) are carried through to those downstream products.
[71] EPA, "Scope 3 Inventory Guidance," December 15, 2023.

# Information and Data Sources

In preparing this report, the Commission used information obtained from its questionnaires, relevant literature, hearing testimony, written briefs and submissions, site visits, and interviews and correspondence with interested persons.[72] The Commission also received statements from interested persons during the public hearing it held on December 7, 2023, and via written submissions to the investigation record.[73]

Calculation of the Commission's product category-level emissions intensity estimates required information on facility-level emissions, product category-level production, and allocation parameters. Primary information on facility-level direct emissions from the EPA's GHGRP was used when available. When facility-level direct emissions were not available from the GHGRP, the Commission calculated these emissions using data inputs from the Commission's questionnaire and emissions factors from the calculations within the GHGRP regulation specified in the *Code of Federal Regulations* (C.F.R.), 40 C.F.R. § 98.[74] Indirect facility-level emissions were calculated using questionnaire data as well as the EPA's Emissions and Generation Resource Integrated Database (eGRID) and public, third-party, and Commission-calculated emissions factors. Production volumes for product categories made at U.S. facilities were gathered from the Commission's questionnaire. Parameters used to allocate facility-level emissions to product categories in preparation for estimating product category-level emissions intensities were also gathered from the Commission's questionnaire.

The Commission consulted several frameworks released by industry research groups, international organizations, government research centers, and the European Commission to develop the calculation approach for the average and highest emissions intensity estimates in each product category. More information on the Commission's calculation methodology and data sources and, specifically, regarding the frameworks and standards the Commission consulted is available in chapter 3 and appendix E, respectively.

Per the request letter, the Commission collected information to generate emissions intensity estimates that reflect operations in the U.S. steel and aluminum industries in 2022. Box 1.3 summarizes changes that have occurred in the U.S. steel and aluminum industries through the timing of this report's publication in early 2025.

---

[72] These interested persons included representatives from steel and aluminum companies, industry associations, U.S. government agencies, advocacy organizations, think tanks, universities, and multilateral organizations. The Commission conducted more than 50 information-gathering interviews. In addition, it conducted follow-up meetings, phone interviews, and email correspondence with questionnaire respondents.

[73] See appendix C for a list of hearing participants and appendix D for summaries of views of interested persons.

[74] The Commission's use of emissions factors for the purposes of this investigation is described in detail in chapter 3 and appendix E of this report.

**Box 1.3** Changes in the Structure of the U.S. Steel and Aluminum Industries since 2022

The structure of the U.S. steel and aluminum industries in early 2025 differs from that in 2022 given various changes to the operating status and capacities of plants since that time. A brief summary of these changes in the upstream segments of these industries is provided below.

**Steel:** The U.S. steel industry has increased its capacity and production since 2022 as a result of new electric arc furnace (EAF) facilities coming online. No new integrated facilities have opened since 2022 but some individual blast furnaces at integrated facilities have been idled and others have been restarted, leaving steelmaking capacity from integrated sources relatively stable.[a]

**Aluminum:** Since the beginning of 2022, two of the six U.S. primary unwrought aluminum smelters have idled or fully curtailed production, while one other has partially curtailed production.[b] In contrast to the smelters, several new secondary unwrought aluminum facilities have opened since 2022.[c]

[a] U. S. Steel "U. S. Steel Restarts Idled Mon Valley Works BF," accessed January 3, 2025; U. S. Steel "U. S. Steel Returns Idled Blast Furnace to Service," accessed January 3, 2025; Cleveland-Cliffs, "Cleveland-Cliffs Idles One of Two Blast Furnaces at Cleveland Works," accessed January 3, 2025; Cleveland-Cliffs, "Cleveland-Cliffs to Indefinitely Idle Blast Furnace No. 4, the Last One Left on Indiana Harbor's West Side," accessed January 3, 2025; U. S. Steel, "Softening Demand Forces U. S. Steel to Idle Blast Furnaces," accessed January 3, 2025; Holmes, "New Steel Line Opens at Big River Facility in Osceola," October 12, 2023; U. S. Steel, "United States Steel Corporation Breaks Ground on the Most Technologically Advanced Steel Mill in North America," February 9, 2022; Nucor, "Nucor Provides One-Year Update on New West Virginia Sheet Mill," accessed January 3, 2025.[b] WRI, *GHG Protocol Scope 2 Guidance*, 2015, 4.

[b] "Century Aluminum, "Products and Plants: Hawesville, KY," accessed December 20, 2024; Sustainable Aluminum Network, "Statement on the Curtailment of Magnitude 7 Metals Aluminum Smelter," January 24, 2024; Alcoa, "Alcoa Announces Partial Curtailment at Warrick Smelter in Indiana," July 1, 2022. Hydro, "New Michigan Plant Recycles American Aluminum Scrap," November 16, 2023.

[c] Hydro, "Hydro Opens New Extrusion Press and Increases Recycling Capacity," October 3, 2024; Gränges, "New Recycling and Casting Capacity in Huntingdon Fully Operational," accessed December 20, 2024; Gränges, "Gränges to Invest USD 33 Million to Increase Aluminum Casting Capacity," March 25, 2021; See also, Aluminum Association, "U.S. Aluminum Drives Modern Manufacturing with $10+ Billion Invested," accessed December 20, 2024.

# Primary Data Collection

In accordance with the request letter, the Commission conducted a survey of companies and their associated U.S. facilities producing covered steel and aluminum products in 2022.[75] In its questionnaire, the Commission sought quantitative data not publicly available for the generation of product category-level emissions intensity estimates.

The Commission conducted its survey in two parts. To accurately identify which U.S. facilities produced covered steel and aluminum products in 2022, the Commission issued one questionnaire (the "company-level questionnaire") to companies that possibly had one or more U.S. facilities producing these covered products.[76] In the company-level questionnaire, the companies were asked to confirm that they had such facilities and, if so, to provide the address and contact information for these sites. Upon submission of the company-level questionnaire, the facilities identified in the response were sent a different questionnaire (the "facility-level questionnaire"). The facility-level questionnaire gathered data on the

---

[75] Submission of responses to the Commission's questionnaires was mandatory for companies and facilities with production of covered products in the United States in 2022. 19 U.S.C. § 1333(a). More information on the survey process is available in appendix H. The Commission's questionnaire is available at USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024.

[76] For more information on this process and the resources consulted to develop this list of companies, see the "Survey Population Development" section of appendix H.

production volumes, energy use, and input use and sourcing from these surveyed facilities. The sections of the facility-level questionnaire and descriptions of information they collected are noted in table 1.1 below.

**Table 1.1** Topics covered in each section of the Commission's facility-level questionnaire

| Commission questionnaire section number | Main topic of questions in this section |
|---|---|
| Section 1 | Product types produced at this facility |
| Section 2 | Production volumes for this facility |
| Section 3 | Fuel combusted, energy generated, and allocation of energy across different processes at the facility |
| Section 4 | Energy purchased by the facility |
| Section 5 | Uses and sources of production inputs at this facility |
| Section 6 | Questions related to process emissions for non-GHGRP steel producers |
| Section 7 | Optional reporting of company- or facility-specific environmental data and emissions factors |

Source: Compiled by the USITC. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024.

Data from the facility-level questionnaires were used in combination with the external data sources referenced above (e.g., eGRID, the GHGRP, and public-, third-party-, and Commission-calculated emissions factors) to generate the product category-level emissions intensity estimates. Facilities and companies were not required to calculate or directly provide their emissions or emissions intensity in their questionnaire responses.[77]

Questionnaire data are primarily used to generate emissions intensity estimates and to address the Trade Representative's request to show the location and stage in the production process where emissions occur. The Commission's analysis uses questionnaire data to incorporate the source countries and their associated emissions footprints of inputs into the production of covered steel and aluminum products in the United States. The questionnaire data are also used to show the steps within the U.S. steel and aluminum production processes that are associated with the largest volumes of emissions, according to the responses of facilities producing covered products. These results, as well as emissions intensity estimates for each product category, are presented in chapters 4 and 5.

# Guiding Principles for This Investigation

In establishing its data sourcing approaches, primary data collection strategy, and calculation method approaches to address the Trade Representative's request, the Commission considered the resources of the survey population and findings from its own research. Several guiding principles emerged from this exercise that had to be balanced against one another. The Commission applied these guiding principles in its development of an approach to produce the requested emissions intensity estimates efficiently and effectively. These guiding principles—burden minimization, completeness, interoperability, precision, protection of confidential business information, and transparency—are referenced throughout the report as the rationale for the Commission's decisions on certain research, survey development, and

---

[77] Facilities were given the opportunity to provide this information in the optional section 7 of the Commission's questionnaire.

analysis issues. These six key guiding principles are outlined in the bullets below, with examples within the investigation where these guiding principles were applied or considered.

- **Burden minimization** refers to limiting, where possible, the amount of time and resources companies and facilities would need to spend on responding to the Commission's questionnaire. For example, the questionnaire used skip logic, which enabled facilities to receive and respond to questions tailored to their operations and eliminated the need to respond to many questions unrelated to their operations.
- **Completeness** reflects the aim to gather and analyze a complete picture of emissions resulting from the production of covered steel and aluminum products. This goal was considered in the selection of appropriate system boundaries and the types of GHGs and emissions scopes covered, as well as in decisions regarding the treatment of emissions embedded in waste gases and scrap and production allocation techniques.
- **Interoperability** refers to the Commission's aim, where possible, to develop a data structure and calculation methodology that aligns with other internationally recognized systems of carbon accounting, including frameworks developed by the European Commission, the EPA (particularly the GHGRP), and the UNFCCC. The Commission viewed interoperability with these other systems as important for the provision of emissions information to support international trade policies. Interoperability was considered in the selection of the Commission's system boundaries and the types of GHGs and emissions scopes covered.
- **Precision** refers to both the data and calculation methods the Commission developed and the accuracy of the emissions intensity estimates produced. Choice of emissions factors, selection of computation approach, and structuring of data collection measures in the questionnaire are all decisions in which precision was considered and sought when possible.
- **Confidential business information (CBI) protection** was a key guiding principle the Commission used to develop and report its estimates on emissions intensity. Companies and facilities reported certain information that the Commission has protected, including data provided in questionnaire responses as well as sensitive or identifying information provided in interviews, plant visits, and correspondence.[78] The Commission is committed to protecting CBI in all its investigations, making it the only one of the six guiding principles that could not be altered.
- **Transparency** was a consideration in how the Commission presented the calculations and data sources for its emissions intensity estimates. To this end, the Commission strove in this report to be explicit regarding what types of information it used to develop emissions data, and what steps it took to calculate and produce estimates. In addition, the Commission selected data sources (particularly emissions factors) that were publicly available or replicable where possible.

---

[78] See 19 C.F.R. § 201.6; 18 U.S.C. § 1905; 19 U.S.C. §§ 1332(g), 1337(n), 1677f(b)(1)(A).

# Bibliography

Alcoa. “Alcoa Announces Partial Curtailment at Warrick Smelter in Indiana.” Accessed December 20, 2024. https://news.alcoa.com/press-releases/press-release-details/2022/Alcoa-Announces-Partial-Curtailment-at-Warrick-Smelter-in-Indiana/default.aspx.

Aluminum Association (AA). *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*. January 2022. https://www.aluminum.org/sites/default/files/2022-01/2022_Semi-Fab_LCA_Report.pdf.

Association for Iron & Steel Technology (AIST). “Softening Demand Forces U. S. Steel to Idle Blast Furnaces.” Accessed January 3, 2025. https://www.aist.org/softening-demand-forces-u-s-steel-to-idle-blast-furnaces.

Association for Iron & Steel Technology (AIST). “U. S. Steel Restarts Idled Mon Valley Works BF.” Accessed January 3, 2025. https://www.aist.org/u-s-steel-restarts-idled-mon-valley-works-bf.

Association for Iron & Steel Technology (AIST). “U. S. Steel Returns Idled Blast Furnace to Service.” Accessed January 3, 2025. https://www.aist.org/u-s-steel-returns-idled-blast-furnace-to-service.

Aslam, Hina, and Emma Aisbett. “Why Embedded Emissions Accounting Is Key to Unleashing the Power of Circularity.” World Economic Forum, September 11, 2023. https://www.weforum.org/stories/2023/09/how-product-embedded-emissions-accounting-frameworks-offer-opportunities-for-circularity/.

Berg, Rebecca. “Why Report Your Greenhouse Gas Emissions.” The Climate Registry, July 18, 2023. https://theclimateregistry.org/why-report-your-greenhouse-gas-emissions/.

Century Aluminum Company. “Products and Plants: Hawesville, KY.” Accessed December 20, 2024. https://centuryaluminum.com/products-and-plants/hawesville-ky/default.aspx.

CHAPTER XXVII- ENVIRONMENT - 7 . United Nations Framework Convention on Climate Change. May 9, 1992. https://treaties.un.org/Pages/ViewDetailsIII.aspx?src=IND&mtdsg_no=XXVII-7&chapter=27&Temp=mtdsg3&clang=_en.

Crains Cleveland. “Cleveland-Cliffs Idles One of Two Blast Furnaces at Cleveland Works | Crain’s Cleveland Business.” Accessed January 3, 2025. https://www.crainscleveland.com/manufacturing/cleveland-cliffs-idles-one-two-blast-furnaces-cleveland-works.

Deloitte. “Comprehensive Analysis of the SEC’s Landmark Climate Disclosure Rule.” *Heads Up*, April 8, 2024. https://dart.deloitte.com/USDART/home/publications/deloitte/heads-up/2024/sec-climate-disclosure-rule-ghg-emissions-esg-financial-reporting.

EPD Australasia. “What’s the Difference? EPDs vs ISO 14067 Carbon Footprint.” EPD News, March 14, 2023. https://epd-australasia.com/2023/03/whats-the-difference-epds-vs-iso-14067-carbon-footprint/.

EPD International. “Environmental Product Declarations.” Accessed November 6, 2024. https://www.environdec.com/all-about-epds/the-epd.

European Commission (EC). “Commission Implementing Regulation (EU) 2018/2066.” December 19, 2018. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R2066

European Commission (EC). "Commission Implementing Regulation (EU) 2023/1773." August 17, 2023. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1773

European Commission (EC). "Guidance Document on CBAM Implementation for Installation Operators Outside the EU." Brussels, Belgium, December 8, 2023. https://taxation-customs.ec.europa.eu/document/download/2980287c-dca2-4a4b-aff3-db6374806cf7_en?filename=Guidance%20document%20on%20CBAM%20implementation%20for%20installation%20operators%20outside%20the%20EU.pdf.

European Commission (EC). "What Is the EU ETS?" Accessed November 15, 2023. https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/what-eu-ets_en.

European Commission (EC). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 27, 2023. https://edis.usitc.gov/external/search/document/809394.

European Environment Agency (EEA). "Term: Cradle to Grave." Glossary. Accessed September 20, 2024. https://www.eea.europa.eu/help/glossary/eea-glossary/cradle-to-grave.

Feldman, Daniel, Kevin Poloncarz, W. Andrew Jack, Jayni Hein, Paul Mertenskotter, Tim Duncheon, and Bradford McGann. "Calculating and Reporting Greenhouse Gas Emissions: A Primer on the GHG Protocol." *Inside Energy & Environment*. November 8, 2023. https://www.insideenergyandenvironment.com/2023/11/calculating-and-reporting-greenhouse-gas-emissions-a-primer-on-the-ghg-protocol/.

Gränges. "New Recycling and Casting Capacity in Huntingdon Fully Operational" Accessed December 20, 2024. https://www.granges.com/newsroom/in-focus/new-recycling-and-casting-capacity-in-huntingdon-fully-operational/.

Gränges. "Gränges to Invest USD 33 Million to Increase Aluminium Casting Capacity in the US." March 25, 2021. https://www.granges.com/newsroom/press-releases/2021/granges-to-invest-usd-33-million-to-increase-aluminium-casting-capacity-in-the-us/.

Greenhouse Gas Protocol (GHG Protocol). "About Us." About Us. Accessed November 15, 2023. https://ghgprotocol.org/about-us.

Greenhouse Gas Protocol (GHG Protocol). "Product Standard." Accessed April 29, 2024. https://ghgprotocol.org/product-standard.

Holmes, Paul. "New Steel Line Opens at Big River Facility in Osceola." *Talk Business & Politics*. October 12, 2023. https://talkbusiness.net/2023/10/new-steel-line-opens-at-big-river-facility-in-osceola/.

Hydro. "New Michigan Plant Recycles American Aluminum Scrap into High Quality Products." December 20, 2024. https://www.hydro.com/us/global/media/news/2023/hydro-opens-new-aluminium-recycling-plant-in-cassopolis-michigan/.

Hydro. "Hydro Opens New Extrusion Press and Increases Recycling Capacity in Cressona, Pennsylvania." Accessed December 20, 2024. https://www.hydro.com/us/global/media/news/2024/hydro-opens-new-extrusion-press-and-increases-recycling-capacity-in-cressona-pennsylvania/.

Intergovernmental Panel on Climate Change (IPCC). "2006 IPCC Guidelines for National Greenhouse Gas Inventories." July 2023. https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

Intergovernmental Panel on Climate Change (IPCC). "2.10.2 Direct Global Warming Potentials - AR4 WGI Chapter 2: Changes in Atmospheric Constituents and in Radiative Forcing." IPCC Fourth Assessment Report: Climate Change 2007, 2007. https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html.

Intergovernmental Panel on Climate Change (IPCC). "Chapter 4: Methodological Choice and Identification of Key Categories." In 2006 IPCC Guideline for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change (IPCC), 2006. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_4_Ch4_MethodChoice.pdf.

Intergovernmental Panel on Climate Change (IPCC). *Climate change 2013: The physical science basis*. *Working Group I contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change*. 2013. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_all_final.pdf.

Intergovernmental Panel on Climate Change (IPCC). *Climate change 2021: The physical science basis*. *Working Group I contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change*. 2013. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf.

Intergovernmental Panel on Climate Change (IPCC). "Decision IPCC/XLIV-5. Sixth Assessment Report (AR6) Products, Outline of the Methodology Report(s) to Refine the 2006 Guidelines for National Greenhouse Gas Inventories." April 13, 2016. https://www.ipcc-nggip.iges.or.jp/home/2019refinement/fod/Decision_IPCC_XLIV-5.pdf.

Intergovernmental Panel on Climate Change (IPCC). "Intergovernmental Panel on Climate Change." Accessed August 21, 2024. https://www.ipcc.ch/.

Intergovernmental Panel on Climate Change (IPCC), Task Force on National Greenhouse Gas Inventories (TFI). "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories." Accessed April 29, 2024. https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html.

Intergovernmental Panel on Climate Change (IPCC), Task Force on National Greenhouse Gas Inventories (TFI). "The Task Force on National Greenhouse Gas Inventories." Accessed April 28, 2024. https://www.ipcc.ch/working-group/tfi/.

International Aluminium Institute (IAI). "Guidelines on Transparency – Aluminum Scrap." IAI, September 2022. https://international-aluminium.org/wp-content/uploads/2022/09/IAI-Guidelines-Transparency-Final_Sept-2022.pdf.

International Organization for Standardization (ISO). ISO 14025:2006 - Environmental Labels and Declarations — Type Iii Environmental Declarations — Principles and Procedures. July 2006. https://www.iso.org/standard/38131.html.

International Organization for Standardization (ISO). ISO 14067:2018. April 22, 2022. https://www.iso.org/standard/71206.html.

Latimer, Jen. "What Is LCA? Essential Guide to Life Cycle Assessment." Vaayu. Accessed November 15, 2024. https://www.vaayu.tech/insights/what-is-lca.

Massachusetts Institute of Technology (MIT) Climate Portal. "Greenhouse Gases." Explainer, MIT Climate Portal, May 22, 2023. https://climate.mit.edu/explainers/greenhouse-gases.

McGrath, Amanda, and Alexandra Jonker. "What Is Greenhouse Gas Reporting?" IBM, January 17, 2024. https://www.ibm.com/topics/ghg-reporting.

National Aeronautics and Space Administration (NASA). "What Is the Greenhouse Effect?" Accessed April 22, 2024. https://science.nasa.gov/climate-change/faq/what-is-the-greenhouse-effect/.

National Academies of Science, Engineering, and Medicine, "*Climate Change: Evidence and Causes: Update 2020.*" 2020. https://doi.org/10.17226/25733.

NWI Times. "Cleveland-Cliffs to Indefinitely Idle Blast Furnace No. 4, the Last One Left on Indiana Harbor's West Side." Accessed January 3, 2025. https://www.nwitimes.com/news/local/cleveland-cliffs-to-indefinitely-idle-blast-furnace-no-4-the-last-one-left-on-indiana/article_d01e0f35-1c67-5d40-8072-a71d708e8599.html.

Nucor. "Nucor - Nucor Provides One-Year Update on New West Virginia Sheet Mill." Accessed January 3, 2025. https://investors.nucor.com/news/news-details/2023/Nucor-Provides-One-Year-Update-on-New-West-Virginia-Sheet-Mill-02-23-2023/default.aspx.

Office of the Federal Chief Sustainability Officer. "Federal Buy Clean Initiative." Accessed August 27, 2024. https://www.sustainability.gov/buyclean/.

Peterdy, Kyle. "Carbon Accounting." Corporate Finance Institute. Accessed November 4, 2024. https://corporatefinanceinstitute.com/resources/esg/carbon-accounting/.

Pyrgioti, Sofia. "Sustainability Standards Explained: ISO 14000 Family." CarbonCloud. April 13, 2023. https://carboncloud.com/blog/iso-14000/.

ResponsibleSteel. ResponsibleSteel International Standard Version 2.0. September 14, 2022. https://assets-global.website-files.com/6538e481169ed7220c330f0a/66034300556ac7c2610cd8d0_ResponsibleSteel-Standard-2.0.pdf.

Su, Wenying, Kate Marvel, Roberto Delgado, Sarah Aarons, Abhishek Chatterjee, Margaret E. Garcia, Zeke Hausfather, et al. *Ch. 2: Climate Trends in Fifth National Climate Assessment*. U.S. Global Change Research Program, 2023. https://doi.org/10.7930/NCA5.2023.CH2.

Sustainable Aluminum Network. "Statement on the Curtailment of the Magnitude 7 Metals Aluminum Smelter." Accessed December 20, 2024. https://www.sustainablealuminumnetwork.org/reports-news-and-insights/statement-on-closure-of-magnitude-7-metals.

United Nations Environment Programme (UNEP). "About Montreal Protocol." Accessed November 18, 2024. https://www.unep.org/ozonaction/who-we-are/about-montreal-protocol.

United Nations Framework Convention on Climate Change (UNFCCC). Decision 24/CP.19, Report of the Conference of the Parties on Its Nineteenth Session, Held in Warsaw from 11 to 23 November 2013. FCCC/CP/2013/10/Add.3. January 31, 2014. https://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf.

United Nations Framework Convention on Climate Change (UNFCCC). "National Inventory Submissions 2023." Accessed April 28, 2024. https://unfccc.int/ghg-inventories-annex-i-parties/2023.

United States Steel Corporation. "United States Steel Corporation Breaks Ground on the Most Technologically Advanced Steel Mill in North America." United States Steel Corporation, February 9, 2022. https://investors.ussteel.com/news-events/news-releases/detail/47/united-states-steel-corporation-breaks-ground-on-the-most.

U.S. Environmental Protection Agency (EPA). "Greenhouse Gas Reporting Program: Emission Calculation Methodologies." July 2015. https://www.epa.gov/sites/default/files/2015-07/documents/ghgrp_methodology_factsheet.pdf.

U.S. Environmental Protection Agency (EPA). "Greenhouse Gas Reporting Program: Subpart C Methodologies." December 2017. https://www.epa.gov/sites/default/files/2017-12/documents/subpartcmethodologiesfactsheet.pdf.

U.S. Environmental Protection Agency (EPA). "Greenhouse Gas Inventory Data Explorer." August 18, 2023. https://cfpub.epa.gov/ghgdata/inventoryexplorer/#industrialprocesses/entiresector/allgas/category/current.

U.S. Environmental Protection Agency (EPA). "Overview of Greenhouse Gases." Overviews and Factsheets, October 10, 2023. https://www.epa.gov/ghgemissions/overview-greenhouse-gases.

U.S. Environmental Protection Agency (EPA). "Scope 3 Inventory Guidance." Overviews and Factsheets, December 15, 2023. https://www.epa.gov/climateleadership/scope-3-inventory-guidance.

U.S. Environmental Protection Agency (EPA). Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2022. EPA 430-R-24-004. 2024. https://www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-main-text_04-18-2024.pdf.

U.S. Environmental Protection Agency (EPA). "Understanding Global Warming Potentials." Greenhouse Gas Emissions, August 8, 2024. https://www.epa.gov/ghgemissions/understanding-global-warming-potentials.

U.S. Environmental Protection Agency (EPA). "Basics of Climate Change." November 1, 2024. https://www.epa.gov/climatechange-science/basics-climate-change.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). "Greenhouse Gas Inventory Data Explorer." August 18, 2023. https://cfpub.epa.gov/ghgdata/inventoryexplorer/#allsectors/allsectors/allgas/econsect/current.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). "Inventory of U.S. Greenhouse Gas Emissions and Sinks." Reports and Assessments, October 22, 2024. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). "Power Profiler." Emissions and Generation Resource Integrated Database (eGRID), accessed various dates. https://www.epa.gov/egrid/power-profiler.

U.S. Environmental Protection Agency (EPA), Office of Air and Radiation (OAR). "Technical Support Document for Stationary Fuel Combustion Emissions: Proposed Rule for Mandatory Reporting of Greenhouse Gases." January 30, 2009. https://downloads.regulations.gov/EPA-HQ-OAR-2008-0508-0004/content.pdf.

U.S. Environmental Protection Agency (EPA), Office of Air and Radiation (OAR). "What Is the GHGRP?" Overviews and Factsheets, April 18, 2024. https://www.epa.gov/ghgreporting/what-ghgrp.

U.S. General Services Administration (GSA). "GSA Pilots Buy Clean Inflation Reduction Act Requirements for Low Embodied Carbon Construction Materials." Press Release, May 16, 2023. https://www.gsa.gov/about-us/newsroom/news-releases/gsa-pilots-buy-clean-inflation-reduction-act-requirements-for-low-embodied-carbon-construction-materials-05162023.

U.S. Global Change Research Program. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. 2017. https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf.

U.S. House Appropriations Committee. Conference Report on the Consolidated Appropriations Act. 2008. https://www.govinfo.gov/content/pkg/CPRT-110HPRT39564/pdf/CPRT-110HPRT39564-DivisionF.pdf

U.S. International Trade Commission (USITC). Hearing Transcript in Connection with Inv. No. 332-598, Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level. December 7, 2023. https://edis.usitc.gov/external/search/document/810108.

U.S. International Trade Commission (USITC). Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_facility-level_questionnaire_aluminum_and_steel_combined.pdf.

U.S. International Trade Commission (USITC). U.S. Securities and Exchange Commission (SEC). "SEC Adopts Rules to Enhance and Standardize Climate-Related Disclosures for Investors." Press Release, March 6, 2024. https://www.sec.gov/news/press-release/2024-31.

World Resources Institute (WRI). GHG Protocol Scope 2 Guidance. 2015. https://ghgprotocol.org/sites/default/files/2023-03/Scope%202%20Guidance.pdf.

World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard. September 2011. https://ghgprotocol.org/sites/default/files/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf.

World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard. March 2004. https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf.

World Steel Association (worldsteel). Life Cycle Inventory Methodology Report. 2017. https://worldsteel.org/wp-content/uploads/Life-cycle-inventory-methodology-report.pdf.

# Chapter 2
# Covered Steel and Aluminum Products: Production Processes and Emissions

## Introduction

Greenhouse gas (GHG) emissions are generated during the production of covered steel and aluminum products. This chapter describes where emissions occur in these production processes and how the production pathway and mix of inputs impact emissions at the facility and product level. First for steel and next for aluminum, the chapter provides an overview of the domestic industry and follows with descriptions of the products covered under this investigation and the product categories used to collect and present information about them. The chapter then walks through the manufacturing steps used to produce covered steel and aluminum products and the emissions associated with each step. Diagrams presenting the system boundaries that the Commission used to estimate the emissions associated with covered steel and aluminum products conclude the chapter.[79]

## Steel

Steel, an alloy of iron and carbon, is the world's most consumed metal, and accounts for about 95 percent of all metals produced annually in the world.[80] Production of iron and steel generates emissions; these processes were estimated to account for approximately 7 percent and 11 percent of global anthropogenic GHG and carbon dioxide ($CO_2$) emissions, respectively.[81] This section describes the structure of the U.S. steel industry, and the products covered by this investigation. It then discusses the production processes and associated emissions for those covered products. Finally, it provides the system boundary used to calculate emissions estimates for the U.S. steel industry in this investigation.

---

[79] A system boundary is a clearly defined scope of the greenhouse gas (GHG) emissions meant to be covered when accounting for all GHG emissions associated with a specific product, facility, or company.

[80] worldsteel, "What Is Steel?," accessed September 21, 2024. In general terms, a product is made of steel if iron predominates by weight over any other base metals; if it is usefully malleable; and if it contains by weight 2 percent or less of carbon. There are exceptions to these criteria: in particular, ferrous materials provided for in HTS heading 7203 (direct reduced iron, hot briquetted iron, and iron pellets)—which may have low amounts of carbon—are not considered steel. Also, certain chromium steels may contain higher proportions of carbon but are still considered steel. See also USITC, HTS (2024) Revision 10, section XV, note 7 and chapter 72, note 1(d–f). USGS, "Iron and Steel Statistics and Information," accessed September 21, 2024.

[81] USDOE, "U.S. Department of Energy Announces $28 Million to Decarbonize Domestic Iron and Steel Production," April 18, 2024.

# Domestic Steel Industry

The U.S. steel industry includes steel mills that produce semifinished steel (steel in the first solid state after melting, suitable for further processing or for sale), as well as downstream producers that use semifinished steel and other upstream steel products as substrate to create steel mill products like hot-rolled flat steel, steel wire, or tubular products. In terms of global production, the United States produced 81 million metric tons (mmt) of semifinished steel in 2022, making it the fifth-leading producer in the world, after China (1,019 mmt), the European Union (EU) member countries (136 mmt), India (125 mmt), and Japan (89 mmt).[82] The value of the raw steel produced by the U.S. iron and steel industry in 2022 was an estimated $132 billion.[83] Total semifinished steel production capacity in the United States was about 106 mmt in 2022.[84]

The U.S. steel industry is concentrated, with the five largest firms accounting for more than four-fifths (83.7 percent) of the country's semifinished steel production in 2022.[85] In addition to concentration, another notable industry trend in the United States has been the shift in steel production methods. A growing share of domestic production comes from minimills that melt ferrous scrap in electric-arc furnaces (EAFs), continuing the long-term shift of the U.S. steel industry away from large, integrated mills that rely on blast furnaces (BFs) and basic oxygen furnaces (BOFs) as shown in figure 2.1. EAF mills produced 69.0 percent of steel produced in the United States in 2022, up from 60.6 percent in 2013.

---

[82] EU member countries include: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden; worldsteel, *World Steel in Figures 2023: Major Steel-Producing Countries*, accessed April 12, 2024, 10.

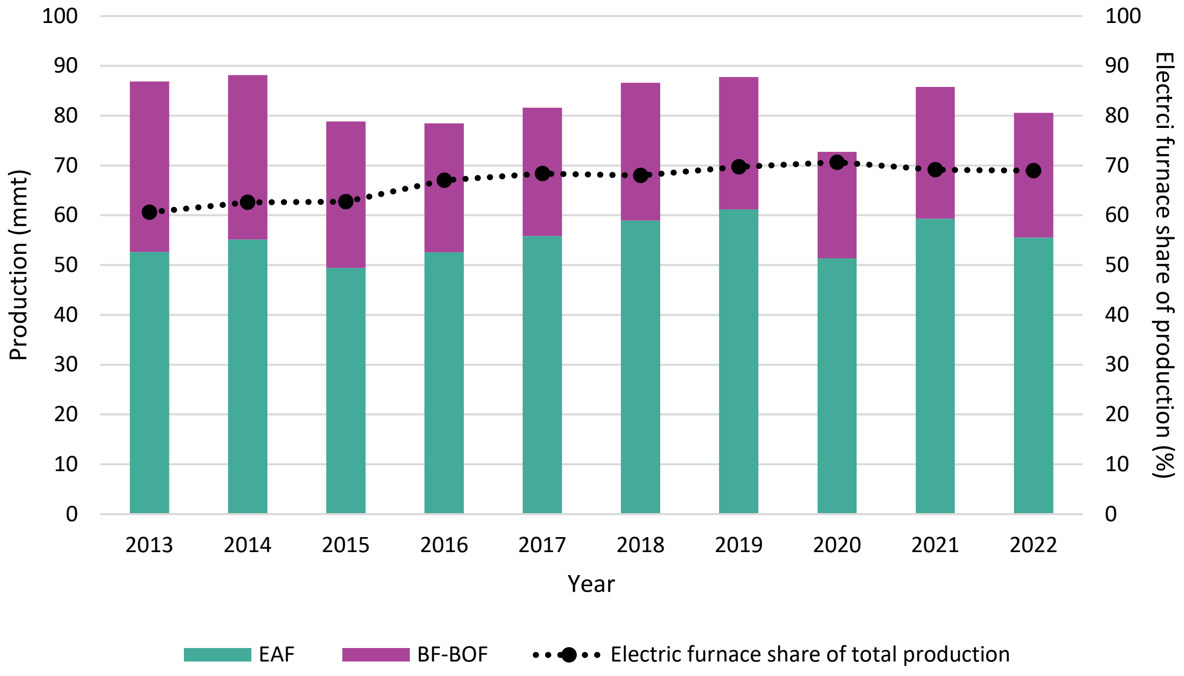
[83] Raw steel is a term used by industry that is consistent with the Commission's definition of semifinished steel. This report uses "semifinished" unless quoting an outside source. USGS, *Mineral Commodity Summaries 2023: Iron and Steel*, January 2023.

[84] USGS, *Mineral Commodity Summaries 2023: Iron and Steel*, January 2023.

[85] The top U.S. steel firms (and their steel outputs) in 2022 were Nucor Corporation (21 mmt), Cleveland-Cliffs Inc. (17 mmt), U. S. Steel Corporation (14 mmt), Steel Dynamics Inc. (10 mmt), Commercial Metals Co. (6 mmt), compared to all others (13 mmt. worldsteel, *World Steel in Figures 2023: Major Steel-Producing Countries*, accessed April 12, 2024, 9.

**Figure 2.1** United States: semifinished steelmaking by process, 2013–22

In million metric tons (mmt) and percentages (%). EAF = Electric-arc furnace; BF-BOF = Blast furnace and basic oxygen furnace. Underlying data for this figure can be found in appendix J, table J.8.



Sources: worldsteel, *Steel Statistical Yearbook 2023*, December 14, 2023; worldsteel, *World Steel in Figures 2023*, June 7, 2023.

# Covered Steel Products

The products within the scope of this investigation, as presented in Attachments A and B of the request letter from the U.S. Trade Representative (Trade Representative), include those steel products covered under the section 232 tariff actions, as set forth in Presidential Proclamation 9705 of March 8, 2018.[86] This includes a range of products that can be classified into four general categories: semifinished, flat, long, and tubular products.[87] Steel mill products can be further subdivided within these general categories, illustrated later in this section. Most of these products are sold to distributors, machinery manufacturers, and steel processors.[88] Steel products can also be sold to other facilities producing downstream steel products.

Brief descriptions of the five steel product categories that appear in Attachment A of the Trade Representative's request letter are provided:

---

[86] 83 Fed. Reg. 11625 (March 15, 2018). Covered products correspond only to the products included in Presidential Proclamation 9705. They do not include products added in subsequent Proclamations, such as those covering derivative articles of iron and steel.

[87] Attachment A of the Trade Representative's request letter contained five steel categories. These were carbon and alloy semifinished, flat, long, and tubular products as well as a category for all stainless steel products, inclusive of the four general categories listed.

[88] Processors are facilities that engage in light manufacturing processes that do not substantively transform one category of product into another.

- **Semifinished products—**Carbon and alloy ingots, blooms, slabs, billets, and beam blanks (whether batch or continuously cast), as well as liquid steel not cast into a form on-site. These products are intermediate solid forms of molten steel, to be reheated and further forged, rolled, shaped, or otherwise worked into finished steel products (i.e., flat, long, and tubular). Semifinished steel is the most upstream steel product produced at steel mills and is the substrate material for most downstream steel mill products before further processing.
- **Flat products—**Carbon and alloy sheets, strips, and plates, whether or not annealed, pickled, or tempered, in either coils or cut lengths. Flat products can be hot-rolled, cold-rolled, or coated. Processors typically process the flat steel sheets and strips into products usable by the construction, industrial, and automotive industries.[89] Flat products are downstream of semifinished steel and produced by rolling semifinished slabs into sheets, strips, or plates.
- **Long products—**Carbon and alloy rolled, drawn, extruded, or forged bars, concrete reinforcing bars, structural shapes (angles, shapes, sections, and sheet pilings), rails, wire rods, and wire. Long products can be hot-worked or cold-formed or finished. Reinforcing bars are used as tension devices in reinforced concrete and other masonry structures. Steel bar is commonly used in residential and nonresidential construction.[90] Long products are also produced from semifinished steel and can be hot-worked or cold-formed.
- **Tubular products—**Carbon and alloy seamless or welded (non-seamless) tubes, pipes, and hollow profiles, but not fittings or other attachments. These products are most commonly used in the construction and energy sectors.[91] Tubular products are produced in two ways: directly from semifinished steel or from flat products via welding.
- **Stainless steel—**All semifinished, flat, long, or tubular products containing, by weight, 1.2 percent or less of carbon and 10.5 percent or more of chromium, with or without other elements.

In addition to the product categories in Attachment A, the Trade Representative's letter indicated that the Commission could produce emissions intensity estimates for additional product categories, including the narrower product categories laid out in Attachment B of the letter. As such, the Commission generated emissions intensity estimates for an additional, more granular set of product categories encompassing all covered steel products.[92] These additional product categories formed the basis for data collection in the questionnaire. Each additional product category is a subset of the carbon and alloy flat, carbon and alloy long, carbon and alloy tubular, or stainless steel product categories (referred to as

---

[89] Faber, *Iron & Steel Manufacturing in the US*, February 2022, 17.

[90] USDOC, ITA, "Global Steel Report 2019," March 2021, 13.

[91] USDOC, ITA, "Global Steel Report 2019," March 2021, 13.

[92] The level of disaggregation of the product categories presented by the Commission in this report is between Attachment A (covering 5 broad categories of steel products) and Attachment B (covering 54 more granular categories.

"aggregate product categories" for steel).[93] In defining these additional product categories, the Commission took several considerations into account:

- The Commission sought to define steel product categories consistently with the *Harmonized Tariff Schedule of the United States* (HTS) to provide clarity in terms of the technical distinctions among products. This included reference to the HTS within the product categories listed in the questionnaire and descriptions of these product categories that relied on terminology from the HTS.[94]
- The Commission sought to use product definitions that would be well recognized by industry representatives to improve the quality of data responses in the questionnaire and reduce the burden on facilities providing those responses.[95]
- The Commission defined these additional product categories with a view to the type or amount of processing involved such that they include products at comparable stages of processing. This reduced the effect of product mixing on the emissions intensity estimates generated for these additional product categories.[96] In addition, the linking of product category definitions to the type or amount of processing involved allowed for the collection of questionnaire data covering facility processes and production that could be mapped to each other and used in the material flow analyses described in chapter 3.[97]

---

[93] For carbon and alloy steel, the flat steel products aggregate product category contains hot-rolled flat, cold-rolled flat, and coated flat steel product categories; the long steel products aggregate product category contains the hot-worked long and cold-formed long steel product categories; the tubular aggregate product category contains the seamless tubular and non-seamless tubular product categories. For stainless steel, the stainless aggregate product category contains the stainless hot-rolled flat, stainless cold-rolled flat, stainless hot-worked long, stainless cold-formed long, stainless seamless tubular, and stainless non-seamless tubular product categories.

[94] In general, the Commission sought to define product categories based on product characteristics that were consistently used in HTS definitions for the range of covered steel products. For example, most flat and long products are consistently defined in HTS subcategories based on whether they are hot-rolled (or hot-worked, forged, or extruded) or cold-rolled (or cold-formed). Most of these common distinctions in the HTS occur at the HTS 4 heading level or the HTS 6 subheading level; however, in some cases, the Commission incorporated distinctions from narrower HTS 8 subheading or HTS 10 statistical reporting numbers into its defined product categories in order to maintain these distinctions.

[95] The American Iron and Steel Institute (AISI) recommended defining product categories based on their recognition by companies producing steel and aluminum. USITC, hearing transcript, December 7, 2023, 62 (testimony of Kevin Dempsey, AISI).

[96] Emissions intensity estimates for categories listed in Attachment A of the Trade Representative's request letter, however, include a mix of products of different types or levels of processing. For example, the "stainless steel" aggregate product category from Attachment A of the request letter includes products as far upstream as stainless semifinished steel and as far downstream as stainless non-seamless tubular steel products. The amount of additional processing and associated emissions that occur between the initial steelmaking process and the production of non-seamless tubular products is substantial, as described in this chapter and in chapter 4.

[97] Domestic steel producers U. S. Steel and Outokumpu recommended defining product categories for carbon and alloy steel products and stainless steel products, respectively, based on their level of processing using definitions similar to those shown in tables 2.1 and 2.2. Outokumpu also recommended dividing stainless hot-rolled flat steel products based on whether those products were annealed or pickled. Although annealing and pickling represent additional levels of processing beyond hot-rolling flat steel products, the Commission did not break out stainless hot-rolled flat steel products on this basis because these finishing steps (particularly annealing) may occur at most or all stages of production which would have warranted similar breakouts for all steel product categories.

Throughout this report, the term “product category” is inclusive of semifinished, aggregate product categories and the additional product categories contained within. Steel product categories are listed in tables 2.1 (for carbon and alloy steel products) and 2.2 (for stainless steel products) below along with corresponding HTS classifications used in the definition of those products. The glossary of this report contains full definitions of each product category. In addition, tables 2.1 and 2.2 show how products listed in Attachment B to the Trade Representative’s request letter correspond with the steel product categories used in this report. The correspondence is relatively straightforward among the product categories between those in the Commission’s questionnaire and the Trade Representative’s request letter for semifinished steel, flat-rolled steel, and long-rolled steel products. By contrast, the Trade Representative’s request letter delineated the steel tubular products by their end-use applications whereas the Commission, following the considerations outlined above, defined tubular products based on whether they are seamless or non-seamless.

---

Subdivision of all steel product categories on this basis would have significantly expanded the length of the questionnaire and would have also resulted in product categories that could not be consistently defined using the HTSUS, counter to the first consideration described above. USITC, hearing transcript, December 7, 2023, 89 (testimony of Jeff Becker, U. S. Steel); U. S. Steel, written submission to the USITC, November 29, 2023, 36–42; Outokumpu, written submission to the USITC, December 21, 2023, 39–41.

**Table 2.1** Covered carbon and alloy steel products: *Harmonized Tariff Schedule of the United States* (HTS) classification, and corresponding coverage in Attachment B of the request letter

| USITC product category | HTS classifications | U.S. Trade Representative's request letter, Attachment B (non-stainless categories) |
|---|---|---|
| Semifinished steel | 7206, 7207, 7224 | Ingots for steel and castings; blooms, billets, and slabs. |
| Hot-rolled flat steel products | 7208, 7211.13, 7211.14, 7211.19, 7225.11, 7225.19, 7225.30, 7225.40, 7226.11, 7226.19, 7226.20, 7226.91 | Hot-rolled sheet; hot-rolled strip; hot-rolled plate in coils; plate in cut lengths;[a] and electrical sheets and strip. |
| Cold-rolled flat steel products | 7209, 7210.70.30, 7211.23, 7211.29, 7211.90, 7212.40, 7225.50, 7225.99, 7226.92, 7226.99.0180 | Cold-rolled sheet; cold-rolled strip; cold-rolled black plate. |
| Coated flat steel products | 7210 (other than 7210.70.3000), 7212 (other than 7212.40), 7225.91, 7225.92, 7226.99.0110, 7226.99.0130 | Hot-dipped galvanized sheet and strip; electrolytically galvanized sheet and strip; tin plate; tin free steel; all other metallic coated sheet and strip. |
| Seamless steel tubular products | 7304.19, 7304.23, 7304.29, 7304.31, 7304.39, 7304.51, 7304.59, 7304.90 | Oil country goods; line pipe (all sizes), mechanical tubing; pressure tubing; standard pipe; structural pipe and tube; pipe for piling; pipe and tube non-classified. |
| Non-seamless steel tubular products | 7305, 7306.19, 7306.29, 7306.30, 7306.50, 7306.61.10, 7306.61.30, 7306.61.70.60, 7306.69.10, 7306.69.30, 7306.69.50, 7306.69.70.60, 7306.90 | Oil country goods; line pipe (all sizes and not specified), mechanical tubing; pressure tubing; standard pipe; structural pipe and tube; pipe for piling; pipe and tube non-classified. |
| Hot-worked long steel products | 7213, 7214, 7216.10, 7216.21, 7216.22, 7216.31, 7216.32, 7216.33, 7216.40, 7216.50, 7216.99, 7227, 7228.10.0010, 7228.20.10, 7228.30, 7228.70, 7228.80, 7301.10, 7302 | Reinforcing bars, hot-rolled bars,[b] wire rods, light shaped bars, heavy structural shapes; steel piling; railway accessories; standard rails; all other rails. |
| Cold-formed long steel products | 7215, 7217, 7228.10.0030, 7228.10.0060, 7228.20.50, 7228.50, 7228.60, 7229 | Cold-formed bars, shapes, and wire drawn. |

Sources: USITC, *Greenhouse Gas (GHG) Emissions intensities Questionnaire: Facility-Level, 2024,* Section 1.2, Facility Information, 22–23; appendix A: USTR, Request Letter, Attachment B: Steel and Aluminum Product Categories, June 5, 2023.

Note: For the Commission's questionnaire, painted or other non-metallically coated flat steel products that are not otherwise cold-rolled or coated, plated, or clad with metal are considered hot-rolled flat steel products. One category in Attachment B, "tool steel," includes steel products that are covered in all of the product categories in this table other than the two tubular product categories.

[a] The Attachment B category "plates in cut lengths" includes HTS statistical reporting numbers that primarily are covered by "carbon and alloy hot-rolled flat steel products" in this report. Plates in cut lengths also includes HTS statistical reporting numbers 7210.90.1000 (covered by "carbon and alloy coated flat steel products" in this report) and 7225.50.6000 (covered by "carbon and alloy cold-rolled flat steel products" in this report).

[b] The Attachment B category "hot-rolled bars" includes HTS statistical reporting numbers that are primarily covered by "carbon and alloy hot-worked long steel products" in this report. Hot rolled bars also includes HTS statistical reporting numbers 7215.90.1000 and 7228.60.6000, covered by "carbon and alloy cold-formed long steel products" in this report.

**Table 2.2** Covered stainless steel products: *Harmonized Tariff Schedule of the United States* (HTS) classification, and corresponding coverage in Attachment B of the request letter

| USITC product category | HTS classifications | USTR request letter, Attachment B (stainless categories) |
|---|---|---|
| Semifinished steel | 7218 | Ingots for steel and castings; blooms, billets and slabs. |
| Hot-rolled flat steel products | 7219.11, 7219.12, 7219.13, 7219.14, 7219.21, 7219.22, 7219.23, 7219.24, 7220.11, 7220.12 | Hot-rolled sheet; hot-rolled strip; hot-rolled plate in coils; plate in cut lengths.[a] |
| Cold-rolled flat steel products | 7219.31, 7219.32, 7219.33, 7219.34, 7219.35, 7219.90, 7220.20, 7220.90 | Cold-rolled sheet; cold-rolled strip; cold-rolled plate in coils. |
| Seamless steel tubular products | 7304.11, 7304.22, 7304.24, 7304.41, 7304.49 | Oil country goods; line pipe; other stainless pipe and tube. |
| Non-seamless steel tubular products | 7306.11, 7306.21, 7306.40, 7306.61.7030, 7306.69.7030 | Oil country goods; line pipe; other stainless pipe and tube. |
| Hot-worked long steel products | 7221, 7222.11, 7222.19, 7222.40 | Hot-rolled bars; wire rods; heavy structural shapes. |
| Cold-formed long steel products | 7222.20, 7222.30, 7223 | Cold-formed bars; drawn wire. |

Sources: USITC, *Greenhouse Gas (GHG) Emissions intensities Questionnaire: Facility-Level*, 2024, Section 1.2, Facility Information, 22–23; appendix A: USTR, Request Letter, Attachment B: Steel and Aluminum Product Categories, June 5, 2023.

[a] The Attachment B category for stainless "plate in cut lengths" includes HTS statistical reporting numbers that primarily are covered by "stainless hot-rolled flat steel products" in this report. Stainless plate in cut lengths also includes HTS statistical reporting number 7219.31.0050, covered by "stainless cold-formed long steel products" in this report.

The Commission received requests at its public hearing and during the public comment period for its draft questionnaire to disaggregate the list of steel product categories included in the questionnaire.[98] Some industry representatives requested that the Commission collect data at the most disaggregate level possible.[99] Other industry representatives noted that additional product categories would increase facilities' reporting burden and would increase the risk that emissions intensity estimates could not be presented because of confidentiality considerations.[100] In order to balance these considerations, the Commission collected production data for certain subcategories of several steel product categories listed in tables 2.1 and 2.2 without also collecting data on the use of fuel, energy, and material inputs in the

---

[98] The Commission received requests from industry representatives to break out rebar, wire rod, and heavy structural shapes and sheet piling from other hot-worked long products; to break out oil country tubular goods (OCTG) from other seamless and non-seamless pipe products; to break out ingots, blooms and billets, and slabs within the semifinished steel category; and to break out plate from other forms of hot-rolled flat steel. Nucor Corporation, written submission to the USITC, January 5, 2024, 2; Nucor, written submission to the USITC, December 21, 2023, 4–5; U. S. Steel, written submission to the USITC, December 21, 2023, 12; AISI, written submission to the USITC, November 21, 2023, 7; USITC, hearing transcript, December 7, 2023, 163–164 (testimony of Kevin Dempsey, AISI).

[99] CPTI, SDI, and Silverado Policy Accelerator recommended that the Commission collect data and generate emissions for as many of the Attachment B product categories as possible. Silverado Policy Accelerator, written submission to the USITC, November 17, 2023; USITC, hearing transcript, December 7, 2023, 142 (testimony of Roger Schagrin, CPTI); CPTI, written submission to the USITC, December 21, 2023, 2; SDI, written submission to the USITC, December 21, 2023, 3.

[100] One industry representative noted that the burden of disaggregating a facility's energy and input use across many specific product types would be especially pronounced among small specialty steel producers with many different specialized orders. USITC, hearing transcript, December 7, 2023, 127 (testimony of Joseph Green, SSINA). Nucor expressed concern that product categories defined too narrowly would reveal confidential business information. Nucor, written submission to the USITC, December 21, 2023, 3–5.

production of those specific product subcategories. This approach allowed the Commission to calculate emissions intensity estimates for these steel product subcategories using emissions data collected for the product categories defined in tables 2.1 and 2.2.[101]

# Steel Production Processes

## Upstream Processes

### Iron Ore, Sinter, and Pellet Production

Iron ore delivers the ferrous material required for ironmaking.[102] After mining and beneficiation, most iron ore inputs are processed before they are used in ironmaking.[103] The majority of U.S. iron ore mines produce iron ore in pellet form on-site at pelletization plants via agglomeration.[104] These pellets are used by steelmakers in blast furnaces (BFs).[105] U.S. integrated steelmakers principally consume iron in pellet form but also use some sinter as iron inputs.[106] Sinter (chunks of very small iron pieces or fines that have been combined) is made from iron ore, fluxes, and other recycled materials, and typically produced in plants located near an iron ore mine or at integrated steel mills.[107] The majority of GHG emissions related to iron ore, sinter, and pellet production are from the agglomeration processes, where fuel is combusted in indurating and sintering furnaces and where the carbon in feedstock materials (including iron ore, flux materials, and coke) contribute to process emissions.[108] In contrast, mining and initial processing of iron ore (particularly the grinding of ore into smaller pieces) emit comparatively small amounts of GHG emissions.[109]

### Direct Reduced Iron Production

Iron ore is used in the production of ore-based metallics, which are intermediate iron-bearing materials used in steelmaking. Ore-based metallics include pig iron (discussed in greater detail below, “Integrated

---

[101] Chapter 3 and appendix E contain more information on how emissions intensity estimates were calculated for product subcategories. For a list of product subcategories and associated reference products (which are all also steel product categories), see table E.12 in the “III.C.1. Calculation of Product-Level Emissions Inventories for Product Subcategories” section of appendix E. Product subcategory definitions, including corresponding HTS numbers, are included in the glossary.

[102] World Bank Group, *The Platform for Cooperation on Tax*, January 24, 2017, 20.

[103] Beneficiation is the process of removing impurities and unwanted material from the ore to produce a higher grade product. Vitz et al., “Beneficiation,” accessed August 24, 2024.

[104] Agglomeration is the process of combining iron ore with clay as a binder to form pellets, which are then heat hardened in indurating furnaces, typically fired by natural gas or coal. USGS, *Minerals Yearbook 2022: Iron Ore*, September 24, 2024, Table 3.

[105] OECD, *Addressing Information Gaps on Prices of Mineral Products: The Transformation Chains and Products of Gold, Copper and Iron Ore Mines*, October 2015, 11.

[106] Industry representative, interview by USITC staff, August 2023.

[107] ArcelorMittal, “Sinter Plant,” accessed October 22, 2024; Industry representative, interview by USITC staff, August 30, 2023; AISI, “Glossary,” accessed August 25, 2024.

[108] EPA, OAR, “Technical Support Document for the Iron and Steel Sector,” August 28, 2009.

[109] Haque and Norgate, “20 - Life Cycle Assessment of Iron Ore Mining and Processing,” January 1, 2015.

BF-BOF Steelmaking") and direct reduced iron.[110] Direct reduced iron is produced via the reduction (i.e., chemical removal of oxygen) of iron, using hydrogen ($H_2$) and carbon monoxide (CO)—generally derived from natural gas, synthetic gas, or coal—as reducing agents. Essentially all direct reduced iron originating in the United States and its main import sources is produced via natural gas-based furnaces.[111] Direct reduced iron can be used in both of the predominant steelmaking processes.[112] In the United States, direct reduced iron production occurs off-site from the steel mill.[113] GHG emissions related to direct reduced iron production include both fuel combustion emissions from the use of gas or coal and process emissions from the reduction processes.

## Metallurgical Coke Production

Metallurgical coke is an input used as a feedstock during iron and steelmaking.[114] To produce coke, metallurgical coal is heated, in the absence of air, to an elevated temperature in a battery of adjacent coke ovens to drive off the volatile hydrocarbons (coke oven gases), tars, and other impurities such as sulfur, nitrogen, and other trace elements. Coke ovens are often fueled by burning the recovered and processed coke oven gases.[115] Some integrated steel mills in the United States have on-site coke plants, although there are many coke plants that are not directly associated with steel mills.[116] The process of heating coal and chemically transforming it into coke is a source of both process and fuel combustion emissions from burning coke oven gases and other fuel sources like natural gas.

## Flux Materials Production

Limestone and dolomite, either used directly or after processing (e.g., into lime or dolime, respectively), are fluxing agents that remove impurities such as sulfur, phosphorus, and silica in the ironmaking and steelmaking processes.[117] In their raw forms, limestone and dolomite are commonly used in ironmaking processes, including the blast furnace, pellet plants, and sinter plants.[118] For use in steelmaking processes, these two flux materials are usually further processed in a rotary lime kiln to create calcined (i.e., "burnt") lime or dolime.[119] Some emissions occur during the mining of limestone and dolomite, generally related to extraction of these materials (e.g., through use of explosives in quarrying) and the

---

[110] Direct reduced iron also includes hot briquetted iron, a premium form of direct reduced iron that has been compacted and has a higher density. Because of its compaction, HBI is less porous and, therefore, less reactive and does not suffer from the risk of self-heating associated with other forms of direct reduced iron. IIMA, "Ore Based Metallics," 2021.

[111] DRI is also produced using coal-based rotary furnaces but this only occurs in India. IIMA, "DRI Production," accessed September 21, 2024.

[112] Midrex Technologies, Inc., "Direct Reduced Iron (DRI)," accessed November 13, 2024.

[113] U.S. industry representative, email message to USITC staff, October 10, 2023.

[114] IEA, *Iron and Steel Technology Roadmap*, October 8, 2020, 27–28; USDOE, *Fossil Energy Study Guide: Coal*, February 10, 2010, 9.

[115] Pokladnik, "The Myth of 'Green Steel' in Ohio and Its Steel Valleys," May 8, 2024.

[116] EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 4.

[117] Limestone is a sedimentary rock of calcium carbonate, composed of the minerals calcite and aragonite. Dolomite is also a sedimentary rock of calcium-magnesium carbonate composed of the mineral dolomite. NLA, "Iron and Steel," accessed August 25, 2024; AIST, "AIST Steel Wheel," accessed November 5, 2024.

[118] Satyendra, "Limestone and Dolomite," May 8, 2013.

[119] AIST, "AIST Steel Wheel," accessed November 5, 2024; Satyendra, "Limestone and Dolomite," May 8, 2013.

electricity needed to crush and grind materials.[120] However, most emissions associated with fluxing agents are created in the production of calcined lime and dolime. Calcination involves heating lime to elevated temperatures to separate the carbon from the lime or dolime and remove impurities. The carbon released from calcination results in scope 1 $CO_2$ process emissions. Scope 1 fuel combustion emissions are also generated by the fuels (e.g., coal, fuel oil, or natural gas) required to operate the equipment that heats lime to required levels.[121] Most production of lime and dolime occurs off-site from steel mills.[122]

### Emissions from Upstream Processes

These upstream processes can occur on-site at a steelmaking facility or off-site at a separate facility. When upstream materials are purchased from off-site, rather than being produced on-site, the emissions created in the production of these materials are allocated to scope 3 for the steelmaking facility using the materials.[123] When upstream material production occurs on-site, process emissions resulting from chemical transformations of these upstream materials are allocated to scope 1. Fuel combustion emissions associated with fuel used in on-site upstream processes—including when fuel is combusted on-site to generate electricity, heat, steam, or hot water for upstream processes—are likewise considered scope 1 emissions. Emissions from generating any electricity that the facility purchased and used in upstream processes are considered scope 2 emissions. Even where upstream processes occur on-site, they commonly use other upstream materials that have embedded scope 3 emissions.

## Semifinished Steelmaking

Steel mills operate in two distinct ways to produce molten semifinished steel. Integrated mills feature the BF-BOF production process which relies on raw materials like iron ore, flux materials, and coke. Minimills use EAFs to melt ferrous scrap and other iron sources.[124] Though BF-BOF and EAF methods require different feedstocks and utilize different production processes, both result in molten semifinished steel.[125] The molten semifinished steel is then cast into solid semifinished steel in the forms

---

[120] Kittipongvises, "Assessment of Environmental Impacts of Limestone Quarrying," November 27, 2017.

[121] EPA, OAR, "Technical Support Document for the Lime Manufacturing Sector," January 22, 2009.

[122] USITC, Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level, 2024, responses to question 2.1.1.

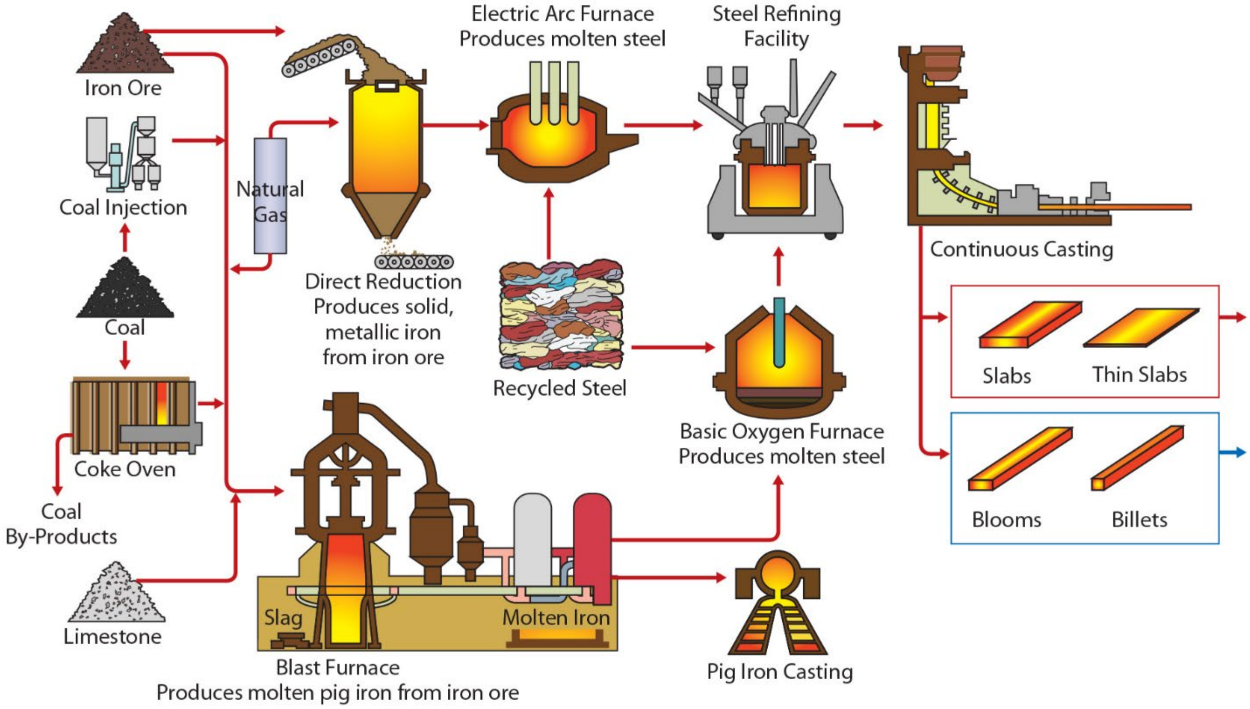
[123] Scope designations in this chapter are based on the Commission's scope framework established in chapter 1, unless otherwise noted.

[124] BF-BOFs and EAFs are the primary production methods used to make semifinished steel, but some specialty steel producers use electric induction furnaces for melting ferrous scrap or electric slag remelting furnaces or vacuum induction melting furnaces for melting and refining ingots. Valbruna Group, "Stainless Steel Long Products," accessed September 22, 2024.

[125] A source of continuing debate in the steel industry is whether there are certain grades of steel that can only be made using integrated steelmaking. Some industry representatives at the Commission's hearing stated that certain advanced flat steel products must be produced via the BF-BOF process rather than by EAF. Other industry representatives countered by stating that EAFs can make virtually any product that a blast furnace makes, with the exception of tin plate, and that market decisions rather than capability have been the strongest influence on what products are made via EAF. There is general agreement that ferrous scrap alone does not have the characteristics required to make all grades of steel. Depending on the grade, end use, or form of steel produced, the level of residual metals like copper or tin contained in certain grades of ferrous scrap can lead to defects like cracking

of ingots, blooms, slabs, billets, blanks, or other shapes, and then are allowed to cool.[126] In some cases, the molten semifinished steel is continuously cast into thin slabs that pass directly from the caster to the finishing steps without cooling.[127] Rolling mills shape semifinished steel into other categories of steel products, generally classified as either "flat" products (e.g., plates, sheets, and strip) or "long" products (e.g., bars, rods, profiles or shapes, rails, and wires). After rolling, steel products typically undergo finishing steps, separately or in combination, to coat, galvanize, or paint them to impart desired properties before delivery to customers.[128] Figure 2.2 illustrates the process for producing semifinished steel.

**Figure 2.2** Overview of semifinished steel production processes



Source: AISI, "Steel Production," accessed November 13, 2023.

## Integrated BF-BOF Steelmaking

The older and more globally prevalent method for smelting iron is in a BF (typically used in conjunction with a BOF, referred to as "BF-BOF").[129] Hot air is blown in at the bottom of the furnace to ignite the coke that generates the heat as it burns to melt the ferrous and flux materials to produce molten pig iron

---

during hot-rolling. For grades of steel requiring lower residual metals and for flat steel products generally, pig iron or DRI is used to reduce the relative amount of residual elements in the steel produced. USITC, hearing transcript, December 7, 2023, 123 (testimony of Phillip Bell, SMA), 182 (testimony of Kevin Dempsey, AISI); Dworak, Rechberger, and Fellner, "How Will Tramp Elements Affect Future Steel Recycling in Europe?," April 2022, 1–2; Su and Assous, "Starting from Scrap," June 2022.

[126] Watson, *Domestic Steel Manufacturing: Overview and Prospects*, May 17, 2022, 1.

[127] Industry representative, interview by USITC staff, August 2023.

[128] Watson, *Domestic Steel Manufacturing: Overview and Prospects*, May 17, 2022, 1.

[129] worldsteel, "Glossary," accessed August 25, 2024; National Lime Association, "Iron and Steel," accessed August 25, 2024.

(figure 2.2).[130] The flux materials form a molten slag to separate out the impurities from the molten iron.[131] Blast furnaces also generate blast furnace gas as a by-product of the use of coke, iron, and other materials.[132] Blast furnace gas is a combination of carbon monoxide (CO), carbon dioxide ($CO_2$), other gases, and dust, and is highly emissions intensive relative to other fuels due to its low heating value.[133] Blast furnace gas is combusted in blast furnace stoves used to preheat the furnace and in other integrated facility processes, or in some cases may be flared.[134]

The pig iron produced in blast furnaces, in either molten or solid form, is fed into BOFs along with ferrous scrap and flux materials for conversion into molten steel.[135] Oxygen gas is blown into the molten iron to lower its carbon content from about 4 percent to about 0.4 percent, the threshold required for most steel products.[136] The carbon removed from the pig iron bonds with the oxygen and is emitted as

---

[130] Pig iron is not exclusively used in BOFs and can be externally shipped, including for use in EAF steelmaking.

[131] AIST, “AIST Steel Wheel, Blast Furnace,” accessed November 5, 2024.

[132] Within the steel industry, exploratory efforts are underway to reduce the overall emissions footprint of the BF-BOF production process. Some steel producers have been exploring a nascent technology referred to as “blast furnace hydrogen injection” in which coal—a major source of $CO_2$ emissions in the BF-BOF process—is replaced with hydrogen—a comparatively less emissions-intensive reducing agent. According to industry trials and academic research sources, hydrogen injection technology can reduce the emissions footprint of the BF-BOF process by 20–33 percent. No steel was known to be produced at commercial scale using this technology in the United States in 2022. As of December 2024, hydrogen injection was primarily in its testing phases in the United States and other steel-producing markets, although exploration of the technology began several years before. Cleveland-Cliffs, for example, announced it was actively testing hydrogen injection at its U.S. Indiana Harbor and Middletown Works facilities beginning in 2023. In Europe and Asia, hydrogen injection technology testing began as early as 2019, with trials and research undertaken in the years since by steel producers like Thyssenkrupp Steel Europe AG, Stegra, ArcelorMittal, and Nippon Steel, among others. Nippon Steel, “Verified the World’s Highest Level of CO2 Emissions Reduction at 33% by Heated Hydrogen Injection in the Super COURSE50 Test Furnace,” February 6, 2024; ArcelorMittal, “ArcelorMittal Europe to Produce ’green Steel’ Starting in 2020,” October 13, 2020; Cleveland-Cliffs, “Cleveland-Cliffs Selected to Receive $575 Million in US Department of Energy Investments for Two Projects to Accelerate Industrial Decarbonization Technologies,” March 25, 2024; SSAB, “SSAB Selected by U.S. Department of Energy to Explore Possibilities for Production of Fossil-Free Steel in the U.S.,” March 25, 2024; Stegra, “Stegra Boden – World’s First Large-Scale Green Steel Plant,” accessed December 16, 2024; ThyssenKrupp, “Sustainable Steel: Review of Phase 1 of the Injection Trials,” accessed December 20, 2024; worldsteel. “Hydrogen (H2)-Based Ironmaking,” June 2022; Yilmaz, Wendelstorf, and Turek, “Modeling and Simulation of Hydrogen Injection into a Blast Furnace to Reduce Carbon Dioxide Emissions,” June 15, 2017.

[133] IPCC, “2006 IPCC Guidelines for National Greenhouse Gas Inventories,” July 2023, 2.18–2.19; EPA, OAR, “Technical Support Document for the Iron and Steel Sector,” August 28, 2009, 4–6. While not a GHG, carbon monoxide (CO) emissions that are oxidized as a result of iron and steel production to form $CO_2$ are also highlighted in this chapter.

[134] EPA, OAR, “Technical Support Document for the Iron and Steel Sector,” August 28, 2009, 5–6.

[135] An older steelmaking technology, the open-hearth furnace method, accounts for about 0.4 percent of global steel production. This process is highly energy intensive, and its use worldwide has declined over the years owing to its adverse environmental impacts and economic disadvantages. worldsteel, “What Is Steel?,” accessed September 21, 2024.

[136] Carbon content can make steel harder and stronger, however, it can also make the steel more brittle and more difficult to weld, hence content levels are controlled. AIST, “AIST Steel Wheel, Basic Oxygen Furnace,” accessed November 5, 2024; Verichek Technical Services, Inc., “How To Determine Carbon Content in Steel,” June 22, 2017.

$CO_2$ gas.[137] Additionally, $CO_2$ may be released to a lesser extent from the fluxing materials and other additives that are charged to the furnace.[138]

The emissions from integrated facilities are substantial, largely driven by the emissions associated with BF operations that produce pig iron.[139] Integrated facilities' scope 1 emissions associated with BF-BOF operations include both the fuel combustion emissions that occur when blast furnace gas and other fuels are used to heat blast furnace stoves as well as the process emissions associated with BOF operations and the flaring of blast furnace gas. These operations also rely on electricity and may also use steam; when some of this energy is generated on-site, its use is associated with a mix of embedded scope 1 and scope 2 emissions. In addition, BF-BOF operations can also have significant scope 3 emissions associated with use of metallurgical coke, sources of iron ore, and flux materials used in the blast furnace.[140] Likewise, facilities that produce steel using pig iron received from external sources have substantial scope 3 emissions.[141]

## Electric Arc Furnace Steelmaking

The other predominant method for producing molten steel is via an EAF, which uses the heat from the electric arcs generated between graphite electrodes to melt batches (also called "charges" or "heats") of ferrous materials. The furnace charge is typically composed of ferrous scrap but may also contain pig iron, coal, or direct reduced iron to produce molten steel. Lime or dolime is added as a slag-forming material. Once the ferrous scrap has been melted, the molten steel is tapped into a transfer ladle for further processing and the slag is poured off in preparation for the next heat.[142]

Scope 1 process emissions are generated during the melting and refining process which removes carbon from the charge material and carbon electrodes as $CO_2$. EAF facilities also generate scope 1 fuel combustion emissions associated with the pre-heating of materials in EAFs prior to the melting process. However, unlike integrated mills that use a combination of fuel types, EAFs typically use natural gas to operate these processes.[143] The EAF melting process requires substantial electricity to power the furnaces, which means there are scope 2 emissions related to electricity generation.[144] Lastly, scope 3

---

[137] AIST, "AIST Steel Wheel, Basic Oxygen Furnace," accessed November 5, 2024.
[138] EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 8.
[139] USITC, hearing transcript, December 7, 2023, 88–89 (Jeff Becker, U. S. Steel). An analysis from SMA found that scope 1 and 2 emissions from pig iron production in the United States were 1.46 mt $CO_2e$/mt of pig iron and that scope 1 and 2 emissions from semifinished steel production in BOF facilities (inclusive of pig iron produced on-site) totaled 1.67 mt $CO_2e$/mt of semifinished steel. SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 11–12.
[140] SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 8.
[141] USITC, hearing transcript, December 7, 2023, 82 (testimony of Roxanne Brown, USW).
[142] In EAF facilities, these materials are primarily sourced externally. AIST, "AIST Steel Wheel, Electric Arc Furnace," accessed November 5, 2024.
[143] EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 19.
[144] IEA, *Iron and Steel Technology Roadmap*, October 8, 2020, 37.

emissions attributable to upstream inputs like pig iron or DRI are embedded in EAF production.[145] Compared to BF-BOF steelmaking, however, EAF steelmaking's predominant use of ferrous scrap over pig iron and DRI inputs results in substantially fewer embedded emissions. Ferrous scrap is considered to have zero embedded emissions, as detailed in the "Steel System Boundary" section later in this chapter.

The EAF sector is characterized by lower capital and energy costs per metric ton of steel produced than the integrated sector.[146] According to the World Steel Association, the $CO_2$ emissions intensity for BF-BOF versus ferrous scrap-based EAF production processes were 2.33 versus 0.68 metric tons (mt) of $CO_2$ per metric ton of semifinished steel, respectively, in 2022 (table 2.3).[147]

**Table 2.3** Global average GHG emissions intensities in steelmaking by process, per metric ton of semifinished steel cast, 2022

In metric tons of carbon dioxide equivalent (mt $CO_2e$).

| Process | GHG emissions intensity |
|---|---|
| Blast furnace and basic oxygen furnace | 2.33 |
| Electric-arc furnace (ferrous scrap) | 0.68 |
| Electric-arc furnace (direct-reduced iron) | 1.37 |
| Global average | 1.91 |

Source: worldsteel, Sustainability Indicators 2023 Report, 2023.

Note: Global average is calculated as the sum of emissions multiplied by the share of global production for each process.

## Refining and Casting

The molten steel produced by the BF-BOF or EAF is transferred to the refining station in a ladle (also called the ladle metallurgy furnace) where it is stirred with an inert gas, such as argon, to remove

---

[145] New production technologies have explored the potential of using clean hydrogen as a means of lowering the emissions footprint of EAF-produced steel. Hydrogen is currently used in the production of direct reduced iron (an iron source used in EAFs as well as BF-BOFs), typically in combination carbon monoxide or other gases. However, as of December 2024, most of the hydrogen used in direct reduced iron production is extracted from hydrogen-bearing fuels like natural gas, which generates $CO_2$ emissions when hydrogen is produced in this manner. A cleaner means of producing hydrogen via water electrolysis is also available but, as of December 2024, is not yet produced at a large scale. The incorporation of hydrogen produced via water electrolysis, using electricity generated from low to zero emission electricity sources, has the potential to significantly reduce emissions from direct reduced iron production, which in turn would reduce the embedded emissions of steel produced using direct reduced iron. Several global producers have attempted to incorporate this new production technology into their operations. In 2024, Stegra, a Swedish steel producer, opened its Boden plant, a facility capable of producing hydrogen via water electrolysis using renewable electricity to produce direct reduced iron. The direct reduced iron is then used in the company's EAFs to produce low to zero emissions steel. In the United States, Cleveland-Cliffs and SSAB have announced plans to build hydrogen-based direct reduced iron production facilities using fossil-free energy. As of December 2024, these new facilities were in planning phases. worldsteel. "Hydrogen (H2)-Based Ironmaking." June 2022; Stegra, "Stegra Boden—World's First Large-Scale Green Steel Plant," accessed December 16, 2024; SSAB, "Fossil Free Steel," accessed December 16, 2024; Cleveland-Cliffs, "Cleveland-Cliffs Selected to Receive $575 Million in US Department of Energy Investments for Two Projects to Accelerate Industrial Decarbonization Technologies," March 25, 2024.

[146] Faber, *Iron and Steel Manufacturing in the US*, February 2022.

[147] Emission intensities by production pathway (i.e., BF-BOF and EAF) presented here are global averages from the World Steel Association. U.S. emissions intensities for BF-BOF and EAF production pathways estimated by other organizations are presented in chapter 4. To protect confidentiality, in view of the limited number of companies that have BF-BOF facilities in the United States, estimates of emissions intensity by production pathway calculated by the Commission have not been presented in this report.

impurities.[148] At this stage, the molten steel can also be transferred to a secondary metallurgical station, vacuum degasser, or argon oxygen decarburization vessel for further compositional "fine tuning" to yield the desired steel chemistry.[149] If needed, metallic additives and ferroalloys (e.g., ferrosilicon, silicomanganese, etc.) are added to the refining ladle to adjust the content of nonferrous metals.[150] The refined steel is then transferred to the casting facility where it is either batch-cast into ingots or blooms or continuously cast into slabs, billets, beam blanks, or other semifinished forms.[151]

Compared to the BF-BOF and EAF semifinished steelmaking, refining and casting operations are generally not significant emitters of GHGs.[152] These operations do result in some scope 1 fuel combustion emissions, however, from natural gas used to reheat the ladle and the use of reheat furnaces during the refining process.[153] Additionally, scope 1 process emissions are generated by the decarburization process from the blown-in oxygen gas combining with carbon removed from the molten steel.[154] The ladle refining process reheats liquid steel in the ladle using electricity which is conducted through graphite electrodes, generating scope 2 emissions.[155]

## Finished Steel Production

The semifinished steel is subsequently transferred to rolling and coating mills that produce the various types of finished steel mill products (figure 2.3).[156] Most steel producing facilities have a "melt shop" that produces the semifinished steel for subsequent processing in the facility's rolling and coating mills. Finishing facilities without a melt shop purchase their semifinished steel inputs from other domestic, foreign, or both types of steel producers and perform the subsequent processing steps.[157] Compared to BF-BOF and EAF semifinished steelmaking, the various processes (described in the subsections below) that transform semifinished steel into finished steel mill products are lower emitters of GHGs but nevertheless can produce significant emissions themselves.[158] These processes include hot-rolling and hot-working, cold-rolling and cold-forming or finishing, pipe and tube production, and metallic surface coating.

---

[148] AIST, "AIST Steel Wheel, Refining Station," accessed November 5, 2024.

[149] AIST, "AIST Steel Wheel, Refining Station," accessed November 5, 2024; AIST, "AIST Steel Wheel, Ladle Metallurgy Furnace," accessed November 5, 2024; AIST, "AIST Steel Wheel, Vacuum Degassing," accessed November 5, 2024; AIST, "AIST Steel Wheel, Argon Oxygen Decarburizations," accessed November 5, 2024.

[150] Industry representatives, interviews by USITC staff, August 2023.

[151] AIST, "AIST Steel Wheel, Casting," accessed November 5, 2024.

[152] EPA, OAR, "Technical Support EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 21.

[153] EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 19.

[154] EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 19.

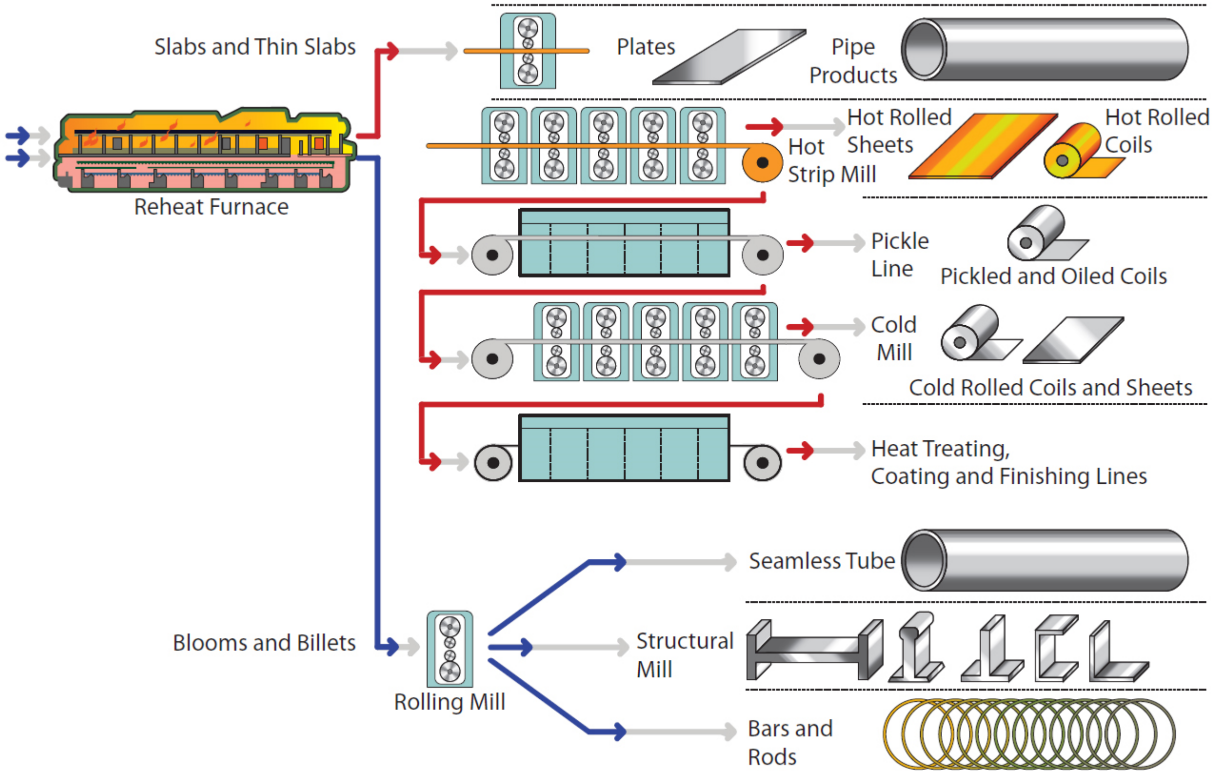
[155] Satyendra, "Ladle Metallurgy," April 23, 2014.

[156] AIST, "AIST Steel Wheel, Shaping and Treating," 2015, accessed November 15, 2023.

[157] AISI, "Glossary," accessed August 25, 2024; USGS, *Minerals Yearbook 2022: Iron Ore*, September 2024, 37.1.

[158] EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 19.

**Figure 2.3** Overview of the finished steel production processes



Source: AISI, “Steel Production,” accessed November 13, 2023.
Note: Red lines in the figure denote flat steel and non-seamless tubular steel production processes. Blue lines denote long steel and seamless tubular steel production processes

- **Hot-rolling or hot-working**—Semifinished steel is prepared for subsequent finishing operations by being reheated in a furnace to temperatures required for the hot-rolling or hot-working process.[159] Reheated slabs are subsequently hot-rolled into flat-rolled products such as plates and sheets.[160] After hot-rolling, the plate or sheet is reheated and then passed through roughing mills and then finishing mills.[161] Through these processes, a hot-rolled sheet or strip in coil form is produced.[162] For long products, reheated billets and beam blanks are hot-rolled by being passed between successive grooved rolls to produce hot-rolled or hot-worked bars (in straight lengths), rods (in coils), structural shapes, and railway rails.[163] The shape of the grooves imparts the cross-sectional shape and any surface protrusions to long-rolled products.

---

[159] Energetics, Inc., *ITP Steel: Energy and Environmental Profile of the U.S. Iron and Steel Industry*, August 2000, 79.
[160] In the Commission's questionnaire, these products are referred to as “hot-rolled flat steel products” and “hot-rolled plate”.
[161] In some mills that use the continuous casting process, the hot mill does not have any additional furnaces to reheat the steel since it comes into the rolling mill hot, via a “shuttle furnace” that keeps the semifinished steel hot as it moves from the casting process to the rolling mill. Industry representatives, interviews by USITC staff, August 2023.
[162] Industry representative, interview by USITC staff, August 2023.
[163] In the Commission's questionnaire, these products are referred to as “hot-worked long steel products”.

- **Cold-rolling or cold-forming**—Hot-rolled or hot-worked steel mill products can be further cold-rolled or cold-formed at ambient temperatures to improve the surface quality, achieve final dimensions, or both by rolling, forming, or drawing operations.[164] Most cold-rolling is done continuously with steel being fed through rolls from a coil. During cold-rolling, hot-rolled steel inputs are reduced progressively as they advance through each stand. In addition to roll stands, a typical cold mill may have other equipment or lines for intermediate annealing and cleaning of steel. After rolling, some form of heat-treatment (e.g., annealing) is applied to most cold-rolled sheet or strip to restore the ductility lost in cold reduction, except when the improved strength developed in cold-rolling is required.[165] After annealing, depending on the end use, cold-rolled sheet or strip may be sent through a temper mill that provides the desired flatness and other surface characteristics.[166]
- **Tubular production**—The two categories of pipe and tube, seamless or non-seamless (e.g., welded), are distinguished by the methods used in their production. Electric-resistance welded and other welded pipe is produced by cold-forming flat sheet into a rounded tube and welding the edges together.[167] Seamless pipe is produced by heating a steel billet and piercing a hole in it before rolling to create a tube. The pierced billet is then rolled to reduce its outside diameter and wall thickness, forming a tube. The tube is then reheated and stretched to meet desired physical specifications before being cooled, cut, and finished.[168] Some seamless tubular products go through heat-treating after manufacturing to impart hardness.[169]
- **Metallic surface coating**—After the rolling or forming process, some flat steel and some long steel products are coated with nonferrous metals (e.g., zinc, chromium, or tin, among others) to impart properties such as corrosion resistance.[170] The two most common processes used for producing corrosion-resistant steel (a common form of zinc-coated steel) are the continuous hot-dip process and the electrogalvanizing (i.e., electroplating) process.[171] Electrogalvanizing involves using an electric current to coat steel with zinc dissolved in a plating bath.[172] In both cases, the substrate for adding the corrosion-resistance properties is typically cold-rolled steel.[173] In the hot-dip galvanizing process (the most commonly used method), the steel is thoroughly cleaned with solution, pickled, passed through an annealing furnace, and then dipped in a bath of molten zinc.[174] In the bath, the zinc metallurgically reacts with the iron in the steel and forms a

---

[164] More specifically, flat-rolled products are cold rolled, bars are cold formed or drawn, and wire is cold drawn from wire rod. Energetics, Inc., *ITP Steel: Energy and Environmental Profile of the U.S. Iron and Steel Industry*, August 2000, 81.

[165] Fenton, *Mineral Commodity Profiles—Iron and Steel*, 2005, 13; worldsteel, "Glossary," accessed August 25, 2024.

[166] Energetics, Inc., *ITP Steel: Energy and Environmental Profile of the U.S. Iron and Steel Industry*, August 2000, 80.

[167] Nucor, "Steel Pipe," accessed October 19, 2024.

[168] Satyendra, "Production of Seamless Pipes," July 26, 2014.

[169] American Piping Products, "Welded vs. Seamless Steel Pipe," July 2, 2018.

[170] AISI, "Glossary," accessed August 25, 2024.

[171] AISI, "Glossary," accessed August 25, 2024.

[172] AGA, "Electroplating," accessed October 21, 2024.

[173] AISI, "Glossary," accessed August 25, 2024.

[174] AGA, "Batch Hot-Dip Galvanizing," accessed October 21, 2024; AISI, "AIST Steel Wheel, Galvanized," accessed October 21, 2024.

coating on the steel that prevents corrosion.[175] Certain types of coated products go through annealing after the coating process.[176]

With respect to scope 1 emissions, typically, there are no scope 1 process emissions associated with downstream finished steel production; however, scope 1 fuel combustion emissions are emitted from furnaces when steel is heated before being further worked or shaped process or when steel is heat treated. Scope 2 emissions result from electricity consumption, which is used to operate machinery that shapes and finishes steel products, such as hot-rolling, cold-rolling, or metallic coating lines. Finally, upstream inputs, including steel products themselves, that are externally sourced and used as substrate in production of downstream covered products contain embedded scope 3 emissions. Steel products that are metallically coated also have scope 3 emissions associated with those coating metals.

# Steel System Boundary

**Box 2.1** A Discussion of the Commission's Approach to System Boundaries

The Commission adopted a "cradle-to-gate" methodology in determining its system boundaries. Under this methodology, emissions from resource extraction to the facility gate are included in the calculation of a facility's overall emissions.[a] The Commission's goal in setting the system boundaries was to be as thorough as possible and to meet the specific requirements of the request letter. This included accounting for emissions associated with most inputs into the production of steel and aluminum manufacturing. The Commission aimed to be as complete and inclusive as possible in accounting for all sources of emissions in the production of steel and aluminum, which may compromise interoperability where boundaries diverge between standards (see tables E.14 and E.15 in appendix E for a comparison of methodologies between the Commission's approach and other frameworks). For example, the Commission's system boundaries for steel and aluminum extend further upstream and include a wider array of material inputs than those used in the European Union's Carbon Border Adjustment Mechanism. Further downstream, the Commission's system boundaries include production of downstream steel mill products like cold-rolled steel while other standards like ResponsibleSteel Standard 2.1 include only production of crude (i.e., semifinished) steel. At the same time, the Commission did exclude certain processes as described below from its system boundaries for steel and aluminum that some other methodologies include to varying degrees.

[a] Industry representative, interview by USITC staff, July 24, 2023; Subject matter expert, interview by USITC staff, August 24, 2023.

The system boundary for the U.S. steel industry includes most inputs and processes used to make semifinished steel (figure 2.4) and downstream products and processes used to make finished steel products (figure 2.5). Processes used to make major inputs and semifinished steel include mining, processing of materials into upstream intermediate inputs, production of iron in blast furnaces and direct reduced iron facilities, and steelmaking itself.

Items outside the system boundary in figures 2.4 and 2.5 represent a non-exhaustive list of processes excluded from the Commission's emissions calculations.[177] Processes not directly contributing to the

---

[175] AGA, "Batch Hot-Dip Galvanizing," accessed October 21, 2024.

[176] Industry representative, interview by USITC staff, September 7, 2023.

[177] The items are noted here specifically to clarify their exclusion from calculations, even though: (1) The Commission collected data on them in its questionnaire (this applies to items a through d in figures 2.4 and 2.5); (2) this process is included in other commonly used corporate accounting frameworks like the GHG Protocol (this applies to item e); and (3) estimates including a range of emissions potentially generated from these processes are presented in a sensitivity analysis (this applies to item f).

production of covered products, such as ancillary activities not involved with production floor operations and activities of other producers operating on-site, are excluded from the system boundary to ensure the emissions included in the emissions intensity estimates were specific to the product category. Certain processes are excluded from the steel system boundary when incorporating those processes would likely significantly add burden on facilities or create significant uncertainty in estimates of associated emissions. The system boundaries also exclude certain processes occurring at steel facilities where those processes do not contribute to the production of covered products by that facility (figure 2.4). Processes related to the sorting and distribution of scrap (including shredding of scrap) were excluded from the system boundary because the supply chain for scrap is highly complex, extended, and variable by facility.[178] Similarly, the Commission did not estimate emissions from the transportation of covered products and upstream materials between facilities or in on-site operations. A request for data necessary to estimate transportation-related emissions—such as the transportation mode or distance, the origin of materials where not otherwise requested, or the length of the supply chain beyond immediate suppliers—would have substantially increased the burden on responding facilities.[179] Processes related to extracting or processing coal and natural gas were also excluded.[180] Although processes related to extracting or processing coal and natural gas result in emissions (primarily fugitive methane emissions), significant uncertainty surrounds the measurement of these emissions.[181] Sensitivity analysis in appendix F examines the potential implications of including such emissions on emissions intensity estimates. The system boundaries also exclude certain processes occurring at steel facilities where those processes do not contribute to the production of covered products by that facility (figure 2.4).

---

[178] Industry representative, interview by USITC staff, July 24, 2023; Subject matter expert, interview by USITC staff, August 24, 2023.

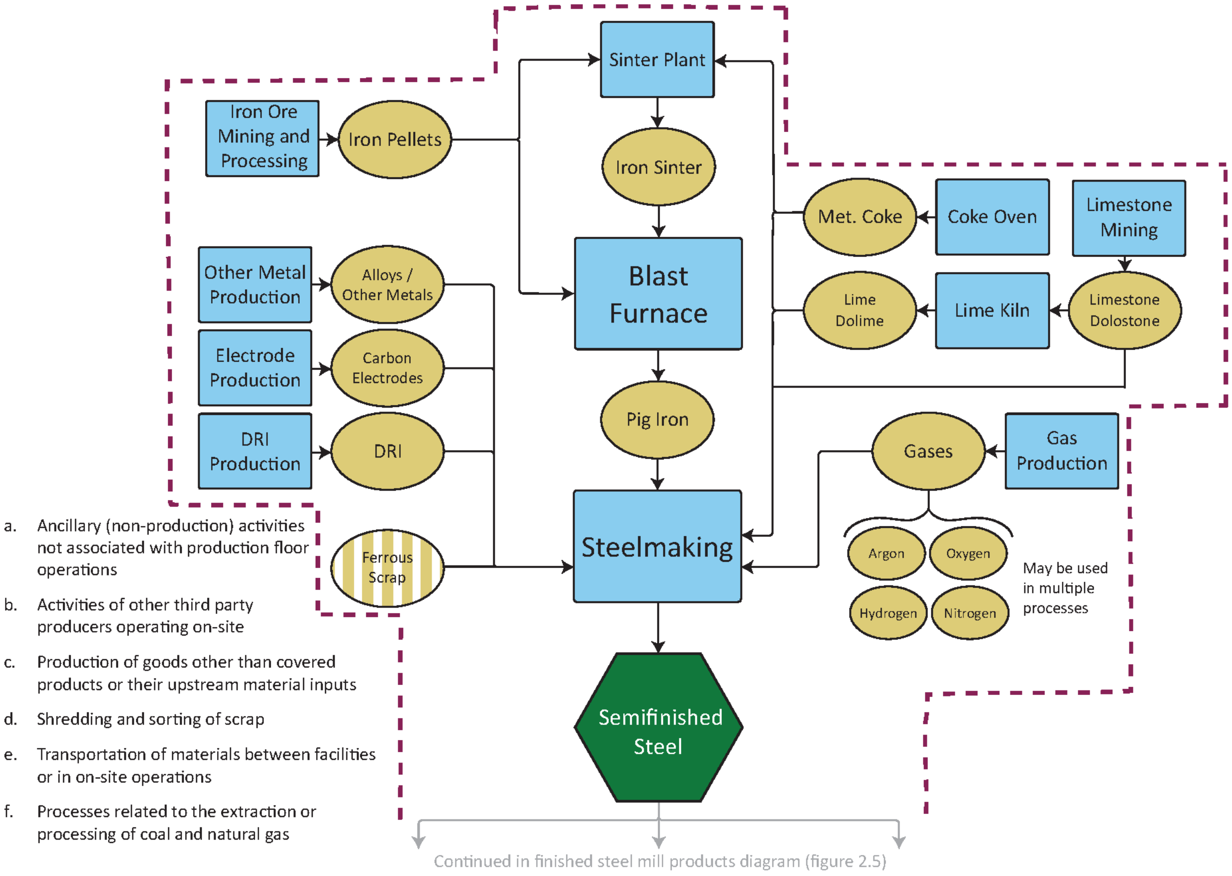
[179] In addition, the Commission's decision to not estimate transportation-related emissions was based on its effort to maintain consistency with emissions data reported under the GHGRP. Under the GHGRP, facilities are required to report fuel combustion emissions under subpart C for stationary combustion sources only and are asked to exclude emissions from nonstationary (including transport) sources. 40 C.F.R § 98.30.

[180] Although emissions associated with transportation, sorting and distribution of scrap, and extraction and processing of fuel and coal are not explicitly accounted for in the Commission's system boundary, it is possible that some of these emissions are included in certain scope 3 emissions calculations. The Commission used default emissions factors derived from other sources, particularly *ResponsibleSteel International Production Standard Version 2.1*, that included those processes within their own system boundaries. ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 79–81; Subject matter expert, email message to USITC staff, November 8, 2024.

[181] Olczak, Piebalgs, and Balcombe, "A Global Review of Methane Policies Reveals That Only 13% of Emissions Are Covered with Unclear Effectiveness," May 19, 2023; SIA Partners, "Reducing Methane Emissions," November 7, 2024; Rutherford et al., "Closing the Methane Gap in US Oil and Natural Gas Production Emissions Inventories," August 5, 2021; Bussewitz, "Difficulty Measuring Methane Slows Plan to Slash Emissions," January 31, 2023.

**Figure 2.4** Steel system boundary for the Commission's emissions estimates: semifinished steel production

DRI = direct reduced iron.



a. Ancillary (non-production) activities not associated with production floor operations

b. Activities of other third party producers operating on-site

c. Production of goods other than covered products or their upstream material inputs

d. Shredding and sorting of scrap

e. Transportation of materials between facilities or in on-site operations

f. Processes related to the extraction or processing of coal and natural gas

Source: Compiled by the USITC.

Notes: The dashed outline around the box indicates the system boundary. Emissions related to items within the system boundary are included in the USITC's emissions calculations. All items (a through f) outside the system boundary in the diagram were excluded from the USITC's emissions calculations. The Commission's questionnaire specifically asked about items a through d. Although excluded from the Commission's main emissions intensity findings, the potential contribution to emissions intensities of fugitive methane emissions released in the processes in item f is calculated in a sensitivity analysis featured in appendix F of this report.

Within the system boundary, hexagons represent covered products, rectangles represent main processes performed to generate these inputs and covered products, and arrows represent the flow of inputs into these processes. Covered products can sometimes serve as inputs for other covered products—all other inputs are shown as ovals. Scrap, shown in the striped oval, is an input for which data from facilities are collected in the Commission's questionnaire, but zero emissions burden is assigned, as explained below. Preheating or melting of steel scrap as part of the steelmaking process is included in the system boundary.

The Commission followed the practice of several existing steel emissions accounting standards by collecting data on scrap usage in its questionnaire but assigning zero embedded emissions to scrap inputs.[182] Assignment of an emissions burden to scrap associated with original production of steel would extend the steel system boundary to the life cycles (value chains) of other products.[183] Although certain companies track information on the sources of supply of their scrap, industry representatives indicated

---

[182] ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 81, 88–91; EC, DG-TAXUD, *CBAM Guidance for Installations*, December 8, 2023, 69–70, 182–83; Wright et al., *Steel GHG Emissions Reporting Guidance*, June 2023, 11–12; SBTi, *Steel Science-Based Target-Setting Guidance: Version 1.0*, July 2023, 38.

[183] USITC, hearing transcript, December 7, 2023, 115 (testimony of David Miracle, Nucor).

that many companies do not.[184] Scrap supply chains have limited traceability, meaning that facilities would generally not be able to report where, when, or how the steel that became scrap was produced.[185] Steel scrap can be recycled multiple times, adding an additional level of complexity in the assignment of emissions to that material based on earlier production processes.[186] Therefore, assigning a specific emissions factor to scrap associated with original production of steel would be subject to significant uncertainty.[187] However, under the standards referenced above, scrap data are used as supplemental information to contextualize or benchmark the GHG emissions of specific facilities.[188] Similar to these approaches, the Commission used scrap use data as a factor to contextualize the emissions intensity results for steel products in chapter 4. See table E.14 in appendix E ("IV. Standards Informing the Commission's Methodology Development") for a comparison of methodologies between the Commission's approach and other frameworks, including emissions accounting for scrap.

Figure 2.5 shows the downstream processes and steel product groupings covered under this investigation. This diagram begins with semifinished steel, where figure 2.4 ended. With the exception of coated flat steel, information on each of the covered product groupings below was collected separately for carbon and alloy steel and for stainless steel in the Commission's questionnaire. Consistent with the request letter, the Commission's system boundary ends at the producer's "gate." Emissions from the transportation of these covered products to and from facilities and emissions from downstream activities, such as the production of goods using these covered products as input materials, were excluded.

---

[184] USITC, hearing transcript, December 7, 2023, 173 (testimony of Jeff Hansen, SDI), 173 (testimony of Max Puchtel, AISC), 173 (testimony of Jeff Becker, U. S. Steel), 173 (testimony of Camilla Kaplin, Outokumpu).

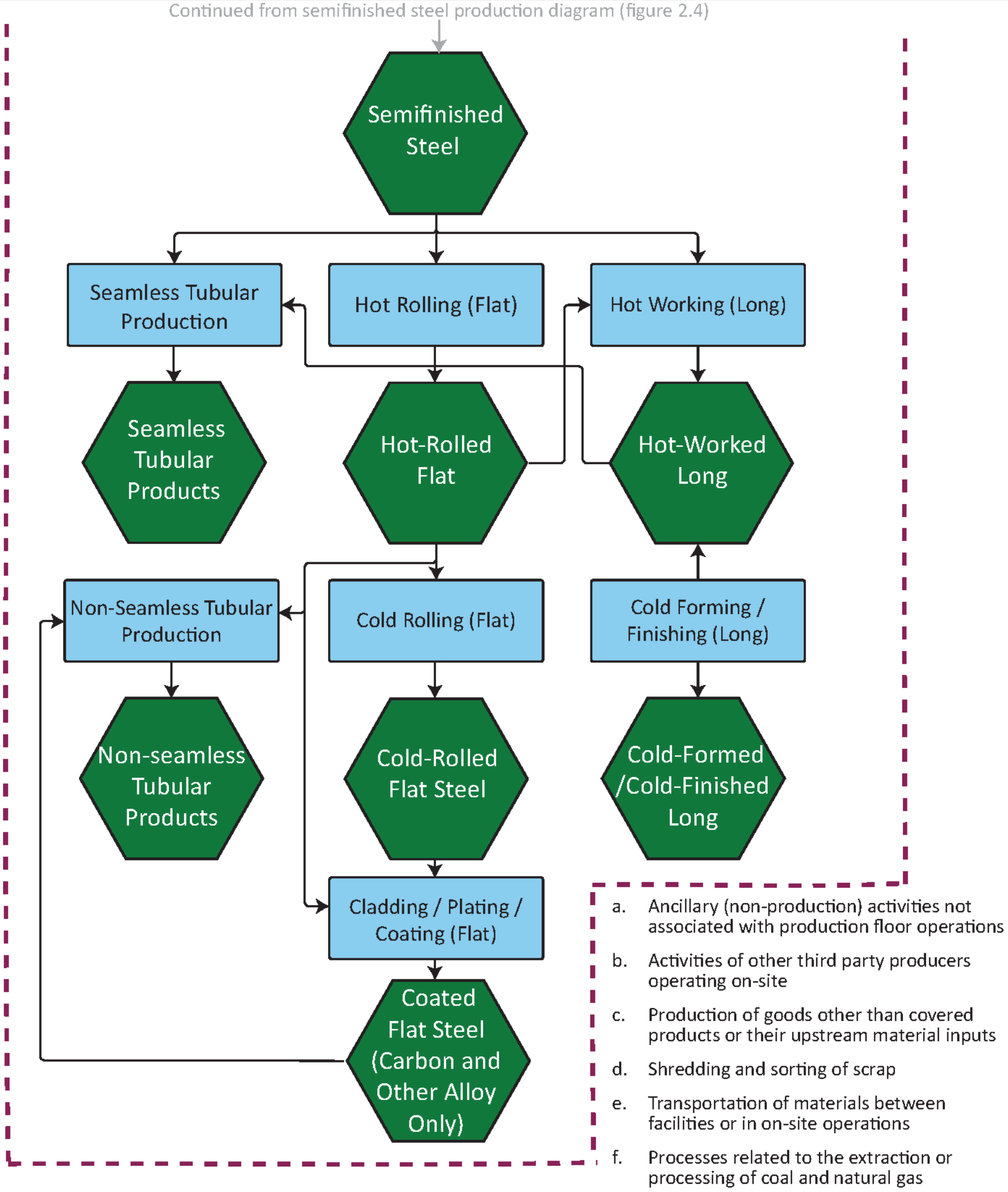
[185] Industry representatives, interview by USITC staff, July 14, 2023; industry representatives, interview by USITC staff, July 17, 2023.

[186] USITC, hearing transcript, December 7, 2023, 211, 214 (testimony of Adam Shaffer, ISRI).

[187] Steel scrap is used as an input in both EAF and BF-BOF steelmaking. Industry representatives at the Commission's hearing, representing both EAF and BF-BOF steelmaking, stated that scrap should not have embedded emissions associated with the original production of steel in that scrap. USITC, hearing transcript, December 7, 2023, 119–21 (testimony of Jeff Becker, U. S. Steel), 123 (testimony of John Hill, Cleveland-Cliffs), 123–24 (testimony of David Miracle, Nucor), 344 (testimony of Andrew David, Silverado Policy Accelerator).

[188] Although several of the standards listed above include such approaches, *The Steel Climate Standard* of the Global Steel Climate Council (GSCC) does not contextualize the emissions intensity estimates of steel products based on scrap content. Likewise, the American Iron and Steel Association (AISI)'s *Steel Production Greenhouse Gas Emissions Calculation Methodology Guidelines* does not suggest using scrap content as a basis for contextualizing the emissions intensity estimates of steel products. GSCC, *The Steel Climate Standard*, August 2023, 9; AISI, *Steel Production GHG Calculation Methodology Guidelines*, November 3, 2022.

**Figure 2.5** Steel system boundary for the Commission’s emissions estimates: finished steel mill products



a. Ancillary (non-production) activities not associated with production floor operations

b. Activities of other third party producers operating on-site

c. Production of goods other than covered products or their upstream material inputs

d. Shredding and sorting of scrap

e. Transportation of materials between facilities or in on-site operations

f. Processes related to the extraction or processing of coal and natural gas

Source: Compiled by the USITC.

Notes: The dashed outline around the box indicates the system boundary. Emissions related to items within the system boundary are included in the USITC’s emissions calculations. All items (a through f) outside the system boundary in the diagram were excluded from the USITC’s emissions calculations. The Commission’s questionnaire specifically asked about Items a through d. Although excluded from the Commission’s main emissions intensity findings, the potential contribution to emissions intensities of fugitive methane emissions released in the processes in item f is calculated in a sensitivity analysis featured in appendix F of this report.

Within the system boundary, hexagons represent covered products, rectangles represent main processes performed to generate these inputs and covered products, and arrows represent the flow of inputs into these processes. Covered products can sometimes serve as inputs for other covered products.

# Aluminum

Aluminum is the world's second-most consumed metal, behind steel.[189] Its production is also responsible for two percent of global anthropogenic GHG emissions.[190] This section describes the structure of the U.S. aluminum industry, the products covered in this investigation, and the production processes for those products, including where emissions occur within those production processes.[191] Finally, it describes the system boundary used to calculate emissions estimates for the U.S. aluminum industry.

## Domestic Aluminum Industry

The U.S. aluminum industry comprises three major segments: primary unwrought aluminum production, secondary unwrought aluminum production, and wrought aluminum production. The term "unwrought" refers to aluminum in a cast form that has not been further worked.[192] Primary unwrought aluminum is produced from raw materials (e.g., alumina). Secondary unwrought aluminum is recycled from aluminum scrap or dross. Wrought aluminum refers to aluminum that has been further worked from its unwrought form via methods such as rolling or extruding. U.S. production is principally focused on secondary unwrought and wrought products, with very little primary unwrought aluminum production.[193]

The U.S. primary unwrought aluminum industry was the world's 10th largest in terms of production in 2022, accounting for approximately 1.3 percent of global primary aluminum production.[194] Within the United States, the primary aluminum segment is the smallest segment, with the smallest production volume and only three companies operating six facilities in 2022.[195] Domestic primary unwrought aluminum smelters produced approximately 877,000 mt in 2022, operating at approximately 53 percent capacity.[196] U.S. primary production has been decreasing since the early 2000s.[197]

---

[189] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 43; Padamata, Yasinskiy, and Polyakov, "A Review of Secondary Aluminum Production and Its Byproducts," July 30, 2021, 2603. In general terms, aluminum is defined as an article comprised of metallic substances in which aluminum predominates by weight over each of the other elements. See also USITC, HTS (2024) Revision 10, section XV, chapter 72, note 1(a–b).

[190] World Economic Forum, "Exploring Pathways to Decarbonize the Aluminium Industry," November 2020, 3.

[191] Scope designations in this chapter are based on the Commission's scope framework established in chapter 1, unless otherwise noted.

[192] For the purposes of this investigation, unwrought aluminum may also refer to aluminum in a molten form. See below section titled "Covered Aluminum Products" for further details.

[193] Based on production volumes as reported in USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, responses to questions 2.2.1–2.2.3.

[194] USGS, *Mineral Commodity Summaries 2024: Aluminum*, January 2024.

[195] USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, responses to questions 2.2.1–2.2.3. See also chapter 5, table 5.1, and Appendix H, table H.4.

[196] See appendix H, table H.4. Domestic primary unwrought aluminum production capacity was 1.64 mmt in 2022. USGS, *Mineral Commodity Summaries 2024: Aluminum*, January 2024.

[197] CRS, *U.S. Aluminum Manufacturing: Industry Trends and Sustainability*, October 6, 2022, 2, 3–5.

The U.S. secondary unwrought aluminum industry was the world's second largest in 2021, after China, accounting for approximately 20.1 percent of global secondary unwrought aluminum production.[198] Within the United States, the secondary unwrought aluminum segment had the second-largest production volume of the three aluminum segments and consisted of 102 facilities in 2022.[199] Domestic secondary unwrought production reached 9.7 mmt in 2022, accounting for approximately 92 percent of total domestic unwrought production.[200] Contrary to the primary aluminum industry, the domestic secondary aluminum industry has been growing since the early 2000s because it is a lower-cost production method as a result of its significantly reduced energy requirements.[201]

The U.S. wrought aluminum segment was the largest of the three segments by production volume, and had the largest number of facilities, at 417 in 2022.[202] Wrought aluminum producers make a variety of semifinished products including bars, rods, and profiles; plates, sheets, and strips; foil; wire; tubes, pipes, and tube or pipe fittings; forgings; and castings.[203] Domestic wrought producers produced approximately 9.8 mmt in 2022.[204] Plates, sheets, and strip made up over half of wrought production in 2022. About a quarter of wrought production was bars, rods, and profiles. The remaining quarter was, in descending order of quantity, castings, wire, foil, tubes, pipes, and tube or pipe fittings, and forgings.[205]

Many companies producing secondary unwrought aluminum from scrap also produce downstream wrought products.[206] Some of these companies keep their production of upstream and downstream products separated, while others have fully integrated facilities in which they are able to remelt scrap and also produce wrought products all in one location. Primary unwrought aluminum smelters in the United States are not integrated with any other type of production.[207]

---

[198] As a large share of secondary unwrought aluminum is captively consumed in the production of wrought aluminum, most estimates on global and country-level secondary unwrought aluminum production only include secondary unwrought aluminum production that is shipped off-site before being further worked into a wrought product. Data on global secondary unwrought production were not available for 2022. The 2021 data is from LSEG, "WBMS, World Metal Statistics Yearbook 2022," 2023.

[199] USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, responses to questions 2.2.1–2.2.3. See appendix H, tables H.4 and H.7, and chapter 5, table 5.1.

[200] See appendix H, table H.4.

[201] Secondary unwrought aluminum production consumes 90–95 percent less energy than primary unwrought aluminum production. USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 52; AA, "Infinitely Recyclable," accessed November 5, 2024; CRS, *U.S. Aluminum Manufacturing: Industry Trends and Sustainability*, October 6, 2022.

[202] USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, responses to questions 2.2.1–2.2.3. See also appendix H, tables H.4 and H.7 and chapter 5, table 5.1. Data on global wrought aluminum production are too limited to determine top producing countries.

[203] Aluminum castings produced by either the foundry or die-casting processes are typically not considered by the aluminum industry as "wrought products." For the purposes of the questionnaire, however, castings were included as wrought products to reduce the number of questions and burden on respondents, and to better align with language in the *Harmonized Tariff Schedule of the United States* (HTS).

[204] See appendix H, table H.4.

[205] USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, responses to questions 2.2.1–2.2.3.

[206] USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, responses to questions 2.2.1–2.2.3. See also USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 138–39.

[207] USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, responses to questions 2.2.1–2.2.3; USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 135–36.

## Covered Aluminum Products

The products within the scope of this investigation, as presented in attachments A and B of the Trade Representative's request letter, include those aluminum products covered under the section 232 tariff actions, as set forth in Presidential Proclamation 9704 of March 8, 2018.[208] This includes unwrought aluminum products produced from either primary or secondary materials, as well as several wrought aluminum products also sometimes referred to as "semifinished," "semis" or "mill products," and castings.[209] The Commission considered unwrought aluminum and wrought aluminum to be aggregate product categories for aluminum. As explained in more detail below, the unwrought aluminum aggregate product category is composed of primary unwrought aluminum and secondary unwrought aluminum product categories. The wrought aluminum aggregate product category is composed of aluminum bars, rods, and profiles; aluminum wire; aluminum plates, sheets, and strip; aluminum foil; aluminum tubes, pipes, and tube or pipe fittings; aluminum forgings; and aluminum castings. Table 2.4 provides a brief description of the covered products and the HTS heading or statistical reporting number under which these products are covered.

---

[208] 83 Fed. Reg. 11619 (March 15, 2018).

[209] Note that the term "semifinished" is also used to describe certain steel products, though the type of products considered "semifinished" are not consistent across metals, as "semifinished" steel products more closely align with those products referred to as "unwrought" in the aluminum industry.

**Table 2.4** Covered aluminum products: *Harmonized Tariff Schedule of the United States* (HTS) classification and description

| USITC product category | HTS classification | Description |
|---|---|---|
| Unwrought aluminum | 7601 | Ingots, slabs, blocks, billets, sows, etc., produced by casting molten aluminum of either primary or secondary origin, but not further machined or processed, other than by simple trimming, scalping, or descaling. Includes unalloyed and alloyed aluminum. |
| Aluminum bars, rods, and profiles (wrought) | 7604 | Wrought aluminum products with a solid cross-section, typically produced via extrusion. Aluminum rods have a solid circular cross section; bars can have a number of flat sides. Profiles, also referred to as “shapes” or “sections,” have various cross-sectional shapes that differ from those of other wrought products. |
| Aluminum wire (wrought) | 7605 | Wire produced by drawing unwrought aluminum wire rod through one or more steel dies to attain the desired final outside dimensions. |
| Aluminum plates, sheets, and strip (wrought) | 7606 | Flat-rolled wrought aluminum products. Plates are at least 6.0 millimeters thick (6.3 millimeters in the United States) and are cut to length. Sheets range in thickness from 0.20 millimeters to under 6.0 millimeters (0.15 millimeters to under 6.3 millimeters in the United States). Strip is slit from coiled aluminum into narrower widths than the original coil. |
| Aluminum foil (wrought) | 7607 | Flat-rolled wrought aluminum of thickness not exceeding 0.20 millimeters. |
| Aluminum tubes, pipes, and tube or pipe fittings (wrought) | 7608, 7609 | Hollow wrought aluminum products. Tubes have uniform wall thicknesses along their length. Pipes are a type of tube with standardized outside diameter and wall thicknesses. Tube or pipe fittings consist of products such as couplings, elbows, and sleeves. |
| Forgings (wrought) | 7616.99.5170 | Mechanical products formed by applying pressure to shape unwrought aluminum using either open or closed dies. |
| Castings (wrought*) | 7616.99.5160 | The solid, rough, finished, or near-finished (near-net) aluminum shapes resulting from the foundry or die-casting processes. |

Sources: USITC, *Greenhouse Gas (GHG) Emissions intensities Questionnaire: Facility-level, 2024,* Section 1.2, Facility Information, 22–23; appendix A: USTR, Request Letter, Attachment B: Steel and Aluminum Product Categories, June 5, 2023.

Note: Product categories in this table match those provided in attachment B of the Trade Representative’s request letter, with the exception of aluminum tubes, pipes, and tube or pipe fittings which were combined into a single product category, as in attachment A of the Trade Representative’s letter. The Commission also collected emissions intensity estimates for the further disaggregated unwrought product categories of primary and secondary, as described later in the chapter. Aluminum castings (*) produced by either the foundry or die-casting processes are typically not considered “wrought products.” For the purposes of the questionnaire, castings were included as wrought products to reduce the number of questions and burden on surveyed facilities and to better align with language in the *Harmonized Tariff Schedule of the United States* (HTS).

In some instances, product descriptions and groupings provided for in the HTS did not align with the domestic industry’s categorization of aluminum products. In these instances, the Commission made decisions on when to comport with the HTS or the industry in defining each covered product. Additionally, the Commission developed estimates for product categories for primary unwrought and secondary unwrought aluminum within the unwrought aluminum aggregate product category to capture important emissions differences between these two subgroups. Descriptions of the adjustments made to individual product categories are given below.

- **Unwrought aluminum:** As noted above, although not separated as such in the HTS, the Commission collected data on and provided emissions estimates for primary and secondary unwrought aluminum as subcategories of the unwrought aluminum product group. The

Commission considered the significant difference in emissions between primary and secondary unwrought production important to capture, especially given that a vast majority of unwrought production in the United States is secondary. Some industry representatives suggested that the Commission should instead produce estimates for alloyed and unalloyed unwrought aluminum subcategories, to better comport with the HTS.[210] The Commission did not calculate such estimates, however, because it did not appear that significant differences in emissions between alloyed and unalloyed wrought aluminum were likely; alloys typically make up a small share of the metal content of alloyed aluminum, and most alloys have emissions factors similar to (although often lower than) that of primary unwrought aluminum.[211] In addition, given the number of alloys that can be used by aluminum producers, and the lack of available emissions factors for some of these alloys, producing estimates for alloyed and unalloyed aluminum would have substantially increased the complexity of the Commission's questionnaire without significantly improving the accuracy of emissions estimates.[212] Instead, alloying element inputs were assigned a primary unwrought aluminum emissions factor.[213] Additionally, some producers of unwrought aluminum ship molten aluminum off-site prior to casting, though this is likely a rare occurrence, as molten aluminum can only be shipped short distances.[214] While the HTS does not include molten aluminum in its description of unwrought aluminum, production of molten aluminum that is shipped off-site may be included in the Commission's emissions estimates.[215]

- **Bars, rods, and profiles; and tubes, pipes, and tube or pipe fittings:** Wrought aluminum profiles are made when aluminum billet is pushed through an extrusion die into the desired shape with a

---

[210] HTS subheading 7601.10 covers unwrought unalloyed aluminum, subheading 7601.20 covers unwrought alloyed aluminum. Century Aluminum Company, written submission to the USITC, January 8, 2024; USITC, hearing transcript, December 7, 2023, 303 (testimony of Andrew David, Silverado Policy Accelerator).

[211] According to the Aluminum Association, alloying elements typically constitute between 1 percent and 15 percent of the total weight of aluminum products. AA, "The Environmental Footprint of Semi-Fabricated Aluminum," January 2022, 46. Because common alloying elements used in alloyed aluminum have higher emissions intensities than the Commission's average emissions intensity for secondary aluminum (2.46 mt $CO_2e$/mt aluminum) but lower emissions intensity than the Commission's average emission intensity for primary aluminum (14.52 mt $CO_2e$/mt), the similarity is greater in terms of emissions intensities between alloyed and unalloyed aluminum compared to the difference between primary and secondary aluminum. For examples of emissions intensities for common alloying elements see IAI, "IAI Scope 3 Calculation Tool Guidance," September 13, 2022, 32.

[212] U.S. industry representative, interview by USITC staff, August 7, 2023; U.S. industry representative, interview by USITC staff, August 23, 2023.

[213] This method avoided undercounting the emissions burden from the inclusion of these alloying materials, as well as reduced burden on companies that consume a relatively negligible amount of this material and may not be able to separate their alloy use by material type. This method of using a primary unwrought aluminum emissions factor for alloying inputs is used by several other technical papers and comparative emissions collection efforts. See AA, "The Environmental Footprint of Semi-Fabricated Aluminum Products," January 2022, 46; EU, C, DG-TAXUD, *CBAM Guidance for Installations*, December 8, 2023, 66; RMI, "Aluminum Emissions Reporting Guidance," December 2023, 20.

[214] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 51; U.S. industry representative, interview by USITC staff, September 13, 2023.

[215] Although no respondents explicitly noted shipments of molten aluminum in the questionnaire, the definition of "unwrought" aluminum provided in the Commission's questionnaire allowed for molten aluminum shipments to be included in reporting.

solid cross-section. Aluminum tubes and pipes can be made using the same process but resulting in a shape with a hollow cross section. Some facilities reported that their tracking systems were not able to differentiate between production of a solid or a hollow cross-section, and so they had difficulty accurately splitting their production between the two categories.[216] In these cases, the Commission relied on the best estimate of production from the surveyed facility.

- **Forgings**: In the forging process, unwrought aluminum ingots are heated and pressed, pounded, or squeezed to shape under intense pressure.[217] Some facilities in the survey are recognized as and identified themselves as producers of aluminum forgings but used wrought aluminum bars as inputs, rather than unwrought aluminum. Forgings created via this production process differ slightly from the definition of forgings established by the HTS and used in this survey. Nonetheless, these producers and the upstream emissions from their wrought inputs were also included in these estimates.
- **Castings**: Casting is a process by which molten aluminum is forced or poured into a mold to create a specific shape.[218] Die-casting uses pressure to force or inject the aluminum into a mold, while other types of "foundry" casting such as sand-casting or permanent-mold casting are done by pouring the aluminum into a mold.[219] Aluminum castings produced by either the foundry or die-casting processes are typically not considered "wrought products." For the purposes of the questionnaire, castings were included as wrought products to reduce the number of questions and burden on surveyed facilities and to better align with language in the HTS. Some producers of aluminum automotive castings reported that they had no production in this product category because the entirety of their production was automotive parts and accessories more accurately corresponding to HTS Chapter 87. Such facilities were excluded from the questionnaire.

# Aluminum Production Processes

## Primary Unwrought Aluminum Production

### Upstream Processes

The process of making primary unwrought aluminum begins with the mining of bauxite ore from open pit mines.[220] Bauxite is loosened from the deposit using explosives and then sometimes crushed and treated with water to remove impurities before it is shipped.[221] Bauxite is then refined through a

---

[216] U.S. industry representative, email message to USITC staff, June 28, 2024; U.S. industry representative, email message to USITC staff, July 1, 2024; U.S. industry representative, email message to USITC staff, July 22, 2024.

[217] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 534.

[218] LeClaire Manufacturing Co., "Which Aluminum Casting Method Is Right For You?," April 16, 2019.

[219] Although the processes are quite similar, castings produced by die casters or foundries are considered to be a different product than castings produced by primary or secondary unwrought aluminum producers. Aluminum Association, written submission to the USITC, January 5, 2024, 4.

[220] A limited amount of bauxite is mined in the United States, but only for nonmetallurgical use. Although bauxite can be imported for refining in the United States, it is typically refined into alumina before being imported. USGS, *Mineral Commodity Summaries 2024: Bauxite and Alumina*, January 2024; USDOE, *U.S. Energy Requirements for Aluminum Production*, February 2007, 10–11.

[221] PE Americas, "Final Report: Life Cycle Impact Assessment of Aluminum Beverage Cans," May 21, 2010, 32.

chemical process into alumina, the immediate precursor to primary unwrought aluminum production.[222] Approximately four mt of bauxite is required to produce two mt of alumina powder (aluminum oxide), which in turn produces one mt of primary unwrought aluminum.[223]

Emissions in bauxite mining are attributed to the fuels used to power stationary and mobile mining equipment.[224] Stationary heat-generating equipment such as digesters, calciners, and dryers are responsible for about 99 percent of the emissions from the alumina refining process.[225] For primary unwrought aluminum producers, the use of alumina, sourced externally, contributes to the facility's scope 3 embedded emissions. According to the International Aluminium Institute (IAI), bauxite mining accounts for approximately 0.26 percent of all emissions associated with primary aluminum production and the refining of alumina accounts for 17.2 percent (table 2.5).

## Smelting and Casting

After bauxite is refined into alumina, the alumina is shipped to an aluminum smelter (figure 2.6).[226] At the smelter, several carbon cathode-lined steel pots in a row make up a "potline," with molten aluminum being produced in each pot.[227] Carbon anodes, typically made on site from packing and baking a mixture of calcined petroleum coke and coal tar pitch, are lowered into the pot.[228] Within the pot, alumina is dissolved in a molten cryolite bath, and a large quantity of electricity is passed through the bath and the anodes, separating the oxygen from the alumina.[229] The oxygen reacts to the carbon in the anode, producing $CO_2$ gas, leaving molten aluminum to accumulate at the bottom of the pot. This process is called the Hall-Héroult electrolytic process, hereafter called "electrolysis." The molten aluminum is periodically transferred from the pot to a holding furnace. Molten aluminum can be cast into various primary unwrought aluminum products at the casthouse; these include ingots, billets (extrusion ingot),

---

[222] The process of refining bauxite into alumina is called the Bayer Process. For more information on this process, see AA, "Alumina Refining 101," accessed November 5, 2024; Encyclopedia Britannica Online, s.v. "Alumina," November 5, 2024.

[223] Springer and Hasanbeigi, "Emerging Energy Efficiency and Carbon Dioxide Emissions-Reduction Technologies for Industrial Production of Aluminum," June 2016, 6.

[224] According to a report by the Australian Aluminium Council, about 80 percent of emissions from bauxite mining are associated with diesel used in mining and hauling equipment and around 20 percent from electricity used in processing and ship loading equipment. Australian Aluminium Council Ltd., *Bauxite*, July 2022.

[225] The remaining 1 percent of emissions typically come from processes such as flue-gas desulfurization, combustion of organic compounds in ores, and cleaning of equipment. Biberman, Toledano, and Ram Mohan, "GHG Accounting Methods in the Aluminum Industry," 2023, 11.

[226] Some countries may choose to keep their aluminum smelters and alumina refineries close to the mine, to reduce transportation needs. In the United States, smelters typically receive their alumina by train or barge. Industry representatives, interviews by USITC staff, September 2023.

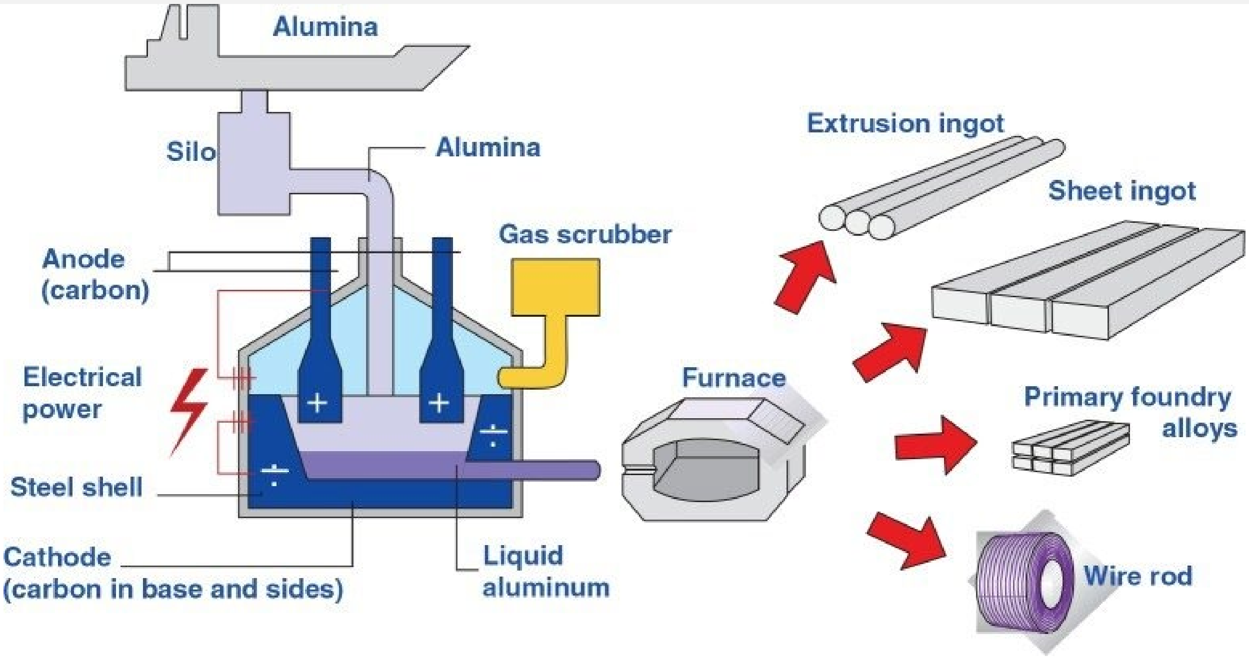
[227] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 51.

[228] Calcined petroleum coke is a high-purity carbon substance created by heating green petroleum coke (a by-product of oil refining) to remove impurities and volatiles. Coal tar pitch is a by-product of coal distilling. For more on these materials, see Rain Industries, "Carbon," accessed November 5, 2024. In the United States, "prebake" carbon anodes are typically produced on-site to meet the specific needs of the pots at that smelter. Industry representatives, interview by USITC staff, September 2023. See also USITC, hearing transcript, December 7, 2023, 225 (testimony of Matt Aboud, Century Aluminum), 261 (testimony of Laura Chambers, Alcoa).

[229] Cryolite is a mineral composed of fluoride, sodium, and aluminum. In the aluminum electrolysis process, it acts as a solvent to dissolve the alumina. Kvande and Drabløs, "The Aluminum Smelting Process," May 8, 2014; AA, "Primary Production 101," accessed March 11, 2024.

slabs, sows, or wire rod.[230] Before casting, aluminum may be alloyed with other metals such as silicon or magnesium to enhance certain characteristics such as corrosion resistance, hardness, or strength. After casting, some products may require certain finishing treatments.[231] For example, sheet ingot and extrusion billet often require homogenization, a type of heat-finishing process, that requires additional natural gas use.[232] Other types of unwrought aluminum do not typically undergo heat treatment until they are transformed into wrought products.

**Figure 2.6** Aluminum smelting process



Source: Kvande and Drabløs, "The Aluminum Smelting Process," May 8, 2014.

Emissions at a primary aluminum smelter are produced in several areas of the production process. During anode baking, scope 1 fuel combustion emissions are produced from the combustion of fuels used in the baking furnace. Scope 1 process emissions, in the form of $CO_2$, are produced in the combustion of furnace packing material, and are also released from the anode itself.[233] Anode material also contains embedded (scope 3) emissions. Scope 1 process emissions from electrolysis include $CO_2$ emissions from anode consumption and perfluorocarbons emissions from "anode effects" resulting from

---

[230] Typically, molten aluminum can only be shipped short distances to customers, whereas solid forms can be transported over long distances. USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 51.

[231] Industry representative, interview by USITC staff, August 7, 2023; Industry representatives, email to USITC staff, July 31, 2024.

[232] Industry representatives, email to USITC staff, July 31, 2024. Homogenization is a type of heat treatment in which aluminum is reheated and slowly cooled to ensure uniformity in strength and other characteristics by allowing the alloying materials to become more evenly distributed throughout the aluminum. This process also creates a more workable material. L&L Special Furnace, "Aluminum Heat Treatment," June 11, 2021.

[233] Biberman, Toledano, and Ram Mohan, "GHG Accounting Methods in the Aluminum Industry," 2023, 12.

voltage changes within the pot.[234] Emissions associated with generating the electricity used in electrolysis are classified as either scope 1 or scope 2 depending on the location of the power source.[235] On average, globally, smelting one ton of aluminum requires 14.1 megawatt-hours (MWh) of electricity.[236] In the United States, in 2022, smelting one mt of aluminum required 15.6 MWh of electricity.[237] This is more electricity than the average U.S. household consumes in a year.[238] Electricity-related emissions vary considerably, depending on the fuel mix used to generate the electricity.[239]

At the casthouse, a smaller amount of scope 1 or scope 2 emissions is produced from the use of fuels or electricity to power furnaces for holding and heat-treating.[240] These emissions account for less than one percent of total emissions in primary aluminum production (table 2.5). Alloying elements mixed in with the molten aluminum before casting also have embedded scope 3 emissions.[241]

---

[234] Biberman, Toledano, and Ram Mohan, "GHG Accounting Methods in the Aluminum Industry," 2023, 14–18. Anode effects occur when an insufficient supply of alumina to the smelting pot causes a rapid spike in voltage in the pot, leading to cryolite decomposition and the emission of gases containing perfluorocarbons. For a more detailed description of this occurrence, see Kremser et al., "Anode Effect Prediction in Hall-Héroult Cells," December 18, 2020. Depending on the level of the voltage change, anode effects can be characterized as "low-voltage" or "high-voltage." Currently U.S. aluminum smelters do not typically track low-voltage anode effects and associated PFCs. USITC, hearing transcript, December 7, 2023, 261 (testimony of Matt Aboud, Century Aluminum); Alcoa Corporation, written submission to the USITC, December 21, 2023, 8. Estimates of high-voltage anode effect emissions are included in the GHGRP reporting data. Low-voltage anode effects and associated emissions are not currently detectable by most reporting smelters; thus, they are not included within the estimates provided in this report. For more information, see appendix E, box E.1 and "II.B.1.b GHGRP Primary Unwrought Aluminum Production Calculations."

[235] Some smelters generate their own electricity on-site; others draw electricity from off-site sources. Emissions from electricity generated on-site are classified as direct (scope 1); emissions generated from off-site sources are classified as indirect (scope 2).

[236] IAI, "Primary Aluminium Smelting Energy Intensity (2022)," September 21, 2024; USITC, hearing transcript, December 7, 2023, 194 (testimony of Laura Chambers, Alcoa); industry representatives, interview by USITC staff, September 2023.

[237] Estimated using responses from USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, see chapter 5, table 5.2.

[238] According to the EIA, in 2022, the average U.S. household consumed approximately 10.8 MWh a year. EIA, "FAQs: How Much Electricity Does an American Home Use?" accessed September 16, 2024.

[239] Globally, electricity accounts for about 78.0 percent of emissions in the electrolysis process, or 58.9 percent of total emissions in primary aluminum production, on average. IAI, "Greenhouse Gas Emissions Intensity – Primary Aluminum," accessed March 13, 2024. For more information on fuel mix and electricity, see discussion of "Factors Influencing Emissions Intensities" for primary unwrought aluminum, in chapter 5.

[240] These furnaces can be used either for reheating of aluminum or alloying elements before casting, or for heated finishing treatments.

[241] The Commission's calculation methodology assigned a primary unwrought aluminum emissions factor to alloys, an accepted practice used in other emissions accounting methodologies. According to the Aluminum Association, alloying elements typically constitute between 1 percent and 15 percent of the total weight of aluminum products. AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 46. For examples of emissions intensities for common alloying elements see IAI, "IAI Scope 3 Calculation Tool Guidance," September 13, 2022, 32.

**Table 2.5** Average greenhouse gas emissions in primary aluminum production, by process
In metric tons of carbon dioxide equivalent (mt $CO_2e$) and percentages (%).

| Process | Emissions (mt $CO_2e$) | Share of total emissions (%) |
|---|---:|---:|
| Bauxite mining | 0.04 | 0.26 |
| Refining (alumina production) | 2.6 | 17.2 |
| Anode production (baking) | 0.9 | 6.0 |
| Electrolysis | 11.4 | 75.5 |
| Casting | 0.1 | 0.66 |
| All processes | 15.1 | 100.0 |

Source: IAI, “Primary Aluminium Greenhouse Gas Emissions for 2022,” April 11, 2024.
Note: Based on average global emissions as collected by the IAI. Because of rounding, shares may not add to 100 percent.

## Secondary Unwrought Aluminum Production

Secondary unwrought aluminum is produced by melting recycled aluminum scrap or dross (see box 2.2), recovered from both manufacturing processes and post-consumer sources.[242] This process often starts with shredding and sorting of the scrap into different alloys.[243] The scrap may then need to go through a decoating process in which the metal is heated to remove paints, lacquers, and other coatings. These processes may be done on-site or completed by scrap processors before arriving at the secondary facility. The aluminum scrap is then melted in a furnace and mixed as needed with primary aluminum and additional alloying materials. After melting, the aluminum can be sold in its liquid state or cast into various unwrought products such as ingots, billets, or slabs.[244] Like primary unwrought aluminum, secondary unwrought aluminum may be heat-treated after casting.

**Box 2.2** Dross Recycling

Dross is a by-product of the aluminum melting and casting process made up of oxidized aluminum and other waste material. The aluminum within the dross can be separated and reused. This requires a more specialized recycling process than typical scrap recycling. Secondary unwrought aluminum producers may have equipment to recycle both aluminum scrap and aluminum dross on-site, but they often ship their dross out to have it processed by specialized recyclers. In this process, oxidized aluminum, salts, and other contaminants are separated from the aluminum metallic content via crushing, milling, and screening. Then, larger particles of high metallic content are delivered into remelting furnaces and the molten metal is further refined and purified. The material may then be batched, cast, and sawed. The final output is packaged secondary aluminum ingots.[a]

[a] AA, The Environmental Footprint of Semi-Fabricated Aluminum Products, January 2022, 80–81.

---

[242] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 52. Scrap recovered from manufacturing processes, also sometimes referred to as “pre-consumer scrap,” “fabrication scrap,” or “new scrap,” can come from the aluminum production process or from the manufacturing of further downstream products made from aluminum, such as cans, cars, or appliances.

[243] To reduce raw material costs, secondary producers often select a mix of aluminum alloy scrap for the melting furnace to achieve the desired alloy content in the molten aluminum, after diluting with primary unwrought aluminum. In this way, secondary producers minimize the need for additional virgin alloying materials in their production. USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 52–53.

[244] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 52.

Secondary unwrought aluminum production consumes 90–95 percent less energy than primary unwrought aluminum production because it avoids the two steps of refining bauxite into alumina and the subsequent electrolytic smelting of alumina into aluminum.[245] This results in much lower emissions in the secondary process compared to primary production. With respect to scope 1 emissions, no scope 1 process emissions typically are created in the secondary unwrought aluminum production process.[246] Scope 1 fuel combustion emissions are generated from the furnaces when aluminum scrap is being reheated or remelted and when the metal goes through heat treatments.[247] Although these furnaces typically use natural gas, electricity (typically purchased) may also be used for some of these processes, creating scope 2 emissions. In addition, scope 3 emissions are embedded in inputs to the secondary production process, such as primary unwrought aluminum and alloying elements. Emissions from recycling of aluminum make up an estimated 2 percent of global aluminum sector emissions (see figure 2.7).[248]

## Wrought Aluminum Production and Production of Castings

Wrought aluminum production is the further working of unwrought aluminum products, typically by one of the following processes: rolling, extruding, drawing, or forging. These processes, as well as the process for making aluminum castings, are described below.

- Rolling involves passing a heated unwrought aluminum slab or ingot between large steel rollers until it reaches the desired thickness.[249] Rolled products can also be produced directly from molten aluminum via the continuous casting process. In this process, molten aluminum is cast and rolled directly into aluminum strip.[250] The strip is then reduced in thickness via cold-rolling. The continuous casting process is typically less emissions intensive because the metal does not have to be reheated before rolling.[251] Products typically produced by the rolling process include foil, plates, sheets, and strip, though other covered products may also be rolled.[252]
- In the extrusion process, unwrought aluminum billets are reheated and lubricated before entering an extrusion press, where the softened metal is pushed through a precision opening, or

---

[245] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 52; AA, “Infinitely Recyclable,” accessed November 5, 2024; CRS, *U.S. Aluminum Manufacturing: Industry Trends and Sustainability*, October 6, 2022.

[246] Sources indicate that certain methods of dross recycling may result in some process emissions. Because data on the potential size of these emissions are scarce, the Commission’s methodology does not account for process emissions from dross production. Industry representatives, interview by USITC staff, November 7, 2023; Narayanan, “Chemical Interactions of Dross with Water and Water Process Vapor in Aluminum Scrap Remelting,” January 1, 1997; Shinzato and Hypolito, “Solid Waste from Aluminum Recycling,” January 1, 2005.

[247] Several types of heat treatments can be performed on aluminum to change the characteristics of the metal. For example, precipitation hardening increases strength and annealing or aging treatments reduce stress and create a more workable material.

[248] This includes internal scrap remelting, which can occur at any facility that has the capacity to remelt its internally produced scrap, including wrought facilities.

[249] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 54.

[250] Vulcan Aluminum Mill, “Why Continuous Casting?” accessed November 6, 2024.

[251] According to a report by the U.S. Department of Energy, continuous casting provides an energy savings of at least 25 percent compared to rolling a reheated aluminum ingot or slab. USDOE, OIT, *Structural Factors Affecting Formability*, October 2001.

[252] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 54.

die, to produce the desired shape.[253] After exiting the press, the extrusion is cooled, stretched, and cut to length. Extruded products may also be produced directly from molten aluminum.[254] As in continuous casting, this process is typically less emissions intensive because the molten metal does not have to be cast, cooled, and reheated before being shaped. Products typically produced by the extrusion process include bars, rods, profiles, tubes, and pipes.[255]

- In the drawing process, unwrought aluminum rod is mechanically shaped by being pulled through the opening of a steel die.[256] Aluminum wire is produced via drawing. Extruded bars, rods, tubes, and pipes may also be subsequently drawn to improve surface finishes or achieve final outer dimensions. Aluminum wire may also be drawn directly from molten aluminum.[257]
- In the forging process, unwrought aluminum ingots are heated and pressed, pounded, or squeezed to shape under intense pressure.[258]
- Casting is a process by which molten aluminum is forced or poured into a mold to create a specific shape.[259] Die-casting uses pressure to force or inject the aluminum into a mold; other types of "foundry" casting such as sand-casting or permanent-mold casting are done by pouring the aluminum into a mold.

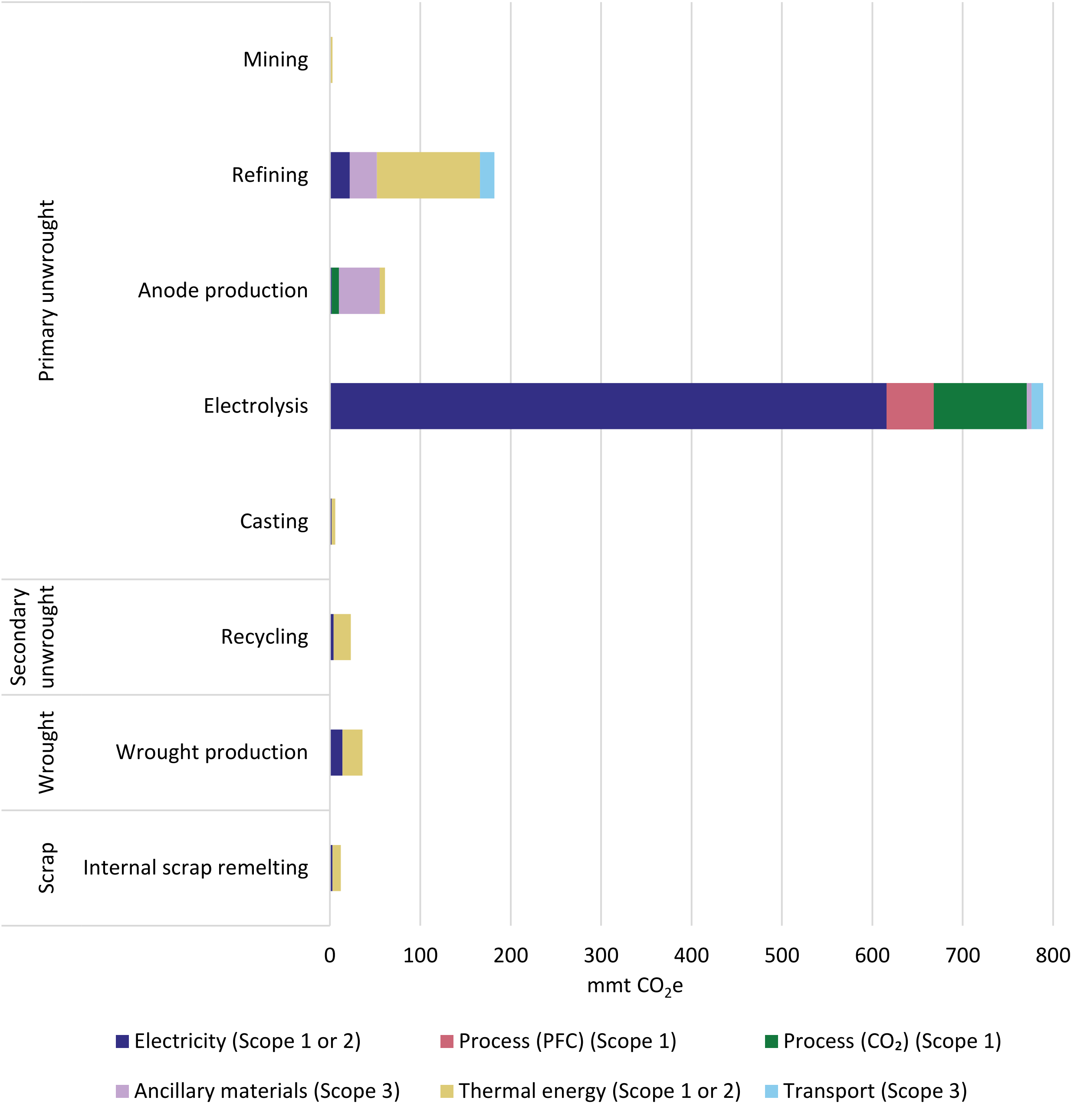
With respect to scope 1 emissions, no scope 1 process emissions typically are associated with wrought aluminum production (figure 2.7). Scope 1 fuel combustion emissions are emitted from furnaces when aluminum is heated before being further worked or shaped or when aluminum is heat-treated. Scope 2 emissions result from electricity consumption, which is used to operate machinery that shapes wrought products, such as rolling lines or extrusion presses.[260] Finally, inputs such as primary aluminum or alloying elements contain embedded scope 3 emissions.

---

[253] USITC, *Aluminum Extrusions from China*, October 2022, I–18.
[254] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 50, 55.
[255] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 55.
[256] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 25, 55.
[257] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 55. As noted for other products produced directly from molten aluminum, drawing from molten aluminum is typically less emission intensive.
[258] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 531.
[259] LeClaire Manufacturing Co., "Which Aluminum Casting Method Is Right For You?," April 16, 2019.
[260] Wrought producers typically purchase electricity, rather than producing it on-site.

**Figure 2.7** Greenhouse gas emissions in the global aluminum industry by process, segment, and sector.

In million metric tons (mmt) carbon dioxide equivalent ($CO_2e$). PFCs = perfluorocarbons; $CO_2$ = carbon dioxide. Underlying data for this figure can be found in appendix J, table J.9.



Source: IAI “Aluminium Sector Greenhouse Gas Emissions for 2022,” April 11, 2024.
Note: With respect to wrought production, the IAI refers to this as “semis production” and does not specify the products it includes in this category; however, such production might include plates, sheets, strip, foil, extrusions, and foundry castings. This coverage may differ slightly from the products included within the “wrought” category as defined in this report. Internal scrap remelting may occur in primary unwrought, secondary unwrought, or wrought production.

## Aluminum System Boundary

As discussed in box 2.1, the Commission adopted a “cradle-to-gate” methodology in determining its system boundaries. The system boundary used in this report to calculate emissions estimates for the domestic aluminum industry encompasses nearly all major inputs and physical or chemical processes used to make the products covered within the request letter, with all relevant scope 1, 2, and 3 emissions included, with some exceptions.

Similar to the steel diagrams earlier in this chapter, items outside the system boundary in figure 2.8 represent a non-exhaustive list of processes that are such exceptions and are excluded from the Commission’s emissions calculations.[261] One exception is the transportation of materials between facilities or in on-site operations. A request for data necessary to estimate transportation-related emissions—such as the transportation mode or distance, the origin of materials where not otherwise requested, or the length of the supply chain beyond immediate suppliers—would have substantially increased the burden on responding facilities.[262] Additionally, although the system boundary includes emissions from reheating or remelting of scrap, it does not include processes that shred or sort scrap. Processes related to extracting or processing coal and natural gas were also excluded given the uncertainty around their estimates.[263] Finally, processes not directly contributing to the production of covered products, such as ancillary activities not involved with production floor operations and activities of other producers operating on-site, are excluded from the system boundary to ensure the emissions included in the emissions intensity estimates were specific to the product category. Figure 2.8 provides a depiction of the system boundary as defined by the Commission for its emissions calculations.

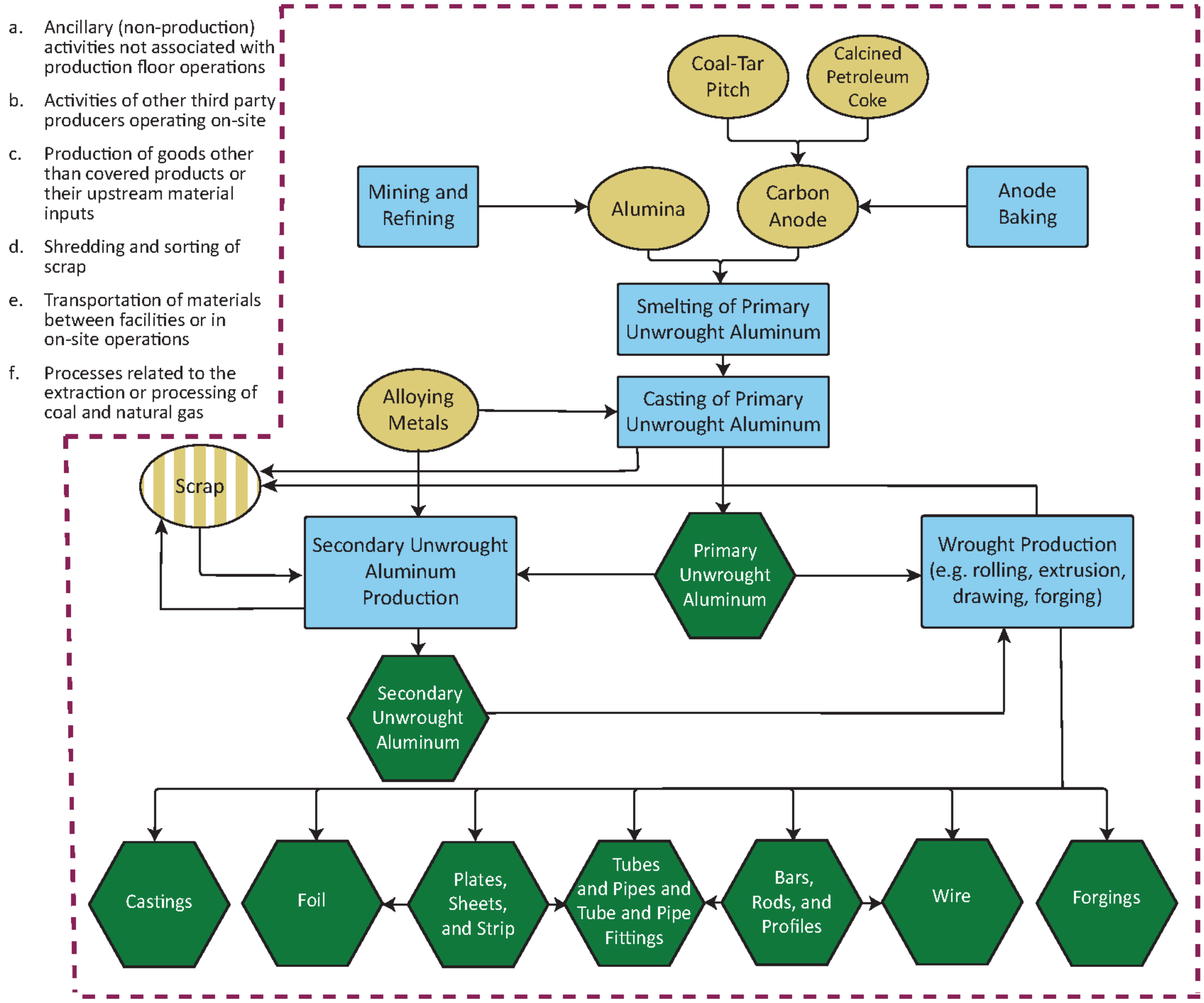
---

[261] The processes are noted here specifically to clarify their exclusion from calculations, even though: (1) the Commission collected data on them in its questionnaire (this applies to items a through d); (2) this process is included in other commonly used corporate accounting frameworks like the GHG Protocol (this applies to item e); and (3) estimates including a range of emissions potentially generated from these processes are presented in a sensitivity analysis (this applies to item f).

[262] In addition, the Commission’s decision to not estimate transportation-related emissions was based on its effort to maintain consistency with emissions data reported under the GHGRP. Under the GHGRP, facilities are required to report fuel combustion emissions under subpart C for stationary combustion sources only and are asked to exclude emissions from non-stationary (including transport) sources. 40 C.F.R § 98.30.

[263] Although emissions associated with transportation, sorting, shredding, and distribution of scrap and extraction and processing of fuel and coal are not explicitly accounted for in the Commission’s system boundary, it is possible that some of these emissions are included in certain scope 3 emissions calculations. The Commission used default emissions factors derived from other sources like the IAI and the Aluminium Stewardship Initiative that included those processes within their own system boundaries. See table G.2 for a complete listing of aluminum default factors and their sources.

**Figure 2.8** Aluminum system boundary for the Commission’s emissions estimates



a. Ancillary (non-production) activities not associated with production floor operations
b. Activities of other third party producers operating on-site
c. Production of goods other than covered products or their upstream material inputs
d. Shredding and sorting of scrap
e. Transportation of materials between facilities or in on-site operations
f. Processes related to the extraction or processing of coal and natural gas

Source: Compiled by the USITC.
Notes: The dashed outline around the box indicates the system boundary. Emissions related to items within the system boundary are included in the USITC’s emissions calculations. All items (a through f) outside the system boundary in the diagram were excluded from the USITC’s emissions calculations. Items a through d were specifically asked about in the Commission’s questionnaire. While excluded from the Commission’s main emissions intensity findings, the potential contribution to emissions intensities of fugitive methane emissions released in the processes in item f is calculated in a sensitivity analysis featured in appendix F of this report.
Within the system boundary, hexagons represent covered products, rectangles represent main processes performed to generate these inputs and covered products, and arrows represent the flow of inputs into these processes. Covered products can sometimes serve as inputs for other covered products—all other inputs are shown as ovals. Scrap, shown in the striped oval, is an input for which data from facilities are collected in the Commission’s questionnaire, but zero emissions burden is assigned.

The system boundary defined in this report is similar in many ways to those in other emissions accounting methodologies.[264] The way in which embedded emissions are treated or calculated for certain items within the system boundary are also often similar to other aluminum emissions accounting methodologies. For example, as noted earlier in this chapter, alloying elements were assigned a primary

---

[264] For more information on the similarities and differences in the Commission’s system boundary approach and other relevant methodologies, see appendix E (“IV. Standards Informing the Commission’s Methodology Development”), table E.15.

aluminum emissions factor, a method used by several other technical papers and comparative emissions collection efforts. The Commission's assignment of zero embedded emissions to scrap inputs is similar to many similar methodologies, but as of this writing no consensus has been reached within the aluminum industry on this treatment of scrap. See table E.15 in appendix E ("IV. Standards Informing the Commission's Methodology Development") for a comparison of methodologies between the Commission's approach and other frameworks, including scrap treatment in emissions accounting. Box 2.3 below provides further details on the Commission's treatment of scrap as compared to other methodologies.

**Box 2.3** Treatment of Embedded Emissions Aluminum Scrap

Broadly, two types of scrap are used in aluminum production. The first, postconsumer or "end-of-life" scrap, has been recovered from items that have fulfilled the purpose for which they were produced. Examples include articles such as used beverage cans or recycled automotive parts. The second, pre-consumer scrap or "process scrap," was produced during the manufacture of aluminum products or downstream processes before reaching the end consumer. The combination of pre-consumer and postconsumer scrap is known as mixed scrap.

Most stakeholders agree that postconsumer scrap should not carry embedded emissions in the emissions accounting of aluminum products. Accounting methodologies generally assign zero emissions to postconsumer scrap. Stakeholders, however, disagree on whether pre-consumer scrap should be treated in the same way. During the Commission's hearing for this investigation, one industry representative said that pre-consumer scrap should carry embedded emissions, while two others said it should not.[a] This divergence of opinions on the treatment of scrap is reflected in the greenhouse gas accounting methodologies used by the aluminum industry in its emissions accounting.[b] For example, the International Aluminium Institute (IAI) presents three options in its draft guidance on the treatment of scrap flows, all of which are derived from different International Organization for Standardization (ISO) standards.[c] Two of these approaches assign some embedded emissions to pre-consumer scrap while the other approach assigns zero embedded emissions to pre-consumer scrap.

The approaches that assign emissions to pre-consumer scrap require the ability to distinguish between the different types of scrap. According to industry representatives, many facilities that produce covered aluminum products receive mixed scrap at their facilities and are unable to distinguish between pre-consumer scrap inputs and postconsumer scrap inputs.[d] Accordingly, the Commission collected data on scrap usage in its questionnaire but designated all scrap as having zero embedded emissions.[e] This approach is consistent with the methodology the European Commission has used in Carbon Border Adjustment Mechanism (CBAM) reporting guidance. Similarly, the Aluminum Association and Aluminum Extruders Councils' cradle-to-gate life cycle analyses on certain aluminum products also treat all upstream scrap as having zero embedded emissions. Additionally, while the IAI, as noted above, offers several approaches for the treatment of scrap, its guidance notes that collecting data on pre- and postconsumer scrap shares, as done by the Commission, is good practice.[f]

[a] USITC, hearing transcript, December 7, 2023, 229–30, 247-48 (testimonies of Dave Neuner, Novelis; Laura Chambers, Alcoa; Charles Johnson, Aluminum Association). See also Soreide, "Hydro's Position on How to Calculate Carbon Footprint of Recycled Aluminium," November 9, 2019.
[b] RMI, "Aluminum GHG Emissions Reporting Guidance," December 2023, 15; IAI, "Reference Document on How to Treat Scrap Flows in Carbon Footprint Calculations for Aluminium Products," January 2023.
[c] IAI, "Reference Document on How to Treat Scrap Flows in Carbon Footprint Calculations for Aluminium Products," January 2023, 59.
[d] Industry representatives, interview by USITC staff, December 12, 2023. See also RMI, "Aluminum Emissions Reporting Guidance," December 2023, 9.
[e] USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, responses to questions 5.2.1a–c, 5.2.2a–c, 5.2.3a–c.
[f] EU, C, DG-TAXUD, *CBAM Guidance for Installations*, December 8, 2023, 66; AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 49; Sphera Solutions, *Aluminum Extrusion EPD Background Report*, November 4, 2022; IAI, "Reference Document on How to Treat Scrap Flows in Carbon Footprint Calculations for Aluminium Products," January 2023

# Bibliography

Adjusting Imports of Aluminum into the United States, 83 Fed. Reg. 11619. March 15, 2018. https://www.federalregister.gov/documents/2018/03/15/2018-05477/adjusting-imports-of-aluminum-into-the-united-states.

Adjusting Imports of Steel into the United States, 83 Fed. Reg. 11625. March 15, 2018. https://www.federalregister.gov/documents/2018/03/15/2018-05478/adjusting-imports-of-steel-into-the-united-states.

Alcoa Corporation. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810882.

Aluminum Association (AA). *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*. January 2022. https://www.aluminum.org/sites/default/files/2022-01/2022_Semi-Fab_LCA_Report.pdf.

Aluminum Association (AA). “Alumina Refining 101.” Accessed November 5, 2024. https://www.aluminum.org/alumina-refining-101.

Aluminum Association (AA). “Infinitely Recyclable.” Accessed November 5, 2024. https://www.aluminum.org/Recycling.

Aluminum Association (AA). “Primary Production 101.” Accessed March 11, 2024. https://www.aluminum.org/primary-production-101.

American Galvanizers Association (AGA). “Batch Hot-Dip Galvanizing.” Accessed October 21, 2024. https://galvanizeit.org/corrosion/corrosion-protection/zinc-coatings/batch-hot-dip-galvanizing.

American Galvanizers Association (AGA). “Electroplating.” Accessed October 21, 2024. https://galvanizeit.org/corrosion/corrosion-protection/zinc-coatings/electroplating.

American Institute of Steel Construction (AISC). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 20, 2023. https://edis.usitc.gov/external/search/document/808944.

American Iron and Steel Institute (AISI). *Steel Production Greenhouse Gas Emissions Calculation Methodology Guidelines*. AISI, November 3, 2022. https://www.steel.org/wp-content/uploads/2022/11/AISI-GHG-Emissions-Calculation-Methodology-Guidelines-final-11-3-22.pdf.

American Iron and Steel Institute (AISI). “Glossary.” Accessed August 25, 2024. https://www.steel.org/steel-technology/steel-production/glossary/.

American Iron and Steel Institute (AISI). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 21, 2023. https://edis.usitc.gov/external/search/document/809088.

American Iron and Steel Institute (AISI). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810875.

American Piping Products. “Welded vs. Seamless Steel Pipe.” American Piping Products, July 2, 2018. https://amerpipe.com/welded-vs-seamless-steel-pipe/.

ArcelorMittal. “ArcelorMittal Europe to Produce ’green Steel’ Starting in 2020.” October 13, 2020. https://corporate.arcelormittal.com/media/news-articles/arcelormittal-europe-to-produce-green-steel-starting-in-2020/.

ArcelorMittal. “Blast Furnace.” Accessed October 18, 2024. https://corporate.arcelormittal.com/about/making-steel/making-iron-steel-blast-furnace/.

ArcelorMittal. “Sinter Plant.” Accessed October 22, 2024. https://corporate.arcelormittal.com/about/making-steel/raw-materials-sinter-plant/.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel, Argon Oxygen Decarburizations.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel, Basic Oxygen Furnace.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel, Blast Furnace.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel, Casting.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel, Electric Arc Furnace.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel, Ladle Metallurgy Furnace.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel, Refining Station.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel, Vacuum Degassing.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association for Iron & Steel Technology (AISTI). “AIST Steel Wheel, Galvanized.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Australian Aluminium Council Ltd. *Bauxite: Australian Bauxite Will Help Meet Global Demand for Aluminium*. July 2022. https://aluminium.org.au/wp-content/uploads/2021/10/220719-PATHWAY-FACT-SHEET-02-BAUXITE.pdf.

Biberman, John, Perrine Toledano, and Rohini Ram Mohan. “GHG Accounting Methods in the Aluminum Industry.” *SSRN Electronic Journal* (2023). https://doi.org/10.2139/ssrn.4407422.

Bussewitz, Cathy. “Difficulty Measuring Methane Slows Plan to Slash Emissions.” AP News, January 31, 2023. https://apnews.com/article/drones-business-climate-and-environment-0a1ab9be3427818cfe5f33521b9b05c2.

Century Aluminum Company. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. January 8, 2024. https://edis.usitc.gov/external/search/document/812141.

Cleveland-Cliffs Inc. “Cleveland-Cliffs Selected to Receive $575 Million in US Department of Energy Investments for Two Projects to Accelerate Industrial Decarbonization Technologies.” News release, March 25, 2024. https://www.clevelandcliffs.com/news/news-releases/detail/629/cleveland-cliffs-selected-to-receive-575-million-in-us.

Cleveland-Cliffs Inc. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 29, 2023. https://edis.usitc.gov/external/search/document/809485.

Congressional Research Service (CRS). *U.S. Aluminum Manufacturing: Industry Trends and Sustainability*. R47294. October 6, 2022. https://crsreports.congress.gov/product/pdf/R/R47294.

Committee on Pipe and Tube Imports (CPTI). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810830.

Dworak, Sabine, Helmut Rechberger, and Johann Fellner. “How Will Tramp Elements Affect Future Steel Recycling in Europe? – A Dynamic Material Flow Model for Steel in the EU-28 for the Period 1910 to 2050.” *Resources, Conservation and Recycling* 179 (April 2022): 106072. https://doi.org/10.1016/j.resconrec.2021.106072.

*Encyclopedia Britannica Online*. “Alumina.” November 5, 2024. https://www.britannica.com/science/alumina#ref148550.

Energetics, Incorporated. *ITP Steel: Energy and Environmental Profile of the U.S. Iron and Steel Industry*. Prepared for U.S. Department of Energy (USDOE). Office of Industrial Technologies. DOE/EE-0229. Energetics, Incorporated, August 2000. https://www.energy.gov/eere/amo/articles/itp-steel-energy-and-environmental-profile-fo-us-iron-and-steel-industry.

European Commission (EC). Directorate-General Taxation and Customs Union (DG TAXUD). *Guidance Document on CBAM Implementation for Installation Operators Outside the EU*. Brussels, Belgium: European Commission, December 8, 2023. https://taxation-customs.ec.europa.eu/document/download/2980287c-dca2-4a4b-aff3-db6374806cf7_en?filename=Guidance%20document%20on%20CBAM%20implementation%20for%20installation%20operators%20outside%20the%20EU.pdf.

Faber, Terry. *Iron and Steel Manufacturing in the US*. Industry Report 33111. IBISWorld, February 2022. https://www.ibisworld.com/united-states/market-research-reports/iron-steel-manufacturing-industry/.

Fenton, Michael D. *Mineral Commodity Profiles—Iron and Steel*. Open-File Report 2005–1254. U.S. Geological Survey (USGS), 2005. https://pubs.usgs.gov/of/2005/1254/2005-1254.pdf.

Global Steel Climate Council (GSCC). *The Steel Climate Standard: Framework for Steel Product Certification and Corporate Science-Based Emissions Targets*. August 2023. https://globalsteelclimatecouncil.org/the-standard/.

Haque, Nawshad, and Terry Norgate. “20 - Life Cycle Assessment of Iron Ore Mining and Processing.” In *Iron Ore*, edited by Liming Lu, 615–30. Woodhead Publishing, January 1, 2015. https://doi.org/10.1016/B978-1-78242-156-6.00020-4.

Intergovernmental Panel on Climate Change (IPCC). “2006 IPCC Guidelines for National Greenhouse Gas Inventories.” July 2023. https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

International Aluminium Institute (IAI). Aluminium Sector Greenhouse Gas Emissions for 2022. September 27, 2024. https://international-aluminium.org/statistics/greenhouse-gas-emissions-aluminium-sector/.

International Aluminium Institute (IAI). “Primary Aluminium Greenhouse Gas Emissions for 2022.” April 11, 2024. https://international-aluminium.org/statistics/greenhouse-gas-emissions-primary-aluminium/.

International Aluminium Institute (IAI). “Reference Document on How to Treat Scrap Flows in Carbon Footprint Calculations for Aluminium Products (Draft for Public Review).” January 2023. https://international-aluminium.org/resource/public-review-guidelines-on-transparency-aluminium-scrap/.

International Energy Agency (IEA). *Iron and Steel Technology Roadmap: Towards More Sustainable Steelmaking*. IEA, October 8, 2020. https://www.iea.org/reports/iron-and-steel-technology-roadmap.

International Iron Metallics Association (IIMA). “Ore Based Metallics.” 2021. https://www.metallics.org/ore-based-metallics.html.

International Iron Metallics Association (IIMA). “DRI Production.” Accessed September 21, 2024. https://www.metallics.org/dri-production.html.

Kittipongvises, Suthirat. “Assessment of Environmental Impacts of Limestone Quarrying Operations in Thailand.” *Environmental and Climate Technologies* 20, no. 1 (November 27, 2017): 67–83. https://doi.org/10.1515/rtuect-2017-0011.

Kremser, Ron, Niclas Grabowski, Roman Düssel, Albert Mulder, and Dietmar Tutsch. “Anode Effect Prediction in Hall-Héroult Cells Using Time Series Characteristics.” *Applied Sciences* (December 18, 2020). https://doi.org/10.3390/app10249050.

Kvande, Halvor, and Per Arne Drabløs. “The Aluminum Smelting Process and Innovative Alternative Technologies.” *Journal of Occupational and Environmental Medicine (JOEM)* 56, no. 5 Suppl (May 8, 2014): S23. https://doi.org/10.1097/JOM.0000000000000062.

LeClaire Manufacturing Co. “Which Aluminum Casting Method Is Right for You?” April 16, 2019. https://www.leclairemfg.com/about-us/blog/which-aluminum-casting-method-is-right-for-you/.

Liu, Wenjuan, and Sravan Chalasani. *Aluminum Emissions Reporting Guidance (Draft for Public Consultation)*. Rocky Mountain Institute (RMI), April 2023. https://rmi.org/wp-content/uploads/dlm_uploads/2023/05/aluminum_guidance_public_consultation.pdf.

L&L Special Furnace. “Aluminum Heat Treatment: Homogenizing.” L&L Special Furnace, June 11, 2021. https://llfurnace.com/blog/aluminum-heat-treatment-homogenizing/.

London Stock Exhange Group (LSEG). “WBMS, World Metal Statistics Yearbook 2022.” LSEG Metals Research, 2023. https://www.lseg.com/en/data-analytics/financial-data/commodities-data/metals-data/world-bureau-of-metal-statistics-wbms.

Midrex Technologies, Inc. “Direct Reduced Iron (DRI).” Midrex Technologies, Inc. Accessed November 13, 2024. https://www.midrex.com/direct-reduced-iron/.

Narayanan, Ramesh. “Chemical Interactions of Dross with Water and Water Vapor in Aluminum Scrap Remelting.” *Materials Transactions JIM* 38, no. 1 (January 1, 1997): 85–88. https://doi.org/10.2320/MATERTRANS1989.38.85.

National Lime Association (NLA). “Iron and Steel.” Accessed August 25, 2024. https://www.lime.org/lime-basics/uses-of-lime/metallurgical-uses-of-lime/iron-and-steel/.

Nippon Steel Corporation. “Verified the World’s Highest Level of CO2 Emissions Reduction at 33% by Heated Hydrogen Injection in the Super COURSE50 Test Furnace.” News release, February 6, 2024. https://www.nipponsteel.com/en/news/20240206_100.html.

Novelis Corporation. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810880.

Nucor Corporation. "Steel Pipe." Accessed October 19, 2024. https://www.nucorskyline.com/globalnav/products/pipe.

Nucor Corporation. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810849.

Nucor Corporation. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. January 5, 2024. https://edis.usitc.gov/external/search/document/811650.

Olczak, Maria, Andris Piebalgs, and Paul Balcombe. "A Global Review of Methane Policies Reveals That Only 13% of Emissions Are Covered with Unclear Effectiveness." *One Earth* 6, no. 5 (May 19, 2023): 519–35. https://doi.org/10.1016/j.oneear.2023.04.009.

Organisation for Economic Co-operation and Development. *Addressing Information Gaps on Prices of Mineral Products: The Transformation Chains and Products of Gold, Copper and Iron Ore Mines*. OECD, October 2015. https://www.scribd.com/document/661338222/Mineral-Product-Transformation-Chains-Studies.

Organisation for Economic Co-operation and Development. *The Heterogeneity of Steel Decarbonisation Pathways*. OECD, April 5, 2023. https://www.oecd.org/publications/the-heterogeneity-of-steel-decarbonisation-pathways-fab00709-en.htm.

Outokumpu Stainless USA, LLC. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 21, 2023. https://edis.usitc.gov/external/search/document/809124.

Padamata, Sai Krishna, Andrey Yasinskiy, and Peter Polyakov. "A Review of Secondary Aluminum Production and Its Byproducts." *Journal of the Minerals, Metals, and Materials Society (JOM)* 73 (July 30, 2021). https://link.springer.com/article/10.1007/s11837-021-04802-y.

PE Americas. "Final Report: Life Cycle Impact Assessment of Aluminum Beverage Cans." May 21, 2010. https://ecomyths.org/wp-content/uploads/2020/11/lca-2010-aluminumassoc.pdf.

Pokladnik, Randi. "The Myth of 'Green Steel' in Ohio and Its Steel Valleys." Cleveland.com, May 8, 2024. https://www.cleveland.com/opinion/2024/05/the-myth-of-green-steel-in-ohio-and-its-steel-valleys-randi-pokladnik.html.

Rain Industries. "Carbon." Rain Industries. Accessed November 5, 2024. https://www.rain-industries.com/business-overview/carbon.

ResponsibleSteel. *ResponsibleSteel International Production Standard: Version 2.1*. May 21, 2024. https://www.responsiblesteel.org/standards.

Rutherford, Jeffrey S., Evan D. Sherwin, Arvind P. Ravikumar, Garvin A. Heath, Jacob Englander, Daniel Cooley, David Lyon, Mark Omara, Quinn Langfitt, and Adam R. Brandt. “Closing the Methane Gap in US Oil and Natural Gas Production Emissions Inventories.” *Nature Communications* 12, no. 1 (August 5, 2021): 4715. https://doi.org/10.1038/s41467-021-25017-4.

Satyendra, Kumar Sarna. “Ladle Metallurgy.” IspatGuru, April 23, 2014. https://www.ispatguru.com/ladle-metallurgy/.

Satyendra, Kumar Sarna. “Limestone and Dolomite and their Use in Iron and Steel Plant.” IspatGuru, May 8, 2013. https://www.ispatguru.com/limestone-and-dolomite-flux-and-their-use-in-iron-and-steel-plant/.

Satyendra, Kumar Sarna. “Production of Seamless Pipes.” IspatGuru, July 26, 2014. https://www.ispatguru.com/production-of-seamless-pipes/.

Science-Based Targets Initiative (SBTi). *Steel Science-Based Target-Setting Guidance: Version 1.0*. July 2023. https://sciencebasedtargets.org/resources/files/SBTi-Steel-Guidance.pdf.

Shinzato, M. C., and R. Hypolito. “Solid Waste from Aluminum Recycling Process: Characterization and Reuse of Its Economically Valuable Constituents.” *Waste Management* 25, no. 1 (January 1, 2005): 37–46. https://doi.org/10.1016/j.wasman.2004.08.005.

SIA Partners, “Reducing Methane Emissions: The Key Role of Data.” November 7, 2024. https://www.sia-partners.com/en/insights/publications/reducing-methane-emissions-key-role-data.

Silverado Policy Accelerator. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 17, 2023. https://edis.usitc.gov/external/search/document/808917.

Soreide, Jostein. “Hydro’s Position on How to Calculate Carbon Footprint of Recycled Aluminium.” Norsk Hydro ASA (Hydro), November 9, 2019. https://www.hydro.com/en/global/about-hydro/publications/white-papers/Carbon-footprint-of-recycled-aluminium-whitepaper/.

Springer, Cecilia, and Ali Hasanbeigi. “Emerging Energy Efficiency and Carbon Dioxide Emissions-Reduction Technologies for Industrial Production of Aluminum.” (June 2016). https://international.lbl.gov/publications/emerging-energy-efficiency-and-0.

SSAB. “Fossil Free Steel.” Accessed December 16, 2024. https://www.ssab.com/en-us/fossil-free-steel.

SSAB. “SSAB Selected by U.S Department of Energy to Explore Possibilities for Production of Fossil-Free Steel in the U.S.” March 25, 2024. https://www.ssab.com/en/news/2024/03/ssab-selected-by-us-department-of-energy-to-explore-possibilities-for-production-of-fossilfree-steel.

Steel Dynamics, Inc. (SDI). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810841.

Steel Manufacturers Association (SMA). *Steelmaking Emissions Report 2022*. June 14, 2022. https://steelnet.org/steelmaking-emissions-report-2022/.

Steel Manufacturers Association (SMA). “Sustainability.” Accessed October 24, 2024. https://steelnet.org/sustainability/.

Stegra. “Stegra Boden – World’s First Large-Scale Green Steel Plant.” Accessed December 16, 2024. https://stegra.com/the-boden-plant.

Su, Romain, and Adrien Assous. *Starting from Scrap: The Key Role of Circular Steel in Meeting Climate Goals*. Sandbag, June 2022. https://sandbag.be/wp-content/uploads/Sandbag-Starting-from-Scrap.pdf.

thyssenkrupp. “Sustainable Steel: Review of Phase 1 of the Injection Trials.” thyssenkrupp AG, accessed December 20, 2024. https://www.thyssenkrupp.com/en/stories/sustainability-and-climate-protection/green-steel-review-of-phase-1-of-the-injection-trials.

United States Steel Corporation (U. S. Steel). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 29, 2023. https://edis.usitc.gov/external/search/document/809484.

United States Steel Corporation (U. S. Steel). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810842.

U.S. Department of Commerce (USDOC), International Trade Administration (ITA). “Global Steel Report 2019.” (March 2021). https://www.trade.gov/sites/default/files/2021-03/Global%20Report%202019%20.pdf.

U.S. Department of Energy (USDOE). *Fossil Energy Study Guide: Coal*. February 10, 2010. https://www.energy.gov/sites/prod/files/2013/04/f0/MS_Coal_Studyguide_draft1.pdf.

U.S. Department of Energy (USDOE). “U.S. Department of Energy Announces $28 Million to Decarbonize Domestic Iron and Steel Production.” April 18, 2024. http://arpa-e.energy.gov/news-and-media/press-releases/us-department-energy-announces-28-million-decarbonize-domestic-iron.

U.S. Department of Energy (USDOE). Industrial Technologies Program. *U.S. Energy Requirements for Aluminum Production*. February 2007. https://www1.eere.energy.gov/manufacturing/resources/aluminum/pdfs/al_theoretical.pdf.

U.S. Department of Energy (USDOE). Office of Industrial Technologies (OIT). *Aluminum Project Fact Sheet: Structural Factors Affecting Formability*. October 2001. https://cat.engr.uky.edu/sites/cat/files/structuralfactors.pdf.

U.S. Energy Information Administration (EIA). "FAQs: How Much Electricity Does an American Home Use?" Accessed September 16, 2024. https://www.eia.gov/tools/faqs/faq.php?id=97&t=3.

U.S. Environmental Protection Agency (EPA). *Economic Impact Analysis for the Final National Emission Standards for Hazardous Air Pollutants: Taconite Iron Ore Processing Amendments*. January 2024. https://www.epa.gov/system/files/documents/2024-02/taconite-eia-12866-final.pdf.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). "Technical Support Document for the Iron and Steel Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases." August 28, 2009. https://www.epa.gov/sites/default/files/2015-02/documents/tsd_iron_and_steel_epa_9-8-08.pdf.

U.S. Geological Survey (USGS). *Mineral Commodity Summaries 2024: Aluminum*. USGS, January 2024. https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-aluminum.pdf.

U.S. Geological Survey (USGS). *Mineral Commodity Summaries 2024: Bauxite and Alumina*. USGS, January 2024. https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-bauxite-alumina.pdf.

U.S. Geological Survey (USGS). *Mineral Commodity Summaries 2024: Iron and Steel*. USGS, January 2024. https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-iron-steel.pdf.

U.S. Geological Survey (USGS). *Minerals Yearbook 2019: Iron Ore*. USGS, September 2024. https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/media/files/myb1-2022-feore-ert_2.xlsx.

U.S. Geological Survey (USGS). *Minerals Yearbook 2022 Tables-Only Release: Iron Ore*. USGS, September 24, 2024. https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/media/files/myb1-2022-feore-ert_2.xlsx.

U.S. Geological Survey (USGS), National Minerals Information Center (NMIC). "Iron and Steel Statistics and Information." Accessed September 21, 2024. https://www.usgs.gov/centers/national-minerals-information-center/iron-and-steel-statistics-and-information.

U.S. International Trade Commission (USITC). *Aluminum: Competitive Conditions Affecting the U.S. Industry*. USITC Publication 4703, June 2017. https://www.usitc.gov/publications/332/pub4703.pdf.

U.S. International Trade Commission (USITC). *Aluminum Extrusions from China*. USITC Publication 5375, October 2022. https://www.usitc.gov/publications/701_731/pub5375.pdf.

U.S. International Trade Commission (USITC). *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_facility-level_questionnaire_aluminum_and_steel_combined.pdf.

U.S. International Trade Commission (USITC). Harmonized Tariff Schedule of the United States (HTS) (2024) Revision 10. Publication Number 5569. November 2024. https://hts.usitc.gov.

U.S. International Trade Commission (USITC). Hearing Transcript in Connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 7, 2023. https://edis.usitc.gov/external/search/document/810108.

Valbruna Group. "Stainless Steel Long Products." Accessed September 22, 2024. https://www.valbruna-stainless-steel.com/production.

Verichek Technical Services, Inc. "How To Determine Carbon Content in Steel." Verichek Technical Services, June 22, 2017. https://verichek.net/carbon-content-in-steel.html.

Vitz, Ed, John Moore, Justin Shorb, Xavier Prat-Resina, Tim Wendorff, and Adam Hahn. "Beneficiation." Chemistry LibreTexts. Accessed August 24, 2024. https://chem.libretexts.org/Bookshelves/General_Chemistry/ChemPRIME_(Moore_et_al.)/22%3A_Metals/22.04%3A_Beneficiation.

Vulcan Aluminum Mill. "Why Continuous Casting?" Accessed November 6, 2024. https://aluminummill.vulcaninc.com/our-process.php.

Watson, Christopher. *Domestic Steel Manufacturing: Overview and Prospects*. Congressional Research Service (CRS), May 17, 2022. https://crsreports.congress.gov/product/pdf/R/R47107.

World Bank Group. *The Platform for Cooperation on Tax: Discussion Draft: Addressing the Information Gaps on Prices of Minerals Sold in an Intermediate Form*. January 24, 2017. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/775571485262636835/Discussion-draft-addressing-the-information-gaps-on-prices-of-minerals-sold-in-an-intermediate-form.

World Economic Forum. "Aluminium for Climate: Exploring Pathways to Decarbonize the Aluminium Industry." World Economic Forum, November 2020. https://www3.weforum.org/docs/WEF_Aluminium_for_Climate_2020.pdf.

World Steel Association (worldsteel). "Glossary." Accessed August 25, 2024. https://worldsteel.org/about-steel/glossary/.

World Steel Association (worldsteel). "Hydrogen (H2)-Based Ironmaking." June 2022. https://worldsteel.org/wp-content/uploads/Fact-sheet-Hydrogen-H2-based-ironmaking.pdf.

World Steel Association (worldsteel). *Sustainability Indicators 2023 Report*. Accessed October 24, 2024. https://worldsteel.org/steel-topics/sustainability/sustainability-indicators-2023-report/.

World Steel Association (worldsteel). "What Is Steel?" Accessed September 21, 2024. https://worldsteel.org/about-steel/what-is-steel/.

World Steel Association (worldsteel). *World Steel in Figures 2023: Major Steel-Producing Countries*. Accessed April 12, 2024. https://worldsteel.org/data/world-steel-in-figures-2023/.

Wright, Lachlan, Xiyuan Liu, Iris Wu, and Sravan Chalasani. *Steel GHG Emissions Reporting Guidance*. RMI, June 2023. https://rmi.org/wp-content/uploads/2022/09/steel_emissions_reporting_guidance.pdf.

Yilmaz, Can, Jens Wendelstorf, and Thomas Turek. "Modeling and Simulation of Hydrogen Injection into a Blast Furnace to Reduce Carbon Dioxide Emissions." *Journal of Cleaner Production* 154 (June 15, 2017): 488–501. https://doi.org/10.1016/j.jclepro.2017.03.162.

# Chapter 3
# Overview of Emissions Intensity Calculation Methodology

To generate product-category-level emissions intensity estimates, the Commission developed a methodology to calculate a facility's total emissions and allocate these emissions to the pertinent covered products the facility produces. This chapter lays out that procedure. It begins by outlining the Commission's approach toward calculating emissions intensity estimates, broken into three stages, and summarizes the types of data sources used to perform these calculations. The chapter then describes the steps undertaken in each stage of the calculation approach to compile, allocate, and analyze data appropriately within the Commission's emissions intensity estimate procedure. An illustrative application of the calculation steps to two sample facilities (one producing covered steel products and one producing covered aluminum products) is interspersed throughout the chapter following descriptions of the steps. These applications of the calculation to the sample facilities are titled as multi-part "Examples" inside boxes throughout the chapter—blue boxes for steel, and yellow boxes for aluminum.[265]

## Overall Approach and Data Used

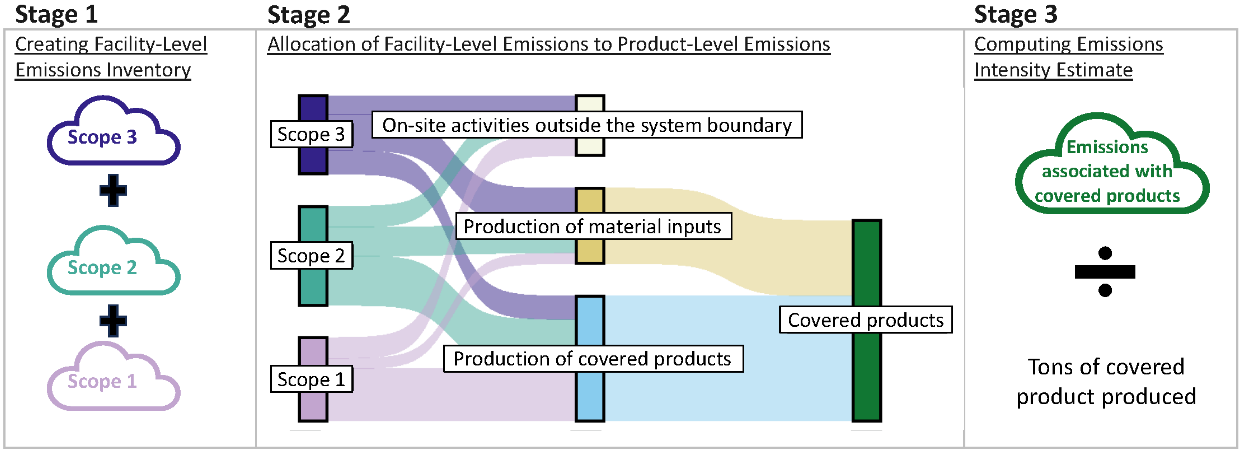
The Commission developed its three-stage calculation approach after reviewing various emissions accounting standards and frameworks and in conjunction with the design of the Commission's survey questionnaire.[266] In each of the three stages of the calculations (as well as in its data collection), the Commission followed the guiding principles laid out in chapter 1 ("Guiding Principles for This Investigation"). Figure 3.1 is a visualization of the calculation stages. In stage 1, the Commission compiled a facility-level emissions inventory for each surveyed facility across all scopes of emissions reported. In stage 2, the Commission calculated product-level emissions by allocating emissions from the facility-level inventory. In stage 3, the Commission computed emissions intensity estimates for each product category from these product-level emissions and production data.

---

[265] Sample facilities are not based on any one actual surveyed facility but are instead an amalgam of a realistic set of operations, energy sourcing, and input use across surveyed facilities.

[266] The Commission released a draft of its proposed methodology on the investigation website during the public comment period for its draft survey questionnaires (November 2023–January 2024). 88 Fed. Reg. 76854 (November 7, 2023). Interested persons provided feedback on the proposed methodology in their hearing testimony, public comments, written submissions, and interviews with Commission staff. The final calculation methodology presented here considered this feedback and incorporated it when possible and appropriate. For more information on this process and a comparison of the Commission's methodology to that of other standards, see appendix E: introduction and "IV. Standards Informing the Commission's Methodology Development."

**Figure 3.1** Illustration of three stages of the Commission's calculation approach



Source: Compiled by the USITC.

To calculate emissions intensities, the Commission relied on five main data types: emissions data, activity data, factor data, production output of covered products data (hereafter "production data"), and allocation information. As indicated below, several of these data types can be used to calculate other data types.

- **Emissions data** report the quantities of emissions produced by a particular industrial activity or embedded within a particular product. Emissions data can represent emissions that have been directly measured or calculated by multiplying activity data by emissions factors (described further below). As discussed in chapter 1 ("Introduction to GHG Emissions"), the quantity of emissions of different greenhouse gases (GHGs) is standardized by the global warming potential (GWP) of each gas relative to carbon dioxide ($CO_2$) for reporting purposes. Emissions data in this report are typically presented in units of metric tons of carbon dioxide equivalent ($CO_2e$).
- **Activity data** are a quantitative measure of a level of activity that results in GHG emissions. Activity data in this investigation measure quantities of inputs received or used by facilities (e.g., gallons of fuel combusted or metric tons of carbon anodes consumed) and are multiplied by an emissions factor to produce emissions data.
- **Emissions factors** are data points that correspond to particular activity data to convert quantity levels of activity into emissions data. Emissions factors are typically presented in units of mt $CO_2e$ per unit of activity data and are multiplied by activity data to calculate emissions associated with an activity. Emissions factors include direct emissions factors that measure direct emissions generated from use of a unit of fuel or material input (e.g., emissions that occur per gallon of fuel combusted). Emissions factors also include indirect emissions factors that measure the indirect emissions associated with the production of energy or material inputs received from other sources (e.g., the emissions embedded in each ton of carbon anodes consumed).
- **Production data** in this investigation measure the quantities of production of covered steel and aluminum products. Production data in this report are presented in units of metric tons of production output.
- **Allocation information** is data used to allocate emissions across different processes occurring at the same facility and to the facility's output of materials shipped off-site. Allocation information includes the reported quantities of fuel, energy, and material used in various facility

subprocesses. In addition, allocation information includes production data split between production for use in the same facility and production for external shipment. Allocation information is typically collected as quantities of inputs or outputs—those quantities are converted to percentages or shares, which are used to subdivide emissions data or activity data.

The Commission gathered these five types of data from three main sources—the U.S. Environmental Production Agency (EPA)'s Greenhouse Gas Reporting Program (GHGRP), the Commission's questionnaire, and other external databases. The main uses of these three data sources in the Commission's calculations are summarized below. More specific applications of these data sources within the calculation steps are explained in greater detail throughout this chapter.

The first of these three data sources is the GHGRP. The GHGRP is an annual program for reporting direct GHG emissions that is required of facilities emitting over 25,000 mt of $CO_2$e annually and facilities conducting certain types of industrial activities with any level of associated emissions.[267] Facilities to which these criteria apply must report emissions across more than 30 source categories to the EPA. The specific reporting requirements are set out in the *Code of Federal Regulations* (40 C.F.R. § 98). Each source category of emissions is designated under a different subpart of the regulation, and each subpart lays out the acceptable methods for emissions calculation.

For facilities that report to the GHGRP and produce steel and aluminum products covered under this investigation, GHGRP-reported emissions typically are categorized under one or two of the following subparts: C (General Stationary Fuel Combustion Sources), F (Aluminum Production), and Q (Iron and Steel Production).[268] Facilities report their self-calculated emissions totals by source category in their GHGRP submissions, and the EPA publishes these facility reports on its website.[269] The Commission used both the emissions data from the GHGRP as well as emissions factor data from the GHGRP regulation in its calculations of facility-level emissions inventories. In addition, the Commission used qualitative and descriptive information from GHGRP reports to allocate facility-level emissions between subprocesses.

The Commission also relied on data collected from surveyed facilities in its questionnaire.[270] The Commission compiled the production data for its emissions intensity calculation from the facility-level questionnaire. The Commission also used activity data from its facility-level questionnaire in its

---

[267] Reporting is required of facilities exceeding 25,000 mt $CO_2$e emissions per year and for all primary aluminum smelters. The particular industrial activities with any level of associated emissions that trigger the reporting requirement are listed in the source categories in table A-3 (where Aluminum Production, referring to primary aluminum production, is listed) and the supplier categories of table A-5 of 40 C.F.R. § 98 subpart A. All other industrial activities that trigger the reporting requirement, in which facilities must report only if they emit over 25,000 mt $CO_2$e annually in combined emissions from stationary fuel combustion units, miscellaneous uses of carbonate, and other applicable source categories, are listed in the source categories in table A-4 (where Iron and Steel Production is listed) of 40 C.F.R. § 98 subpart A. There is a third type of facility that is required to report to the GHGRP if they emit more than 25,000 mt $CO_2$e or more per year in combined emissions from all stationary fuel combustion sources and have an aggregate maximum rated heat input capacity of 30 MMBtu/hr or greater for the stationary fuel combustion units at their facility. 40 C.F.R. § 98(a)(3)(iii).

[268] For certain facilities, emissions were also reported under subparts D (Electricity Generation) and S (Lime Production).

[269] EPA, OAP, FLIGHT database, 2022 Greenhouse Gas Emissions from Large Facilities, accessed November 1, 2024.

[270] An overview of the content and structure of the questionnaire is presented in chapter 1. See also USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024.

calculations.[271] Additionally, data from the facility-level questionnaire regarding energy and input use across multiple on-site activities were used to generate allocation information for the calculations. For facilities that did not report under the GHGRP in 2022 but nonetheless had fuel combustion or process emissions, the Commissions used data from the survey to calculate emissions data consistent with the methods used in GHGRP reporting.

Finally, the Commission also drew on data from several other external databases as sources for information to use in its emissions intensity calculations. These databases include the EPA's Emissions and Generation Resource Integrated Database (eGRID); industry reports published by the International Aluminium Institute, ResponsibleSteel, and the World Steel Association; and data from the International Energy Agency. In most instances these resources served as sources of emissions factor data for use with activity data provided by surveyed facilities.[272] In a few instances, however, these external databases also provided activity data, production data, and allocation information that the Commission used in its calculations.[273] Table 3.1 summarizes the five data types that were procured from each of the three sources and used in each stage of the calculations. The calculation steps in each of these stages will be explained in greater detail and with illustrative examples in the sections that follow.

**Table 3.1** Sources and types of data used in the Commission's calculation methodology

X = source of data was used as this data type in the Commission's calculations; -- = source of data was not used as this data type in the Commission's calculations; ** = data type was requested but not used in the Commission's primary results presentation.

| Sources of data | Emissions data | Activity data | Emissions factors | Production data | Allocation information |
|---|---|---|---|---|---|
| GHGRP public data and regulation | X | -- | X | -- | X |
| Commission's questionnaire | -- | X | ** | X | X |
| Other external databases | X | X | X | X | X |

Source: Compiled by the USITC.

---

[271] Section 4 of the questionnaire requested emissions factors, if known, for responding facility's delivered electricity, which were used as inputs in the sensitivity analysis for the market-based method of computing scope 2 emissions presented in appendix F. Section 7 of the questionnaire allowed for optional reporting of emissions factors for specific inputs. Reporting of known emissions factors across section 7 questions was minimal, however, and therefore not incorporated into the Commission's calculations.

[272] For a list of all public emissions factors used in the Commission's calculations and their sources, see appendix G. The Commission drew most emissions factors directly from these data sources and used some of these external data sources to calculate emissions factors. Data from the International Energy Agency were used in this way to calculate emissions factors covering the embedded emissions of iron and steel products used as materials. For more information on the Commission's calculation of these emissions factors, see appendix F ("Development of Default Emissions Factors for Materials Used by Steel Facilities").

[273] In developing its own steel emissions factors as described in appendix F ("Overview of Partial LCI Approach"), the Commission employed material, fuel, and energy use rate data (activity data) and international production data from external databases such as the World Steel Association Statistical Yearbook. One such instance of the Commission's use of allocation information from external databases is the data on useful thermal output from eGRID. For more information on this application of eGRID data within the calculations, see appendix E ("II.C. Energy-Related Emissions").

# Stage 1: Compiling a Facility-Level Emissions Inventory

The Commission compiled facility-level emissions inventories of the direct and indirect emissions associated with the production of covered steel and aluminum products that fall within the system boundaries described in chapter 2 ("Steel System Boundary" and "Aluminum System Boundary"). In calculating emissions data for these facility-level inventories, the Commission relied on the data sources listed in table 3.2.

**Table 3.2** Mapping of the scope of emissions data collected in the Commission's facility-level emissions inventory to the main sources of data used

| Type of emissions | Emissions data source |
|---|---|
| Scope 1 process emissions | If a surveyed facility is a GHGRP reporter:<br>• GHGRP emissions data (primarily subparts Q and F)<br>If a surveyed facility is not a GHGRP reporter:<br>• Questionnaire section 6 activity data *multiplied by* carbon content information from various sources (see appendix E, "II.A.2. Use of Survey Data to Calculate Scope 1 Process Emissions for Certain EAF Facilities," for more information) |
| Scope 1 fuel combustion emissions | If a surveyed facility is a GHGRP reporter:<br>• GHGRP emissions data (subpart C)<br>If a surveyed facility is not a GHGRP reporter:<br>• Questionnaire section 3 activity data *multiplied by* emissions factors in GHGRP regulation |
| Scope 2 emissions | • Questionnaire section 4 activity data *multiplied by* eGRID emissions factors |
| Scope 3 emissions | • Questionnaire section 5 activity data *multiplied by* emissions factors (either from publicly available sources or derived by USITC) |

Source: Compiled by the USITC.

Notes: For questionnaire sections, see USITC, *Greenhouse Gas Emissions Intensities Questionnaire: Facility-Level*, 2024. Carbon content information is used when calculating scope 1 process emissions through a mass-balance equation, which also may be used by facilities under subpart Q (Iron and Steel Production) of the GHGRP to report process emissions.

The chapter sections below describing the steps in stage 1 of the calculations are organized by the type of emissions, mapped to emissions scopes. As noted in chapter 1 ("Overview of Scope 1, 2 and 3 Emissions"), scopes of emissions are relative to the facility reporting them. For example, process emissions associated with the production of a covered product are scope 1 with respect to the facility producing the product, but scope 3 if the facility sourced that covered product as an input. When scope 1, 2, and 3 emissions are discussed in this report, the perspective is always that of the facility producing the covered product. To make this mapping clear, headings in this section "Stage 1: Compiling a Facility-Level Emissions Inventory" denote the assignment of each of these types of emissions to the scope from the producing facility's perspective.

## Process Emissions (Scope 1)

The "Process Emissions (Scope 1)" subsection describes the Commission's general approach for calculating the emissions associated with on-site production activities that result in process emissions—the emissions from the chemical transformation of raw materials—from the production of steel and aluminum.[274] In calculating process emissions for all aluminum facilities with process emissions and most steel-producing facilities, the Commission relied upon public data from the EPA's GHGRP.[275]

## Steel Process Emissions

The Commission considered scope 1 process emissions generated by facilities producing covered steel products to occur primarily during the production of semifinished steel, although some process emissions also occur in the production of raw material inputs—including lime or dolime, iron sinter, and metallurgical coke. Steel process emissions are reported under the Iron and Steel Production source category under subpart Q of the GHGRP regulation (40 C.F.R. § 98.170–178) for facilities that are required to report.[276] Steel process emissions reported under subpart Q are generally limited to $CO_2$, except where fuel combustion and flaring occur.[277]

As explained in greater detail in chapter 2 ("Semifinished Steelmaking"), semifinished steel can be produced through one of two separate pathways: a blast furnace and basic oxygen furnace (BF-BOF) route or an electric arc furnace (EAF) route. The BF-BOF route, which requires more inputs of ore-based metallics, is more process emissions intensive than that of the scrap-based EAF route. The chemical reaction in a BF-BOF that generates process emissions involves the combination at high temperatures of iron ore, coke, and limestone to yield molten pig iron, which is then reacted with oxygen and some steel scrap to create molten steel. The EAF route, on the other hand, primarily remelts scrap steel with some pig iron or direct reduced iron (in far smaller quantities), fluxing agents and some carbonaceous materials to produce steel.

All U.S. facilities with BOFs and the majority of facilities with EAFs reported under the GHGRP in 2022.[278] For the small number of EAF facilities that did not report to the GHGRP in 2022, the Commission used a mass-balance approach to generate process emissions estimates comparable to those that such facilities would have reported to the GHGRP had they chosen that methodology option. See appendix E ("II.A.2. Use of Survey Data to Calculate Scope 1 Process Emissions for Certain EAF Facilities") for the

---

[274] EPA, "Greenhouse Gas Reporting Program: Emission Calculation Methodologies," July 2015.

[275] 40 C.F.R. § 98.170–171 (Iron and Steel Production) requires facilities that produce iron and steel to report to the GHGRP if such production emits 25,000 mt $CO_2e$ emissions annually. 40 C.F.R. § 98.60–6 (Aluminum Production) requires facilities that produce primary unwrought aluminum to report their annual emissions output for any level of GHG emissions emitted.

[276] The GHGRP regulation allows for calculation of steel process emissions under four methods: default emissions factors, site-specific emissions factors, mass-balance equations approach, and continuous emissions monitoring systems (CEMS). 40 C.F.R. § 98.173. For more information on these methods, see appendix E ("II.A. Process Emissions for Steel").

[277] Some emissions also reported under subpart Q are fuel combustion emissions, which release methane ($CH_4$) and nitrous oxide ($N_2O$) in addition to $CO_2$. Certain emissions from fuel combustion for facilities producing semifinished steel can either be reported under 40 C.F.R. § 98.170–178 (Iron and Steel Production) or 40 C.F.R. § 98.30–38 (General Stationary Fuel Combustion Sources) and cannot be counted under both subparts or they would be double-counted. Reporting of flares that burn blast furnace gas or coke oven gas is done in subpart Q, and similarly includes $CH_4$ and $N_2O$ emissions. Furthermore, certain emissions reported under this subpart are related to processes not reported by covered steel product producers. One such example is direct reduced iron processing—this process also generates process emissions and is captured under subpart Q, but no direct reduced iron was produced at the facilities producing covered products during this investigation.

[278] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to section 1.1 and question 1.2.2.

Commission's approach estimating their steel process emissions. These GHGRP steel process emissions, along with the process emissions calculated for the small number of EAF facilities not reporting to the GHGRP, are the data sources for steel process emissions in the Commission's facility-level inventory.[279]

***Example - Collecting Process Emissions from a Steel Facility (Step 1 of 7)***

*Steel facility Y is a high-volume carbon steel rebar producer that reports to the Greenhouse Gas Reporting Program (GHGRP). The facility has an electric arc furnace (EAF) on-site. The facility uses the EAF to melt down ferrous scrap in combination with flux materials and adds this molten steel along with additional ferroalloys to a ladle furnace to produce semifinished billets. This facility continuously casts all the billets it produces into a hot-rolling mill to produce rebar. Steel facility Y includes all the process emissions associated with its on-site EAF activities in its GHGRP report. The Commission uses these emissions reported under subpart Q of the GHGRP as the scope 1 process emissions portion of this facility's emissions inventory.*

## Aluminum Process Emissions

The Commission considered scope 1 process emissions generated by facilities producing covered aluminum products to occur only in the production of primary aluminum, in alignment with the definition of aluminum process emissions in the EPA's GHGRP.[280] These emissions included $CO_2$ as well as perfluorocarbons (PFCs), specifically perfluoromethane ($CF_4$) and perfluoroethane ($C_2F_6$). Aluminum process emissions are reported under the Aluminum Production source category under subpart F of the GHGRP regulation (40 C.F.R. § 98.60–68) for facilities that are required to report.[281]

Process $CO_2$ emissions occur during the baking of the anode as well as the consumption of the anode during electrolysis.[282] In addition, PFCs are released during anode effects that occur in electrolysis cells.[283] The volume of PFCs released during this process is low compared to $CO_2$ emissions volumes, but

---

[279] EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024.

[280] Some sources indicate that certain methods of dross recycling (a form of secondary unwrought aluminum production) may result in some process emissions. Because data on the potential size of these emissions are scarce, the Commission's methodology does not account for process emissions from dross recycling. Industry representative, meeting with USITC, November 7, 2023; Narayanan, "Chemical Interactions of Dross with Water and Water Vapor in Aluminum Scrap Remelting," January 1, 1997; Shinzato and Hypolito, "Solid Waste from Aluminum Recycling Process," January 1, 2005. Low voltage anode effects have also been recently discovered as a source of process emissions. Biberman, Toledano, and Ram Mohan, "GHG Accounting Methods in the Aluminum Industry," February 2023, 16–18. These low voltage anode effects were not reported to the GHGRP in 2022, however, or accounted for in the Commission's methodology. For further information on low voltage anode effects, see appendix E ("II.B.1.b GHGRP Primary Unwrought Aluminum Production Calculations").

[281] The GHGRP allows for calculation of aluminum process emissions using a mass-balance method or by using a CEMS. 40 C.F.R. § 98.63. For more information on these methods, see appendix E ("II.B. Process Emissions for Aluminum").

[282] See chapter 2 ("Primary Unwrought Aluminum Production") for further information on anode baking, electrolysis, and the production of primary unwrought aluminum.

[283] Anode effects occur when an insufficient supply of alumina to the smelting pot causes a rapid spike in voltage in the pot, leading to decomposition of cryolite and the emission of gases containing PFCs. For further information see EPA, "Aluminum Production Subpart F, Greenhouse Gas Reporting Program," February 2018, 1–2.

PFCs have a high global warming potential (GWP) because they trap substantially more heat than $CO_2$ for the same given amount of mass, making their per unit impact more acute.[284]

All operating U.S. aluminum smelters in 2022 reported aluminum process emissions to the GHGRP that year.[285] These emissions reported to the GHGRP were used as the sole source of the aluminum process emissions in the Commission's facility-level inventory.

***Example - Collecting Process Emissions from an Aluminum Facility (Step 1 of 7)***

*Aluminum facility Z is a small non-GHGRP-reporting producer that extrudes aluminum profiles and pipes from primary aluminum billets. (In this investigation, this is considered production of covered wrought aluminum products). Some of the profiles produced at the facility are further manufactured into window frames on-site. The facility has an extrusion press, an induction furnace to preheat the billet, a welding station to weld the pieces of the window frames together, and an annealing furnace to heat treat the profiles. Because aluminum facility Z does not smelt primary aluminum on-site, it has no scope 1 process emissions in its facility inventory.*

# Energy Emissions (Scopes 1 and 2)

This section describes the Commission's general approach for calculating two types of energy-related emissions: scope 1 fuel combustion emissions and all scope 2 emissions.[286] Scope 1 fuel combustion emissions are GHG emissions that are released when a facility generates thermal energy via a combustion reaction (i.e., when a solid, gas, or liquid fuel reacts with oxygen). Scope 2 emissions are the indirect GHG emissions associated with a facility's use of purchased energy. The Commission's approach for calculating these emissions considered existing public data sources and common methods for company-level reporting of scope 1 and 2 emissions. As requested in the Trade Representative's letter, public data from the EPA's GHGRP were used when available. Additionally, the data collection and calculation methods for scope 2 emissions closely followed existing guidance from the Greenhouse Gas Protocol and from the EPA.

Steel and aluminum production require significant amounts of energy, which may be generated on-site via fuel combustion, purchased from a third party, or both. While the EPA assigns a zero emissions factor to many nonfossil fuel sources of energy (including nuclear, solar, wind, and hydropower), the U.S. steel and aluminum industries generally rely on fossil fuels to supply much of their energy. In particular, these industries often use fossil fuels for generating high temperatures and for generating some of the electricity used on-site.[287] This reliance on fossil fuels resulted in all U.S. steel and aluminum producers

---

[284] The GWPs for PFCs can be in the thousands or tens of thousands over a 100-year time horizon. EPA, "Understanding Global Warming Potentials," August 8, 2024.

[285] As required under 40 C.F.R. § 98.2(a)(1).

[286] Fuel combustion and purchased energy that are used to produce inputs are included in scope 3 emissions and are not a focus of this section.

[287] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 3.5, 3.6, 4.1, 4.4b, and 4.5a; IEA, "The Challenge of Reaching Zero Emissions in Heavy Industry," September 19, 2020; EPA, OAR, *eGRID2022 Technical Guide*, January 2024, 10.

covered by this investigation having scope 1 emissions from fuel combustion, scope 2 emissions from purchased energy, or a combination of these emissions.[288]

The Commission's approach for calculating energy emissions primarily relied on three data sources: the EPA's GHGRP data, the EPA's Emissions and Generation Resource Integrated Database (eGRID), and responses to the Commission's questionnaire.[289]

GHGRP data provide scope 1 fuel combustion emissions for all facilities producing covered steel and aluminum facilities that are required to report.[290] Subpart C of the GHGRP specifically covers emissions from stationary fuel combustion sources.[291] As described in Box 1.1, carbon dioxide emissions data from these fuel combustion sources may be reported using tier 1, 2, 3, or 4 methodologies. Tier 1 methodology is the least complex, using fuel quantity data and default emissions factors for that fuel type to estimate the emissions. Tier 4 is the most complex and precise, using continuous emissions monitoring systems (CEMS) to measure and report the emissions.[292]

The EPA's eGRID database contains electricity generation information on plants that are connected to the grid and have a capacity of at least 1 megawatt (MW), which covers almost all the electric power generated in the United States.[293] These eGRID data can be used for scope 2 emissions data. The database contains eight levels of data aggregation, ranging from data for individual boilers and turbines

---

[288] Electricity purchased from the grid always resulted in some scope 2 emissions due to the Commission's use of location-based method accounting; those emission rates are discussed at the end of this section. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 3.5, 3.6, 4.1, 4.4b, and 4.5a.

[289] Specifically, the Commission used the following sources for data inputs to its energy emissions calculations: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024; EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024; EPA, "SRL22," January 30, 2024; EPA, "PLNT22," January 30, 2024.

[290] Reporting was required of facilities exceeding 25,000 mt $CO_2e$ emissions per year, and for all primary aluminum smelters. In addition to the annual emissions condition, secondary and wrought aluminum producing facilities must also have an aggregate maximum rated heat input capacity of 30 MMBtu per hour or greater across the facility's stationary fuel combustion units to trigger the GHGRP reporting requirement. This additional condition did not appear to meaningfully reduce the number of U.S. aluminum-producing facilities reporting to the GHGRP. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Company-level*, 2024, responses to question 1.1.3b; USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 3.5 and 3.6; 40 C.F.R. § 98.2a, 98.60, 98.61; Tables A-3 and A-4 to Subpart A of Part 98, Title 40.

[291] One of the aluminum producers covered by this investigation also reported 2022 emissions under Subpart D, for a utility-scale power generation plant that is co-located with the aluminum smelter and operated by the aluminum producer. The Commission's calculations include these subpart D emissions.

[292] 40 C.F.R. § 98.30–98.38. Some environmental groups have raised concerns about the prevalence of lower-tier data in the GHGRP for fuel combustion emissions from U.S. steel and aluminum facilities. The Sierra Club testified at the Commission's hearing that lower tiers of the GHGRP assume no accidental releases of emissions; many U.S. steel and aluminum facilities are relatively old, increasing the uncertainty about whether these assumptions are accurate. The Sierra Club also acknowledged that more widespread collection of Tier 4 data would require significant investments in equipment and training. USITC, hearing transcript, December 7, 2023, 288–89, 307–308 (testimony of Yong Kwon, Sierra Club); Mighty Earth, written submission to the USITC, June 21, 2024; Synapse Energy Economics, *Coming Clean on Industrial Emissions*, September 12, 2023, 75–77.

[293] EPA, "What Information Is Contained in eGRID?," September 4, 2024. One additional limitation is whether the generating plants report data to the U.S. government. Some eGRID data are available for Puerto Rico, but not for the other U.S. territories. Puerto Rican production is included in the Commission's survey population of steel and aluminum facilities. EPA, OAR, *eGRID2022 Technical Guide*, January 2024, 1, 6.

to U.S.-wide data. The Commission's energy emissions calculation approach used plant-level data to capture the attributes of specific power-generation and cogeneration plants; it used subregional-level data for purchases of electricity that were not attributed to a specific plant.[294] Because the eGRID data treat electricity sourced from hydropower, nuclear, solar, wind, and some geothermal resources as having no emissions factor, the Commission did not assign any emissions to these types of electricity generation.[295] Combustion of biomass is also treated as a low or sometimes zero emission source of GHG emissions.[296]

The EPA's subregional eGRID data were developed to provide useful U.S. emissions rate data. The EPA designed subregional boundaries so that the emissions rates from generation could most accurately represent the emissions for electricity delivered within the subregion.[297] These 27 subregions and their relative emissions intensities are shown in figure 3.2. The emissions intensity of electricity generation in the United States varies considerably across eGRID's subregions because of differences in the shares of fossil fuels in the generation mix.[298]

---

[294] EPA, "SRL22," January 30, 2024.

[295] EPA, OAR, *eGRID2022 Technical Guide*, January 2024, 10, 110, 127.

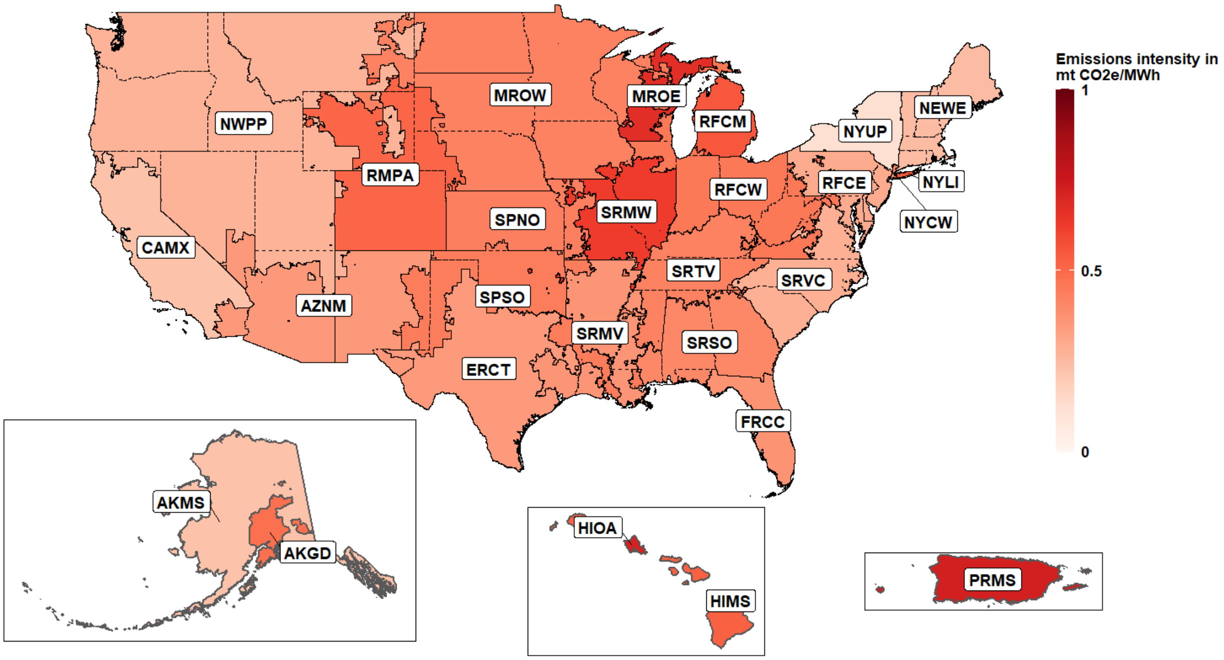
[296] For plants that combust a mixture of biomass and non-biogenic materials (such as plastic and tires), eGRID eliminates only carbon emissions from the biomass component of the fuel in its biomass-adjusted factors. This is common in plants that combust municipal solid waste (i.e., garbage) to generate power. Additionally, eGRID's adjusted factors reduce methane and nitrous oxide emissions from landfill gas (one type of biomass) that is combusted for electricity generation, assuming that the landfill gas would have otherwise been flared and emitted these GHGs. EPA, OAR, *eGRID2022 Technical Guide*, January 2024, 14–15, 109.

[297] EPA, OAR, *eGRID2022 Technical Guide*, January 2024, 23.

[298] The NYUP subregion had the lowest emissions rate in 2022: 0.125 mt $CO_2$e per MWh. NYUP used no coal-fired generation and only sourced about 30 percent of its electricity from fossil fuels in 2022. By contrast, the MROE subregion had the highest emissions rate in the mainland United States at 0.675 mt $CO_2$e per MWh. MROE sourced about 46 percent of its electricity from coal and 38 percent from natural gas. See variables SUBRGN, SRC2ERTA, SRCLPR, SROLPR, SRGSPR, SRTNPR. EPA, "SRL22," January 30, 2024.

**Figure 3.2** Map of the Emissions and Generation Resource Integrated Database (eGRID)'s 27 subregions and the emissions intensities of their electricity generation

In metric tons of carbon dioxide equivalent per megawatt-hour (mt $CO_2e$/MWh). Underlying data for this figure can be found in appendix J, table J.10.



Sources: EPA, eGRID Mapping Files, accessed August 23, 2024; EPA, "SRL22", accessed January 30, 2024.

To calculate scope 1 and 2 emissions associated with energy use, the Commission supplemented the EPA data discussed above with the following data collected in sections 3 (fuel combustion) and 4 (purchased energy) of the Commission's questionnaire:

- fuel types and quantities combusted (scope 1 fuel combustion emissions);
- sourcing of purchased electricity (scope 2 emissions);
- sourcing of heat, steam, and hot water from units operated by third parties (scope 2 emissions);
- on-site generation of electricity, heat, steam, and hot water by the facility operator (scope 1 fuel combustion emissions); and
- subprocess-specific use of fuels, electricity, heat, steam, and hot water (scope 1 fuel combustion and scope 2 emissions).[299]

## Scope 1 Fuel Combustion Emissions

The Commission's approach for calculating facility-wide scope 1 fuel combustion emissions was based on the methodology used in the GHGRP's reporting for stationary fuel combustion units (subpart C).[300] For facilities that reported 2022 data to the GHGRP, the Commission's calculations use GHGRP emissions

---

[299] See appendix E ("II.C. Energy-Related Emissions") for more detail on how questionnaire data were used in the energy emissions calculations.

[300] 40 C.F.R., Subpart C, § 98.33. As noted earlier, fuel combustion emissions to support iron and steelmaking processes may also be reported under subpart Q of the EPA's GHGRP. Calculations for fuel combustion emissions under this subpart follow the same calculations as those in subpart C.

data for fuel-specific, facility-wide emissions totals. For facilities that did not report to the GHGRP, the calculations use the GHGRP's methodology of applying fuel-specific direct emissions factors to fuel quantity activity data to estimate fuel-specific, facility-wide emissions.[301] The GHGRP's methodology also influenced the Commission's treatment of emissions associated with waste gases, which is explained in greater detail in box 3.1. For the purposes of this report, waste gases consist of coke oven gas and blast furnace gas. These gases result in significant emissions when combusted but are sometimes sent to third parties rather than being combusted at the coke or steelmaking facility that produced them.

---

[301] The calculations of scope 1 fuel combustion emissions for facilities that did not report to the GHGRP use default factors from the GHGRP that are based on the average characteristics of the type of fuel combusted. These factors are high heating values (only used for natural gas when data were not reported in therms or million British thermal units); direct $CO_2$, methane ($CH_4$), and nitrous oxide ($N_2O$) emissions factors for combusting each fuel type, listed in Tables C-1 and C-2 of the GHGRP; and global warming potential factors for methane and nitrous oxide from Table A-1. This process is described in more detail in appendix E ("II.C. Energy-Related Emissions") and the emissions factors are presented in table G.1. Table A-1 to Subpart A and tables C-1 and C-2 to Subpart C of Part 98, Title 40.

### **Box 3.1** Treatment of Coke Oven Gas and Blast Furnace Gas

Within the United States, two types of waste or by-product gas are commonly recovered from steel-related production activities: coke oven gas and blast furnace gas.[a] These waste gases generally contain carbon monoxide (CO) in combination with other gases and particulate matter.[b] If not used as a source of fuel in another industrial product, by-product gases are flared (combusted for disposal). Combustion of by-product gases results in GHG emissions; in particular, combustion converts the carbon monoxide content to carbon dioxide ($CO_2$). (Carbon monoxide by itself is not a GHG.)[c]

Coke oven gas is generated at facilities that manufacture coke from metallurgical coal; these facilities typically use the gas to keep the coke ovens heated but also generate surplus coke oven gas that may be sent off-site as a fuel source.[d] Blast furnace gas is generated from the blast furnace steelmaking process described in chapter 2 ("Semifinished Steelmaking"). It produces much less thermal energy (per unit of volume) when combusted than coke oven gas but is still often combusted to generate heat, steam, or electricity.[e]

Several methodologies for assessing facility-specific emissions from steelmaking apply special treatment to coke oven gas and blast furnace gas. This treatment allows comparison among facilities that combust these waste gases on-site to support their production operations and facilities that send these gases to third parties and use other (typically lower emission) sources of energy for their on-site operations. Without cokemaking and steelmaking operations there would be no incentive to create or use these gases, so the methodologies assign some burden to facilities creating the gases, regardless of whether they also combust the gas on-site.[f] To avoid overcounting waste gas emissions that were already included in the EPA's Greenhouse Gas Reporting Program (GHGRP) and Emissions and Generation Resource Integrated Database (eGRID), this report's methodology measured only emissions from blast furnace gas and coke oven gas at the point of combustion.

Most of the generation of coke oven gas occurred at facilities that operated independently from iron- and steelmaking facilities. These facilities were not covered by this investigation. Therefore, the emissions associated with coke oven gas were largely measured through the default scope 3 emissions factor assigned to purchased metallurgical coke.[g] Several U.S. steelmaking facilities are located near to and sometimes integrated with cokemaking operations. This can result in coke oven gas being used to provide energy for steelmaking operations.[h] This report's methodology treats the consuming facility as fully responsible for coke oven gas combustion emissions, possibly resulting in a higher allocation of coke oven gas emissions to U.S. steel production than other approaches.

As indicated by the GHGRP data and supported by public U. S. Steel and Cleveland-Cliffs sustainability reports, the U.S. facilities using the integrated blast furnace and basic oxygen furnace process for steelmaking generally use the blast furnace gas that they generate on-site to support their production operations.[i] Therefore, the emissions associated with blast furnace gas would typically be fully assigned to the facility, regardless of which methodological approach is used. The Commission's approach may result in a higher share of the blast furnace gas emissions being allocated to further downstream steel production occurring at the facility, rather than to the facility's semifinished steel production.

[a] BOFs also produce a by-product waste gas. This gas is flared in the United States but is sometimes combusted for energy in other countries. U.S. industry representative, interview by USITC staff, August 1, 2023.

[b] IEA, ETSAP, "Technology Brief 102: Iron and Steel," May 2010; Metius, "DRI Production Using Coke Oven Gas (COG)," March 2016.

[c] Tables C-1 and C-2 to Subpart C of Part 98, Title 40.

[d] U.S. industry representative, interview by USITC staff, August 3, 2024.

[e] Table C-1 to Subpart C of Part 98, Title 40; Cleveland-Cliffs Inc., *Sustainability Report 2022*, April 3, 2023, 28; U. S. Steel, *2022 ESG Report*, June 13, 2023, 91.

[f] EC, DG-TAXUD, *Guidance Document on CBAM Implementation*, December 8, 2023, 91–93; Janjua and Maciel, *$CO_2$ Data Collection User Guide, Version 11*, May 30, 2024, 19, 21; ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 84–86.

[g] See appendix G for scope 3 emissions factors.

[h] U. S. Steel, "Locations," accessed October 24, 2024; Cleveland-Cliffs Inc., "Burns Harbor," accessed October 24, 2024; EPA, "eGRID 2022 Database, Emissions by Unit and Fuel Type," 2024.

[i] EPA, OAP, "GHGRP, Emissions by Unit and Fuel Type Dataset," accessed September 9, 2024; Cleveland-Cliffs Inc., *Sustainability Report 2022*, April 3, 2023, 28; U. S. Steel, *2022 ESG Report*, June 13, 2023, 91.

The GHGRP generally requires facilities to report emissions data for each unit that combusts fuel (such as boilers, incinerators, and process heaters), but also sometimes allows fuel combustion units to be grouped and reported as a single total.[302] For example, some facilities can group all their units together—even when the facility has different types of fuel combustion units—when the units all combust natural gas received from a common supply pipe.[303] As a result, GHGRP data on emissions from stationary fuel combustion can vary from a single, facility-wide "unit" with a generic label to more detailed data specific to different heaters, boilers, and other units. These unit-level data do not consistently provide a way to allocate emissions associated with the production of different types of products at a single facility. Consequently, the Commission's questionnaire collected fuel quantity data from all facilities covered by this investigation, whether or not the facility was a GHGRP reporter.

***Example - Collecting Fuel Combustion Emissions from a Steel Facility (Step 2 of 7)***

*Steel facility Y combusts natural gas directly in the EAF and in certain furnaces in the rebar rolling mill. As a GHGRP reporter, steel facility Y reports its facility-wide emissions associated with fuel combustion to the EPA under subpart C. The Commission uses these fuel combustion emissions totals to add to the scope 1 emissions portion of each facility's emissions inventory.*

***Example - Collecting Fuel Combustion Emissions from an Aluminum Facility (Step 2 of 7)***

*Aluminum facility Z combusts natural gas to heat the annealing furnace that is used to heat treat profiles. The Commission collects activity data on aluminum facility Z's natural gas use in question 3.6 of its questionnaire response. This volume of natural gas used by the facility is multiplied by a natural gas emissions factor from table C-1 of the GHGRP regulation (40 C.F.R. § 98.38) to generate an emissions total. The Commission uses these fuel combustion emissions totals to add to the scope 1 emissions portion of each facility's emissions inventory.*

## Scope 2 Emissions

The Commission's methodology for calculating facility-wide scope 2 emissions is primarily based on the EPA Center of Corporate Climate Leadership's Greenhouse Gas Inventory Guidance on Indirect Emissions from Purchased Electricity.[304] This EPA guidance uses the same framework as the GHG Protocol but provides more detailed information on how EPA data can be used to calculate these emissions for organizations operating in the United States.[305]

The Commission employed the location-based method using subregion-level data from eGRID as the primary methodology for its calculations of scope 2 emissions from purchased electricity. The EPA guidance specifies three different emissions factors that may be used for this method, listed in order of

---

[302] 40 C.F.R. § 98.30.

[303] The units must also fall under a maximum rated heat input capacity of 250 million British thermal units per hour to be grouped together. 40 C.F.R. § 98.36.

[304] EPA, *GHG Inventory Guidance*, December 2023.

[305] EPA, *GHG Inventory Guidance*, December 2023, ii, 6,7; WRI, *GHG Protocol Scope 2 Guidance*, 2015.

preference: direct line, eGRID subregion, and national emissions factors.[306] Because eGRID subregion emissions factors were available for all covered facilities, the Commission did not use national emissions factors. To calculate scope 2 emissions for a facility, the Commission first calculated emissions associated with any electricity purchased from a direct line connection to a generation source. Direct line connections are an uncommon setup that allows electricity to flow directly to the facility rather than first flowing through the grid.[307] Among the facilities covered by this investigation, direct line connections were rare but sometimes used to source considerable amounts of electricity.[308] If a facility reported a direct line connection, the Commission used plant-level data from eGRID to identify a plant-specific $CO_2e$ emissions factor to multiply by the quantity of these purchases to calculate an emissions total associated with the electricity from a direct line connection. Second, for all other purchases of electricity, the Commission's calculations followed the EPA guidance's recommendation to use eGRID subregional emissions factors for the default regional emissions factor.[309] These subregional emissions factors were each based on the facility's location and were applied to the amount of purchased electricity not attributed to any direct line connections.[310] The Commission added these two emissions values to calculate the total emissions from purchased electricity.

Scope 2 purchases of steam, heat, and hot water are much less common than purchases of electricity but did occur at some U.S. steel and aluminum facilities in 2022.[311] In such cases, the Commission used eGRID data on direct emissions from the cogeneration plant where these thermal outputs were sourced to assign an appropriate emissions factor. When these data were incomplete or otherwise unavailable, the Commission requested emissions factors from the surveyed facility.

---

[306] Specifically, the EPA guidance recommends using regional emissions factors when direct line connection emissions factors are not available or relevant and specifies that U.S. operations should use the eGRID subregion emissions factor as their regional emissions factor. EPA, *GHG Inventory Guidance*, December 2023, 6,7.

[307] EPA, *GHG Inventory Guidance*, December 2023, 6,7.

[308] USITC, *Greenhouse Gas (GHG) Emissions Questionnaire: Facility-Level*, 2024, responses to questions 4.4b and 4.5a.

[309] EPA, *GHG Inventory Guidance*, December 2023, 6, 7.

[310] Most zip codes map to only a single eGRID subregion, but some U.S. facilities producing covered steel and aluminum products are in locations that cannot be mapped to a single subregion without utility provider information. The Commission collected eGRID subregion data in its questionnaire (requesting questionnaire respondents to identify their subregion by using the EPA's Power Profiler tool) and used facility zip codes to verify the accuracy of these data and make corrections as needed. EPA, OAR, "Power Profiler," accessed various dates.

[311] The Commission collected data on electricity, steam, heat, and hot water using feedback during the questionnaire development process on which forms of energy U.S. steel and aluminum producers purchased from third parties. Scope 2 emissions can also include purchased cooling, but this is less common in the United States than systems enabling purchases of heat and hot water. USDOE, EERE, "District Energy," September 2020. USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level*, 2024, responses to question 3.2a; Industry representatives, interviews by USITC staff, November 29, December 11, and December 12, 2023.

***Example - Collecting Scope 2 Emissions from a Steel Facility (Step 3 of 7)***

*Steel facility Y purchases electricity from the local grid to power its EAF, ladle metallurgy furnace, and the stands in its rebar rolling mill. Data on electricity purchases are collected in question 4.1 of the questionnaire. These purchases are multiplied by an emissions factor from the eGRID database that is specific to the electrical grid in the subregion where facility Y is located. These emissions from purchased electricity, along with any emissions from purchased steam, heat, or hot water, are added as the scope 2 portion of each facility's emissions inventory.*

***Example - Collecting Scope 2 Emissions from an Aluminum Facility (Step 3 of 7)***

*Aluminum facility Z purchases electricity from the local grid to power its extrusion press, induction furnace, welding station, and annealing furnace. Data on electricity purchases are collected in question 4.1 of the questionnaire. These purchases are multiplied by an emissions factor from the eGRID database that is specific to the electrical grid in the subregion where facility Z is located. These emissions from purchased electricity, along with any emissions from purchased steam, heat, or hot water, are added as the scope 2 portion of each facility's emissions inventory.*

# Emissions Embedded in Material Inputs from External Sources (Scope 3)

Most facilities producing covered products receive some material inputs from external sources. Externally sourced materials have embedded scope 3 emissions: indirect emissions that occur during upstream production processes in the value chain that produce those materials.[312] The Commission estimated each facility's scope 3 emissions in order to ensure that total product-level emissions estimates across facilities included emissions embedded in all materials and processes within the system boundaries. This section provides a broad overview of how those scope 3 emissions estimates were calculated.

In this investigation, scope 3 emissions for each facility that received upstream materials (referred to here as a "consuming facility") include those that resulted from another facility's (a "supplier facility's") production of materials. Supplier facilities include off-site facilities under ownership different than that of the consuming facility, off-site facilities that share common ownership to that of the consuming

---

[312] The GHG Protocol defines scope 3 emissions as covering indirect emissions resulting from upstream and downstream value chain activities. WRI and WBCSD, *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*, 2013, 4. As described in chapter 1 ("Scope 3: Indirect Value Chain Emissions"), the Commission estimated a narrower subset of scope 3 emissions (i.e., upstream scope 3) covering indirect emissions related to each facility's received material inputs.

facility, and on-site facilities that are not under the operational control of the consuming facility.[313] The consuming facility may receive materials from supplier facilities under a variety of arrangements, including purchases, transfers, or toll-processing arrangements.[314]

Scope 3 emissions include those consistent with the system boundaries used throughout this investigation. The Commission sought to measure scope 3 emissions covering the same greenhouse gases—carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and perfluorocarbons (PFCs, for aluminum)—that were captured in scope 1 and 2 estimates. These emissions also include all of the supplier facility's own indirect emissions associated with sourcing of energy or further upstream materials in addition to the supplier facility's direct emissions from production operations. Facilities producing covered products differ in terms of their reliance on external sourcing of materials versus production of those materials on-site.[315] Therefore, an approach that incorporates scope 3 emissions for certain facilities relying primarily on externally sourced materials allows for consistency and comparability with the scope 1 and 2 emissions for other facilities relying primarily on materials produced on-site.

## Calculating Facility-Level Scope 3 Emissions

As with other parts of this investigation's methodology for calculating facility-level or product-level emissions data, the Commission did not ask facilities to report their own scope 3 emissions data.[316] Instead, the Commission calculated scope 3 emissions by multiplying facilities' activity data by emissions

---

[313] In the GHG Protocol's *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* (the "*Scope 3 Standard*"), the definition of scope 3 emissions used in this investigation includes emissions that resulted from the operations of supplier facilities under common ownership, which differs from the definition of scope 3 used by the *Scope 3 Standard*. Because that standard covers corporate-level accounting of GHG emissions, scope 3 emissions determined under that standard consider whether the value chain activities occurred outside of the operational control of the company, not individual facilities owned by that company. In this investigation, however, the objective was to measure product-level emissions for each U.S. facility producing steel and aluminum, requiring an adaptation of the *Scope 3 Standard* definition. WRI and WBCSD, *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*, 2013, 28–29.

[314] A toll processor is a facility that engages in the production of a product on behalf of another facility that owns the product before, during, and after production.

[315] For example, as noted in chapter 2, some steelmaking facilities produce pig iron on-site, while others source pig iron from external sources. Similarly, some facilities that produce wrought aluminum also produce secondary unwrought aluminum on-site, while others source unwrought aluminum from external sources.

[316] Some industry representatives reported that they could provide directly measured or calculated scope 3 emissions covering at least some of their material receipts using information provided by suppliers. USITC, hearing transcript, December 7, 2023, 136 (testimony of David Miracle, Nucor); 136–37 (testimony of Jeff Hansen, SDI); 137 (testimony of Tamara Weinert, Outokumpu). Other facilities, particularly smaller manufacturers, are likely unable to directly measure scope 3 emissions because those indirect emissions occur outside of their operational control. USITC, hearing transcript, December 7, 2023, 73 (testimony of Joseph Green, SSINA); 249–51 (testimony of James Warren and Omar Nashashibi, FIA). The questionnaire did not ask facilities to report their own scope 3 emissions but did allow facilities the option to report emissions factors covering some or all their material receipts. See USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level,* 2024, responses to question 7.2. Very few facilities reported their own source-specific emissions factors. Because these were not commonly reported, the Commission did not use these in its calculation of the emissions intensity estimates of covered products. Facilities' reported source-specific emissions factors included source-specific emissions factors that were higher and lower than the actual emissions factors used to calculate scope 3 emissions for those receipts.

factors.[317] The main activity data used to calculate scope 3 emissions were consuming facilities' external receipts. External receipts are quantities of materials received in 2022 for use in production, expressed in metric tons for solid materials or standard cubic feet for gaseous materials. The emissions factors used to calculate scope 3 emissions are the emissions intensity values of materials used as inputs by the receiving facility; they are the amount of GHG emissions that occurred as a direct or indirect result of the production of the material received, expressed as metric tons of carbon dioxide equivalent ($CO_2e$) per unit of material received. The Commission used two types of emissions factors in its scope 3 analysis, defined below:

- **Supplier-specific emissions factors** refer to the emissions intensity estimates of materials produced by an identified steel or aluminum-producing facility that responded to the Commission questionnaire and supplied a downstream steel or aluminum facility with materials. In this investigation, the Commission used its own estimates of the emissions intensities of covered products from supplier facilities as supplier-specific emissions factors.
- **Default emissions factors** refer to the emissions intensities of materials produced by an industry and are meant to cover representative production practices and calculations based on industry-wide or sampled data. Default emissions factors can be specific to individual countries (i.e., "country-specific emissions factors") or globally representative (i.e., "global emissions factors"). The Commission collected default emissions factors used in scope 3 analysis from a variety of sources, including published standards for GHG emissions accounting in these sectors and reports by industry associations. For steel products and pig iron, default emissions factors were calculated by the Commission.[318] Default emissions factors are reported in appendix G.

The Commission calculated scope 3 emissions using approaches that varied depending on the material category and the specificity of underlying data. For all upstream materials other than covered steel and aluminum products used in the production of covered steel and aluminum products (other than pig iron and alumina), the Commission multiplied total external receipts (activity data) by a global emissions

---

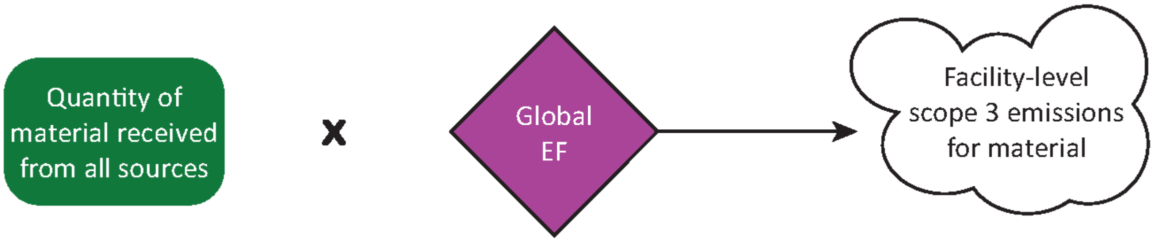
[317] The GHG Protocol also envisioned in its *Scope 3 Standard* that calculation-based approaches would be used more often than direct measurement of scope 3 emissions. WRI and WBCSD, *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*, 2013, 68.

[318] A description of how the Commission selected default emissions factors for scope 3 calculations is provided in appendix E ("II.D.2 Selection of Default Emissions Factors"). That section of appendix E also contains the sources for emissions factors used to calculate scope 3 emissions for facilities producing covered aluminum products. Appendix F ("Development of Default Emissions Factors for Materials Used by Steel Facilities") provides a description of how the Commission selected and calculated emissions factors for materials used by facilities producing covered steel products.

factor corresponding with that material (see figure 3.3).[319] This report refers to this as the "global approach" to calculating a facility's scope 3 emissions associated with a specific material. In general, the Commission used a global approach to calculate scope 3 emissions for materials where variations in embodied emissions by source were considered unlikely to substantially affect the overall emissions intensity estimates of products. For example, the Commission used a global approach for goods that were far upstream in the product system boundaries or where variation in sources was not substantial. In these cases, the questionnaire did not impose an additional burden on facilities using those materials by asking them to separate external receipts by source. The Commission also used a global approach for materials where no source-specific emissions factor was found or otherwise developed in this investigation, even for materials where source-specific activity data were collected in the questionnaire.

**Figure 3.3** Illustration of global approach to calculating facility-level scope 3 emissions

EF = emissions factor.



Source: Compiled by the USITC.

For covered steel and aluminum products, pig iron, and alumina used in the production of covered steel and aluminum products, the Commission calculated scope 3 emissions using an approach referred to in this report as the multisource approach. Consuming facilities reported external receipts of these materials from multiple sources (individual countries and supplier facilities). Each of these source-specific quantities was multiplied by corresponding emissions factors; these sums were then aggregated

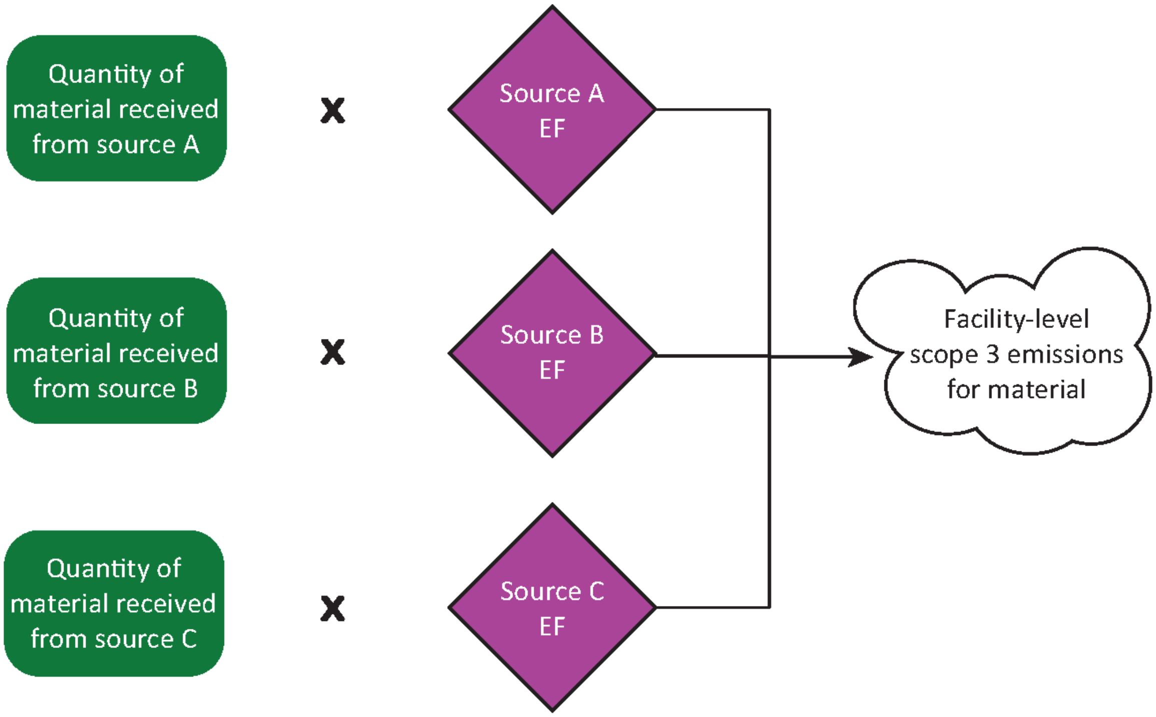
---

[319] For certain materials, the Commission used the total quantity of materials used by a facility as activity data for calculating scope 3 emissions instead of total material receipts. The Commission collected data on use of material (regardless of source) in different processes throughout the facility primarily as allocation information, as described in greater detail below ("Stage 2: Using Facility-Level Emissions to Calculate Product-Level Emissions") and appendix E ("III. Computing Product-Level Emissions Inventories"). Certain materials were not produced by facilities that produced covered products, so the Commission assumed that all material used by these facilities came from external sources and could be used as activity data in scope 3 accounting. This approach was used for non-calcined limestone and dolomite, ferroalloys and other alloying metals, and coating metals (for steel calculations) and for calcined petroleum coke, coal tar pitch, and alloying elements (for aluminum calculations). This approach was also used in isolated cases for individual facilities when a facility's external receipt data were missing or incomplete and would be better replaced by material use data. In some cases, facilities that had significant buildups or drawdowns of externally sourced material inventories in 2022 adjusted the reported external receipts in their questionnaire responses to better reflect actual use of those materials to avoid substantial overstatement or understatement of scope 3 emissions related to their production using those materials in that year.

to estimate facility-level scope 3 emissions for that material (see figure 3.4).[320] Multisource approaches were used for materials where variations in embodied emissions by source were considered likely to substantially affect emissions intensity estimates. In particular, multisource approaches were pursued for widely traded, further-finished materials with high embodied emissions.[321]

**Figure 3.4** Illustration of multisource approach to calculating facility-level scope 3 emissions

EF = emissions factor.



Source: Compiled by the USITC.

---

[320] The Commission calculated scope 3 emissions associated with consuming facilities' receipts of pig iron, primary aluminum, and steel products from identified U.S. supplier facilities using supplier-specific emissions factors if the suppliers themselves were questionnaire respondents. For all other receipts of these materials and for all receipts of alumina and other aluminum products, the Commission used country-specific activity data and corresponding default emissions factors to calculate scope 3 emissions. Appendix E (II.D.1 "Calculation of Facility-Level Scope 3 Emissions") contains more detail on how multisource approaches were applied for various materials.

[321] The use of multisource approaches was also based on the request letter, where the Commission was asked to collect information on the volume and origin of intermediate steel and aluminum products when used as materials.

***Example - Collecting Emissions Embedded in Material Inputs from a Steel Facility (Step 4 of 7)***

*Steel facility Y uses ferrous scrap, flux materials, and ferroalloys in its production of semifinished steel as well as injections of oxygen. For each of these materials, the Commission collects activity data on the amount of inputs received or used for the production of covered products in questions 5.1.14, 5.1.8, 5.1.11, and 5.1.10 of the questionnaire. With the exception of ferrous scrap, which is assigned a zero emissions burden, these activity data are multiplied by corresponding emissions factors from external databases (see tables G.3 and G.4 in appendix G for these emissions factors). This resulting emissions totals embedded in these material inputs are added as the scope 3 portion of each facility's emissions inventory.*

***Example - Collecting Emissions Embedded in Material Inputs from an Aluminum Facility (Step 4 of 7)***

*Aluminum facility Z purchases and uses only primary aluminum billets as inputs for the production of covered products that fall within the Commission's system boundary. The Commission collects activity data on the amount and country of smelt of the primary aluminum billets received in questions 5.2.3 and 5.2.5 of the questionnaire. These amounts are multiplied by corresponding emissions factors from external databases in the case of imports (see table G.2 in appendix G for these emissions factors) and by emissions factors specific to U.S. smelters (if known) in the case of domestic products. The resulting emissions totals embedded in these material inputs are added as the scope 3 portion of each facility's emissions inventory.*

# Stage 2: Using Facility-Level Emissions to Calculate Product-Level Emissions

The Trade Representative's letter asked the Commission to develop national estimates of the product-level emissions intensities associated with specific steel and aluminum products. It is common for facilities to produce multiple covered products or other materials, meaning that facility-level emissions could not be used directly to calculate product-level emissions intensities. Instead, the Commission allocated facility-level emissions between processes and then assigned those process-level emissions to product-level emissions inventories. A product-level emissions inventory includes all direct and indirect emissions that occur during processes along a product's value chain within the system boundaries described in chapter 2 ("Steel System Boundary" and "Aluminum System Boundary"). This section describes how the Commission calculated product-level emissions inventories using an approach derived from life cycle assessment techniques and tailored to emissions data collected for individual facilities' operations.[322]

---

[322] A life cycle assessment is a "compilation and evaluation of the inputs, outputs, and potential environmental impacts" of the processes in a product's life cycle. ISO, *ISO 14040:2006*, 2006, 2. In this investigation, the Commission used concepts derived from life cycle assessment techniques such as the establishment of a system boundary, emission allocation techniques, and compilation of product-level inventories of emissions based on component unit processes. Life cycle assessments are generally not limited to individual facilities but rather

# Allocation of Facility-Level Emissions to Unit Processes

As a first step toward developing product-level emissions inventories, the Commission allocated facility-level emissions (calculated using the methods described in the previous section, "Stage 1: Compiling a Facility-Level Emissions Inventory") to on-site "unit processes."[323] This report defines a unit process as the most narrowly defined production process for which input and output data were quantifiable and that directly produces an individual "reference product." Reference products refer to the products for which product-level emissions inventories were calculated using the approaches described in this section. In this report, reference products include (1) most steel and aluminum product categories for which emissions intensity estimates are presented in this report and (2) upstream material inputs made at facilities producing covered products.[324]

To allocate facility-level emissions to unit processes, the Commission used techniques from the *GHG Protocol Product Life Cycle Accounting and Reporting Standard* (the "*Product Standard"*).[325] In particular, it used a technique that the *Product Standard* refers to as "process subdivision." Process subdivision divides emissions associated with common processes that cover multiple reference products (e.g., all manufacturing occurring in a facility) into multiple processes more specific to one or a few reference products.[326] Using questionnaire data and GHGRP data, the Commission subdivided facility-level emissions data into production processes using the facilities' own knowledge of their production practices and uses of inputs. These processes, referred to in this report as "subprocesses," were defined to cover all processes that occur within steel and aluminum production facilities. Subprocesses were also defined to be mutually exclusive from each other, to relate to the smallest number possible of reference products, and to be well understood by industry representatives filling out facility-level

---

quantify emissions across the full life cycle of a product regardless of where processes occur. For this reason, life cycle assessments generally do not include analyses of emissions organized by scope. Also, a life cycle of a product includes not only the value chain leading up to its production, but also its use and end of life. In this investigation, the Commission did not analyze inputs and outputs within product life cycles beyond the production of steel and aluminum products. See also ISO, *ISO 14040:2006*, 2006; WRI and WBCSD, *GHG Protocol Product Life Cycle Accounting and Reporting Standard*, September 2011, 21–25; Ecoinvent, "UPR, LCI and LCIA," February 14, 2024.

[323] Unit processes are defined in the ISO's life cycle assessment standard (ISO 14040:2006) as the "smallest element considered in the life cycle inventory analysis for which input and output data are quantified." ISO, *ISO 14040:2006*, 2006, 5.

[324] A full list of reference products is included in table E.1 of appendix E ("I. Overview of Product-Level Emissions Intensity and Inventory Calculations"). Examples of reference products that are upstream material inputs include carbon anodes, iron sinter, and pig iron. Examples of reference products that are covered product categories include primary unwrought aluminum and carbon and alloy hot-rolled flat steel products. Some steel and aluminum product categories are aggregates of multiple underlying product categories (e.g., wrought aluminum) and do not have corresponding reference products for which product-level emissions inventories were calculated using the approaches described here. In addition, emissions intensities are presented for certain product subcategories (e.g., carbon and alloy rebar, a subcategory of carbon and alloy hot-worked long steel products) that also do not have corresponding reference products. The methods for calculating product-level emissions inventories for these aggregate product categories and product subcategories are described in appendix E ("III.C.2 Calculation of Product-Level Emissions Inventories for Aggregate Product Categories").

[325] WRI and WBCSD, *GHG Protocol Product Life Cycle Accounting and Reporting Standard*, September 2011.

[326] WRI and WBCSD, *GHG Protocol Product Life Cycle Accounting and Reporting Standard*, September 2011, 65.

questionnaires.[327] Table E.1 in appendix E ("I. Overview of Product-Level Emissions Intensity and Inventory Calculations") contains a list of these subprocesses along with corresponding reference products.

As described in greater detail throughout appendix E, the Commission's methods for allocating facility-level emissions into subprocesses differed by scope. Scope 1 process emissions data from the GHGRP database (subparts F, Q, and S) were available at a sufficient level of process-specific granularity to allow for direct allocation to the subprocesses used in this investigation.[328] For energy emissions (scope 1 fuel combustion and scope 2) and scope 3 emissions, the Commission used allocation information in the questionnaire responses to determine each facility's proportional use of fuels, energy, and material inputs by subprocess. Facilities reported quantities of inputs used in each of these subprocesses. Those quantities as a share of the facility-wide use of those inputs were multiplied by total facility-wide emissions associated with each input to determine subprocess-level emissions. For example, if a facility reported using 25 percent of its purchased electricity in seamless tubular steel production, then 25 percent of its facility-level emissions associated with that purchased electricity was allocated to the seamless tubular steel production subprocess.[329]

Although subprocesses were defined such that they related to the fewest reference products possible, some subprocesses produced more than one reference product.[330] In these cases, the Commission

---

[327] These goals were not always mutually supportive. For example, hot-rolled flat steel products are defined for purposes of this investigation to include hot-rolled sheets, strips, and plates, whether or not annealed, pickled, or tempered, in either coils or cut lengths, and not cold-rolled nor clad, plated, or coated with metal. The subprocess that makes stainless and carbon and alloy types of hot-rolled flat steel—"hot-rolling flat steel products"—was designed to capture all processes that produced hot-rolled flat steel. Therefore, if a facility pickled hot-rolled flat steel but did not actually pass the product through a hot-rolling line on-site, it would nonetheless report material and energy use in the "hot-rolling flat steel products" subprocess. Some industry representatives indicated that they considered pickling lines to be a different process from hot-rolling. To address this potential source of confusion, the Commission sought to clearly define the process in the questionnaire and worked extensively with facilities to determine where various inputs used in specific production lines would fall within subprocess definitions.

[328] EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024.

[329] Facilities producing covered products were most often primarily focused on that production; however, many facilities also had other on-site operations that included processes outside of the system boundaries. The Commission designed several subprocesses under which facilities reported fuel, energy, and material inputs. Using the same subdivision techniques described, the Commission excluded emissions associated with these noncovered subprocesses from any product-level emissions inventories of covered products. These subprocesses included: (1) activities of other producers operating on-site; (2) processes used to make products other than covered steel, covered aluminum, or their upstream material inputs; (3) ancillary (nonproduction) activities that are not associated with production floor operations (e.g., an office complex on-site at a facility); and (4) stationary equipment that shreds or sorts scrap. Although scrap shredding and sorting supports production of covered products, emissions (scope 1 fuel combustion emissions and scope 2 emissions) associated with this subprocess were excluded from any product-level emissions inventory in order to consistently treat emissions from shredding and sorting of scrap as outside the system boundary.

[330] Subprocesses were defined more broadly than the production of individual reference products when asking facilities to subdivide input use data by a narrower process category would likely create a burden on facilities or would likely significantly expand the length of the questionnaire. For example, all steel production subprocesses were defined without specifying whether the products made were stainless steel or carbon and alloy steel. Expanding all questions necessary for process subdivision into carbon and alloy versus stainless types would have

further divided subprocess-level emissions into unit process emissions associated with individual reference products using “physical allocation.” Physical allocation uses an underlying physical attribute—in this investigation, production quantities measured in metric tons—to divide emissions between individual products.[331] For each subprocess requiring additional physical allocation, the Commission calculated the production of each reference product made by that subprocess as shares of total subprocess production. The Commission then multiplied those production shares by subprocess-level emissions to estimate unit process-level emissions associated with each reference product. (See the route of emissions under subprocess A in figure 3.5).[332]

In other cases, subprocesses were defined narrowly to cover production of a single reference product. For example, the subprocess “blast furnace operations” corresponded solely with production of pig iron and the subprocess “production of secondary unwrought aluminum” corresponded solely with production of that reference product. In these cases, emissions divided into subprocesses were considered equivalent to unit process emissions associated with the reference product. (See the route of emissions under subprocess B in figure 3.5).[333]

---

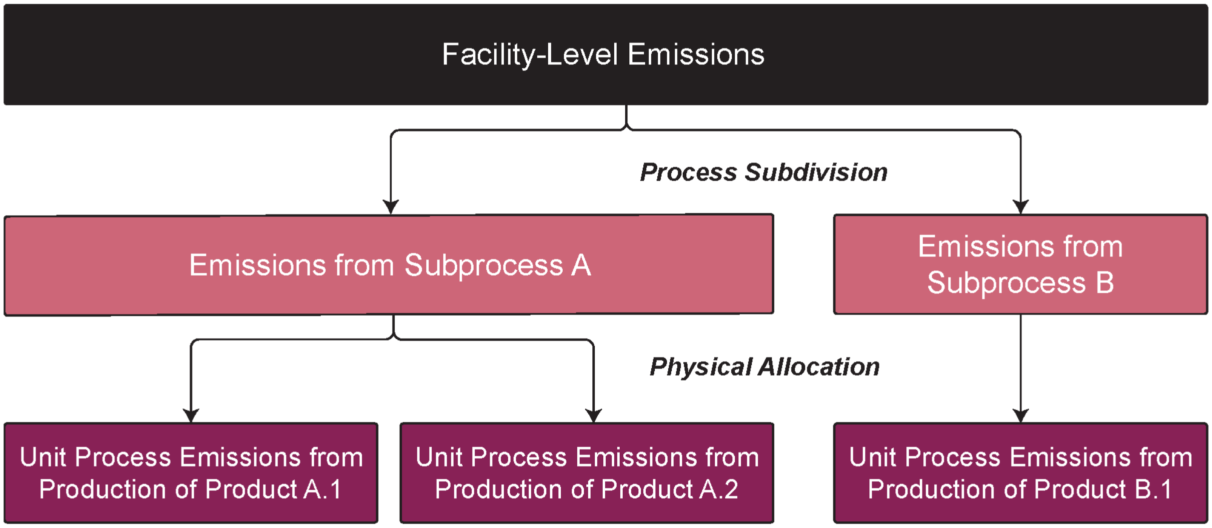
significantly expanded the questionnaire length and added a significant burden on the relatively few facilities that produced both steel types.

[331] WRI and WBCSD, *GHG Protocol Product Life Cycle Accounting and Reporting Standard*, September 2011, 63, 69.

[332] Subprocesses with more than one associated unit process or reference product included: (1) all steel production processes (allocated between stainless versus carbon and alloy versions of each product); (2) gas production (allocated among oxygen, nitrogen, argon, and hydrogen production); (3) calcined lime and dolime production—i.e., lime kilns (allocated between calcined lime versus calcined dolime production); and (4) wrought aluminum production (allocated among production of bars, rods, and profiles; wire; plates, sheets, and strip; foil; tubes, pipes, and tube and pipe fittings; castings; and forgings). The Commission also used physical allocation to allocate emissions associated with each facility’s ambient heating, cooling, ventilation, and lighting supply to unit processes associated with reference products as well as to production of noncovered products on the basis of each product’s production tonnage. Appendix E (“II. Compiling a Facility-Level Emissions Inventory and Allocating to Subprocesses and Unit Processes”) provides more detail on physical allocation approaches.

[333] Subprocesses with only one associated unit process or reference product included: (1) all production processes used to make aluminum products other than wrought aluminum; (2) carbon anode production; (3) metallurgical coke production; (4) iron sinter production; (5) liquid pig iron production in a rotary hearth furnace; (6) blast furnace operations; and (7) coating, cladding, or plating flat steel products.

**Figure 3.5** Simplified example of process subdivision and physical allocation



Source: Compiled by the USITC.

***Example - Allocation of Facility-Level Emissions to Subprocess and Unit Process Emissions from a Steel Facility (Step 5 of 7)***

*The emissions inventory of steel facility Y is allocated among the subprocesses of semifinished steelmaking and hot-working of long products. At this facility, scope 1 process emissions only occur at the EAF (see step 1). The facility's material receipts are similarly used only in the steelmaking process (see step 4). Therefore, scope 1 process emissions and scope 3 emissions are allocated to the steelmaking subprocess only. Scope 1 fuel combustion emissions associated with the natural gas combusted to power the EAF and other on-site furnaces and scope 2 emissions associated with electricity use are allocated to the steelmaking or hot-working subprocesses using allocation information (fuel and electricity use data) from questions 3.8 and 3.9 of the questionnaire. Although steelmaking can result in the production of stainless or carbon and alloy semifinished steel, facility Y only produces carbon and alloy semifinished steel. Therefore, 100 percent of subprocess-level emissions associated with steelmaking are allocated to the unit process producing carbon and alloy semifinished steel. Likewise, 100 percent of subprocess-level emissions associated with hot-working are allocated to the unit process producing carbon and alloy hot-worked long steel.*

***Example - Allocation of Facility-Level Emissions to Subprocess and Unit Process Emissions from an Aluminum Facility (Step 5 of 7)***

*The two covered aluminum products facility Z produces are both wrought aluminum products, so the entire emissions inventory is allocated to one subprocess (wrought aluminum production). However, data reported in question 3.9 of the facility's questionnaire provide allocation information on the portion of electricity used to power the welding station where the window frames are made (i.e., a process used to make products other than covered steel, covered aluminum, or their upstream material inputs). The scope 2 emissions associated with electricity use are allocated to covered wrought aluminum production based on the question 3.9 data, allocating all except the share associated with welding window frames to wrought aluminum production. Facility Z allocates all its natural gas use to covered aluminum production in question 3.8, so 100 percent of scope 1 fuel combustion emissions are allocated to covered wrought aluminum products. Facility Z produces wrought aluminum products in two reference product categories: wrought aluminum bars, rods, and profiles, and wrought aluminum tubes, pipes, and tube or pipe fittings. The subprocess emissions for covered wrought aluminum products are divided between unit processes based on the relative tonnage of profiles and pipe produced.*

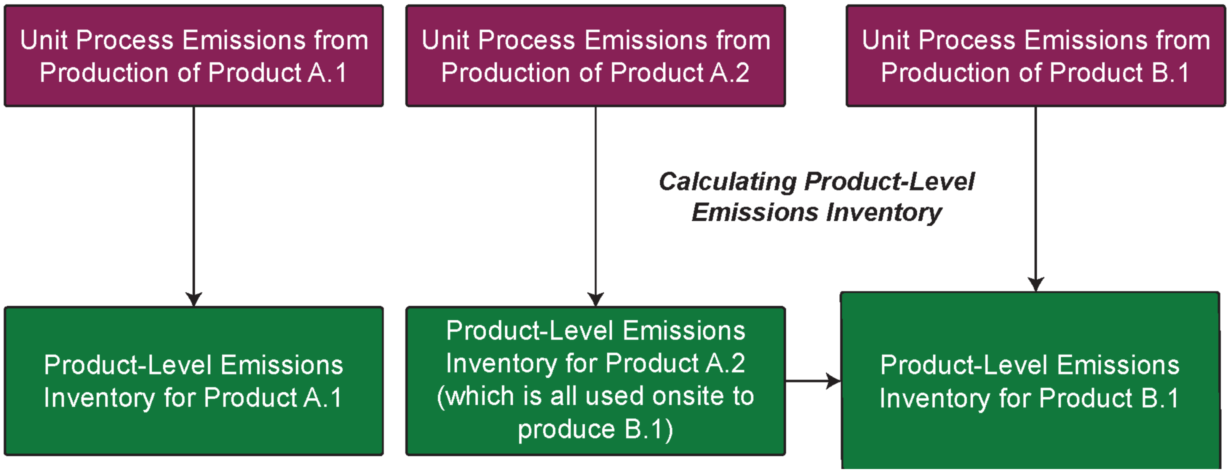
## Calculation of Product-Level Emissions Inventories of Reference Products

After facility-level emissions were allocated to unit processes, unit process emissions were reassembled into product-level emissions inventories for all reference products made at the facility. Many facilities produce one or more products consumed internally in the production of other products.[334] Therefore, product-level emissions inventories calculated for each reference product included not only the unit process emissions associated with the reference product but also the emissions that were attributable to the facility's upstream production of material inputs used to make the reference product. Figure 3.6 shows a simplified example of this, where the product-level emissions inventory for product B.1 includes not only the unit process emissions associated with that product but also the product-level emissions inventory of upstream product A.2, which is used as a material in the production of B.1.

---

[334] For example, chapter 2 describes how integrated steel facilities may produce iron sinter and metallurgical coke on-site and will produce pig iron along with semifinished steel. Flat, long, and seamless tubular steel products are frequently made in facilities that have upstream semifinished steel production. In addition, wrought aluminum producers may produce multiple wrought products or have secondary unwrought aluminum production on-site.

**Figure 3.6** Simplified example of product-level emissions inventory calculation



Source: Compiled by the USITC.

Critically, any emissions attributable to the facility's upstream production of material inputs that were shipped off-site—and were therefore not used in the facility's downstream production—were not included in downstream product-level emissions inventories.[335] Similarly, if a facility produced upstream covered steel or aluminum products and then shipped those products off-site, or used those products to produce noncovered products, the emissions associated with those upstream steel or aluminum products were not aggregated within the product-level emissions inventories of downstream covered products produced by the facility.

***Example - Calculating Product-Level Inventories of Reference Products for a Steel Facility (Step 6 of 7)***

*Steel facility Y produced two reference products: carbon and alloy semifinished steel (i.e., carbon steel billets) and carbon and alloy hot-worked long products (i.e., rebar). The product-level emissions inventory for carbon and alloy semifinished steel includes only the unit process emissions associated with the production of that product, as there were no further upstream materials made at the facility. Steel facility Y does not ship any billets off-site and uses those entirely in the production of rebar; therefore, the product-level emissions inventory for carbon and alloy hot-worked long steel includes (1) the entirety of the product-level emissions inventory for carbon and alloy semifinished steel and (2) the unit process emissions associated with production of carbon and alloy hot-worked long steel.*

---

[335] This report does not include emissions intensity estimates for upstream materials made by facilities making covered products. However, the Commission's calculation of product-level emissions inventories for those materials allowed for the exclusion of emissions associated with those materials that were shipped off-site without being used in downstream production of covered products. For example, calculation of product-level emissions inventories for pig iron production allowed for exclusion of emissions associated with pig iron shipped off-site from the product-level emissions inventories for semifinished steel produced by the facility.

***Example - Calculating Product-Level Inventories of Reference Products for an Aluminum Facility (Step 6 of 7)***

*Aluminum facility Z produced products within two reference product categories: wrought aluminum bars, rods, and profiles, and wrought aluminum tubes, pipes, tube or pipe fittings. The product-level inventory for profiles and the product-level inventory for pipes are each equal to their respective unit process emissions developed in the previous step.*

# Stage 3: Computation of Average and Highest Emissions Intensity Estimates

Once emissions were allocated to product categories, the final step of the calculation methodology incorporated production data to generate the average and highest emissions intensity estimates by product category at the national level. All types of emissions described above—process emissions (scope 1), energy emissions (scopes 1 and 2), and emissions embedded in material inputs (scope 3)—that were allocated to each product category produced in that facility were aggregated to generate total emissions for that product category at the facility level. These facility-specific, product-level total emissions were then summed across all facilities producing that product category, resulting in national total emissions for that product category. Similarly, facility-specific, product-level production was summed across all facilities for each product category to generate the national total production of the product category.

## Average Emissions Intensity Calculation

The Commission computed the product category-level production-weighted emissions intensity by dividing the national total emissions (in metric tons of $CO_2e$) by the national total production (in metric tons) produced for the product category. This calculation was run for each covered steel and aluminum product category to generate a production-weighted national average emissions intensity for each of those product categories.[336]

For each product category:

$$\text{National average emissions intensity} = \frac{\text{total emissions attributed to the product category by all facilities}}{\text{total production of the product category by all facilities}}$$

---

[336] Refer to appendix H (“Computational Methods”) for further details on average and highest measure calculation methods.

***Example - Computing the Average Emissions Intensities for Covered Products in a Steel Facility (Step 7 of 7)***

*Steel facility Y is among dozens of facilities responding to the Commission’s questionnaire that produced carbon and alloy hot-worked long steel in 2022.*

*— Both the product-level emissions inventories and the production of this reference product (from question 2.1.1) are summed across all these facilities.*

*— Next, the national total emissions inventory for carbon and alloy hot-worked long steel is divided by the total reported production of this product to reach the average emissions intensity of this product category.*

*The same steps are used to calculate the average emissions intensity estimates of all product categories, including carbon and alloy semifinished steel also made by steel facility Y. Because the only hot-worked long product that steel facility Y produces is rebar, this facility’s hot-worked long product-level emissions inventory is also used to determine an emissions intensity for the rebar subcategory as well.*

***Example - Computing the Average Emissions Intensities for Covered Products in an Aluminum Facility (Step 7 of 7)***

*Aluminum facility Z is among dozens of facilities responding to the Commission’s questionnaire that produced aluminum bars, rods, and profiles in 2022.*

*— Both the product-level emissions inventories and the production of this reference product (from question 2.2.3b) are summed across all these facilities.*

*— Next, the national total emissions inventory for aluminum bars, rods, and profiles is divided by the total reported production of this product to reach the average emissions intensity of this product category.*

*The same steps are used to calculate the average emissions intensities for all product categories, including aluminum tubes, pipes, and tube or pipe fittings also made by aluminum facility Z.*

# Highest Emissions Intensity Calculation

The Commission computed the “highest” emissions intensity as the production-weighted average emissions intensity of the facilities with the highest emissions intensity estimates that constituted 10 percent (i.e., 90–100th percentile range) of the production of a particular product category, following the steps outlined below:

1. Facility-level emissions intensity estimates were computed for each product category that was produced in that facility.
2. Within the product category, facilities were then arranged in descending order of their emissions intensities, and cumulative production shares were calculated.

3. Facilities were included until 10 percent of cumulative production for that product category was captured from the top end of the emissions intensity distribution.[337]
4. Production-weighted average emissions intensity estimates were then calculated for this percentile range over the facilities identified using the same formula as the production-weighted national average calculation.

Production-weighted averages were also calculated for the 50–100th, 60–100th, 70–100th, and 80–100th percentile ranges (i.e., the most emissions-intensive facilities representing 50 percent, 40 percent, 30 percent, and 20 percent of production, respectively) for each product category and are presented in appendix I.

---

[337] For facilities that straddle the 10 percent threshold (i.e., where inclusion of the next most emissions-intensive facility captures less than 10 percent of cumulative production and inclusion of the current facility captures more than 10 percent), only a portion of the emissions and production for that facility is included. For example, if 40 percent of a facility's production was above the 10 percent threshold and 60 percent was below the threshold, only 40 percent of that facility's production and the emissions associated with that 40 percent of the production would be considered in the calculation of cumulative production and emissions for the production-weighted averages of the 90–100th percentile range.

# Bibliography

Biberman, John, Perrine Toledano, and Rohini Ram Mohan. "GHG Accounting Methods in the Aluminum Industry." *SSRN Electronic Journal* (February 2023). https://doi.org/10.2139/ssrn.4407422.

Cleveland-Cliffs Inc. *Sustainability Report 2022*. April 3, 2023. https://d1io3yog0oux5.cloudfront.net/_325748997fff417ed2c0d15435f37b03/clevelandcliffs/db/1188/11490/file/CLF_SustainabilityReport_2023_Spreads_04032023.pdf.

Cleveland-Cliffs Inc. "Burns Harbor." Accessed October 24, 2024. https://www.clevelandcliffs.com/operations/steelmaking/burns-harbor.

Ecoinvent. "UPR, LCI and LCIA." February 14, 2024. https://support.ecoinvent.org/upr-lci-lcia.

European Commission (EC). Directorate-General Taxation and Customs Union (DG-TAXUD). *Guidance Document on CBAM Implementation for Installation Operators Outside the EU*. Brussels, Belgium: European Commission, December 8, 2023. https://taxation-customs.ec.europa.eu/document/download/2980287c-dca2-4a4b-aff3-db6374806cf7_en?filename=Guidance%20document%20on%20CBAM%20implementation%20for%20installation%20operators%20outside%20the%20EU.pdf.

International Energy Agency (IEA). "The Challenge of Reaching Zero Emissions in Heavy Industry." IEA, September 19, 2020. https://www.iea.org/articles/the-challenge-of-reaching-zero-emissions-in-heavy-industry.

International Energy Agency (IEA). Energy Technology Systems Analysis Programme (ETSAP). "Technology Brief 102: Iron and Steel." May 2010. https://iea-etsap.org/E-TechDS/PDF/I02-Iron&Steel-GS-AD-gct.pdf.

International Organization for Standardization (ISO). *ISO 14040:2006*. 2006. https://www.iso.org/standard/37456.html.

Janjua, Rizwan, and Felipe Maciel. *$CO_2$ Data Collection User Guide, Version 11*. V11, 30/05/2024. WorldSteel Association, May 30, 2024. https://worldsteel.org/wp-content/uploads/CO2_User_Guide_V11.pdf.

Metius, Gary. "DRI Production Using Coke Oven Gas (COG): Test Results of Thermal Reactor System™ (TRS®)." Midrex Technologies, Inc., March 2016. https://www.midrex.com/tech-article/dri-production-using-coke-oven-gas-cog-test-results-of-thermal-reactor-system-trs/.

Mighty Earth. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. June 21, 2024. https://edis.usitc.gov/external/search/document/824410.

Narayanan, Ramesh. "Chemical Interactions of Dross with Water and Water Vapor in Aluminum Scrap Remelting." *Materials Transactions JIM* 38, no. 1 (January 1, 1997): 85–88. https://doi.org/10.2320/MATERTRANS1989.38.85.

ResponsibleSteel. *ResponsibleSteel International Production Standard: Version 2.1*. May 21, 2024. https://www.responsiblesteel.org/standards.

Shinzato, M. C., and R. Hypolito. "Solid Waste from Aluminum Recycling Process: Characterization and Reuse of Its Economically Valuable Constituents." *Waste Management* 25, no. 1 (January 1, 2005): 37–46. https://doi.org/10.1016/j.wasman.2004.08.005.

Synapse Energy Economics. *Coming Clean on Industrial Emissions*. September 12, 2023. https://www.sierraclub.org/sites/default/files/2023-09/Coming-Clean-On-Industrial-Emissions.pdf.

U.S. Department of Energy (USDOE). Office of Energy Efficiency & Renewable Energy (EERE). "District Energy." (September 2020).

U.S. Environmental Protection Agency (EPA). "Aluminum Production Subpart F, Greenhouse Gas Reporting Program." February 2018. https://www.epa.gov/sites/default/files/2018-02/documents/f_infosheet_2018.pdf.

U.S. Environmental Protection Agency (EPA). "eGRID2022 Unit, Generator, Plant, State, Balancing Authority Area, eGRID Subregion, NERC Region, U.S., and Grid Gross Loss (%) Data Files (eGRID 2022 Database, Emissions by Unit and Fuel Type)." 2024. https://www.epa.gov/system/files/documents/2024-01/egrid2022_data.xlsx.

U.S. Environmental Protection Agency (EPA). "eGRID Subregion Year 2022 Data (SRL22)." Emissions and Generation Resource Integrated Database (eGRID), January 30, 2024. https://www.epa.gov/egrid/download-data.

U.S. Environmental Protection Agency (EPA). "eGRID Mapping Files." Accessed August 23, 2024. https://www.epa.gov/egrid/egrid-mapping-files.

U.S. Environmental Protection Agency (EPA). *Greenhouse Gas Inventory Guidance: Indirect Emissions from Purchased Electricity*. December 2023. https://www.epa.gov/sites/default/files/2020-12/documents/electricityemissions.pdf.

U.S. Environmental Protection Agency (EPA). "Greenhouse Gas Reporting Program: Emission Calculation Methodologies." July 2015. https://www.epa.gov/sites/default/files/2015-07/documents/ghgrp_methodology_factsheet.pdf.

U.S. Environmental Protection Agency (EPA). "Greenhouse Gas Reporting Program (GHGRP). Envirofacts GHG Query Builder." Accessed September 18, 2024. https://enviro.epa.gov/query-builder/ghg.

U.S. Environmental Protection Agency (EPA). "Plant Year 2022 Data (PLNT22)." Emissions and Generation Resource Integrated Database (eGRID), January 30, 2024. https://www.epa.gov/egrid/download-data.

U.S. Environmental Protection Agency (EPA). "Understanding Global Warming Potentials." Greenhouse Gas Emissions, August 8, 2024. https://www.epa.gov/ghgemissions/understanding-global-warming-potentials.

U.S. Environmental Protection Agency (EPA). "What Information Is Contained in eGRID?" Overviews and Factsheets, Frequent Questions about eGRID, September 4, 2024. https://www.epa.gov/egrid/frequent-questions-about-egrid#egrid3.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). *The Emissions and Generation Resource Integrated Database: eGRID Technical Guide with Year 2022 Data*. Clean Air Markets Division (CAMD), January 2024. https://www.epa.gov/system/files/documents/2024-01/egrid2022_technical_guide.pdf.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). "Power Profiler." Emissions and Generation Resource Integrated Database (eGRID), accessed various dates. https://www.epa.gov/egrid/power-profiler.

U.S. Environmental Protection Agency (EPA). Office of Atmospheric Protection (OAP). "Greenhouse Gas Reporting Program (GHGRP). Emissions by Unit and Fuel Type Dataset." Accessed September 9, 2024. https://www.epa.gov/system/files/other-files/2023-09/emissions_by_unit_and_fuel_type_c_d_aa_09_2023_0.zip.

U.S. International Trade Commission (USITC). *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Company-Level*. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_company-level_questionnaire.pdf.

U.S. International Trade Commission (USITC). *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_facility-level_questionnaire_aluminum_and_steel_combined.pdf.

U.S. International Trade Commission (USITC). Hearing Transcript in Connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 7, 2023. https://edis.usitc.gov/external/search/document/810108.

United States Steel Corporation (U. S. Steel). "Locations." Accessed October 24, 2024. https://www.ussteel.com/about-us/locations.

United States Steel Corporation (U. S. Steel). *2022 Environmental, Social and Governance (ESG) Report: Essential for Our Future*. June 13, 2023. https://www.ussteel.com/documents/40705/43725/2022+ESG+Report.pdf/00a10a26-a1c5-8373-4555-7b19524f76b6?t=1686331083478.

World Resources Institute (WRI). *GHG Protocol Scope 2 Guidance*. 2015. https://ghgprotocol.org/sites/default/files/2023-03/Scope%202%20Guidance.pdf.

World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*. 2013. https://ghgprotocol.org/scope-3-calculation-guidance-2.

World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). *GHG Protocol Product Life Cycle Accounting and Reporting Standard*. Accessed August 3, 2023. https://ghgprotocol.org/sites/default/files/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf.

# Chapter 4
# Emissions Intensities of U.S. Steel Products

This chapter presents the production-weighted average and highest emissions intensity in metric tons (mt) of carbon dioxide equivalent ($CO_2e$) per metric ton (mt) of the given steel product category (mt $CO_2e$/mt steel) produced in the United States in 2022. Estimates are presented for the five steel product categories listed in Attachment A of the Trade Representative's request letter, 14 additional product categories, and 20 steel product subcategories (e.g., slabs, rebar, wire). This chapter also describes the facilities producing covered steel products that responded to the Commission's questionnaire, the factors impacting steel products' emissions intensities, comparisons to other emissions intensity estimates, and additional analyses performed on survey data.

## Key Findings

- The average emissions intensity for carbon and other alloy ("carbon and alloy") semifinished steel was 1.02 mt $CO_2e$/mt steel, compared to 2.23 mt $CO_2e$/mt steel for stainless semifinished steel. The emissions intensity of carbon and alloy semifinished steel is primarily influenced by the production pathway (the more emissions-intensive blast furnace and basic oxygen furnace, or BF-BOF, pathway, versus the electric arc furnace, or EAF, pathway) and the relative use of emissions-intensive upstream material inputs like pig iron and direct reduced iron. For stainless semifinished steel, no stainless semifinished steel-producing facilities reported operating a BF-BOF and, therefore, the reliance on emissions-intensive ferroalloys is the primary driver of emissions for stainless steel products.
- For carbon and alloy steel mill products, the most emissions-intensive processes in the U.S. steel industry occur during the production of pig iron and semifinished steel. Nevertheless, the additional subprocesses used to produce downstream products are not insignificant, leading to meaningful differences in emissions intensities across the carbon and alloy steel product categories.
- Average emissions intensities among carbon and alloy steel mill products ranged between 0.67 mt $CO_2e$/mt steel for hot-worked long products and 2.17 mt $CO_2e$/mt steel for coated flat products. Average emissions intensities among stainless steel mill products ranged between 2.31 mt $CO_2e$/mt steel for hot-rolled flat and 4.55 mt $CO_2e$/mt steel for wire. Stainless steel mill products are more emissions intensive than their carbon and alloy steel counterparts, which is due to higher energy intensities and the larger quantities of ferroalloys like chromium and nickel used in the production of stainless steel that contribute to higher scope 3 emissions.
- In general, carbon and alloy flat steel products are more emissions intensive than carbon and alloy long steel products. Looking at aggregate product categories, average emissions intensities were 1.83 mt $CO_2e$/mt steel for carbon and alloy flat steel products and 0.75 mt $CO_2e$/mt steel for carbon and alloy long products. The primary driver for this difference was that the semifinished steel inputs used in the production of long products were made exclusively via the

EAF pathway, rather than via the more emissions-intensive BF-BOF production pathway. Conversely, flat products were made using semifinished steel inputs from both production pathways.

- The total amount of electricity purchased by facilities producing covered steel products was heavily concentrated in the subregion which spans states historically associated with the U.S. steel industry (Indiana, Ohio, and parts of Illinois and Pennsylvania). Electricity purchased in this subregion carried an emissions factor that was over 21 percent higher than the national average.
- Further downstream steel products generally had higher emissions intensities than less-processed steel products, because each successive process in the production of steel products contributes to the emissions intensities of downstream goods.
- Upstream materials and steel products used in the manufacturing of covered steel products were sourced from domestic and international sources or from a facility’s own production. Externally sourced pig iron and semifinished steel were more often imported than further downstream products like hot-rolled flat steel and hot-worked long steel that were more frequently sourced domestically.

# Surveyed Facilities

The survey population for the Commission's questionnaire was drawn from existing public information and lists of known producers of covered steel products from trade associations and other sources.[338] To be included in the population, facilities were required to have produced covered steel products in 2022. These surveyed facilities are referred to as “facilities” in this chapter.

Table 4.1 shows the number of facilities manufacturing each covered steel product. There were nearly 4 times as many facilities producing carbon and alloy steels as there were facilities producing stainless steels. The largest product-category segments in terms of number of facilities were carbon and alloy cold-formed long products, with 99 facilities, and carbon and alloy non-seamless tubular products, with 97. The smallest were stainless seamless tubular products, with 10, and stainless hot-worked long products, with 14. Facilities also produced differing combinations of covered steel products, with some manufacturing both stainless and carbon and alloy steels. Many facilities producing hot-rolled steel also produced cold-rolled or coated steels. Similarly, some producers of hot-worked long products also produced cold-formed long products. The scale of production also varied between facilities with some producers of semifinished steel or downstream products reporting manufacturing less than 1,000 mt of steel products and other facilities producing over 100,000 mt. For more information on the survey population and survey methods, including response rates, see appendix H (“Description of the Commission’s Survey Methodology”). For a brief description of covered steel products and the HTS heading or statistical reporting number under which these products are categorized, see table 2.1 and 2.2 in chapter 2 (“Covered Steel Products”).

---

[338] Stand-alone steel scrap shredders or processors were not included in the survey population.

**Table 4.1** Steel products: number of facilities producing by product category

In number of facility questionnaires.

| Type | Product | Facilities |
|---|---|---|
| Carbon and alloy steels | Semifinished | 87 |
| Carbon and alloy steels | Hot-rolled flat | 47 |
| Carbon and alloy steels | Cold-rolled flat | 41 |
| Carbon and alloy steels | Coated flat | 45 |
| Carbon and alloy steels | Hot-worked long | 70 |
| Carbon and alloy steels | Cold-formed long | 99 |
| Carbon and alloy steels | Seamless tubular | 21 |
| Carbon and alloy steels | Non-seamless tubular | 97 |
| Stainless steels | Semifinished | 17 |
| Stainless steels | Hot-rolled flat | 14 |
| Stainless steels | Cold-rolled flat | 15 |
| Stainless steels | Hot-worked long | 14 |
| Stainless steels | Cold-formed long | 22 |
| Stainless steels | Seamless tubular | 10 |
| Stainless steels | Non-seamless tubular | 21 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 1.2.3.

Note: A total line is not given at the bottom of the table for the number of the facilities. Because some facilities produced covered steel products in more than one product category, the sum would not equal the total number of facilities producing steel products (418 facilities).

# Factors Influencing Emissions Intensities

The steel product emissions intensities, presented later in this chapter, are influenced by several factors. These factors include the production pathway used to produce semifinished steel, the energy used in steel production processes, and the sourcing patterns for key material inputs. This section describes some of the key factors that impact the emissions intensity of covered steel products made in the United States.

## Production Pathway and Scrap Utilization

One of the most significant factors impacting the emissions intensities of steel products is the production pathway—the specific technology or production method—used to produce semifinished steel.[339] As described in chapter 2 ("Semifinished Steelmaking"), steel mills produce semifinished steel using two distinct production pathways: the BF-BOF production pathway, occurring at large integrated mills, and the EAF production pathway, occurring at minimills.[340] The BF-BOF production pathway is far more emissions intensive. According to a report published by the Steel Manufacturers Association (SMA), an industry group that represents EAFs, emissions intensities (inclusive of scope 1–3 emissions) for U.S. EAF- and BF-BOF-produced semifinished steel were 0.68 mt $CO_2$/mt steel and 2.11 mt $CO_2$/mt steel,

---

[339] Semifinished steel is used as substrate—either directly or indirectly—in the production of all downstream covered steel product categories, and therefore the emissions embedded in semifinished steel are included within the emissions intensities of downstream products.

[340] See "Steel Production Processes" in chapter 2 for discussion of how emerging technologies like hydrogen use in blast furnaces or in direct reduced iron production could influence pathway-specific emissions intensities in the future.

respectively.[341] In 2022, 31.0 percent of semifinished steel produced in the United States was made using the BF-BOF method, compared to 71.7 percent of semifinished steel produced globally.[342]

The source of metallic inputs used in steelmaking—which is in large part driven by the production pathway—is also a major driver of the emissions intensities of semifinished steel. As discussed in chapter 2 (“Steel System Boundary”), scrap is considered to have zero embedded emissions in this investigation; therefore, the scrap utilization rate of facilities producing covered steel products reduces the emissions intensities of products made at those facilities. BOFs within integrated mills use molten pig iron sourced directly from on-site blast furnaces as the main metallic input used in steel production, although they can also include ferrous scrap quantities up to 35 percent of total metallic inputs.[343] By contrast, EAFs producing semifinished steel use primarily ferrous scrap as the metallic input.[344] Facilities with EAFs that produce carbon and alloy semifinished steel will typically also rely on smaller quantities of pig iron and direct reduced iron.[345] Stainless semifinished steel is also made using EAFs in the United States, and producers of stainless steel similarly rely primarily on stainless steel scrap but also use significant quantities of ferroalloys.[346] U.S. industry representatives linked their companies’ high scrap utilization rates with the low emissions intensities of their products relative to those of other global producers.[347]

# Energy Used in Steel Production Processes

The emissions intensities of covered steel products are also affected by the types of fuel and the sources of purchased electricity used in steel production processes. Among facilities that produced covered steel products and reported to the U.S. Environmental Protection Agency (EPA)’s Greenhouse Gas Reporting Program (GHGRP) in 2022, over 99.9 percent of their facility-wide fuel combustion emissions (reported under subpart C of the GHGRP) came from three fuels: natural gas, blast furnace gas, and coke oven gas. Natural gas was the most used fuel type among steel producers, with natural gas combustion totaling almost 15 mmt $CO_2e$ across all facilities producing covered steel products and reporting to GHGRP. This quantity, however, was only about 40 percent of the total subpart C fuel combustion emissions from these facilities. Eight facilities—all integrated steel producers—reported combusting blast furnace gas. Although occurring at far fewer facilities, this blast furnace gas combustion resulted in over 20 mmt $CO_2e$, or about 56 percent of the total subpart C emissions from covered steelmaking facilities reporting to the GHGRP. The remaining 5 percent of emissions came from a small number of integrated

---

[341] SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 13.
[342] worldsteel, *Steel Statistical Yearbook 2023*, accessed September 21, 2024.
[343] USITC, hearing transcript, December 7, 2023, 135 (testimony of Kevin Dempsey, AISI), 213 (testimony of Adam Shaffer, ISRI).
[344] USITC, hearing transcript, December 7, 2023, 112 (testimony of David Miracle, Nucor); EPA, OAR, “Technical Support Document for the Iron and Steel Sector,” August 28, 2009, 18–19; EPA, *AP 42, Compilation of Air Emissions Factors from Stationary Sources*, January 1995, 12.5-3.
[345] Su and Assous, *Starting from Scrap*, June 2022, 27.
[346] Outokumpu, written submission to the USITC, November 21, 2023, 5; USITC, hearing transcript, December 7, 2023, 74 (testimony of Joe Green, SSINA), 138–139 (testimony of Camilla Kaplin, Outokumpu).
[347] USITC, hearing transcript, December 7, 2023, 74 (testimony of Joe Green, SSINA), 90–91 (testimony of Tamara Weinert, Outokumpu), 105–06 (testimony of Jeff Hansen, SDI); Nucor, written submission to the USITC, November 11, 2023, 3–4.

steelmaking facilities that reported combusting coke oven gas.[348] Although some GHGRP facilities also use coal or coke, these fuels were almost always used as a feedstock that contributed to process emissions (reported under subpart Q of the GHGRP) and blast furnace gas outputs rather than as direct fuel combustion.[349]

U.S. facilities producing covered steel products exist in most regions of the United States, and therefore their scope 2 emissions from electricity purchases are affected in large part by differences in the mix of generation sources of electricity in each region. A heat map of the U.S. steel industry's electricity purchases is shown in figure 4.1. The total amount of electricity purchased by facilities producing covered steel products was heavily concentrated in the RFCW subregion, which spans states historically associated with the U.S. steel industry (Indiana, Ohio, and parts of Illinois and Pennsylvania).[350] Electricity purchased in this subregion carried an emissions factor that was 21.1 percent higher than the national average—0.46 mt of $CO_2e$ per megawatt-hour, compared to 0.38 mt of $CO_2e$ per megawatt-hour (table 4.2).[351] Facilities producing covered steel products in areas of the southeastern United States also purchased substantial amounts of electricity, particularly in the SRMV subregion east of Texas, as well as in the SRTV subregion covering Kentucky, Tennessee, and parts of Mississippi and Alabama. Although the emissions factors vary across U.S. regions, they are generally lower than the global average emissions factor for electricity generation in 2022 (0.49 mt $CO_2e$/MWh).[352]

**Table 4.2** Total electricity purchases from facilities producing covered steel products, by purchase quantity in the top five Emissions and Generation Resource Integrated Database (eGRID) subregions

In gigawatt-hours (GWh) and metric tons of carbon dioxide equivalent per megawatt-hour (mt CO2e/MWh). n.a. = not available; — (em dash) = not applicable.

| eGRID subregion | eGRID subregion name | Purchase quantity (GWh) | Emissions factor (mt $CO_2e$/MWh) |
|---|---|---:|---:|
| RFCW | RFC West | 22,472 | 0.456 |
| SRTV | SERC Tennessee Valley | 7,172 | 0.426 |
| SRMV | SERC Mississippi Valley | 6,705 | 0.365 |
| SRSO | SERC South | 4,796 | 0.407 |
| SRVC | SERC Virginia-Carolina | 4,200 | 0.284 |
| All other | — | 13,049 | n.a. |
| Total | — | 58,394 | 0.380 |

Sources: USITC, Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level, 2024, responses to questions 4.1 and 4.2a; EPA, "SRL22," January 30, 2024.

Notes: Purchased electricity quantities for each subregion aggregate total facility-wide purchases of electricity and include electricity purchased to make noncovered products. The data do not include on-site electricity generation.

---

[348] Percentages do not total to 100 because of rounding. EPA, OAP, "GHGRP, Emissions by Unit and Fuel Type Dataset," accessed September 9, 2024.

[349] EPA, OAP, "GHGRP, Emissions by Unit and Fuel Type Dataset," accessed September 9, 2024. For more information on blast furnace gas, see box 3.1 in chapter 3.

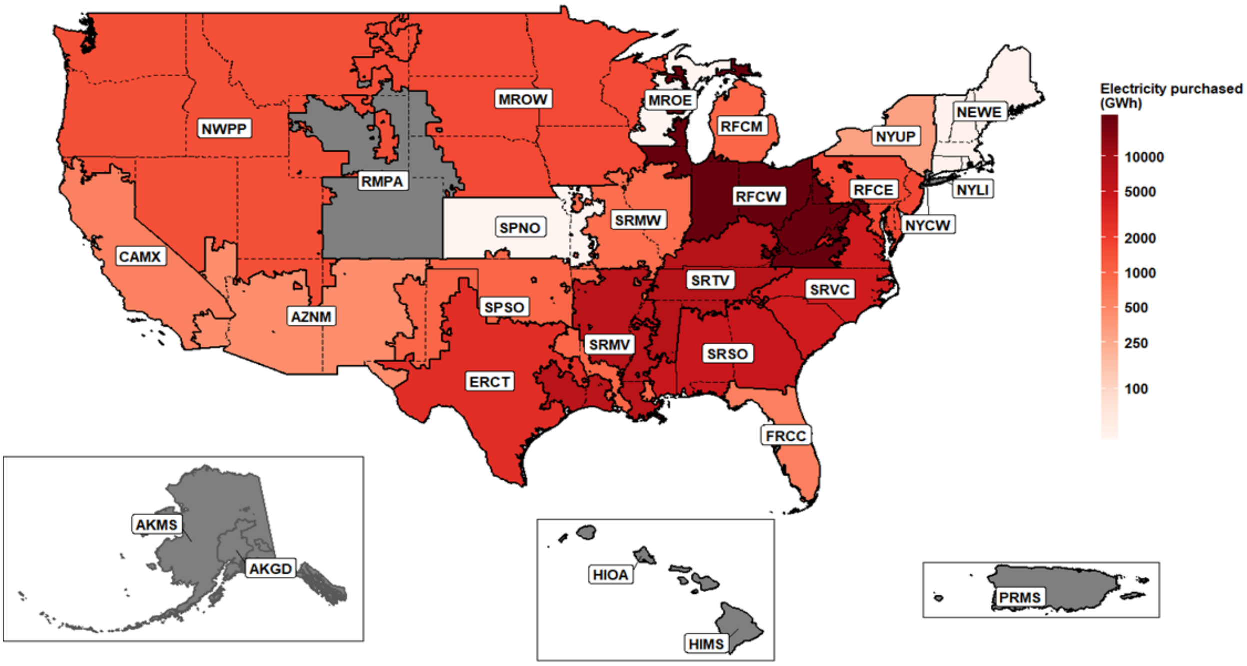
[350] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 4.1 and 4.2a.

[351] Calculated from variable SRC2ERTA, converted from pounds to mt. EPA, "SRL22," January 30, 2024.

[352] Ember, "Electricity Data Explorer," accessed November 8, 2024.

**Figure 4.1** Total electricity purchases from facilities producing covered steel products, by Emissions and Generation Resource Integrated Database (eGRID) subregion

In gigawatt-hours (GWh). Dark gray shading indicates data are suppressed because of confidentiality. Underlying data for this figure can be found in appendix J, table J.11.



Sources: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 4.1 and 4.2a; EPA, eGRID Mapping Files, accessed August 23, 2024.
Note: Purchased electricity quantities for each subregion aggregate total facility-wide purchases of electricity and include electricity purchased to make noncovered products. The data do not include on-site electricity generation.

# Foreign-Origin Material Inputs

The emissions intensities of U.S. covered steel products are affected not only by the production practices that occur in the United States, but also those in other countries that export key raw materials—particularly pig iron, ferroalloys, and semifinished steel—to the United States. Foreign emissions are embedded in U.S. steel products when domestic producers use imported materials in their production. Because different countries have different production practices, fuel mixes, electricity emissions factors, and uses of raw materials, emissions intensities of each country vary substantially.[353]

Studies have found that U.S. semifinished steel—the common material input in virtually all downstream steel production—has relatively low emissions intensities compared to those of other countries. These studies have generally found that the U.S. emissions intensity for semifinished steel was lower than that of other countries whether emissions intensities were measured on a pathway-specific basis or as a national average. For example, a 2023 study by the European Commission's Joint Research Centre found that the emissions intensities of U.S. pig iron and carbon semifinished steel made using BF-BOF methods

---

[353] Hasanbeigi, "Steel Climate Impact - An International Benchmarking of Energy and $CO_2$ Intensities," April 2022, 19.

were lower than the emissions intensities of pig iron and carbon semifinished steel made using BF-BOF methods in all other major European trading partners and the European Union itself.[354] A 2022 study by Global Efficiency Intelligence likewise reported that the United States had lower emissions intensities for steel produced using either BF-BOF and EAF methods compared to most other countries studied. Additionally, this study found that when EAF and BF-BOF results were aggregated for each country according to the relative concentration of each production pathway, the United States had the second-lowest emissions intensity of all countries studied.[355] Likewise, the Steel Manufacturers Association found that the emissions intensity (inclusive of scope 1 and 2 emissions) of U.S. semifinished steel was approximately 37 percent lower than that of European semifinished steel because of the high concentration of EAF steelmaking in the United States.[356]

---

[354] This chapter includes references to emissions intensity estimates from JRC's 2023 report, *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries in the EU and Its Main Trading Partners*. This report used a "top-down" approach to calculating $CO_2$ emissions intensities based on national-level data (particularly energy use and output data from the International Energy Agency) and emissions factors rather than corporate or facility-level reporting. As a result, these data were not calculated or presented in terms of scopes 1, 2, and 3. JRC produced these data for specific production pathways but only presented data corresponding to the production pathway with the highest emissions intensity (which was the BF-BOF production pathway for most countries). Estimates were based on system boundaries that incorporated upstream production of steel products used as substrate, pig iron, DRI, iron pellets and sinter, and certain ferroalloys. In this section on foreign-origin material inputs, the comparison of the emissions intensities of U.S. products and other countries' products are based on JRC's reported emissions intensity results calculated for Combined Nomenclature codes 7201 and 7206.90.00, which represent broader categories of pig iron and non-alloy slabs, billets, and blooms, respectively. Vidovic et al., *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 11, 15–16, 18, 50, 131–47. See also Koolen and Vidovic, *Greenhouse Gas Intensities of the EU Steel Industry and Its Trading Partners*, June 22, 2022, 2.

[355] This chapter includes references to emissions intensity estimates from Global Efficiency Intelligence's 2022 "Steel Climate Impact" report. The Global Efficiency Intelligence report used data from the International Energy Agency and other national-level data sources to estimate different countries' $CO_2$ emissions intensities for steel. These data were not calculated or presented in terms of scopes 1, 2, and 3. Global Efficiency Intelligence's estimates were based on system boundaries that incorporated upstream production of metallurgical coke, iron pellets and sinter, pig iron, and DRI. These estimates are expressed on a crude steel basis (i.e., $CO_2$ emissions per metric ton of semifinished steel produced) but include emissions from hot-rolling, cold-rolling, and other steel processing activities such as coating. The study's authors noted that this approach might cause countries with higher amounts of processing downstream from semifinished steel production (like the United States) to have higher emissions intensities relative to countries with lower amounts of downstream processing activities than would be the case under an approach where such downstream activities were excluded from the system boundary. Hasanbeigi, "Steel Climate Impact - An International Benchmarking of Energy and $CO_2$ Intensities," April 2022, 6-7, 15, 16, 19, 26-29.

[356] This chapter includes references to emissions intensity estimates from SMA's *Steelmaking Emissions Report 2022*. SMA's emissions intensity estimates cover $CO_2$ only and vary in terms of scope coverage, with scope 3 emissions omitted in estimates that compare emissions intensities across countries or aggregate emissions intensities across production pathways. Where SMA's reported estimates include scope 3, the system boundary incorporates upstream production of semifinished steel, pig iron, DRI, metallurgical coke, iron pellets and sinter; iron and coal mining; and scrap processing and transportation. SMA's emissions intensity estimates are based on an analysis performed by CRU. CRU is a firm that provides analysis on steel and other metals markets and has developed an emissions analysis tool that includes facility-level emissions intensities. CRU uses public corporate reporting of emissions and then performs additional analysis to produce emissions intensity estimates that are directly comparable across facilities. SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 4, 7, 9, 10, 13; CRU, "CRU Emissions Analysis Tool," 2024.

These studies suggest that when U.S. facilities use foreign-origin material inputs, they are likely to have higher embedded emissions in their covered products. However, the effect of foreign material use on the emissions intensities of covered products varies depending on the source of that material. For example, a representative from Nucor (a producer of carbon and alloy steel products) reported that imported pig iron from Brazil produced from renewable eucalyptus-based charcoal allowed them to reduce their emissions.[357] Outokumpu (a producer of stainless steel products) reported that it makes ferrochrome—a key ferroalloy input in stainless steel production—in Finland, employing primarily low-emissions sources of electricity (such as nuclear power) and reused waste gases for combined heat and power operations in this production. As a result, Outokumpu's Finnish-origin ferrochrome is less emissions intensive than ferrochrome from other sources. Outokumpu uses its Finnish-origin ferrochrome in its U.S. production, helping to lower its emissions intensity for the production of stainless steel.[358]

In addition, some of the most emissions-intensive foreign-origin products may not be commonly used as substrate by U.S. facilities. For example, multiple industry representatives highlighted the emissions intensities of steel products made in China as being higher than those in the United States.[359] However, publicly available data from the U.S. Department of Commerce's Steel Import Monitoring Analysis System indicate that steel melted and poured in China accounted for less than one percent of U.S. imports of semifinished steel, hot-rolled flat steel, and hot-worked long steel products in 2022.[360] Therefore, the contribution of emissions from these steel products made in China to the emissions intensities of covered steel products made in the United States is likely to be relatively low.

# Average and Highest Emissions Intensities

This section presents the production-weighted average emissions intensity ("average emissions intensity") and a measure of the highest emissions intensity in metric tons $CO_2e$ per metric ton (mt $CO_2e$/mt) of production in the given steel product category by U.S. producers in 2022. The Commission estimated the product-category-level production-weighted emissions intensity by dividing the total associated emissions in metric tons of $CO_2e$ by the total national production in metric tons produced for the product category.[361] The highest estimate ("highest emissions intensity") is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent (i.e., 90–100th percentile range) of production within each respective product category, unless otherwise noted.[362] The emissions intensities are presented for all steel product categories and subcategories. This section also provides more granular data where possible showing the contributions of materials, processes, and scopes to average emissions intensities.

---

[357] USITC, hearing transcript, December 7, 2023, 115 (testimony of David Miracle, Nucor).

[358] Outokumpu, written submission to the USITC, December 21, 2023, app. 1; Outokumpu, *EPD: Ferrochrome*, July 6, 2023, 4; Outokumpu, *2023 Sustainability Review*, 2024, 48.

[359] USITC, hearing transcript, December 7, 2023, 59 (testimony of Kevin Dempsey, AISI), 90–91 (testimony of Tamara Weinert, Outokumpu), 103 (testimony of Roger Schagrin, Schagrin Associates), 110 (testimony of Jeff Hansen, SDI).

[360] USDOC, ITA, "Melt and Pour Dashboard," accessed November 8, 2024.

[361] See appendix H for emissions intensity calculation equations. For the full table of highest emissions estimates by product, see appendix I.

[362] Production-weighted averages also have been calculated for the 50–100th, 60–100th, 70–100th, and 80–100th percentile ranges (i.e., the most emissions-intensive facilities representing 50 percent, 40 percent, 30 percent, and 20 percent of production, respectively) for each product category and are presented in appendix I.

# Carbon and Alloy Semifinished Steel

Carbon and alloy semifinished steel products are defined by this investigation as those corresponding to HTS headings under 7206, 7207, and 7224 and are also broken into subcategories for slab, ingot, and all other forms of semifinished steel (e.g., billets, blooms). Table 4.3 shows the U.S. average and highest emissions intensities of these products.

Carbon and alloy semifinished steel had an average emissions intensity of 1.02 mt $CO_2e$/mt steel and a highest emission intensity of 2.15 mt $CO_2e$/mt steel. Production of carbon and alloy semifinished steel was reported by EAF and BF-BOF facilities; therefore, these emissions intensity results represent a mix of production from both production pathways.[363] In the United States in 2022, more production of carbon and alloy semifinished steel occurred in EAF facilities than in BF-BOF facilities, contributing to a lower average emissions intensity for this product category than for other countries with more production using the BF-BOF pathway.[364] Likewise, the emissions intensities for semifinished steel subcategories was dictated in large part by production pathway. Only EAF facilities reported production of ingots or all other semifinished steel, whereas both BF-BOF and EAF facilities reported slab production.[365]

**Table 4.3** Carbon and alloy steel semifinished products: average and highest emissions product-level intensities

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented.

| Product category and subcategory | Average emissions intensity | Highest emissions intensity |
|---|---:|---:|
| Semifinished | 1.02 | 2.15 |
| Slab | 1.35 | 2.22 |
| Ingot | 0.61 | 1.44 |
| All other | 0.50 | 1.00 |

Source: USITC estimates based on its calculation methodology; see appendixes E and H.

Because the U.S. steel industry relies heavily on EAFs that primarily rely on scrap, the industry uses scrap as the main metallic input in the production of carbon and alloy semifinished steel.[366] The Commission calculated the amount of scrap used per metric ton of steel produced by facilities producing carbon and alloy semifinished steel (table 4.4). U.S. producers of carbon and alloy semifinished steel used approximately 0.76 mt of scrap for every 1 mt of semifinished steel produced.[367] In the emissions

---

[363] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 1.2.2 and 2.1.1.

[364] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 1.2.2 and 2.1.1. To protect confidentiality, this report does not provide estimates of the emissions intensity of U.S.-produced carbon and alloy semifinished steel by production pathway.

[365] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 1.2.2, 2.1.1, and 2.1.3.

[366] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level,* 2024, responses to questions 5.1.12a, 5.1.13a, and 5.14.

[367] The questionnaire asked facilities to report ferrous scrap use without differentiating between the type of semifinished steel produced (i.e., carbon and alloy versus stainless). Some facilities reported production of both types of semifinished steel. Scrap intensities for carbon and alloy semifinished production represent all semifinished produced for facilities that reported any carbon and alloy semifinished steel production.

intensities in this report, scrap used in steelmaking does not carry any embedded emissions (for more discussion, see chapter 2, "Steel System Boundary"). Therefore, the industry's relatively high use rate of scrap had a corresponding downward effect on the emissions intensities of carbon and alloy semifinished steel.

**Table 4.4** Steel products: ferrous scrap intensity of U.S. facilities producing carbon and alloy semifinished steel, by scrap type

In metric tons of scrap used per metric ton of semifinished steel.

| Type | Ferrous scrap intensity |
|---|---:|
| Pre-consumer externally sourced scrap | 0.18 |
| Post-consumer externally sourced scrap | 0.32 |
| Unknown externally sourced scrap | 0.15 |
| Total externally sourced scrap | 0.65 |
| Pre-casting home scrap | 0.02 |
| Post-casting home scrap | 0.07 |
| Unknown home scrap | 0.02 |
| Total home scrap | 0.11 |
| Total scrap | 0.76 |

Source: USITC, *Greenhouse Gas Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.1.1 and 5.1.14.

Nonetheless, sources of iron other than scrap—pig iron and direct reduced iron—were used in the production of carbon and alloy semifinished steel.[368] The embedded emissions of these ore-based metallic inputs—which may be sourced from on-site or external receipts—contributed a larger portion of the emissions intensity of carbon and alloy semifinished steel than any other material input (see figure 4.2). Steelmaking itself also contributed substantially to the emissions intensities of carbon and alloy semifinished steel, including the direct process and fuel combustion emissions that occurred in BOFs and EAFs as well as the use of electricity in these processes. On average, facilities that reported producing semifinished steel had a fuel intensity of 0.42 million British thermal units per metric ton semifinished steel and an electricity intensity of 0.42 megawatt-hours per metric ton semifinished steel. Converted into thermal units, the total fuel and electricity intensity was 1.86 million British thermal units per metric ton semifinished steel.[369]

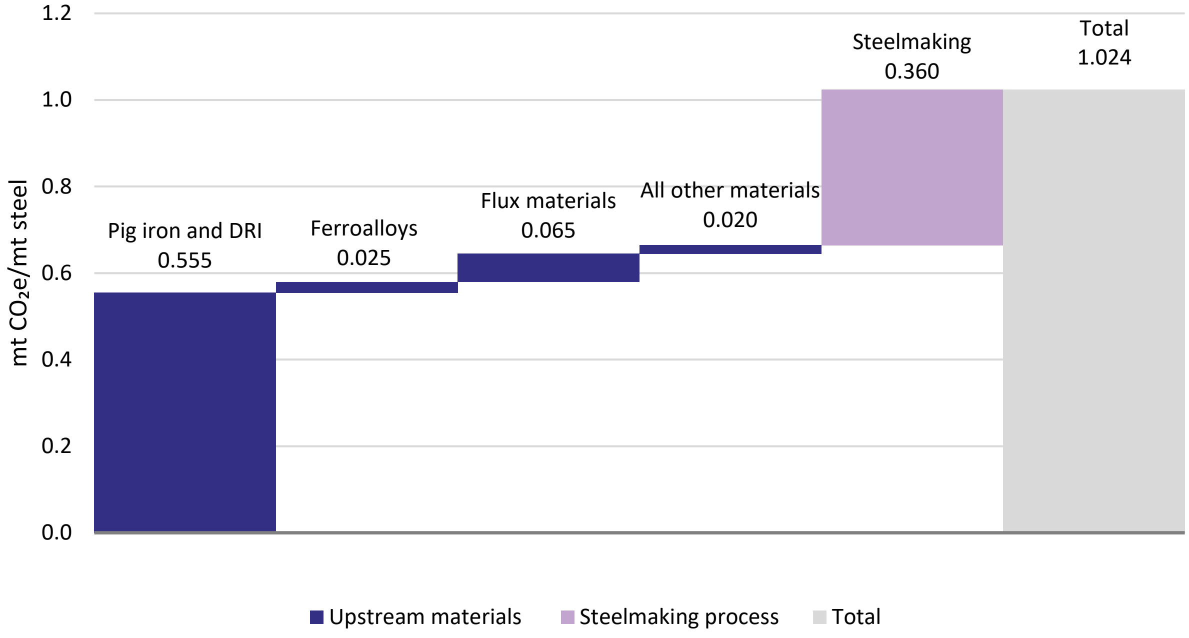
---

[368] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level,* 2024, responses to questions 5.1.12a and 5.1.13a.

[369] USITC estimates based on its calculation methodology. These energy intensities do not include inputs that were reported in subpart Q of the GHGRP, such as coal and coke inputs to BFs and EAFs. Electricity intensity includes use of both purchased electricity and electricity generated on-site.

**Figure 4.2** Carbon and alloy steel: emissions intensities of semifinished steel, contributions from upstream materials and the steelmaking process

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). DRI = direct reduced iron. Underlying data for this figure can be found in appendix J, table J.12.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.
Notes: “All other materials” includes metallurgical coke, carbon electrodes, and industrial gases used directly in steelmaking as well as a small quantity of semifinished steel that is remelted for use in producing a different form of carbon and alloy semifinished steel. The emissions values for materials shown in this figure include the total embedded emissions for these materials, including from off-site sourcing (scope 3 emissions) and from on-site production (which may include emissions under all scopes). Total embedded emissions of materials shown in this figure include any emissions from different upstream materials used in the production of the materials shown; for example, the value for “Pig iron and direct reduced iron” includes the emissions from metallurgical coke, flux materials, iron pellets, and iron sinter used in BFs and direct reduced iron facilities. The emissions value for “steelmaking” includes all scope 1 and 2 emissions in the unit process for the production of carbon and alloy semifinished steel.

Most pig iron used by facilities producing covered steel products was sourced from on-site production.[370] Imports made up the majority of externally sourced pig iron used in production of semifinished steel, with 74.6 percent coming from outside the United States (see table 4.5). An additional 12.8 percent came from unknown sources which could have been sourced in the United States or via imports. U.S. sources made up 12.6 percent of externally sourced pig iron.[371] The largest import source for externally sourced pig iron was Brazil which represented 53.9 percent of all imported pig iron, followed by Ukraine (20.1 percent), and Russia (17.2 percent). An additional 8.8 percent was sourced from all other or unknown import source countries.[372]

---

[370] USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level*, 2024, responses to questions 2.1.1 and 5.1.13c.
[371] USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level*, 2024, responses to question 5.1.13c.
[372] USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level*, 2024, responses to question 5.1.13g.

**Table 4.5** Steel products: share of externally sourced pig iron, by source
In percentages.

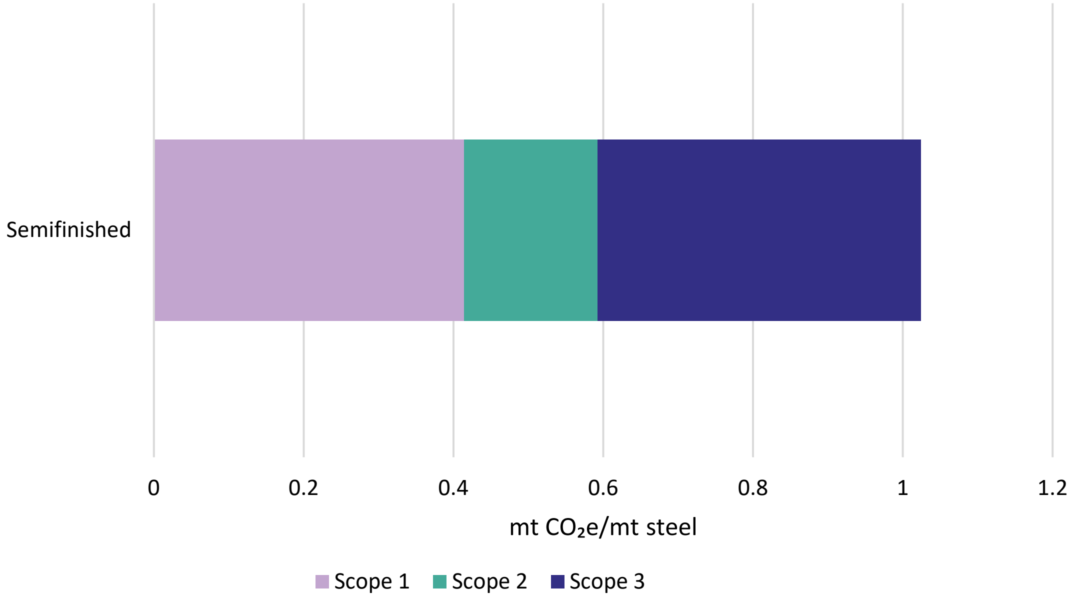
| Source | Share of pig iron |
|---|---:|
| U.S. sources | 12.6 |
| Import sources | 74.6 |
| Unknown | 12.8 |

Source: USITC, *Greenhouse Gas Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 5.1.13c.

Most emissions associated with production of carbon and alloy semifinished steel were either scope 1 or scope 3 emissions, with a smaller contribution from scope 2 (see figure 4.3). The contribution of each scope was largely related to the different practices of BF-BOF facilities and EAF facilities. BF-BOF facilities produce the most emissions-intensive upstream material—pig iron—on-site and may also produce further upstream materials such as iron sinter, metallurgical coke, and flux materials. Integrated facilities also use waste gases from production of metallurgical coke and pig iron to generate electricity and heat on-site. Therefore, integrated facilities had high scope 1 emissions but relatively low external energy requirements and associated scope 2 emissions. By contrast, facilities with EAFs had far lower scope 1 emissions but sourced most or all of their energy from off-site, leading to higher scope 2 emissions. Although the electricity requirements for EAF steelmaking are substantial, the indirect emissions from these electricity purchases were significantly lower than the emissions from BF-BOF facilities. Both types of facilities can have significant scope 3 emissions associated with the materials used to make pig iron (for BF-BOF facilities) or with the receipt of pig iron or direct reduced iron from external sources (for EAF facilities).

**Figure 4.3** Carbon and alloy steel: scopes 1, 2, and 3 contribution to the average emissions intensities of semifinished products

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). Underlying data for this figure can be found in appendix J, table J.13.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

## Comparisons to Other Published Emissions Intensity Estimates

This section compares the Commission's emissions intensity estimates for carbon and alloy semifinished steel with several other published emissions intensity estimates. The emissions intensities reported by other sources presented in this section—and in similar sections below covering downstream carbon and alloy steel products and stainless steel products—may not fully overlap with the Commission's emissions intensity estimates due to methodological and coverage differences. Specific methodological and coverage differences are highlighted in the notes of this chapter upon first reference to the other published estimates.

Many published sources present emissions intensities that are exclusively or heavily weighted toward a specific production pathway. The Commission's emissions intensity for carbon and alloy semifinished steel (1.02 mt $CO_2e$/mt steel), which includes responses that reflect both EAF and BF-BOF steelmaking methods in the United States, was higher than published U.S. emissions intensities associated with EAF steelmaking and lower than those associated with BF-BOF steelmaking.[373] The Steel Manufacturers

---

[373] Per the request letter, the Commission calculated emission intensities for the product categories referenced in the request letter. Although the Commission was able to calculate emission intensities for U.S. produced semifinished steel made via the BF-BOF and EAF pathways respectively, as discussed above, these data are not presented in this report to protect confidentiality. Additionally, most of the other published emissions intensity estimates described in this section are not explicitly limited to carbon and alloy steel; however, products that fall under the definition of carbon and alloy steel constitute the large majority or the entirety of the production covered by these estimates.

Association (SMA) reported a U.S. semifinished steel emissions intensity of 0.68 mt $CO_2$/mt steel for EAF steelmaking.[374] By contrast, SMA estimated that the semifinished steel emissions intensity for U.S. BF-BOF steelmaking was 2.11 mt steel $CO_2$/mt.[375] A report by the European Commission's Joint Research Centre (JRC) estimated a U.S. emissions intensity for non-alloy slabs, billets, and blooms produced using the BF-BOF pathway of 1.75 mt $CO_2$/mt steel.[376]

Other studies reported emissions intensities for semifinished steel based on the U.S. mix of production pathways, which are more similar to the intensity for carbon and alloy semifinished steel generated in this report.[377] SMA reported a U.S. average emissions intensity (based on scopes 1 and 2 only) of 0.85 mt $CO_2$/mt steel.[378] A report published by Global Efficiency Intelligence estimated a U.S. average emissions intensity of semifinished steel produced by both pathways at just under 1.0 mt $CO_2$/mt steel.[379]

# Carbon and Alloy Flat, Long, and Tubular Steel Products

Carbon and alloy flat, long, and tubular steel products as defined by this investigation include hot- and cold-rolled flat steel products; coated flat steel products; seamless and non-seamless tubular products; hot-worked long steel products; cold-formed long steel products. Additionally, product subcategories are included for hot-rolled plate, all other hot-rolled flat, rebar, wire rod, heavy structural shapes, all other hot-worked long, wire, all other cold-formed long, seamless and non-seamless oil country tubular goods (OCTG), and all other seamless and non-seamless tubular products. Table 4.6 shows the average and highest emissions intensities of these products.

---

[374] SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 13. The basis for SMA's emissions intensity estimates is described above (see note in "Foreign-Origin Material Inputs" section).

[375] SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 13.

[376] Vidovic et al., *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 16, 18, 139. The basis for JRC's emissions intensity estimates is described above (see note in "Foreign-Origin Material Inputs" section). In addition to estimates from JRC and SMA, corporate sustainability reports provide estimates that are generally heavily weighted toward specific production pathways and can be used as a basis for comparison with the Commission's estimates. Three of the largest U.S. companies relying on EAF steelmaking—Nucor, Steel Dynamics, and Commercial Metals Company—reported semifinished steel emissions intensity estimates between 0.68 mt $CO_2e$/mt steel and 0.78 mt $CO_2e$/mt steel in their 2023 sustainability reports. The U.S. companies relying predominantly on BF-BOF steelmaking—Cleveland-Cliffs and U. S. Steel—reported semifinished steel emissions intensity estimates (based on scopes 1 and 2 only) between 1.83 mt $CO_2e$/mt steel and 1.89 mt $CO_2e$/mt steel in their 2023 sustainability reports. The estimate reported for U. S. Steel covered North American operations only. Nucor, 2023 Corporate Social Responsibility Report, 2024, 33; SDI, *2023 Sustainability Update*, April 2024, 12; CMC, *2023 Sustainability Report*, 2024, 31; Cleveland-Cliffs, *2023 Sustainability Report*, April 3, 2024, 3. U. S. Steel, *The Future of Steel: United States Steel Corporation 2023 Sustainability Report*, June 25, 2024, 118.

[377] A commonly referenced global emissions intensity for semifinished steel from the World Steel Association (1.92 mt $CO_2$/mt steel) is based on the global mix of production pathways that is more heavily weighted toward BF-BOF steelmaking. worldsteel, *Sustainability Indicators 2024 Report*, November 2024, 3.

[378] SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 12.

[379] The basis for Global Efficiency Intelligence's emissions intensity estimates is described above (see note in "Foreign-Origin Material Inputs" section). Hasanbeigi, "Steel Climate Impact - An International Benchmarking of Energy and $CO_2$ Intensities," April 2022, 15.

**Table 4.6** Carbon and alloy steel flat, long, and tubular products: average and highest product-level emissions intensities

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). OCTG = oil country tubular good. The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production within each respective product category presented. ^ indicates the measures of highest emissions intensities for hot-worked wire rod long products and seamless oil country tubular good products represent 20 percent of production because of confidentiality considerations.

| Product category and subcategory | Average emissions intensity | Highest emissions intensity |
|---|---:|---:|
| Flat | 1.83 | 3.06 |
| Hot-rolled flat | 1.59 | 2.62 |
| Plate | 1.41 | 2.63 |
| All other hot-rolled flat | 1.61 | 2.61 |
| Cold-rolled flat | 1.91 | 3.08 |
| Coated flat | 2.17 | 3.82 |
| Long | 0.75 | 1.89 |
| Hot-worked long | 0.67 | 1.43 |
| Rebar | 0.54 | 0.80 |
| Wire rod | 0.94 | 1.82^ |
| Heavy structural shapes | 0.67 | 1.20 |
| All other hot-worked long | 0.74 | 1.52 |
| Cold-formed long | 1.25 | 2.62 |
| Wire | 1.48 | 2.76 |
| All other cold-formed long | 0.89 | 1.85 |
| Tubular | 1.50 | 2.50 |
| Seamless tubular | 1.09 | 1.43 |
| Seamless OCTG | 1.08 | 1.32^ |
| All other seamless tubular | 1.23 | 1.87 |
| Non-seamless tubular | 1.71 | 2.60 |
| Non-seamless OCTG | 1.52 | 2.37 |
| All other non-seamless tubular | 1.74 | 2.58 |

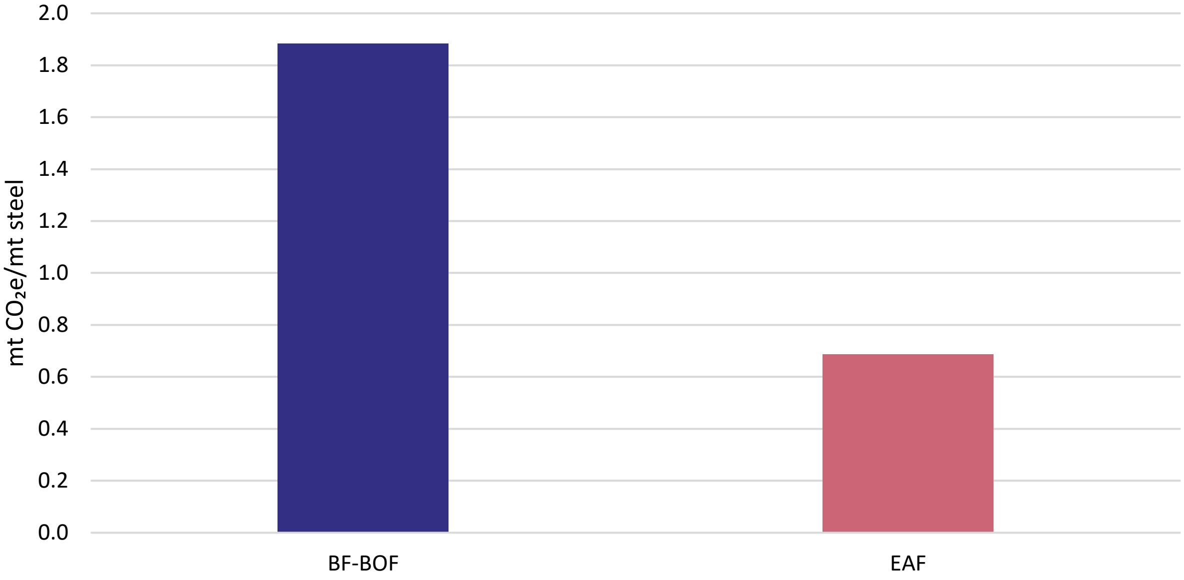
Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Carbon and alloy finished mill products covered in this investigation had a range of average emissions intensities. As shown in table 4.6, the average emissions intensity for carbon and alloy flat steel products was substantially higher at 1.83 mt $CO_2e$/mt steel than the average emissions intensity for carbon and alloy long products (0.75 mt $CO_2e$/mt steel). Likewise, the different emissions intensities between long and flat steel products extend to the more detailed flat and long product categories and subcategories shown in table 4.6. The emissions intensity of carbon and alloy tubular steel products (1.50 mt $CO_2e$/mt steel) reflects a mix between the substantially different emissions intensities of non-seamless tubular steel and seamless tubular steel products.

Because all finished mill products are produced using semifinished steel, the emissions intensities of these carbon and alloy finished steel mill steel products was determined largely by how semifinished steel used in those products was made. The average emissions intensity of carbon and alloy semifinished steel available in the United States (through U.S. production and imports) in 2022 varied by production pathway (figure 4.4). The values in figure 4.4 include the emissions intensities from the sum of U.S. facilities' production of carbon and alloy semifinished steel and imports of carbon and alloy semifinished steel used in U.S. facilities' production, broken out by production pathway.[380] The emissions intensity of carbon and alloy semifinished steel produced using the BOF pathway is almost three times higher than the emissions intensity of the same type of product made using the EAF pathway. U.S. steel mills producing carbon and alloy hot-worked long steel products and seamless tubular steel products from semifinished steel produced on-site universally used the EAF production pathway. By contrast, carbon and alloy hot-rolled flat steel products were produced using semifinished steel made using both pathways.[381] As a result, flat products and non-seamless tubular steel (primarily made from flat steel) were more emissions intensive than long steel products and seamless tubular steel products.

**Figure 4.4** Carbon and alloy steel flat, long, and tubular products: emissions intensity of semifinished steel available (sum of U.S. production and imports) for use in production of downstream products, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace. Underlying data for this figure can be found in appendix J, table J.14.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

The higher emissions intensity of flat steel compared to long and seamless tubular steel products is also due in part to differences within EAF facilities themselves. EAF facilities that produce hot-rolled flat steel products generally use semifinished steel substrate with a higher concentration of pig iron and direct reduced iron than EAF facilities producing hot-worked long steel or seamless tubular steel products, which primarily or in some cases exclusively rely on ferrous scrap as a source of metallic inputs.[382] This

---

[380] To protect confidentiality, this report does not provide estimates of the emissions intensity of U.S.-produced carbon and alloy semifinished steel by production pathway, and instead presents in figure 4.4 the emissions intensity of the sum of U.S. production and imported semifinished steel (i.e., semifinished steel available for use in U.S. production of downstream products).

[381] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 1.2.2 and 2.1.1.

[382] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level,* 2024, responses to questions 1.2.2, 2.1.1, 5.1.12a, 5.1.13a, and 5.1.14a. See also SMA, *Steelmaking Emissions Report 2022*, June 14, 2022.

underscores the limitations in the exclusive use of scrap for products with particular specifications, because scrap can retain traces of other metals, particularly copper and tin, which can lead to cracking during hot-rolling.[383] For EAF facilities that produced carbon and alloy hot-rolled flat steel, pig iron and direct reduced iron contributed 0.50 mt $CO_2e$/mt steel to the emissions intensities of semifinished steel used to make that hot-rolled flat steel. For EAF facilities that produced carbon and alloy hot-worked long steel and seamless tubular steel products, ore-based metallics contributed 0.10 mt $CO_2e$/mt steel and 0.13 mt $CO_2e$/mt steel, respectively, to the emissions intensities of semifinished steel used to make each of those product categories.[384]

The emissions intensities of finished mill products are also affected by the energy intensities of the processes used to make those products.[385] The average fuel, electricity, and combined energy intensity of carbon and alloy steel production processes are shown in table 4.7. Product categories derived from subprocesses that rely on working the steel when it is in a heated state (hot-rolling and hot-working) have higher fuel intensities than product categories derived from subprocesses that process the steel when it is cold (cold-rolling and cold-forming). The data are consistent with testimony from steel industry representatives, who emphasized hot-rolling steel as a more emissions-intensive process than other downstream steel product manufacturing.[386]

---

[383] Transition Asia, “Scrap Steel Explainer,” August 18, 2023.

[384] USITC estimates based on its calculation methodology, see appendixes E and H.

[385] The main emissions intensities in this chapter (i.e., in tables 4.3, 4.6, and 4.8) are cumulative for facilities that used their production of one category of upstream materials or covered products as inputs for producing a different category of covered products. By contrast, the fuel and electricity intensity data presented in this report include only energy use that was directly allocated to the subprocess resulting in the listed product and use allocated to ambient energy. For ambient energy, only the portion of energy use reallocated to the unit process associated with the product is included (see Appendix E, “II.C.2.e Reallocating Emissions from Ambient Heating, Cooling, Ventilation, and Lighting Supply”). The electricity intensities are closely related to the product-level scope 2 emissions intensity but have a couple of important differences. First, when facilities use on-site electricity generation, they are assigned scope 1 rather than scope 2 emissions for that electricity use. Second, scope 2 emissions from electricity use can vary substantially, depending on the facility’s Emissions and Generation Resource Integrated Database (eGRID) subregion.

[386] USITC, hearing transcript, December 7, 2023, 63 (testimony of Kevin Dempsey, American Iron and Steel Institute); 114 (testimony of David Miracle, Nucor); 146 (testimony of Jeff Hansen, Steel Dynamics, Inc.).

**Table 4.7** Carbon and alloy steel flat, long, and tubular products: average fuel and electricity intensities

In million British thermal units per metric ton of production (MMBtu/mt production) and megawatt-hours per metric ton of production (MWh/mt production).

| Product category | Average fuel intensity (MMBtu/mt production) | Average electricity intensity (MWh/mt production) | Average total energy intensity (MMBtu/mt production) |
|---|---|---|---|
| Hot-rolled flat | 1.66 | 0.11 | 2.02 |
| Cold-rolled flat | 0.44 | 0.11 | 0.81 |
| Hot-worked long | 1.62 | 0.14 | 2.10 |
| Cold-formed long | 1.30 | 0.19 | 1.95 |
| Coated | 1.16 | 0.13 | 1.59 |
| Seamless pipe and tube | 3.27 | 0.26 | 4.16 |
| Non-seamless pipe and tube | 0.94 | 0.15 | 1.44 |

Source: USITC estimates based on its calculation methodology.

Note: Total energy intensity is calculated by converting the average electricity intensity to MMBtu/mt (by multiplying it by 3.412) and adding it to the average fuel intensity. Unlike the emission intensities, these energy intensities do not include energy used in upstream product categories that were made at the same facility and used as inputs to the product category. Intensities shown above are generated according to the fuel and electricity usage associated with the corresponding production subprocess; for facilities that also produced stainless steel, the usage was split proportionally based on production data. Energy intensities include energy used in ambient heating, cooling, ventilation, and lighting supply, allocated proportionally across all production categories (including production of noncovered products).

Further downstream carbon and alloy steel products generally had higher emissions intensities than less-processed steel products, because each successive process in the production of carbon and alloy steel products contributes to the emissions intensities of downstream goods. Figure 4.5 displays the scope 1 and 2 emissions intensities of carbon and alloy steel production subprocesses corresponding with each product type in U.S. steel facilities (consistent with the "unit processes" described in chapter 3, "Allocation of Facility-Level Emissions to Unit Processes"). Subprocess-level emissions intensities across these two scopes illustrate the direct and indirect (from purchased electricity, steam, heat, and hot water) emissions associated with each process step in isolation. Specifically:

- Hot-rolling, cold-rolling, and coating flat steel products each contributes 0.10–0.16 mt $CO_2$e/mt steel to the emissions intensities of carbon and alloy products made using those processes. Carbon and alloy cold-rolled flat steel uses hot-rolled flat steel as substrate, whereas carbon and alloy coated flat steel can use either hot-rolled or cold-rolled flat steel as substrate.[387] Therefore, the higher average product-level emissions intensities of cold-rolled and coated flat steel products reflect the additional work performed on these products combined with the embedded emissions of the substrate.
- Similarly, hot-working and cold-forming long steel products each contributes 0.13–0.14 mt $CO_2$e/mt steel to the emissions intensities of carbon and alloy products made using those processes. Because carbon and alloy cold-formed long steel uses hot-worked long steel as substrate, it has a higher product-level emissions intensity.[388]
- Of all subprocesses used to make carbon and alloy finished mill products, the non-seamless tubular steel production subprocess is the least emissions intensive, contributing just under 0.10 mt $CO_2$e/mt steel to the emissions intensities of those products. By contrast, the seamless

---

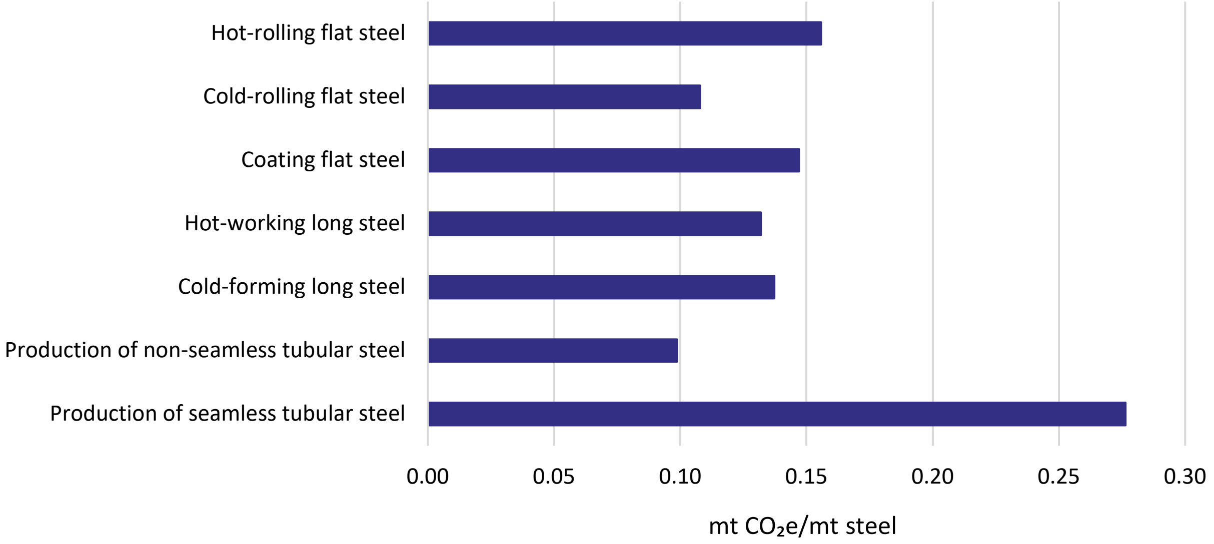
[387] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level,* 2024, responses to questions 5.1.18a and 5.1.19a.

[388] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level,* 2024, responses to question 5.1.24a.

tubular steel production subprocess is highly energy intensive and is the most emissions-intensive steel production subprocess after steelmaking itself (0.28 mt $CO_2$e/mt steel).[389]

**Figure 4.5** Carbon and alloy steel flat, long, and tubular products: scopes 1 and 2 average emissions intensities by subprocess

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2$e/mt steel). Underlying data for this figure can be found in appendix J, table J.15.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.
Note: These emissions intensity estimates solely pertain to the subprocess listed. The emissions intensities shown here do not include estimates for the embedded emissions associated with the upstream inputs, regardless of source, including emissions associated with other subprocesses listed here. For example, even though carbon and alloy cold-rolled flat steel uses hot-rolled flat steel as substrate, the emissions intensity of cold-rolling flat steel does not include the emissions of hot-rolling flat steel in this figure.

The contribution of scope 3 emissions to the average emissions intensities of U.S. covered steel products is determined in large part by the extent to which substrate material is externally sourced and the origin of those receipts.[390] Nearly 15 percent of carbon and alloy semifinished steel used by producers of finished mill products is externally sourced, with over 40 percent of that material being sourced from

---

[389] Seamless tubular steel production involves a number of processing steps that contribute to the emissions intensity of these products. These include: (1) heating of semifinished steel to a temperature suitable for hot-rolling processes; (2) formation of the central cavity using piercing or extrusion; (3) additional hot-rolling processes that lengthen and otherwise form the tube; and (4) additional cold-rolling processes. By contrast, non-seamless tubular steel production usually does not require hot-rolling and involves welding flat steel products into tubular shapes. Both these broad processes may include heat treating. Aries et al., "Best Available Techniques (BAT) Reference Document for the Ferrous Metals Processing Industry," December 5, 2022, 43, 56–58.

[390] Table 4.7, and figures, 4.6, 4.7, and 4.11 present sourcing data for semifinished steel, hot-rolled flat steel, and hot-worked long steel used to produce carbon and alloy flat, long, and tubular products. All these finished mill products are produced from semifinished steel. As described in chapter 2, hot-rolling or hot-working of steel products is the next downstream processing step. All further downstream flat steel products and non-seamless tubular steel products are generally produced from hot-rolled flat steel substrate, although substrate might also be cold-rolled prior to coating or welding processes. Cold-formed long steel products are generally produced from hot-worked long steel substrate. Seamless tubular steel products are generally made directly from semifinished steel.

imports (see table 4.8).[391] Almost half of imported carbon and alloy semifinished steel used by steel producers is from Brazil, although Canada and Mexico are also major sources of semifinished steel (see figure 4.6).[392] Approximately one-third of carbon and alloy hot-rolled flat steel is externally sourced, with the large majority of those receipts coming from U.S. sources.[393] Most imported hot-rolled flat steel used by steel producers is from Canada and Mexico.[394] Almost two-thirds of carbon and alloy hot-worked long steel is externally sourced, with over three-quarters of that material coming from U.S. sources.[395] Import sources of carbon and alloy hot-worked long steel were more diversified: the largest single source for hot-worked long steel was Canada, accounting for under 15 percent of imports used by steel producers.[396]

**Table 4.8** Carbon and alloy steel flat, long, and tubular products: share of externally sourced semifinished steel, hot-rolled flat steel, and hot-worked long steel, by source

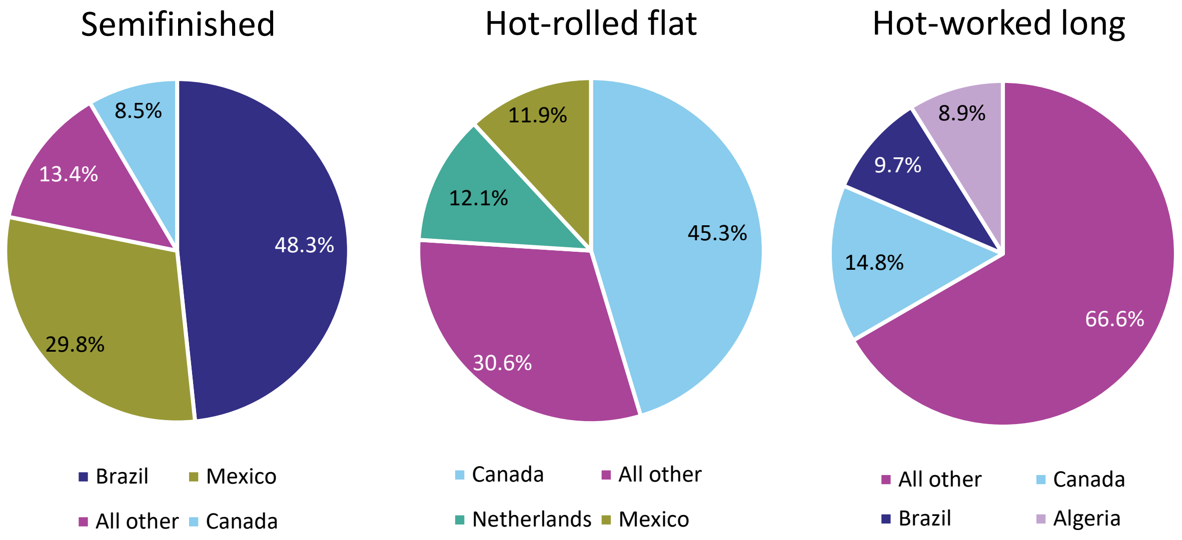
In percentages.

| Source | Semifinished | Hot-rolled flat | Hot-worked long |
|---|---|---|---|
| U.S. sources | 57.7 | 92.6 | 77.1 |
| Import sources | 42.3 | 4.3 | 21.3 |
| Unknown | 0.0 | 3.2 | 1.6 |

Source: USITC, *Greenhouse Gas Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 5.1.17c, 5.1.18c, and 5.1.23c.

**Figure 4.6** Carbon and alloy: share of imports of semifinished, hot-rolled flat, and hot-worked long steel by country of melt and pour

In percentages. Underlying data for this figure can be found in appendix J, table J.16.



Source: USITC, *Greenhouse Gas Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 5.1.17f, 5.1.18f, and 5.1.23f.

---

[391] USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level, 2024*, responses to questions 2.1.1 and 5.1.17c.

[392] USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level, 2024*, responses to question 5.1.17g.

[393] USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level, 2024*, responses to questions 2.1.1 and 5.1.18c.

[394] USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level, 2024*, responses to question 5.1.18g.

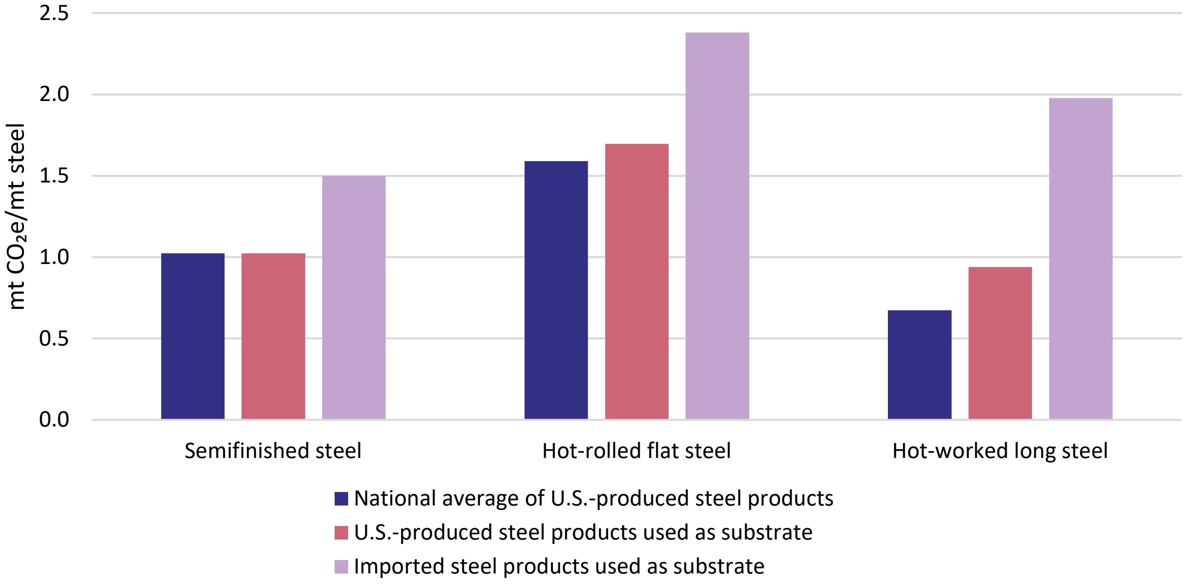
[395] USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level, 2024*, responses to questions 2.1.1 and 5.1.23c.

[396] USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level, 2024*, responses to questions 5.1.23g.

The effect of steel material sourcing on the emissions intensities of downstream carbon and alloy steel products varies depending on the type of steel material. As shown in figure 4.7, U.S.-produced and imported carbon and alloy steel products used as substrate to make carbon and alloy flat, long, and tubular products are generally more emissions intensive than the U.S. average emissions intensity for those products. Along with the additive effect of steel production processes themselves (as shown in figure 4.5), higher emissions intensities of substrate products increase the differences in emissions intensities between steel products at different levels of processing. For example, cold-formed long steel products had an average emissions intensity that was almost double that of the average for hot-worked long steel products, the main substrate used in cold-forming. This is partly due to the emissions that occur during the cold-forming subprocess, but also is due to the higher emissions intensity of hot-worked long steel used as substrate—especially from import sources—as compared to the national average for U.S. produced hot-worked long steel.[397]

**Figure 4.7** Carbon and alloy steel flat, long, and tubular products: emissions intensities of U.S.-produced and imported steel products used as substrate, compared with the national average

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). Underlying data for this figure can be found in appendix J, table J.17.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Figure 4.8 displays the average emissions intensities for carbon and alloy product categories by scope. Scope 1 emissions were highest for carbon and alloy flat steel products because of the role of BF-BOF facilities in production of those product categories. No other carbon and alloy steel product category had comparably high scope 1 emissions. Long and seamless tubular steel products are made using internally

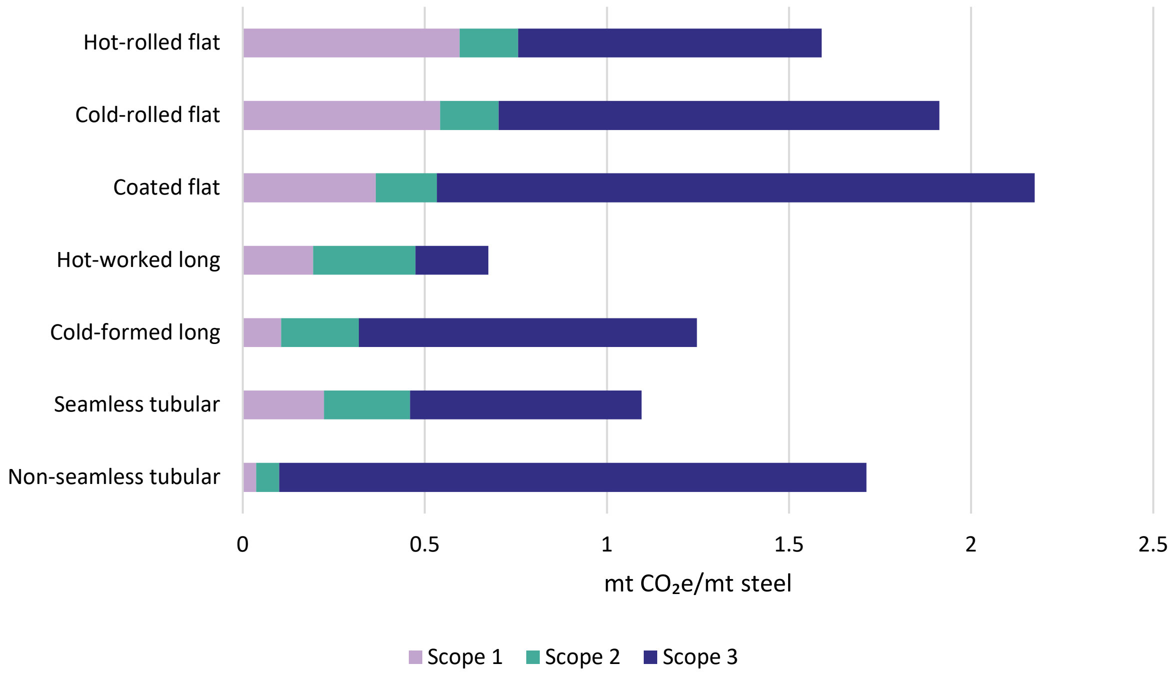
---

[397] The impact described is consistent with the emissions intensity results shown in table 4.5 above for different subcategories of carbon and alloy hot-worked long steel products. The emissions intensities for rebar and heavy structural shapes and sheet piling, which are not typically subsequently cold formed, were lower than the emissions intensities of wire rod and other forms of carbon and alloy hot-worked long steel products. The latter hot-worked products are more frequently used as substrate to produce cold-formed long steel products.

sourced substrate made in EAF facilities or using externally sourced steel produced via the EAF pathway and thus had relatively lower scope 1 emissions. However, these products, particularly hot-worked long steel products, had relatively high scope 2 emissions. The higher level reflected the high purchased electricity intensity of EAF steelmaking and for seamless also the highly energy intensive subprocess it involves. Scope 3 emissions contributed the greatest share of each product category's average emissions intensity, with the exception of hot-worked long steel products, which are mostly made using externally sourced EAF-produced steel substrate using low quantities of pig iron and direct reduced iron inputs.[398]

**Figure 4.8** Carbon and alloy steel flat, long, and tubular products: scopes 1, 2, and 3 contribution to the average emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). Underlying data for this figure can be found in appendix J, table J.18.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

In general, the high contribution of scope 3 emissions within each product category reflects the frequent sourcing of steel substrate from external U.S. and foreign facilities.[399] Most striking is the case for producers of non-seamless tubular steel products, who almost exclusively source substrate steel from external sources.[400] The contribution of scope 3 emissions from the mostly flat steel substrate used to make the non-seamless tubular steel products represents almost the entirety of total emissions for that product category.

---

[398] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 1.2.2, 2.1.1, 5.1.12a, 5.1.13a, and 5.1.14a. See also SMA, *Steelmaking Emissions Report 2022*, June 14, 2022.

[399] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.1.1, 5.1.17c, 5.1.18c, 5.1.19c, 5.1.20b, 5.1.21b, 5.1.22b, 5.1.23c, and 5.1.14b.

[400] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.1.1, 5.1.18c, 5.1.19c, 5.1.20c, 5.1.22b, and 5.1.23c.

## Comparisons to Other Published Emissions Intensity Estimates

Many published emissions intensity estimates focus on semifinished steel production rather than downstream steel mill products, but some sources provide estimates for other downstream products as well.[401] This section includes comparisons of the Commission's emissions intensity estimates for hot-rolled flat steel and hot-worked long steel with published estimates corresponding with those products. As with semifinished steel, published estimates are generally specific to either an EAF or BF-BOF production pathway.

The Commission's emissions intensity for carbon and alloy hot-rolled flat steel (1.59 mt $CO_2e$/mt steel) includes products made using both production pathways and falls in between pathway-specific estimates. In its analysis of U.S. steel production, SMA reported an emissions intensity of 0.97 mt $CO_2$/mt steel for hot-rolled flat steel produced in the United States via the EAF pathway and 2.40 mt $CO_2$/mt steel for hot-rolled flat steel produced via the BF-BOF pathway.[402] JRC estimated that the emissions intensity of U.S.-produced non-alloy hot-rolled flat products made using the BF-BOF method was 1.85 mt $CO_2$/mt steel.[403]

As described above, the Commission's emissions intensity for carbon and alloy hot-worked long steel (0.67 mt $CO_2e$/mt steel) reflects the lack of BF-BOF production within the value chains for long products in the United States. SMA estimated the average emissions intensity for U.S. EAF-produced hot-worked long products to be 0.61 mt $CO_2$/mt steel.[404] These estimates are far lower than JRC's estimate for non-alloy bars, rods, and other long products of 1.85 mt $CO_2$/mt steel, which is derived from an assumption that U.S. long products are also produced using BF-BOF methods.[405]

# Stainless Steel

Stainless steel products are defined by this investigation to include stainless semifinished steel; hot- and cold-rolled flat steel products; seamless and non-seamless tubular products; hot-worked long steel products, and cold-formed long steel products; and product subcategories for slabs, ingots, all other semifinished, wire, and all other cold-formed long steel products. Table 4.9 shows the average and highest emissions intensities of these products.

---

[401] As described in appendix E ("IV. Standards Informing the Commission's Methodology Development"), several commonly used emissions accounting methodologies such as those published by worldsteel and ResponsibleSteel focus on measuring emissions through semifinished steel production with no additional accounting for emissions in downstream production processes. Janjua and Maciel, *$CO_2$ Data Collection User Guide*, *Version 11*, May 30, 2024, 11; ResponsibleSteel, *ResponsibleSteel International Standard Version 2.1*, May 21, 2024, 79–80.

[402] SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 13. The basis for SMA's emissions intensity estimates is described above (see note in "Foreign-Origin Material Inputs" section).

[403] Vidovic et al., *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 16, 21–22, 139–140. The basis for JRC's emissions intensity estimates is described above (see note in "Foreign-Origin Material Inputs" section).

[404] SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 13.

[405] Vidovic et al., *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 16, 19, 139–140.

**Table 4.9** Stainless steel: average and highest product-level emissions intensities

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2$e/mt steel). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented. d.s. = data are suppressed to protect confidentiality.

| Product category and subcategory | Average emissions intensity | Highest emissions intensity |
|---|---|---|
| Stainless steel | 2.78 | 4.21 |
| Semifinished | 2.23 | 3.79 |
| Slab | 2.16 | 3.08 |
| Ingot | 2.85 | 6.93 |
| All other semifinished | d.s. | d.s |
| Hot-rolled flat | 2.31 | 3.26 |
| Cold-rolled flat | 3.08 | 3.76 |
| Hot-worked long | 2.93 | 6.27 |
| Cold-formed long | 3.55 | 5.52 |
| Wire | 4.55 | 7.60 |
| All other cold-formed long | 3.34 | 5.00 |
| Seamless tubular | 4.07 | 7.85 |
| Non-seamless tubular | 3.16 | 4.49 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Stainless steel had an average emissions intensity of 2.78 mt $CO_2$e/mt steel and a highest emissions intensity of 4.21 mt $CO_2$e/mt steel (table 4.9). This is a broad category covering all forms of stainless steel (i.e., semifinished, flat, long, and tubular). As shown in table 4.9, the emissions intensities of all stainless steel product categories were relatively high compared to those of their carbon and alloy counterparts. For example, stainless semifinished steel had an average emissions intensity of 2.23 mt $CO_2$e/mt steel compared to 1.02 mt $CO_2$e/mt steel for carbon and alloy semifinished steel shown in table 4.2.

Unlike carbon and alloy semifinished steels, no stainless semifinished steel-producing facilities reported operating a BF-BOF facility.[406] Therefore, the most important factors for the emissions intensity for stainless semifinished steel were the amounts and types of ferroalloys and scrap used in EAFs, argon oxygen decarburization vessels, and other specialized furnaces used to make stainless steel (figure 4.9).[407] In addition to the required minimum 10.5 percent chromium content for classification as stainless steel, additional alloying metals such as nickel, manganese, and molybdenum are often included depending on the grade of stainless steel being produced.[408] Alloying metals can be supplied by ferroalloys or by stainless scrap.[409] The Commission calculated the amount of scrap used per every

---

[406] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 1.2.2 and 2.1.1. Several facilities responding to the questionnaire informed USITC staff that they used steelmaking techniques other than or in addition to EAF steelmaking to produce stainless semifinished steel.

[407] In addition to the type and amount of ferroalloys used, the grade, country of origin, and production method of ferroalloys also may have a significant impact on the emissions intensities of stainless steel products. Outokumpu, written submission to the USITC, December 21, 2023, 8–9; SSINA, written submission to the USITC, December 21, 2023, 2. The Commission did not ask facilities to report this information, however, because doing so would have substantially increased the burden on facilities responding to the questionnaire. Therefore, the emissions intensity reported here for stainless steel products do not take into account these factors. See appendix E ("II.D.1.a(2) Scope 3 Emissions for Steel Materials Group 2: Global Approach Using Use Data") for more information on how scope 3 emissions were calculated for facilities' receipts of ferroalloys and other alloying metals.

[408] Outokumpu, written submission to the USITC, November 21, 2023, 27.

[409] Outokumpu, written submission to the USITC, November 21, 2023, 5; USITC, hearing transcript, December 7, 2023, 138–139 (testimony of Camilla Kaplin, Outokumpu).

metric ton of steel produced by facilities producing stainless steel semifinished steel (table 4.10). U.S. producers of stainless semifinished steel used approximately 0.89 mt of scrap for every 1 mt of semifinished steel produced.[410] This relatively high stainless scrap intensity (table 4.10) for production of stainless semifinished steel reduces the need for ferroalloys.[411] Nonetheless, ferroalloys still contributed the majority of emissions to the overall emissions intensity of stainless semifinished steel products.

**Figure 4.9** Stainless steel: emissions intensities of semifinished steel, contributions from upstream materials and the steelmaking process

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). Underlying data for this figure can be found in appendix J, table J.19.

Source: USITC estimates based on its calculation methodology, see appendixes E and H.
Notes: "All other materials" includes pig iron, direct reduced iron, metallurgical coke, carbon electrodes, and industrial gases used directly in steelmaking as well as a small quantity of semifinished steel that is remelted for use in production of a different form of carbon and alloy semifinished steel. The emissions values for materials shown in this figure include the total embedded emissions for these materials, including from off-site sourcing (scope 3 emissions) and from on-site production (which may include emissions under all scopes). Total embedded emissions of materials shown in this figure include any emissions from different upstream materials used in the production of the materials shown; for example, the value for ferroalloys includes the emissions from upstream materials used in ferroalloy production. The emissions value for "steelmaking" includes all scope 1 and 2 emissions in the unit process for the production of stainless semifinished steel.

---

[410] The questionnaire asked facilities to report ferrous scrap use without differentiating between the type of semifinished steel produced (i.e., carbon and alloy versus stainless). Some facilities reported production of both types of semifinished steel. For stainless steel, scrap intensity for stainless semifinished steel includes all semifinished produced for facilities that reported any stainless semifinished steel production.

[411] USITC, hearing transcript, December 7, 2023, 74 (testimony of Joe Green, SSINA).

**Table 4.10** Steel products: ferrous scrap intensity of facilities producing stainless semifinished steel, by scrap type.

In metric tons of scrap used per metric ton of semifinished steel.

| Type | Ferrous scrap intensity |
|---|---|
| Pre-consumer externally sourced scrap | 0.14 |
| Post-consumer externally sourced scrap | 0.06 |
| Unknown externally sourced scrap | 0.49 |
| Total externally sourced scrap | 0.69 |
| Pre-casting home scrap | 0.05 |
| Post-casting home scrap | 0.11 |
| Unknown home scrap | 0.04 |
| Total home scrap | 0.20 |
| Total scrap | 0.89 |

Source: USITC, *Greenhouse Gas Emissions Questionnaire: Facility-Level*, 2024, responses to questions 2.1.1 and 5.1.14.

As with carbon and alloy steel, stainless steel flat, long, and tubular products had higher emissions intensities for further downstream product categories. Stainless steel production is more energy intensive than carbon and alloy steel production for all processes (see table 4.11).[412] This generates higher emissions intensities for stainless steel production subprocesses shown in figure 4.10, which ranged from 0.16 mt $CO_2$e/mt steel for hot-rolling to 1.29 mt $CO_2$e/mt steel for seamless tubular steel production. In addition, these processes were repeated or extended by different facilities along the value chains for these products, particularly for products that are cold-rolled, or -formed. Over half the U.S. industry's production of stainless cold-rolled flat steel and cold-formed long steel products occurred in facilities that further processed some or all of those products without changing the product category.[413]

---

[412] See also USITC, hearing transcript, December 7, 2023, 75–76 (testimony of Joe Green, SSINA); 142–143 (testimony of Roger Schagrin, CPTI).

[413] To be included in the questionnaire population, facilities conducting further processing of steel products but not changing the product category must also have (1) transformed inputs into covered products; (2) transformed a covered product in one product category into a covered product in a different product category; or (3) applied heat treatment to a covered product. The definition of production used in this investigation is described in chapter 1 ("Investigation Scope"). USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.1.1, 5.1.19b, and 5.1.24a.

**Table 4.11** Stainless steel products: average fuel and electricity intensities

In million British thermal units per metric ton of production (MMBtu/mt production) and megawatt-hours per metric ton of production (MWh/mt production).

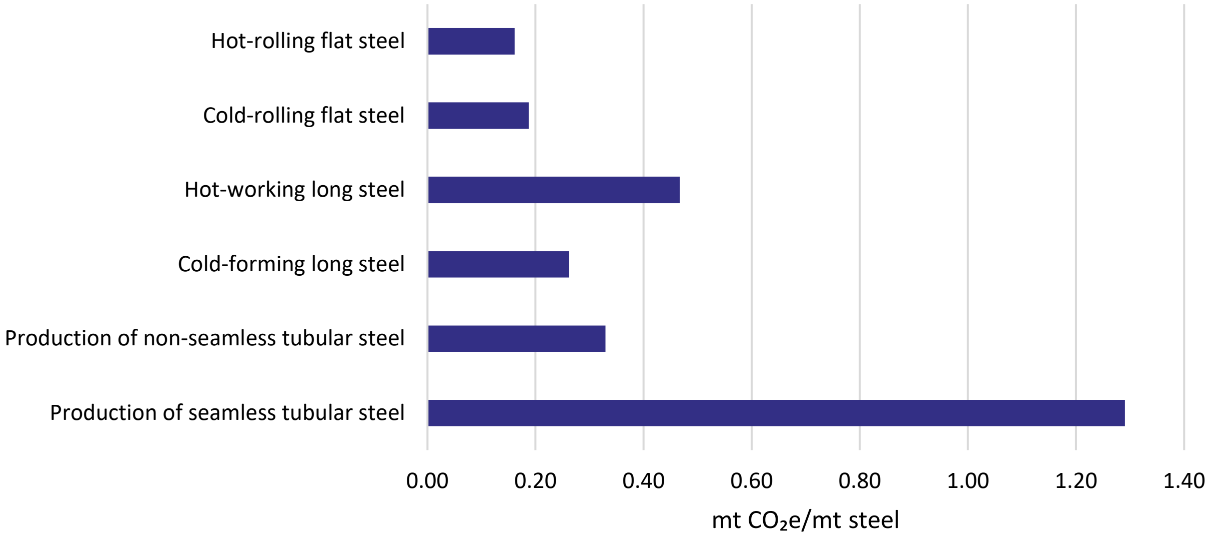
| Product category | Average fuel intensity (MMBtu/mt production) | Average electricity intensity (MWh/mt production) | Average total energy intensity (MMBtu/mt production) |
|---|---|---|---|
| Semifinished | 0.92 | 0.77 | 3.56 |
| Hot-rolled flat | 2.00 | 0.11 | 2.38 |
| Cold-rolled flat | 1.40 | 0.23 | 2.19 |
| Hot-worked long | 5.90 | 0.44 | 7.40 |
| Cold-formed long | 1.43 | 0.43 | 2.90 |
| Seamless pipe and tube | 9.40 | 2.27 | 17.13 |
| Non-seamless pipe and tube | 1.81 | 0.58 | 3.77 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: Total energy intensity is calculated by converting the average electricity intensity to MMBtu/mt (by multiplying it by 3.412) and adding it to the average fuel intensity. Unlike the emission intensities, these energy intensities do not include energy used in upstream product categories that were made at the same facility and used as inputs to the product category. Intensities shown above are generated according to the fuel and electricity usage associated with the corresponding production subprocess; for facilities that also produced stainless steel, the usage was split proportionally based on production data. Energy intensities include energy used in ambient heating, cooling, ventilation, and lighting supply, allocated proportionally across all production categories (including production of noncovered products).

**Figure 4.10** Stainless steel: scopes 1 and 2 average emissions intensities by subprocess

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). Underlying data for this figure can be found in appendix J, table J.20.



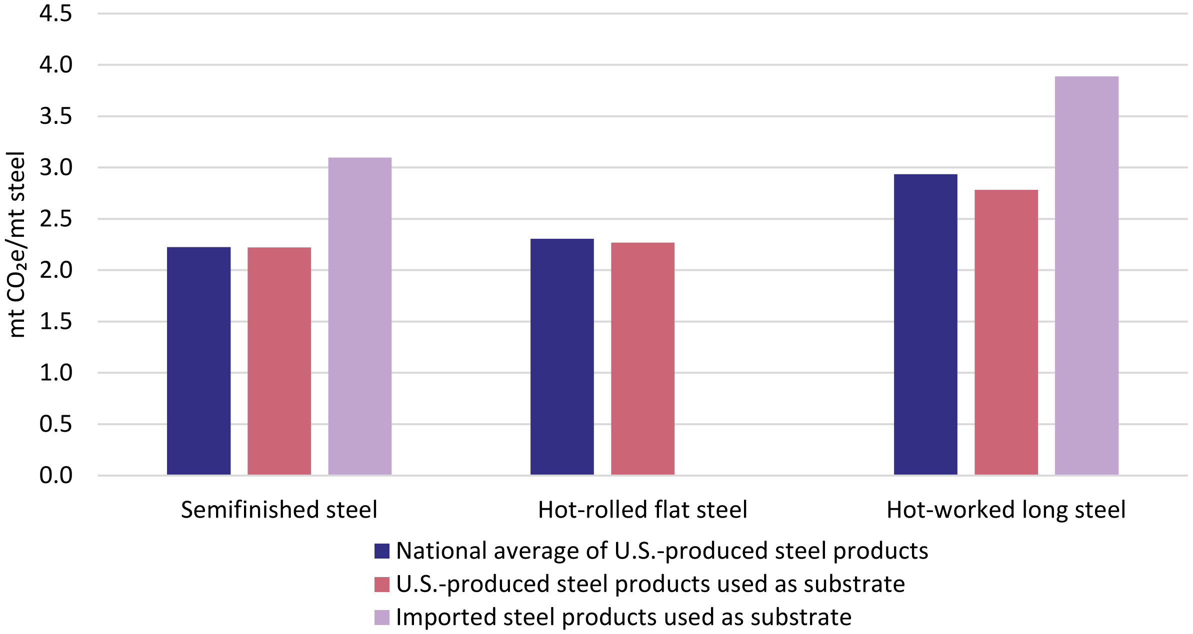
Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: These emissions intensity estimates solely pertain to the subprocess listed. The emissions intensities shown here do not include estimates for the embedded emissions associated with the upstream inputs, regardless of source, including emissions associated with other subprocesses listed here. For example, even though carbon and alloy cold-rolled flat steel uses hot-rolled flat steel as substrate, the emissions intensity of cold-rolling flat steel does not include the emissions of hot-rolling flat steel in this figure.

Like carbon and alloy finished mill products, the inclusion of imported substrate in the production of further downstream stainless product categories affected the emissions intensities of those product categories. The emissions intensities of imported stainless steel products used as substrate were higher than the corresponding average emissions intensities of U.S. produced semifinished steel and hot-worked long (see figure 4.11). Unlike for carbon and alloy finished mill products, the emissions intensities of U.S.-produced stainless steel products used as substrate were comparable to the U.S. average emissions intensities for those product categories.

**Figure 4.11** Stainless steel: emissions intensities of U.S.-produced and imported steel products used as substrate for flat, long, and tubular products, compared with the national average

In metric tons of carbon dioxide-equivalent per metric ton of steel (mt $CO_2$e/mt steel). Underlying data for this figure can be found in appendix J, table J.21.

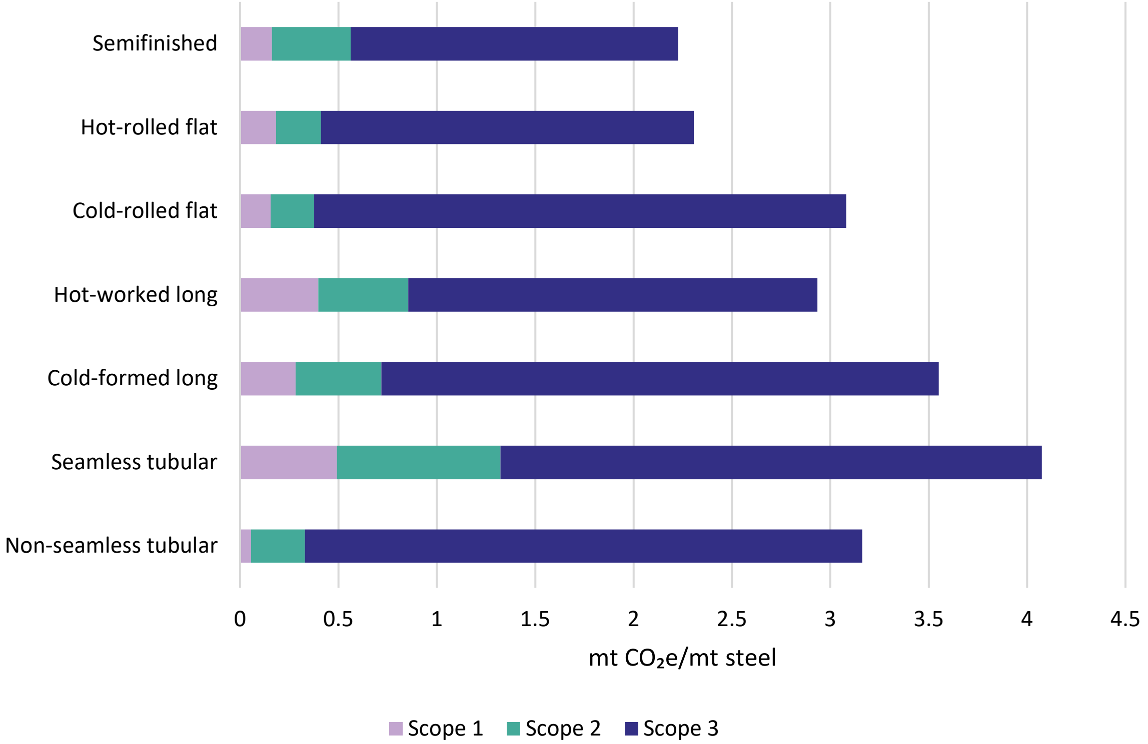


Source: USITC estimates based on its calculation methodology, see appendixes E and H.
Note: The emissions intensity of imported hot-rolled flat steel products used as substrate is suppressed to protect confidentiality.

Stainless steel products are not made using BF-BOFs in the United States, so scope 1 shares are low across the product categories because of the lack of process emissions. Comparatively higher scope 2 shares further reflect the impact of the electricity-intensive EAF process, which is the predominant process used in the United States for making stainless steel. Most notable about the scope 1, 2, and 3 shares for stainless steel product categories is the dominance of scope 3 emissions as a share of total emissions across all stainless product categories (see figure 4.12). As mentioned above, the higher scope 3 emission shares for stainless steel are mostly attributable to the higher alloy content and the embedded emissions associated with their production and use.

**Figure 4.12** Stainless steel: scopes 1, 2, and 3 contribution to the average emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). Underlying data for this figure can be found in appendix J, table J.22.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

## Comparisons to Other Published Emissions Intensity Estimates

The availability of other published emissions intensity estimates for stainless steel products is limited in comparison to those for carbon and alloy steel. Available estimates are generally focused on production of stainless steel reported on a crude basis (i.e., corresponding with semifinished steel) and are not geographically specific. In its 2024 Stainless Steel $CO_2$ Emissions Report, worldstainless reported a wide range of emissions intensity estimates for stainless semifinished steel that varied based on the scrap and alloying material content used in production. This report stated that the emissions intensity for stainless semifinished steel with 85 percent scrap content—which another study found corresponded most closely with U.S. production—was 1.95 mt $CO_2$/mt steel.[414] JRC’s 2023 study estimated a much higher emissions intensity for U.S.-produced stainless ingots and forgings of 5.01 mt $CO_2$/mt steel, a value that

---

[414] worldstainless’s reported $CO_2$ emissions intensities include scope 1, 2, and 3 emissions. They are based on system boundaries that incorporate upstream sources of alloying metals such as nickel, chromium, and molybdenum. worldstainless, “Stainless Steel $CO_2$ Emissions Report,” August 2023. worldstainless estimated that the scrap ratio (the amount of scrap used relative to output from steelmaking) was 83 percent in the United States. worldstainless, *Global Life Cycle of Stainless Steel*, June 26, 2023.

was driven in large part by its use of estimates incorporating BF-BOF production.[415] The Commission's emissions intensity for stainless semifinished steel is between these two estimates, at 2.23 mt $CO_2e$/mt steel. As discussed above, no stainless steel was produced in the United States via the BF-BOF process.

---

[415] Vidovic et al., *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 16, 25, 141. The basis for JRC's emissions intensity estimates is described above (see note in "Foreign-Origin Material Inputs" section).

# Bibliography

Aries, Eric, Jorge Gómez Benavides, Stilianos Mavromattis, Gabriele Klein, Georgios Chronopoulos, and Serge Roudier. “Best Available Techniques (BAT) Reference Document for the Ferrous Metals Processing Industry.” JRC Publications Repository, December 5, 2022. https://doi.org/10.2760/196475.

Cleveland-Cliffs Inc. *2023 Sustainability Report*. April 3, 2024. https://www.clevelandcliffs.com/sustainability.

Commercial Metals Company (CMC). *2023 Sustainability Report*. 2024. https://esg.cmc.com/wp-content/uploads/CMC_ESG_REPORT_2023.pdf.

CRU Group (CRU). “CRU Emissions Analysis Tool.” Emissions Analysis Tool, 2024. https://www.crugroup.com/emissions-analysis-tool/.

Ember. “Electricity Data Explorer.” Accessed November 8, 2024. https://ember-energy.org/data/electricity-data-explorer.

Hasanbeigi, Ali. “Steel Climate Impact - An International Benchmarking of Energy and CO2 Intensities.” *Global Efficiency Intelligence* (April 2022). https://www.globalefficiencyintel.com/steel-climate-impact-international-benchmarking-energy-co2-intensities.

Janjua, Rizwan, and Felipe Maciel. *$CO_2$ Data Collection User Guide, Version 11*. WorldSteel Association, May 30, 2024. https://worldsteel.org/wp-content/uploads/CO2_User_Guide_V11.pdf.

Koolen, Derck, and Danko Vidovic. *Greenhouse Gas Intensities of the EU Steel Industry and Its Trading Partners*. June 22, 2022. https://doi.org/10.2760/170198.

Nucor Corporation. *2023 Corporate Social Responsibility Report*. 2024. https://nucor.com/sustainability.

Nucor Corporation. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 11, 2023. https://edis.usitc.gov/external/search/document/809074.

Outokumpu. *2023 Sustainabilty Review*. 2024. https://www.outokumpu.com/en/investors/materials/2023.

Outokumpu. *Environmental Product Declaration: Ferrochrome from Outokumpu Chrome Oy*. July 6, 2023. https://www.outokumpu.com/en/sustainability/sustainability-downloads.

Outokumpu Stainless USA, LLC (Outokumpu). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 21, 2023. https://edis.usitc.gov/external/search/document/809124.

Outokumpu Stainless USA, LLC (Outokumpu). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810868.

ResponsibleSteel. *ResponsibleSteel International Production Standard: Version 2.1*. May 21, 2024. https://www.responsiblesteel.org/standards.

Specialty Steel Industry of North America (SSINA). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810863.

Steel Dynamics, Inc. (SDI). *2023 Sustainability Update*. April 2024. https://www.steeldynamics.com/wp-content/uploads/2024/04/2023-Sustainability-Update.pdf.

Steel Manufacturers Association (SMA). *Steelmaking Emissions Report 2022*. June 14, 2022. https://steelnet.org/steelmaking-emissions-report-2022/.

Su, Romain, and Adrien Assous. *Starting from Scrap: The Key Role of Circular Steel in Meeting Climate Goals*. June 2022. https://sandbag.be/wp-content/uploads/Sandbag-Starting-from-Scrap.pdf.

Transition Asia. "Steel Scrap Explainer." August 18, 2023. https://transitionasia.org/wp-content/uploads/2023/08/TA-Scrap-Steel-Explainer2023-1.pdf.

U.S. Department of Commerce (USDOC). International Trade Administration (ITA). "Melt and Pour Dashboard." Accessed November 8, 2024. https://www.trade.gov/data-visualization/melt-and-pour-dashboard.

U.S. Environmental Protection Agency (EPA). *AP 42, Compilation of Air Emissions Factors from Stationary Sources*. January 1995. https://www3.epa.gov/ttn/chief/ap42/ch12/index.html.

U.S. Environmental Protection Agency (EPA). "eGRID Mapping Files." Accessed August 23, 2024. https://www.epa.gov/egrid/egrid-mapping-files.

U.S. Environmental Protection Agency (EPA). "eGRID Subregion Year 2022 Data (SRL22)." Emissions and Generation Resource Integrated Database (eGRID), January 30, 2024. https://www.epa.gov/egrid/download-data.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). "Technical Support Document for the Iron and Steel Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases." August 28, 2009. https://www.epa.gov/sites/default/files/2015-02/documents/tsd_iron_and_steel_epa_9-8-08.pdf.

U.S. Environmental Protection Agency (EPA). Office of Atmospheric Protection (OAP). "Greenhouse Gas Reporting Program (GHGRP). Emissions by Unit and Fuel Type Dataset." Accessed September 9, 2024. https://www.epa.gov/system/files/other-files/2023-09/emissions_by_unit_and_fuel_type_c_d_aa_09_2023_0.zip.

U.S. International Trade Commission (USITC). *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_facility-level_questionnaire_aluminum_and_steel_combined.pdf.

U.S. International Trade Commission (USITC). Hearing Transcript in Connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 7, 2023. https://edis.usitc.gov/external/search/document/810108.

United States Steel Corporation (U. S. Steel). *The Future of Steel: United States Steel Corporation 2023 Sustainability Report*. June 25, 2024. https://www.ussteel.com/documents/40705/43725/USS_ESG_Report_2023.pdf/60c7b0ab-c5cd-b3e0-ccc6-de5ab25064f2?t=1719236815431.

Vidovic, Danko, Alain Marmier, Lovro Zore, and Jose A. Moya. *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries in the EU and Its Main Trading Partners*. European Commission. Joint Research Centre (JRC), 2023. https://data.europa.eu/doi/10.2760/359533.

worldstainless. *Global Life Cycle of Stainless Steel*. June 26, 2023. https://www.worldstainless.org/news/global-life-cycle-of-stainless-steel/.

World Steel Association (worldsteel). *Steel Statistical Yearbook 2023*. Accessed September 21, 2024. https://worldsteel.org/publications/bookshop/ssy_subscription-2023/.

World Steel Association (worldsteel). *Sustainability Indicators 2024 Report*. November 2024. https://worldsteel.org/wp-content/uploads/Sustainability-Indicators-report-2024.pdf.

# Chapter 5
# Emissions Intensities of U.S. Aluminum Products

This chapter presents the production-weighted average and highest emissions intensity in metric tons of carbon dioxide equivalent ($CO_2e$) per metric ton (mt) of the given aluminum product category (mt $CO_2e$/mt aluminum product) produced in the United States in 2022. Estimates are presented for the aggregate unwrought and wrought aluminum categories, for the more granular primary and secondary unwrought aluminum product categories, and for the wrought aluminum product categories listed in Attachment A of the Trade Representative's request letter. This chapter also describes the facilities producing covered aluminum products that responded to the Commission's questionnaire, the factors impacting aluminum products' emissions intensities, comparisons to other emissions intensity estimates and additional analyses performed on survey data.

## Key Findings

- The emissions intensity of primary unwrought aluminum in the United States (14.52 mt $CO_2e$/mt aluminum) is chiefly driven by the large quantities of electricity needed for electrolysis, and the fuel mix used to generate these high quantities of necessary electricity.
- Production of secondary unwrought aluminum is less energy-intensive, using over 150 times less electricity than primary unwrought production. The emissions intensity of secondary unwrought aluminum in the United States (2.46 mt $CO_2e$/mt aluminum) is influenced by the amount of primary aluminum versus scrap used as inputs and, to a lesser extent, the efficiency of the furnaces used to heat the metal.
- The average emissions intensities for wrought product categories ranged from 4.97 mt $CO_2e$/mt aluminum for plates, sheets, and strip, to 8.66 mt $CO_2e$/mt aluminum for foil. The two main factors that drive the differences in emissions intensities between wrought product categories are the amount of primary versus secondary aluminum used and the energy intensity of the various manufacturing processes.
- For the subregional grid supplying the largest portion of electricity purchases by aluminum producers, the emissions per unit of power generated are 13 percent higher than the national average according to the U.S. Environmental Protection Agency's (EPA's) Emissions and Generation Resource Integrated Database (eGRID). This subregion, which covers Kentucky, Tennessee, and parts of Mississippi and Alabama, is home to two primary unwrought aluminum smelters as well as several secondary and wrought facilities.
- For all surveyed facilities, about two-thirds (66.6 percent) of their primary aluminum inputs were imported. The majority of imports came from Canada (70.6 percent). Primary aluminum smelted in Canada has a lower emissions intensity because nearly all of Canada's primary unwrought aluminum smelters use hydroelectric power, so these imports helped lower U.S. aluminum emissions intensities. For example, using the default factors that were used in the calculations,

imports of Canadian primary aluminum made up about 71 percent of the quantity of primary aluminum imports but only about 48 percent of emissions from primary aluminum imports.

- Of the metal in secondary unwrought aluminum and wrought aluminum inputs imported by surveyed facilities, the most common type was primary aluminum whose country of smelt was Canada (56.2 and 35.6 percent, respectively).

# Surveyed Facilities

The survey population for the Commission's questionnaire was drawn from existing public information and lists of known producers of covered aluminum products from trade associations and other sources.[416] To be included in the population, facilities were required to have produced covered aluminum products in 2022. These surveyed facilities are referred to as "facilities" in this chapter.

Table 5.1 shows the number of facilities that responded to the Commission's questionnaire and manufactured each covered aluminum product in 2022. There were nearly four times as many facilities producing wrought products as there were facilities producing unwrought products. The largest product category segments in terms of number of facilities were castings, with 200 facilities, and bars, rods, and profiles, with 126. The smallest were primary unwrought aluminum, with 6 facilities, and foil, with 8. Facilities that produced aluminum castings varied widely in size. More than a dozen facilities made over 10,000 mt of castings in 2022 and almost 50 made less than 100 mt of castings.[417] Facilities also produced multiple types of covered aluminum products, with some manufacturing both secondary unwrought and wrought aluminum products or multiple wrought products. For more information on the survey population and survey methods, including response rates, see appendix H ("Description of the Commission's Survey Methodology"). For a brief description of the aluminum covered products and the HTS heading or statistical reporting number under which these products are categorized, see table 2.4 in chapter 2 ("Covered Aluminum Products").

---

[416] Stand-alone aluminum scrap shredders or processors were not included in the survey population.

[417] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 2.2.3.

**Table 5.1** Aluminum products: number of U.S. facilities producing by product category
In number of facility questionnaires.

| Product | Facilities |
|---|---|
| Unwrought | 108 |
| Primary unwrought | 6 |
| Secondary unwrought | 102 |
| Wrought | 417 |
| Bars, rods, and profiles | 126 |
| Wire | 22 |
| Plates, sheet, and strip | 36 |
| Foil | 8 |
| Tubes, pipes, and tube or pipe fittings | 42 |
| Castings | 200 |
| Forgings | 29 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 1.2.3.
Note: The total number of the facilities in this table does not sum to the total number of facilities producing aluminum products (507 facilities) because some facilities produced more than one product category. The number of facilities producing wrought products will not equal the sum of all wrought products as some facilities produce multiple wrought products.

# Factors Influencing Emissions Intensities

The emissions intensities presented later in this chapter are influenced by several factors. Broadly, these factors include the types, sources, and volumes of energy and material inputs, and the technology used in production. This section describes the major factors influencing emissions intensities for covered products within the U.S. aluminum industry.

## Electricity Sourcing

The main factor determining a primary unwrought aluminum smelter's emissions intensity is its electricity source.[418] This is due to the massive amount of electricity required in the smelter's electrolysis process. Smelters powered by renewable power sources such as hydroelectric power (hydropower) or by nuclear energy typically yield little to no emissions attributable to the electricity sourcing. By contrast, smelters powered by fossil fuel-based electricity (i.e., using coal and natural gas) have much higher electricity emissions.[419] China, for example, generally relies on coal-powered electricity to run its smelters. Consequently, a 2022 study estimated that China is responsible for an estimated 57 percent of

---

[418] Electricity sourcing can also impact the emissions intensities of secondary unwrought and wrought aluminum products, although to a lesser extent, as the production processes used to make these products require significantly less electricity compared to primary unwrought aluminum production. As discussed below, the emissions intensities of primary unwrought aluminum inputs (which are largely driven by electricity sourcing) used in secondary unwrought and wrought aluminum production can have a large impact on these products' scope 3 emissions intensities.

[419] According to estimates from Saevarsdottir et al., the global average value for emissions produced from electricity used in aluminum smelting by a hydroelectric powered plant was equivalent to 0.3 mt of $CO_2$/mt aluminum. The values for nuclear, coal, and natural gas were 0.17, 11.6, and 7.0, respectively. Saevarsdottir, Kvande, and Welch, "Aluminum Production in the Times of Climate Change," November 21, 2019, 5; Springer and Hasanbeigi, "Emerging Energy Efficiency and Carbon Dioxide Emissions-Reduction Technologies for Industrial Production of Aluminum," June 2016, 10; Hydro, "Renewable Power and Aluminum," accessed August 19, 2024.

the world's aluminum production but generated an estimated 67 percent of the world's energy-related $CO_2e$ emissions from aluminum production.[420]

U.S. smelters use a variety of electricity sources, but the majority of their power comes from the burning of fossil fuels.[421] One smelter operating in 2022 produced its own electricity, which was 100 percent coal-powered.[422] Another smelter maintained a direct-line connection to a hydroelectric power plant.[423] The four other smelters operating in 2022 purchased their electricity from the grid.[424] According to the EPA's Emissions and Generation Resource Integrated Database (eGRID) data, the electricity grid in the subregions of those four smelters varied between approximately 51 percent and 71 percent fossil fuel-based electricity.[425] The shares of coal use, the highest emitting of the fossil fuels used in the electricity grid, ranged from 11 percent to 59 percent.[426]

The electricity profile for aluminum smelting globally is similar to the profile of the United States. In 2022, the International Aluminium Institute (IAI) estimated that 50.4 percent of power to the world's smelters was generated from coal-based sources.[427] The remaining power mix was composed of 34.3 percent hydropower, 10.5 percent natural gas, 4.2 percent other renewables, and 0.6 percent nuclear. Regionally, the power mix varies quite a bit. For example, nearly all Canada's primary unwrought aluminum smelters use hydroelectric power.[428] In 2022, the power mix was 93.4 percent hydropower for Europe's smelters and 83.6 percent for South America's.[429] Smelters in Asia were highly reliant on fossil fuels. The power mix was 74.5 percent coal for smelters in China and 94.1 percent for smelters in Asia outside of China. Africa's and Oceania's smelters were fairly evenly split between coal and hydropower. Smelters in the Gulf Cooperation Council region were heavily reliant (99.1 percent) on natural gas.[430]

## Technologies and Inputs

Technologies used by smelters also influence the level of a facility's emissions, though to a lesser extent than the smelter's electricity sourcing. According to a 2022report on U.S. aluminum industry trends, the six U.S. smelters that were operating in 2022 used "older and less energy-efficient technologies than newer facilities abroad."[431] The newest U.S. smelter, the Century Aluminum Company's Mt. Holly smelter, was built in 1980. The energy efficiency of smelters across the globe, by megawatt-hour per metric ton (MWh/mt) of aluminum produced is shown in table 5.2, which groups primary aluminum

---

[420] Hasanbeigi, Springer, and Shi, *Aluminum Climate Report*, February 2022, 8–11; Tabereaux, "The Shift Toward Renewable Power in Aluminum Smelting," March 8, 2023.
[421] Environmental Integrity Project, *The Aluminum Paradox*, September 27, 2023, 7.
[422] GEM, "Warrick Power Plant," July 18, 2024.
[423] Power Authority of the State of New York, "Agreement for the Sale of Firm Hydroelectric Power," March 22, 2019.
[424] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 4.2.a.
[425] Subregions from EPA, OAR, "Power Profiler," accessed various dates.
[426] EPA, "SRL22," January 30, 2024.
[427] IAI, "Primary Aluminium Smelting Power Consumption for 2022," September 27, 2024.
[428] Tabereaux, "The Shift Toward Renewable Power in Aluminum Smelting," March 8, 2023.
[429] IAI, "Primary Aluminium Smelting Power Consumption for 2022," September 27, 2024.
[430] The Gulf Cooperation Council includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.
[431] CRS, *U.S. Aluminum Manufacturing: Industry Trends and Sustainability*, October 6, 2022, 5.

smelting energy intensity by country or region. The United States uses more power per metric ton of aluminum produced compared to the global average. Meanwhile, China, which has developed and used newer energy-conserving technologies, consumes the least amount of power per metric ton of aluminum produced.[432] Despite the higher energy efficiency of the smelters in China, however, research has found that the emissions intensity of China's primary aluminum production has been among the highest of all major aluminum-producing countries, driven by the country's reliance on coal-based captive power and coal-heavy grid electricity powering Chinese smelters."[433]

**Table 5.2** Primary aluminum smelting electricity intensity by country or region
In megawatt-hours of electricity per metric ton of aluminum produced (MWh/mt).

| Source | Electricity intensity |
|---|---:|
| United States | 15.619 |
| North America (includes the United States) | 14.962 |
| South America | 15.572 |
| Europe | 15.481 |
| Africa | 14.463 |
| Gulf Cooperation Council | 15.033 |
| China | 13.443 |
| Asia (excluding China) | 14.739 |
| Global Average | 14.119 |

Sources: U.S. intensity is estimated using responses from USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024; other intensities are sourced from IAI, "Primary Aluminium Smelting Energy Intensity for 2022," April 11, 2024.
Note: In cases where a facility did not separate its electricity use for smelting from other processes such as anode baking and ambient energy use, its electricity use for primary aluminum smelting was estimated by using other U.S. facilities' allocations to estimate the share for smelting.

Secondary unwrought aluminum production is a much less emissions-intensive process. According to a recent study by the Aluminum Association, in North America, producing one metric ton of secondary unwrought aluminum is approximately 94 percent less emissions intensive than producing one metric ton of primary unwrought aluminum.[434] This is due to much lower energy requirements: secondary unwrought aluminum production consumes 90–95 percent less energy than primary unwrought aluminum production.[435]

Within the secondary unwrought aluminum production segment, emissions intensity is primarily influenced by the share and source of primary unwrought aluminum inputs that are used in production.[436] As discussed in the section above, sourcing inputs such as primary unwrought aluminum from producers using clean electricity and energy-efficient smelters can result in lower emissions compared to producers using coal-powered electricity and less efficient smelters. Similarly, the share and

---

[432] IAI, *Development of the Aluminum Industry and Technology in China*, February 5, 2024.
[433] In one report, China's $CO_2$ emissions intensity for its primary aluminum production was the second highest compared to the intensities of Europe and the top 11 aluminum-producing countries in 2019. Hasanbeigi, Springer, and Shi, *Aluminum Climate Report*, February 2022, 8, 15.
[434] $CO_2e$ emissions per metric ton was 8455.31 kg for primary unwrought aluminum and 526.71 kg for secondary unwrought aluminum. AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 15–17, tables 0-1 and 0-3.
[435] USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 52; The Aluminum Association, "Sustainability – Recycling," accessed November 8, 2023; CRS, *U.S. Aluminum Manufacturing: Industry Trends and Sustainability*, October 6, 2022, 5.
[436] In the production of unwrought secondary aluminum, adding primary aluminum helps to dilute impurities and alloys in the scrap to have better control over the chemical composition of the final product.

source of alloying inputs used in production can also impact emissions intensities. In the production of secondary unwrought aluminum, energy efficiency has been gained through more efficient furnaces, an increased number of larger recycling producers taking advantage of economies of scale, and better sorting and pre-treating of scrap.[437]

Similar to secondary aluminum production, the emissions intensity of wrought production is primarily driven by the share and source of primary unwrought aluminum used.[438] According to the aforementioned study by the Aluminum Association, a one percent increase in primary inputs will increase emissions by as much as 117 kg of $CO_2e$ per mt of wrought aluminum.[439] The amount of primary aluminum used in wrought products can vary greatly, even within a product category, depending on the intended end use of the product.[440] As the emissions intensity of primary aluminum inputs decrease, so do the emissions intensities of wrought products using such inputs.[441] The Aluminum Association's study also found that the carbon footprint of North American wrought aluminum products using primary aluminum inputs from China was up to 3.2 times higher than products using primary aluminum inputs from Canada, a result of differences in electricity sourcing for each country.[442]

The processes applied in the production of wrought aluminum also impact the emissions intensity of the products. U.S. wrought aluminum production is generally composed of a larger share of products that do not require heat treating.[443] For the wrought products that do undergo these processes, however, the amount of fuel combusted to heat or heat-treat the aluminum also varies.[444] The ability to skip certain production steps, like reheating aluminum inputs, can also reduce to overall emissions intensity of wrought aluminum products. As noted in chapter 2, shaping a wrought product directly from molten aluminum can create energy savings of up to 25 percent by reducing the need for reheating altogether.[445]

---

[437] AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 25.

[438] For an example demonstrating this, see Sphera Solutions, *Aluminum Extrusion EPD Background Report*, November 4, 2022, 52, figure 4-12.

[439] The Aluminum Extruder's Council found similar results in which a 10 percent increase in primary aluminum inputs in aluminum extrusions increased emissions by 1400 kg $CO_2e$. AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 18; Sphera Solutions, *Aluminum Extrusion EPD Background Report*, November 4, 2022, 51.

[440] For example, the Aluminum Association's report found that the metal composition for "generic sheet" was only 23.8 percent primary aluminum whereas automotive sheet was 75.9 percent primary. AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America*, January 2022, 91.

[441] Sphera Solutions, *Aluminum Extrusion EPD Background Report*, November 4, 2022, 51.

[442] As noted earlier in the section, electricity used to produce primary aluminum in Canada is nearly all generated by hydropower and electricity used to produce primary in China is mostly generated using coal power. AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 20, figure 0-4. Similar results were found in Sphera Solutions, *Aluminum Extrusion EPD Background Report*, November 4, 2022.

[443] Industry representatives, email to USITC staff, July 31, 2024.

[444] Industry representatives, email to USITC staff, July 31, 2024.

[445] USDOE, OIT, *Structural Factors Affecting Formability*, October 2001.

# Average and Highest Emissions Intensities

This section presents the production-weighted average emissions intensity (“average emissions intensity”) and a measure of the highest emissions intensity, in metric tons of $CO_2e$ per metric ton of the given aluminum product category (mt $CO_2e$/mt) by U.S. producers in 2022. The Commission estimated the product-category-level production-weighted emissions intensity by dividing the total associated emissions in metric tons of $CO_2e$ by the total national production in metric tons produced for the product category.[446] The highest estimate (“highest emissions intensity”) is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent (i.e., 90–100th percentile range) of production within each respective product category, unless otherwise noted.[447] Estimates are presented for unwrought and wrought aluminum, with additional breakouts for individual product categories. This section also provides more granular data where possible showing the contributions of materials, processes, and scopes to average emissions intensities.

## Unwrought Aluminum

Unwrought aluminum products are defined in this investigation as those corresponding to HTS heading 7601. They include ingots, slabs, blocks, billets, sows, etc. made from either primary or secondary aluminum.[448] The U.S. average and highest emissions intensities of primary unwrought, secondary unwrought, and overall unwrought aluminum are shown in table 5.3.

**Table 5.3** Unwrought aluminum: U.S. average and highest emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2e$/mt aluminum). The highest estimate is the production-weighted average only of those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented. ^ indicates the highest estimate is an average of the top emissions-intensive facilities with 30 percent of production because of confidentiality.

| Product category | Average emissions intensity | Highest emissions intensity |
|---|---|---|
| Unwrought | 3.46 | 14.82 |
| Primary unwrought | 14.52 | 22.22^ |
| Secondary unwrought | 2.46 | 9.62 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

The U.S. average emissions intensity for primary unwrought aluminum was 14.52 mt $CO_2e$/mt aluminum, higher than the average for secondary unwrought aluminum at 2.46 mt $CO_2e$/mt aluminum. The average emissions intensity for all unwrought aluminum, which includes both primary and secondary, was 3.46 mt $CO_2e$/mt aluminum. The main determinant of the overall unwrought emissions intensity was the ratio of production of primary unwrought aluminum to secondary unwrought aluminum. There was much

---

[446] See appendix H for emissions intensity calculation equations. For the full table of highest emissions estimates by product, see appendix I.

[447] Production-weighted averages also have been calculated for the 50–100th, 60–100th, 70–100th, and 80–100th percentile ranges (i.e., the most emissions-intensive facilities representing 50 percent, 40 percent, 30 percent, and 20 percent of production, respectively) for each product category and are presented in appendix I.

[448] No U.S. smelters produced any covered aluminum product on-site other than unwrought primary aluminum.

more production of secondary than primary unwrought aluminum in the United States in 2022.[449] The secondary unwrought aluminum emissions intensities include both external shipments as well as secondary unwrought aluminum produced and consumed on-site for downstream production in the same facility.[450] The survey results indicate that over half (about 57 percent) of secondary unwrought aluminum production in the United States is material that is produced and used within the same facility.[451] With all this material included, the ratio of secondary unwrought aluminum production to primary unwrought aluminum production is more than 10 to one (see table H.4 in appendix H).

Consistent with the research in the "Factors Influencing Emissions Intensities" section above, the Commission's data also show that two key factors contributed to the differences in the emissions intensities of primary and secondary unwrought aluminum: the electricity-intensive manufacturing process for primary aluminum and the source of the generation (e.g., fuel mix) of that electricity in the United States. The amount of electricity used to make primary unwrought aluminum in the United States was estimated to be over 150 times that used to make secondary aluminum (table 5.4). The average fuel, electricity, and total energy intensities of primary and secondary unwrought aluminum are shown in table 5.4. Primary unwrought aluminum used 16.656 megawatt-hours per metric ton (MWh/mt) of production while secondary unwrought aluminum used only 0.111 MWh/mt of production.

**Table 5.4** Average fuel, electricity, and combined fuel and electricity intensities of aluminum product categories

In million British thermal units per metric ton of production (MMBtu/mt production) and megawatt-hours per metric ton of production (MWh/mt production).

| Product category | Average fuel intensity (MMBtu/mt production) | Average electricity intensity (MWh/mt production) | Average total energy intensity (MMBtu/mt production) |
|---|---|---|---|
| Primary unwrought aluminum | 4.827 | 16.656 | 61.658 |
| Secondary unwrought aluminum | 5.062 | 0.110 | 5.436 |

Source: USITC estimates based on its calculation methodology, see appendix E.

Note: Total energy intensity is calculated by converting the average electricity intensity to MMBtu/mt (by multiplying it by 3.412) and adding it to the average fuel intensity. Energy intensities include energy used in ambient heating, cooling, ventilation, and lighting supply, allocated proportionally across all production categories (including production of noncovered products).

The source location and amount of purchased electricity by all facilities that produced any covered aluminum products in 2022 is shown in figure 5.1. The darker the shade, the more electricity was purchased from that subregion. While the sourcing of electricity is an important factor for the emissions intensity of all aluminum producers, it is particularly important for primary unwrought aluminum producers because of how electricity-intensive the manufacturing process is. The quantities of electricity

---

[449] Including secondary unwrought aluminum used for internal consumption, secondary unwrought aluminum made up about 92 percent of total U.S. unwrought aluminum production in 2022, according to questionnaire response data.

[450] Secondary unwrought aluminum producers can both consume and produce secondary aluminum, complicating efforts to use supplying-facility-specific emissions factors. A national "first-use" secondary aluminum factor was computed from questionnaire response data and used as an emissions factor for any domestically supplied input secondary aluminum. See the appendix E, "II.D.1.b(2) Scope 3 Emissions for Aluminum Materials Group 2: Secondary and Wrought Product Inputs from U.S. Sources" for further details.

[451] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.2.2–2.2.3.

purchased by primary unwrought aluminum smelters are so much higher than for other aluminum producers that their purchases explain much of the shading of the map.

Emissions from the purchase of electricity contributed to most product-level emissions intensities, and figure 5.1 shows that the subregions that contributed most to these purchases were ones with higher emissions from power generation than the national average.[452] The subregion with the largest volume of electricity purchases was the SERC Tennessee Valley (SRTV) subregion, which covers Kentucky, Tennessee, and parts of Mississippi and Alabama. This subregion is home to two primary unwrought aluminum smelters as well as several secondary and wrought facilities. Electricity purchased in this subregion carried an emissions factor that was 13.4 percent higher than the national average—0.43 mt $CO_2e$/MWh, compared to 0.38 mt $CO_2e$/MWh (table 5.5).

The subregion with the second-largest volume of electricity purchases was the SERC Midwest (SRMW) subregion, which covers most of Illinois and Missouri, as well as a small portion of Iowa. This subregion was home to one primary unwrought aluminum smelter in 2022, as well as several facilities producing either wrought or secondary unwrought aluminum. Electricity purchased in this subregion carried the second-highest emissions factor of all U.S. subregions—0.63 mt $CO_2e$/MWh. Facilities producing covered aluminum products in the SWERC Virginia-Carolina (SRVC), RFC West (RFCW), RFC East (RFCE), and NPCC Upstate New York (NYUP) subregions also purchased substantial amounts of electricity. Emissions factors for electricity purchases in these regions ranged from 0.12 mt $CO_2e$/MWh to 0.46 $CO_2e$/MWh.[453]

**Table 5.5** Total electricity purchases from facilities producing covered aluminum products, by purchase quantity in the top five Emissions and Generation Resource Integrated Database (eGRID) subregions

In gigawatt-hours (GWh) and metric tons of carbon dioxide per megawatt-hour (mt CO2e/MWh). n.a. = not available; — (em dash) = not applicable.

| eGRID subregion | eGRID subregion name | Purchase quantity (GWh) | Emissions factor (mt $CO_2e$/MWh) |
|---|---|---:|---:|
| SRTV | SERC Tennessee Valley | 7,578 | 0.426 |
| SRMW | SERC Midwest | 4,112 | 0.626 |
| SRVC | SERC Virginia/Carolina | 2,634 | 0.284 |
| RFCE | RFC East | 2,623 | 0.300 |
| NYUP | NPCC Upstate NY | 2,528 | 0.125 |
| All other | — | 5,308 | n.a. |
| Total | — | 24,783 | 0.380 |

Sources: USITC, Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level, 2024, responses to questions 4.1 and 4.2a; EPA, “SRL22,” January 30, 2024.

Note: Purchased electricity quantities for each subregion aggregate total facility-wide purchases of electricity and include electricity purchased to make noncovered products. The data do not include on-site electricity generation.

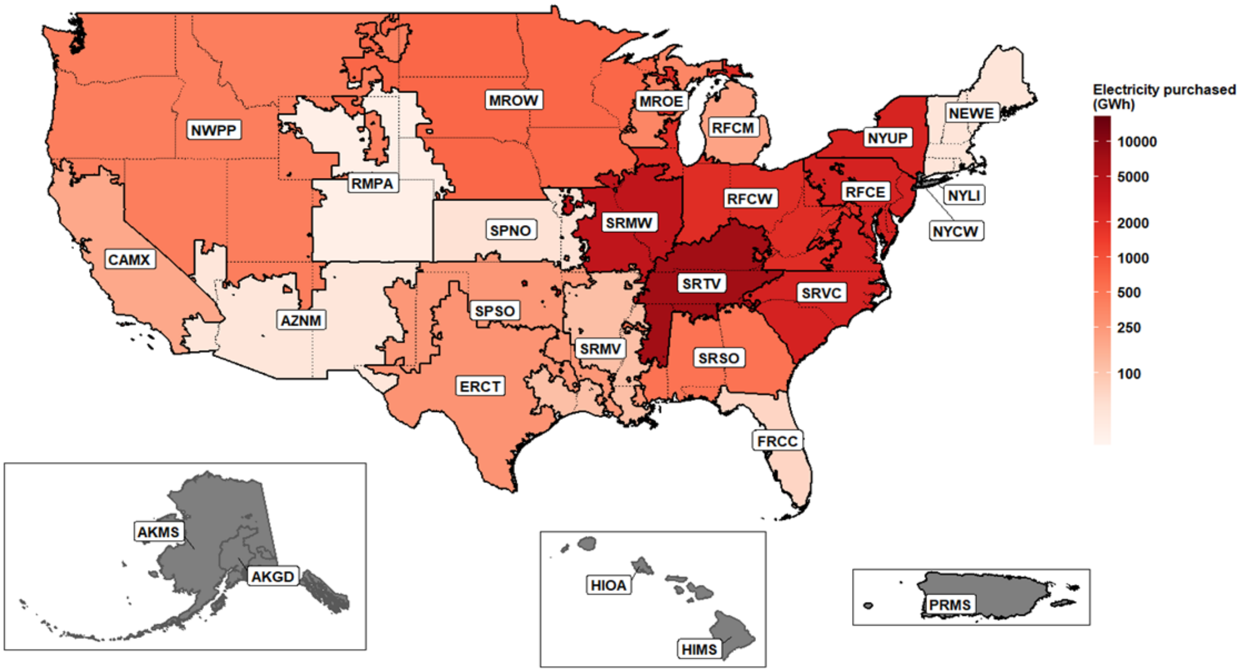
---

[452] Some facilities had no electricity purchases, for example if they generated their electricity on-site.

[453] EPA, “SRL22,” January 30, 2024.

**Figure 5.1** Electricity purchases from facilities producing covered aluminum products in 2022, by Emissions and Generation Resource Integrated Database (eGRID) subregion

In gigawatt-hours (GWh). Dark gray shading indicates data are suppressed because of confidentiality. Underlying data for this figure can be found in appendix J, table J.23.

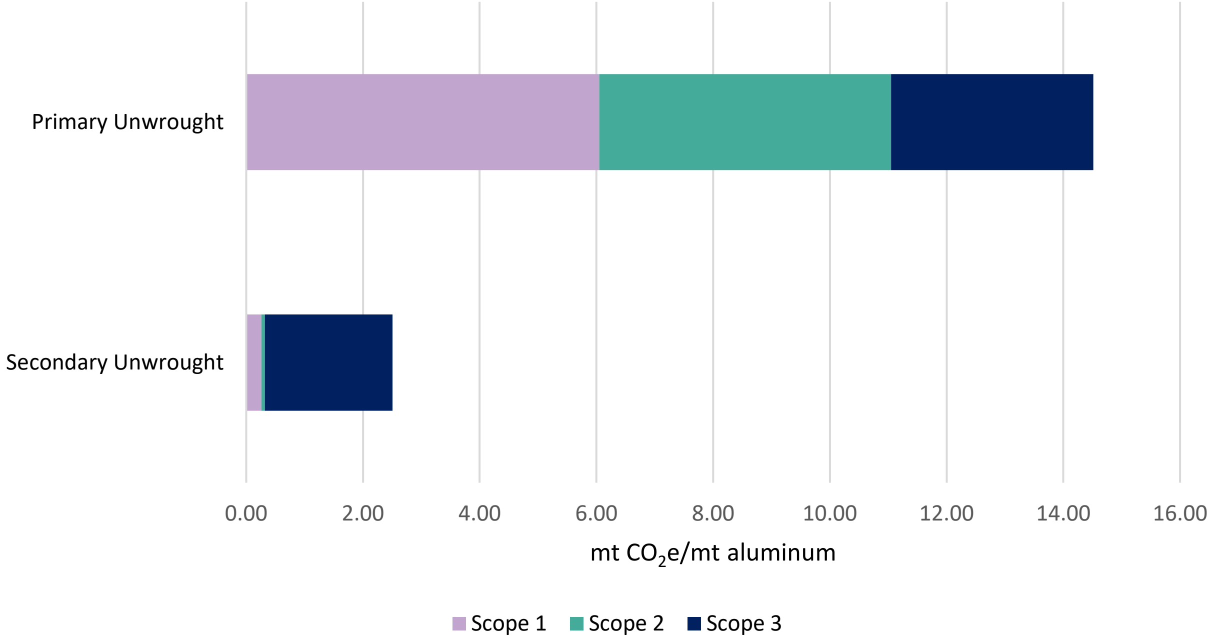


Sources: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 4.1. EPA, “SRL22,” January 30, 2024.
Note: Purchased electricity quantities for each subregion aggregate total facility-wide purchases of electricity and include electricity purchased to make noncovered products. The data do not include on-site electricity generation.

Each emissions intensity is made up of a varying share of scope 1, 2, and 3 emissions. The breakdown of the average primary and secondary unwrought aluminum emissions intensity by the share of emissions coming from each of these scopes is shown in figure 5.2. Primary unwrought aluminum emissions come mostly from scopes 1 and 2; secondary unwrought aluminum emissions come mostly from scope 3. This is because primary unwrought emissions come mostly from the smelting of primary unwrought aluminum (and corresponding electricity use), while secondary unwrought aluminum emissions come mostly from the use of primary unwrought aluminum as an input (and corresponding embedded emissions).

**Figure 5.2** Unwrought aluminum: scopes 1, 2, and 3 contributions to the average emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2e$/mt aluminum). Underlying data for this figure can be found in appendix J, table J.24.

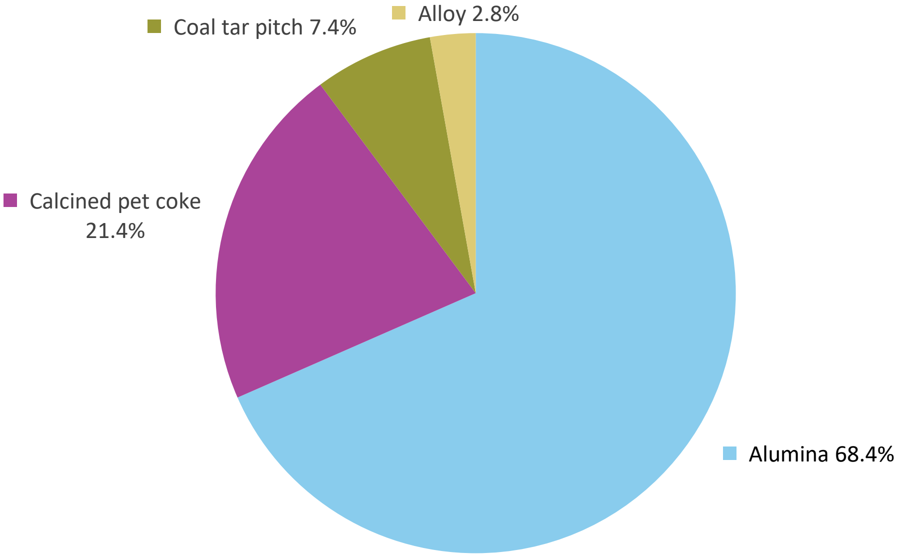


Source: USITC estimates based on its calculation methodology, see appendixes E and H.

The share of scope 1 and 2 emissions per metric ton of product are much higher in the emissions intensities of primary unwrought aluminum than secondary unwrought aluminum, as shown in figure 5.2. Smelting releases significant process emissions (discussed further in the “II.B. Process Emissions for Aluminum” section of appendix E) and requires large amounts of electricity, in addition to any on-site fuel combustion. By contrast, the share of scope 1 and 2 emissions per ton of secondary unwrought aluminum are a fraction of those for primary unwrought aluminum. Scope 1 emissions from secondary unwrought aluminum are exclusively attributed to fuel combustion emissions, as production does not create any process emissions. Scope 2 emissions are also much lower in secondary unwrought production due to much smaller electricity needs. Scope 3 emissions that contribute to the emissions intensity of primary unwrought aluminum are mostly from alumina, including cradle-to-gate bauxite mining emissions. The primary unwrought aluminum scope 3 estimates in figure 5.3 show the shares in percentages by the four major contributors—alumina, calcined petroleum coke, coal tar pitch, and alloys.

**Figure 5.3** Scope 3 primary unwrought aluminum emissions, by contributor

In percentages. Underlying data for this figure can be found in appendix J, table J.25.



Source: USITC estimates based on its calculation methodology, see appendix E.
Note: Bauxite mining emissions were included in calculations using cradle-to-gate alumina factors, so these emissions are included in the alumina emissions portion and not as their own contributor in this figure.

Scope 3 emissions in secondary unwrought aluminum are primarily driven by the amount of primary aluminum used and whether or not that primary aluminum was smelted using power generated via a clean power source (e.g., hydroelectric power). The scope 3 emissions are also influenced by the addition of alloys. For secondary unwrought aluminum producers, about 17.8 percent of primary unwrought aluminum inputs and 73.5 percent of secondary unwrought aluminum inputs were known to be sourced domestically.[454]

## Comparisons to Other Published Emissions Intensity Estimates

This section compares the Commission's emissions intensity estimates for unwrought aluminum with other published emissions intensity estimates. The emissions intensities reported by other sources presented in this section—and in similar sections below covering downstream aluminum products—may not fully overlap with the Commission's emissions intensity estimates because of methodological and coverage differences. Specific differences are highlighted in the notes of these sections.

The Commission's average emissions intensity for U.S. primary unwrought aluminum is 14.52 mt $CO_2e$/mt aluminum compared to the International Aluminium Institute (IAI) 2022 global average of 15.1 mt $CO_2e$/mt aluminum and the Aluminum Association North American emissions intensity of 8.46 mt

---

[454] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 5.2.6.

$CO_2e$/mt aluminum.[455] The differences between the Commission's emissions intensity and the Aluminum Association emissions intensity is mostly explained by the Aluminum Association report's inclusion of Canada. Canada's higher volume of production of primary unwrought aluminum and reliance on hydropower, which bring the emissions intensity average for North America down.[456]

The Commission has only limited ability to compare its secondary unwrought aluminum average emissions intensity (2.46 mt $CO_2e$/mt aluminum) because there is little in the way of published industry-wide estimates with similar methodologies to compare to. The Aluminum Association reported an emissions intensity estimate for North American remelt secondary ingot production with a primary aluminum content of only 5 percent of about one mt $CO_2e$/mt aluminum.[457] The Commission's questionnaire did not collect information on the final metal content of finished products. The amount of primary aluminum reportedly used for secondary aluminum production suggests a primary aluminum content higher than 5 percent for overall secondary aluminum production.[458]

The highest U.S. primary unwrought emissions intensity is 22.22 mt $CO_2e$/mt aluminum for the Commission's study compared to an external estimate at the high end of global primary emissions intensity of more than 25 mt $CO_2e$/mt aluminum for smelters powered by coal.[459] U.S. smelters are typically powered by a substantial share of fossil fuels. One smelter uses 100 percent coal-generated power; for other smelters purchasing from the grid, the share of power generated by coal in the electricity grids ranged from 11 percent to 59 percent.[460]

---

[455] The International Aluminium Institute system boundary includes mining, refining, anode production, electrolysis and casting. Although the associated emissions are covered, the data are not calculated or presented in terms of scopes 1, 2, and 3. The Aluminum Association system boundary also includes mining, refining, anode production, electrolysis and casting and does include a presentation of scopes 1, 2, and 3. IAI, "Primary Aluminium Greenhouse Gas Emissions for 2022," April 11, 2024; AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 106. Aside from country coverage, the differences in scope and methodology between the Aluminum Association's Life Cycle Assessment and the Commission's investigation should not result in significant differences in emissions intensity estimates for unwrought aluminum. For more information, see appendix E section on "IV. Standards Informing the Commission's Methodology," table E.15.

[456] Tabereaux, "The Shift Toward Renewable Power in Aluminum Smelting," March 8, 2023, 67; USGS, *Mineral Commodity Summaries 2024: Aluminum*, January 2024. About 90 percent of Canadian aluminum is produced with hydropower and thus about 78 percent of all North American aluminum is made with hydropower.

[457] The Aluminum Association report includes scrap collection and processing, metal production, electricity generation, and ingot or billet casting. While the associated emissions were covered, these data were not presented in terms of scopes 1, 2, and 3. AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 110.

[458] Another published model estimated primary aluminum content in secondary ingot at 8 percent. Argonne National Laboratory, "Updated Lifecycle Analysis of Aluminum Production and Semi-Fabrication for the GREET Model," September 2015, 10.

[459] Specifically, one source found that emissions intensities were "more than 25 t $CO_2e$/t Aluminum for coal powered smelters." Tabereaux, "The Shift Toward Renewable Power in Aluminum Smelting," March 8, 2023.

[460] Share of power based on the shares of coal generation in the eGRID subregion. EPA, "SRL22," January 30, 2024. GEM, "Warrick Power Plant," July 18, 2024.

## Wrought Aluminum

Wrought aluminum product categories in this investigation include bars, rods, and profiles; wire; plates, sheets, and strip; foil; tubes, pipes, and tube or pipe fittings; castings; and forgings. The average emissions intensities and highest emissions intensities for these products are shown in table 5.6. They generally fall into two groups, with bars, rods, and profiles; wire; foil; and tubes, pipes, and tube or pipe fittings as the more emissions-intensive product categories, and plates, sheets, and strip; castings; and forgings as the less emissions-intensive product categories.

**Table 5.6** Wrought aluminum: average and highest emissions intensity, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2$e/mt aluminum). The highest estimate is the production-weighted average only of those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented. ^ indicates the highest estimate is an average of the top emissions-intensive facilities with 20 percent of production because of confidentiality.

| Product category | Average emissions intensity | Highest emissions intensity |
|---|---|---|
| Wrought | 6.23 | 17.18 |
| Bars, rods, and profiles | 8.35 | 19.76 |
| Wire | 8.35 | 16.11^ |
| Plates, sheets, and strip | 4.97 | 13.22 |
| Foil | 8.66 | 11.80^ |
| Tubes, pipes, and tube or pipe fittings | 8.21 | 15.08 |
| Castings | 6.00 | 20.24 |
| Forgings | 5.00 | 10.19 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

All aluminum wrought product categories had average emissions intensities that fell within an interval of four mt $CO_2$e/mt aluminum product, ranging from plates, sheets, and strip, at 4.97 mt $CO_2$e/mt aluminum product, to foil, at 8.66 mt $CO_2$e/mt aluminum product. However, the range between the average and the highest emissions intensity was larger for some aluminum product categories than for others, indicating a more dispersed distribution of emissions intensities across the facilities producing within a product category.

For example, the highest emissions intensity for castings, of 20.24 mt $CO_2$e/mt aluminum product, was more than triple the average of 6.00 mt $CO_2$e/mt aluminum product. This greater variation could have several causes. First, there were 200 facilities who self-identified as producing castings and some facilities produced very small amounts of product; however, these small facilities sometimes also reported large quantities of energy used in production, possibly reflecting a lack of economy of scale.[461] This disparity could also reflect the difficulty for some producers to allocate and report energy use by the covered aluminum product manufacturing process and other noncovered product manufacturing processes at the facility (e.g., the producer also makes titanium or brass products but is unable to accurately measure the fuel use allocated for each production type). Finally, the composition of wrought aluminum products also varies greatly, even within the same product categories. Some producers only

---

[461] Attachment A of the Trade Representative’s letter noted that emissions intensity estimates for castings and forgings were being requested “to the extent practicable.” See the Covered Aluminum Products section in chapter 2 for further information on the definitions of these products and their classifications in the HTS.

used primary aluminum inputs, which contributed to high scope 3 emissions. Others used only scrap aluminum inputs, which carried no scope 3 emissions.

Another source of variation in the data was from widely varying input material to output production ratios. Some facilities in the survey that produce either bars, rods, and profiles or tubes, pipes, and tube or pipe fittings verified that they input about twice as much primary aluminum into the production process compared to the weight of the final shipped product.[462] Manufacturing these products creates a lot of scrap, which is not counted in the production volume in the Commission's methodology. Thus, these producers had a high input-to-output ratio, which resulted in a high emissions intensity. Bars, rods, and profiles have an estimated average emissions intensity of 8.35 mt $CO_2e$/mt aluminum product and highest emissions intensity of 19.76 mt $CO_2e$/mt product. Tubes, pipes, and tube or pipe fittings have an estimated average emissions intensity of 8.21 mt $CO_2e$/mt aluminum product and highest emissions intensity of 15.08 mt $CO_2e$/mt aluminum product.

One feature of the Commission's scrap methodology is that it did not require facilities to know the source and type of their input scrap. Only 46 of 120 facilities (38.3 percent) that produced wrought products and used external scrap as input knew or were able to estimate the share of their input scrap that was post-consumer (recovered from end-of-life products) as opposed to pre-consumer (recovered from the manufacturing process). Among these 46 facilities, about 35.8 percent of input scrap was reported to be post-consumer.[463]

The breakouts of the product-level average emissions intensities between scopes 1, 2, and 3 for each of the wrought products are shown in figure 5.4. The majority of emissions in these downstream wrought product emissions intensities come from scope 3 emissions. Scope 3 emissions are impacted by the type and sourcing of inputs.

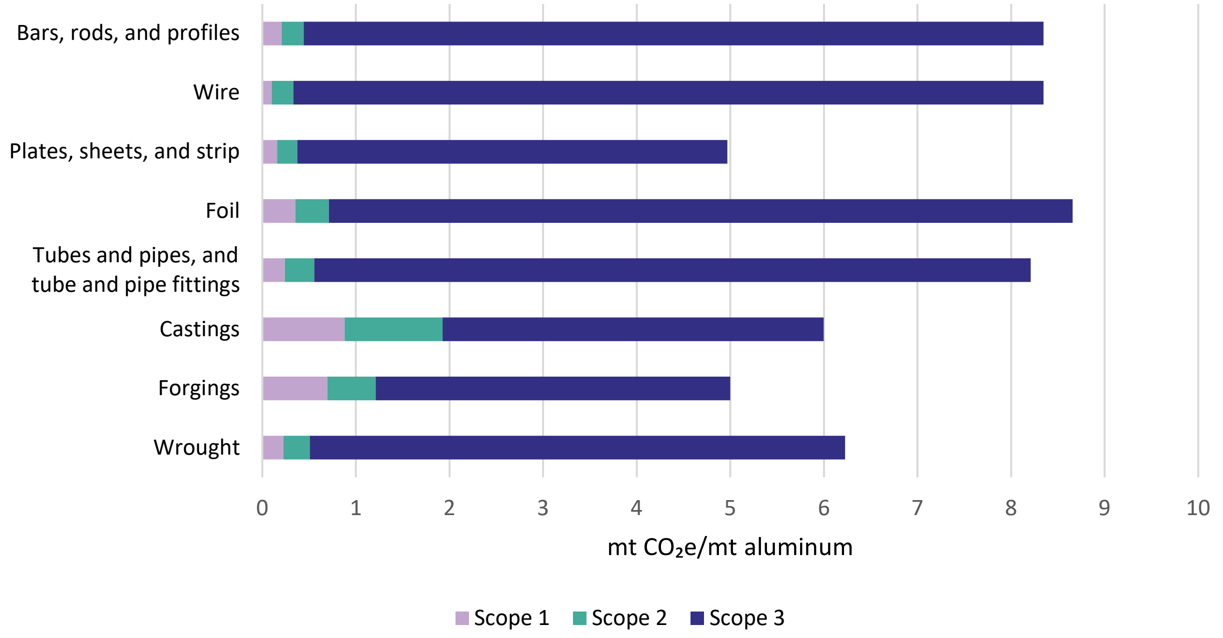
---

[462] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.2.3 and 5.2.3. Another published estimate had a similar finding that "around 40% of all aluminum cast into extrusion billets is scrapped before completion in a fabricated product." Oberhausen, Zhu, and Cooper, "Reducing the Environmental Impacts of Aluminum Extrusion," April 1, 2022.

[463] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.2.3 and 5.2.1c.

**Figure 5.4** Wrought aluminum: scopes 1, 2, and 3 contributions to the average emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2e$/mt aluminum). Underlying data for this figure can be found in appendix J, table J.26.



Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Compared to primary unwrought aluminum where the share of emissions from scope 3 is less than a quarter (figure 5.2), scope 3 emissions accounted for a majority of the emissions for all wrought product categories (ranging from 68 percent for castings to 96 percent for wire). Variation in these scope 3 emissions was driven by the amount, type, and source of metal inputs, especially primary aluminum metal inputs. For example, a product known for its high share of primary aluminum content, aluminum wire (8.35 mt $CO_2e$/mt aluminum product), had a high share of scope 3 emissions (8.01 mt $CO_2e$/mt aluminum) and was toward the upper end of the product-level average emissions intensity range.[464]

The specific impact of the type and source of metal inputs depended on if facilities reported whether their purchases of primary, secondary, and wrought aluminum used as input material came from domestic, international, or unknown suppliers.[465] The shares of primary unwrought aluminum, secondary unwrought aluminum, and wrought aluminum purchases by domestic, international, and unknown suppliers is shown in table 5.7. For facilities that produced secondary unwrought or wrought

---

[464] U.S. industry representative, interview by USITC staff, July 31, 2023.

[465] Some of this material could have been used by manufacturers of covered products to make out-of-scope products. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 5.2.5a, 5.2.6b, and 5.2.7a.

aluminum or both, about a quarter (27.4 percent) of primary aluminum inputs were known to be sourced domestically.[466]

**Table 5.7** Shares of externally sourced primary unwrought aluminum, secondary unwrought aluminum, and wrought aluminum, by source

In percentages.

| Source | Primary unwrought aluminum | Secondary unwrought aluminum | Wrought aluminum |
|---|---|---|---|
| U.S. sources | 27.4 | 73.5 | 78.0 |
| Import sources | 66.6 | 19.4 | 19.7 |
| Unknown | 6.0 | 7.1 | 2.3 |

Source: USITC, *Greenhouse Gas Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 5.2.5b, 5.2.6c, and 5.2.7b.

About two-thirds (66.6 percent) of primary aluminum inputs were known to be sourced from other countries. The reported source of imported primary aluminum (where known) is listed in table 5.8. The majority of imports came from Canada (70.6 percent). The next-largest source was the United Arab Emirates (7.7 percent), with no other source supplying above 4.0 percent. The importance of Canada, a relatively low-emission producer, among import sources helped lower U.S. aluminum emissions intensities. For example, using the default factors that were used in the calculations, provided in appendix G, imports of Canadian primary aluminum made up about 71 percent of the quantity of primary aluminum imports but only about 48 percent of emissions from primary aluminum imports.

**Table 5.8** Sources of primary unwrought aluminum imports used as inputs for covered aluminum production

In percentages.

| Source of imported primary aluminum | Share of total (%) |
|---|---|
| Argentina | 2.8 |
| Australia | 3.0 |
| Bahrain | 3.4 |
| Canada | 70.6 |
| India | 0.4 |
| Qatar | 1.7 |
| Russia | 3.4 |
| South Africa | 0.1 |
| United Arab Emirates | 7.7 |
| All other sources | 6.9 |

Source: USITC, *Greenhouse Gas Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 5.2.5.e.

Note: Totals may not sum to 100 because of rounding.

Canada was also the top country of smelt for the primary aluminum metal contained in secondary aluminum imports, and the top country of smelt for the primary aluminum metal contained in wrought imports. The majority of the metal in secondary unwrought aluminum imported by facilities was primary aluminum whose country of smelt was Canada (56.2 percent), as shown in figure 5.5, which shows the share by type and source of metal in imported secondary unwrought aluminum imports. The same information but for wrought aluminum imports in figure 5.6 shows that most metal in wrought

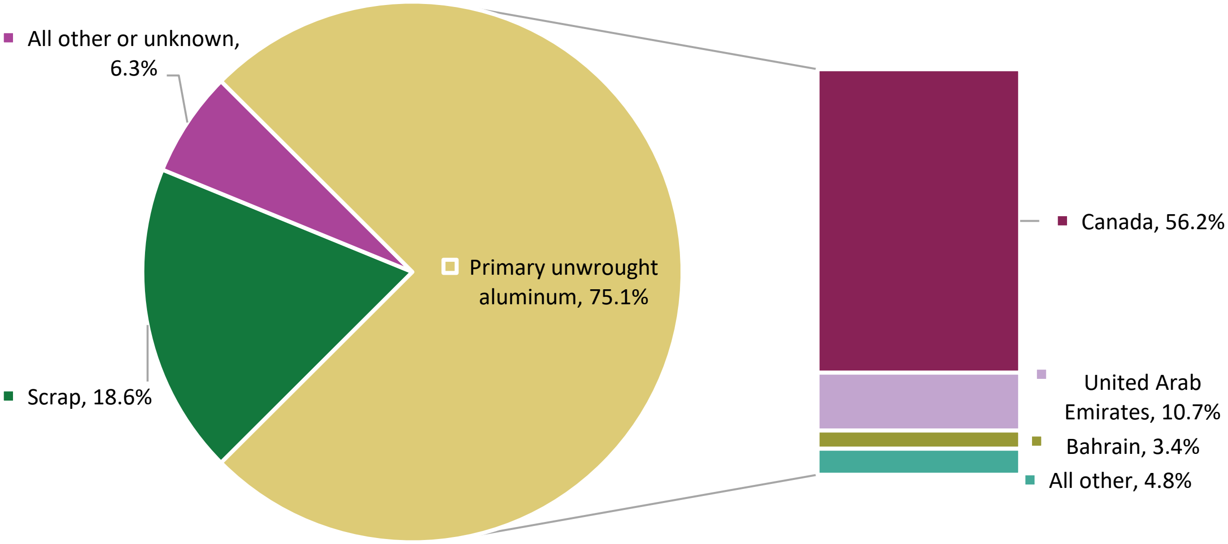
---

[466] Six percent was of an unknown origin. For all input sourcing questions, respondents may have replied to the question with the location of their sourcing agent. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 5.2.5b.

aluminum imported by facilities was primary aluminum whose countries of smelt were Canada (35.6 percent), Oman (18.1 percent), and India (16.6 percent).[467] Primary aluminum smelted in Canada has a lower emissions intensity because nearly all of Canada's primary unwrought aluminum smelters use hydroelectric power.[468] The known scrap content of most imports of secondary unwrought aluminum and wrought aluminum products was relatively low (18.6 and 4.1 percent, respectively). This is not surprising because the United States is the world's largest exporter of aluminum scrap, reflecting high domestic scrap supply.[469] Therefore, demand for imports with a high scrap content likely would not be strong—instead, most secondary unwrought and wrought aluminum are imported for their high primary aluminum content. These low-scrap imports were not widely used, because known imports made up less than one-fifth of total secondary and wrought inputs (table 5.7).

**Figure 5.5** Sources of metal in imported secondary unwrought aluminum

In percentages. Underlying data for this figure can be found in appendix J, table J.27.



Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 5.2.6.f.
Note: Source countries are country of smelt. Totals may not sum to 100 because of rounding.

---

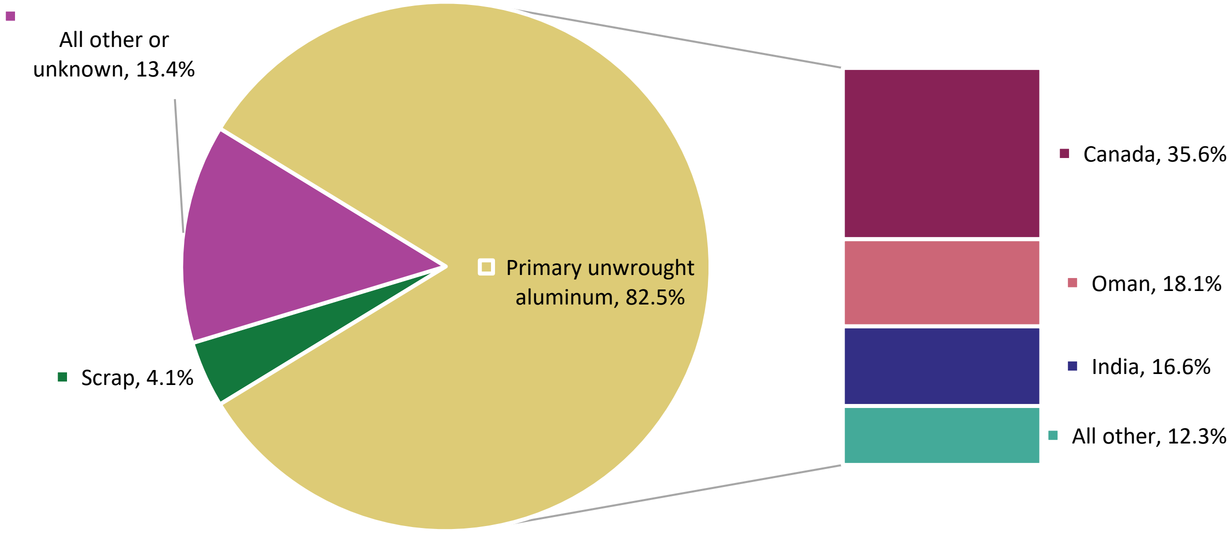
[467] The U.S. Department of Commerce's Aluminum Import Monitoring and Analysis (AIM) System also tracks imports of aluminum products by the country of smelt, defined as the country where the largest volume of new aluminum metal is produced from alumina (aluminum oxide) by the Hall-Héroult electrolytic process. Data on major sources of primary unwrought aluminum, as collected by AIM, are similar to those reported by questionnaire respondents, but the data are not totally comparable. AIM data were collected for only the second half of 2022, although the period of data collection in the Commission's questionnaire covers all of 2022. Additionally, AIM covers all imports, whereas the Commission questionnaire collected information only on imports used by facilities that produce covered aluminum products. Thus, imports from some countries, as reported in AIM, may be largely used in downstream (out-of-scope) production processes, instead of in the production of covered aluminum products. Finally, because no HTS provision distinguishes secondary unwrought aluminum, AIM is unable to collect data on the country of smelt for that product. The closest comparable data are for unwrought aluminum as a whole.

[468] Tabereaux, "The Shift Toward Renewable Power in Aluminum Smelting," March 8, 2023.

[469] AlCircle, "Top Five Aluminium Scrap Exporting Countries in the World," February 18, 2017.

**Figure 5.6** Sources of metal in imported wrought aluminum

In percentages. Underlying data for this figure can be found in appendix J, table J.28.



Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 5.2.7.e.
Note: Source countries are country of smelt. Totals may not sum to 100 because of rounding.

While the variation in sourcing of inputs among facilities affected the emissions intensities of the products they produced, so too did design decisions around the Commission's calculations of emissions factors for these inputs. For example, aluminum foil uses wrought aluminum plates, sheets, and strip as inputs. If a foil-producing facility used domestic wrought inputs, the Commission computed a single emissions factor to apply to all these domestically produced wrought inputs, even if they were sourced from multiple facilities. This emissions factor was a national average emissions intensity estimated by the Commission for wrought aluminum products that excluded the scope 3 emissions associated with any domestic inputs of wrought aluminum.[470] That factor was then applied to the domestically produced wrought inputs used in foil production to get the scope 3 emissions attributable to those inputs.[471] This method was also used in the calculation of emissions from domestically sourced secondary unwrought aluminum inputs.

If instead the foil-producing facility used imported secondary unwrought and wrought aluminum inputs, the facility estimated the primary aluminum content of those imports and identified the source country

---

[470] To avoid double-counting the embedded emissions in the plates, sheets, and strip inputs, those emissions associated with domestic inputs of wrought aluminum are carved out of the calculation of this emissions factor. These emissions are already included in the calculation of the final national average emissions intensities for wrought aluminum products, both as scope 3 emissions for the consuming facility producing foil and as scope 1 and 2 emissions for the supplier facility producing plates, sheets, and strip.

[471] Because of difficulty tracking and using supplier facility-specific emissions factors for wrought products, this domestic wrought factor was used as the emissions factor any domestically sourced input wrought aluminum. See the appendix E, "II.D.1.b(2) Scope 3 Emissions for Aluminum Materials Group 2: Secondary and Wrought Product Inputs from U.S. Sources" for further information.

where that primary aluminum content was smelted.[472] An emissions factor was then applied to that primary aluminum content to arrive at an estimate of scope 3 emissions from that internationally sourced secondary unwrought or wrought input. The estimated primary metal content in the imported secondary unwrought and wrought imports turned out to be high, as shown in figure 5.6. This resulted in the domestically sourced secondary unwrought and wrought inputs having lower emissions factors applied than imported secondary unwrought and wrought inputs. The effect on the emissions intensities is muted somewhat because this imported material made up only a small fraction of overall inputs. Facilities that produced wrought aluminum products sourced about 78.2 of secondary unwrought and 78.0 percent of wrought aluminum inputs domestically.[473]

Although scope 3 emissions were the most impactful to the wrought aluminum product emissions intensities, scopes 1 and 2 still affect emissions intensities and can be examined through the lens of fuel and electricity use. The average fuel and electricity intensities of the wrought product categories are shown in table 5.9. Even for products with the highest fuel or electricity intensities, such as castings—with a fuel intensity of 16.041 MMBtu/mt production and electricity intensity of 2.232 MWh/mt production—the scope 3 emissions are the overall driver of the emissions profile (figure 5.4).

**Table 5.9** Average fuel, electricity, and combined fuel and electricity intensities of aluminum covered product categories

In million British thermal units per metric ton of production (MMBtu/mt production) and megawatt-hours per metric ton of production (MWh/mt production).

| Product category | Average fuel intensity (MMBtu/mt production) | Average electricity intensity (MWh/mt production) | Average total energy intensity (MMBtu/mt production) |
|---|---:|---:|---:|
| Plates, sheet, strip | 3.652 | 0.555 | 5.547 |
| Bars, rods, profiles | 3.451 | 0.502 | 5.165 |
| Tubes, pipes, and tube or pipe fittings | 5.809 | 0.925 | 8.964 |
| Castings | 16.041 | 2.232 | 23.658 |
| Forgings | 10.858 | 1.590 | 16.285 |
| Foil | 6.523 | 0.866 | 9.479 |
| Wire | 3.574 | 0.596 | 5.606 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: Total energy intensity is calculated by converting the average electricity intensity to MMBtu/mt (by multiplying it by 3.412) and adding it to the average fuel intensity. Intensities shown above are generated according to the fuel and electricity usage associated with the corresponding production subprocess: wrought aluminum production split proportionally across the wrought aluminum reference products (bars, rods, and profiles; wire; plates, sheets, and strip; foil; tubes, pipes, and tube or pipe fittings; castings; forgings). Unlike the emission intensities, these energy intensities do not include energy used in upstream product categories that were made at the same facility and used as inputs to the product category. Energy intensities include energy used in ambient heating, cooling, ventilation, and lighting supply, allocated proportionally across all production categories (including production of noncovered products).

In part because these scopes 1 and 2 emissions in wrought aluminum emissions intensities are relatively low, the vast majority of scopes 1 and 2 emissions in the overall aluminum industry occur during the electrolysis process of primary unwrought aluminum. Figure 5.7 shows scopes 1 and 2 emissions broken out by subprocess across the industry. In comparison, very small amounts of these emissions occur during anode baking, casting, and secondary unwrought and wrought production.

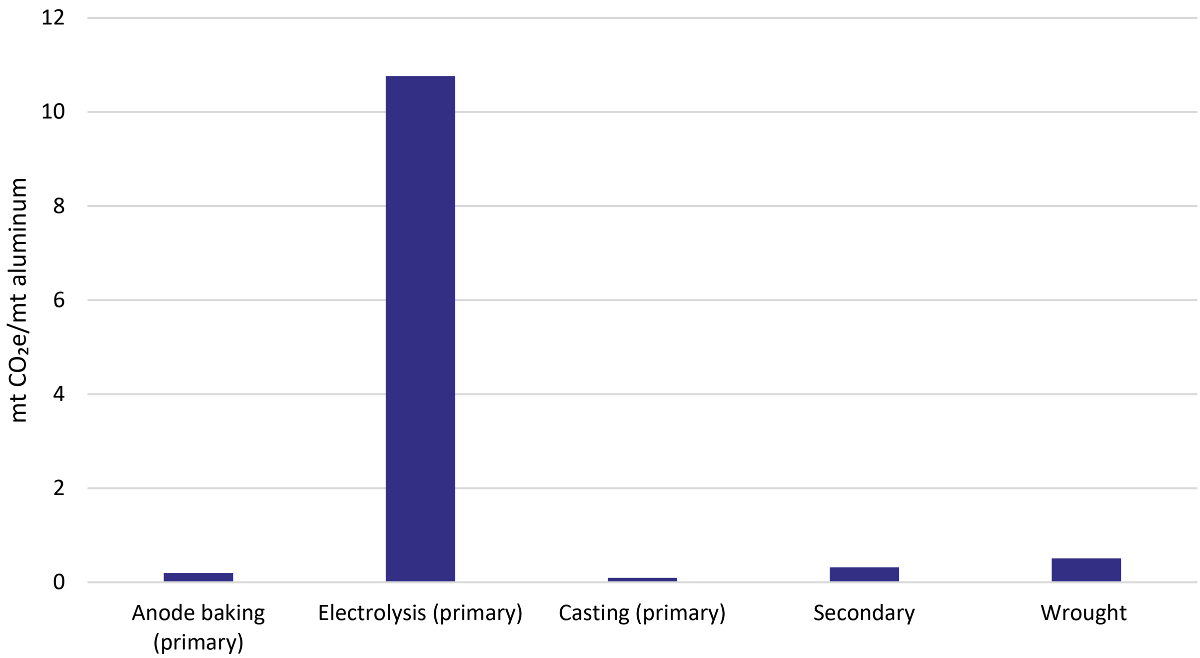
---

[472] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 5.2.7e.

[473] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 5.2.6c and 5.2.7b.

**Figure 5.7** Scopes 1 and 2 emissions, by subprocess

In metric tons carbon dioxide equivalent per metric ton of aluminum (mt $CO_2e$/mt aluminum). Underlying data for this figure can be found in appendix J, table J.29.



Sources: USITC estimates based on its calculation methodology (see appendix E) and IAI, “Primary Aluminium Greenhouse Gas Emissions for 2022,” April 11, 2024.
Note: Shares attributed to each primary subprocess estimated based on shares presented in IAI.

## Comparisons to Other Published Emissions Intensity Estimates

Published wrought product category emissions intensities are generally limited to single-company environmental product declarations, rather than geographically specific estimates of the wider industry. For bars, rods, and profiles, however, there are two published estimates with similar methodologies, although the geographic focus is North America and not the United States. The Aluminum Extruders Council (AEC) estimated the global warming potential of North American extrusions as equivalent to 10.26 mt $CO_2e$/mt product, compared to the Commission intensity for bars, rods, and profiles of 8.35 mt $CO_2e$/mt product. The AEC noted that their estimate was higher than the Aluminum Association emissions intensity of 6.2 mt $CO_2e$/mt product.[474] The AEC attributes the difference in its and the Aluminum Association’s emissions intensity estimate to differences in feedstock and energy sources,

---

[474] “AA shows 6.2 kg $CO_2e$/kg of extrusion ... compared to AEC’s results of 10.26 kg[sic]/kg.” AEC, written submission to the USITC, June 28, 2024, 6; AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 114. Aluminum pipes and tubes are also typically made via extrusion. The Commission’s emissions intensity estimate for pipe, tube, and pipe and tube fittings is 8.21 mt $CO_2e$/mt product.

highlighting that the AEC emissions intensity for its raw material alone is higher than the total Aluminum Association estimate.[475]

JRC's 2023 study estimated the emissions intensity of U.S.-produced wrought products and the results showed intensities with little differentiation across products that were generally higher than the Commission's estimates. These differences were driven by the different methodologies of the JRC study, including its use of outside estimates on production and energy use. The JRC emissions intensities for bars, rods, and profiles; wire; tubes, pipes, and tube or pipe fittings; plates, sheets, and strip; and foil all fell between 8.97 mt $CO_2$e/mt product and 9.51 mt $CO_2$e/mt product.[476] As noted earlier, the Commission's emissions intensities for these products ranged from 4.97 mt $CO_2$e/mt product for plates, sheets, and strip to 8.66 mt $CO_2$e/mt product for foil.

---

[475] The AEC report does not publish scope 1, 2, and 3 data but breaks down emissions intensity by life cycle modules, known as "cradle-to-gate, with options," which is "not that dissimilar from the approach of the AA." AEC, written submission to the USITC, June 28, 2024, 6–7. The AEC's and AA's reports differ from the Commission's report in that they cover all of North America, rather than just the United States. The AA's and AEC's reports also focus on narrower product categories. Other differences likely have a negligible impact on emissions estimates. For more information on how the AEC's assessment compares to the Commission's see appendix E ("IV. Standards Informing the Commission's Methodology"), table E.15.

[476] The 2023 JRC report used a "top-down" approach to calculating $CO_2$ emissions intensities on the basis of national-level data (particularly energy use from the International Energy Agency) and emissions factors rather than corporate or facility-level reporting. The emissions intensities include the processes of "aluminium smelting (primary production route), aluminium recycling (secondary production route), fabrication (cast house) and manufacturing (rolling/sheet, cold-rolling/foil and extrusion)." "The scope begins with the manufacture of unwrought aluminium," indicating some scope 3 emissions upstream of primary unwrought aluminum are not covered, and these data were not calculated or presented in terms of scopes 1, 2, and 3. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 73–79, 162.

# Bibliography

AlCircle. “Top Five Aluminium Scrap Exporting Countries in the World.” February 18, 2017. https://www.alcircle.com/news/top-five-aluminium-scrap-exporting-countries-in-the-world-27046.

Aluminum Association (AA). *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*. January 2022. https://www.aluminum.org/sites/default/files/2022-01/2022_Semi-Fab_LCA_Report.pdf.

Aluminum Association (AA). “Infinitely Recyclable.” Accessed November 5, 2024. https://www.aluminum.org/Recycling.

Aluminum Extruders Council (AEC). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. June 28, 2024. https://edis.usitc.gov/external/search/document/824651.

Argonne National Laboratory. “Updated Lifecycle Analysis of Aluminum Production and Semi-Fabrication for the GREET Model.” September 2015. https://publications.anl.gov/anlpubs/2015/10/121291.pdf.

Congressional Research Service (CRS). *U.S. Aluminum Manufacturing: Industry Trends and Sustainability*. R47294. October 6, 2022. https://crsreports.congress.gov/product/pdf/R/R47294.

Environmental Integrity Project. “Environmental Integrity Growth of Aluminum Industry, Key to Clean Energy, Puts Climate, Air, Water, and Health at Risk.” Accessed November 1, 2024. https://environmentalintegrity.org/news/growth-of-aluminum-industry-key-to-clean-energy-puts-climate-air-water-and-health-at-risk/.

Global Energy Monitor (GEM). “Warrick Power Plant.” July 18, 2024. https://www.gem.wiki/Warrick_Power_Plant.

Hasanbeigi, Ali, Cecilia Springer, and Dinah Shi. *Aluminum Climate Report: An International Benchmarking of Energy and CO2 Intensities*. Global Efficiency Institute, February 2022. https://static1.squarespace.com/static/5877e86f9de4bb8bce72105c/t/624d11ab5a37a4341fd85a6e/1649217981897/Aluminum+benchmarking+report-+Feb2022+rev2.pdf.

International Aluminium Institute (IAI). *Development of the Aluminum Industry and Technology in China*. February 5, 2024. https://international-aluminium.org/resource/development-of-the-aluminum-industry-and-technology-in-china/.

International Aluminium Institute (IAI). “Primary Aluminium Greenhouse Gas Emissions for 2022.” April 11, 2024. https://international-aluminium.org/statistics/greenhouse-gas-emissions-aluminium-sector/.

International Aluminium Institute (IAI). "Primary Aluminium Smelting Energy Intensity for 2022." April 11, 2024. https://international-aluminium.org/statistics/primary-aluminium-smelting-energy-intensity/.

International Aluminium Institute (IAI). "Primary Aluminium Power Consumption for 2022." September 27, 2024. https://international-aluminium.org/statistics/primary-aluminium-smelting-power-consumption/.

Norsk Hydro ASA (Hydro). "Renewable Power and Aluminum." Accessed August 19, 2024. https://www.hydro.com/us/global/aluminum/about-aluminum/renewable-power-and-aluminum/.

Oberhausen, Gregory, Yongxian Zhu, and Daniel R. Cooper. "Reducing the Environmental Impacts of Aluminum Extrusion." *Resources, Conservation and Recycling* 179 (April 1, 2022): 106120. https://doi.org/10.1016/j.resconrec.2021.106120.

Power Authority of the State of New York. "Agreement for the Sale of Firm Hydroelectric Power and Energy from the St. Lawrence-FDR Power Project to Alcoa USA Corp." March 22, 2019. https://www.nypa.gov/-/media/nypa/documents/document-library/notices-and-agendas/2019/alcoa061319.pdf?la=en.

Saevarsdottir, Gudrun, Halvor Kvande, and Barry Welch. "Aluminum Production in the Times of Climate Change: The Global Challenge to Reduce the Carbon Footprint and Prevent Carbon Leakage." *Journal of the Minerals, Metals, and Materials Society (JOM)* 72 (November 21, 2019). https://doi.org/10.1007/s11837-019-03918-6.

Sphera Solutions, Inc. *Aluminum Extrusion EPD Background Report*. Version 1.1. Aluminum Extruders Council (AEC), November 4, 2022. https://aec.org/sites/default/files/2022-11/AEC_EPDs_Background_Report_20221107_signed.pdf.

Springer, Cecilia, and Ali Hasanbeigi. "Emerging Energy Efficiency and Carbon Dioxide Emissions-Reduction Technologies for Industrial Production of Aluminum." (June 2016). https://international.lbl.gov/publications/emerging-energy-efficiency-and-0.

Tabereaux, Alton. "The Shift Toward Renewable Power in Aluminum Smelting." *Light Metal Age Magazine*, March 8, 2023. https://www.lightmetalage.com/news/industry-news/smelting/the-shift-toward-renewable-power-in-aluminum-smelting/.

U.S. Department of Energy (USDOE). Office of Industrial Technologies (OIT). *Aluminum Project Fact Sheet: Structural Factors Affecting Formability*. October 2001. https://cat.engr.uky.edu/sites/cat/files/structuralfactors.pdf.

U.S. Environmental Protection Agency (EPA). "eGRID Mapping Files." Accessed August 23, 2024. https://www.epa.gov/egrid/egrid-mapping-files.

U.S. Environmental Protection Agency (EPA). "eGRID Subregion Year 2022 Data (SRL22)." Emissions and Generation Resource Integrated Database (eGRID), January 30, 2024. https://www.epa.gov/egrid/download-data.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). "Power Profiler." Emissions and Generation Resource Integrated Database (eGRID), accessed various dates. https://www.epa.gov/egrid/power-profiler.

U.S. Geological Survey (USGS). *Mineral Commodity Summaries 2024: Aluminum*. USGS, January 2024. https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-aluminum.pdf.

U.S. International Trade Commission (USITC). *Aluminum: Competitive Conditions Affecting the U.S. Industry*. USITC Publication 4703, June 2017. https://www.usitc.gov/publications/332/pub4703.pdf.

U.S. International Trade Commission (USITC). *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_facility-level_questionnaire_aluminum_and_steel_combined.pdf.

# Appendix A
# Request Letter

DOCKET NUMBER 3683
OFFICE OF THE SECRETARY
INT'L TRADE COMMISSION

RECEIVED
June 5, 2023
OFFICE OF THE
SECRETARY
U.S. INT'L TRADE
COMMISSION

THE UNITED STATES TRADE REPRESENTATIVE
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON

June 5, 2023

The Honorable David S. Johanson
Chairman
U.S. International Trade Commission
500 E Street, S.W.
Washington, DC 20436

Dear Chairman Johanson,

On October 31, 2021, the United States and the European Union (EU) announced they had taken joint steps to re-establish historical transatlantic trade flows in steel and aluminum and to strengthen our partnership and address shared challenges in the steel and aluminum sectors. As a part of that partnership, the parties announced their intention to negotiate the Global Arrangement on Sustainable Steel and Aluminum (Global Arrangement) to address greenhouse gas (GHG) emissions intensity and global non-market excess capacity in these sectors.

The United States and the EU have a shared commitment to joint action and deepened cooperation in these sectors and are taking joint steps to defend workers, industries, and communities from global excess capacity and climate change. These steps include a new arrangement to discourage trade in emissions-intensive steel and aluminum products that contribute to global non-market excess capacity from other countries and to ensure that domestic policies support lowering the GHG emissions intensity of these industries.

As a first step, the United States and the EU have created a technical working group charged with sharing relevant data and developing a common methodology for assessing the embodied GHG emissions of traded steel and aluminum. The two sides have also begun negotiations regarding the Global Arrangement. The United States and the EU will be the initial Members of the Global Arrangement, and will invite like-minded economies to participate in the Global Arrangement and contribute to achieving the goals of restoring market orientation and reducing trade in emissions-intensive steel and aluminum products. The United States and the EU will seek to conclude the negotiations on the Global Arrangement by October 2023, and discussions of the underlying issues will continue as the Global Arrangement is implemented.

Given the Commission's expertise in analyzing international trade and competitiveness within the steel and aluminum markets as well as its robust, transparent processes for collecting data and soliciting input from a wide range of stakeholders, I am asking today that the Commission conduct an investigation and prepare a report under section 332(g) of the Tariff Act of 1930 to assess the GHG emissions intensity of steel and aluminum produced in the United States, which will help to inform discussions regarding the Global Arrangement. For purposes of this investigation, GHG emissions intensity refers to the quantity of GHG emissions (in metric tons of $CO_2$ equivalent terms) per metric ton of steel or aluminum produced, and steel and aluminum produced in the United States refers to the domestically produced goods that correspond with the scope of imported goods listed in Presidential Proclamations 9704 and 9705 of March 8, 2018 (83 Fed. Reg. 11619 and 83 Fed. Reg. 11625, March 15, 2018). These products are listed in attachment B to this letter.

I ask that the Commission conduct a survey by issuing questionnaires to firms with facilities producing steel and aluminum in the United States, whether the firms are U.S. or foreign owned, to collect data on their production of these goods and associated GHG emissions, to the extent not already reported pursuant to the U.S. Environmental Protection Agency (EPA) GHG Reporting Program (GHGRP) or other publicly available information. To the extent practicable, I request that the Commission use information obtained through the questionnaires and external data sources to estimate the highest (e.g., the 50th through the 90th percentiles) and the average GHG emissions intensity of steel and aluminum produced in the United States by product category in 2022. These percentile and average estimates should, to the extent practicable, be weighted by metric ton of steel or aluminum production associated with each emissions-intensity data point. The Commission should, to the extent practicable, produce GHG emissions intensity estimates for the broad categories of steel and aluminum products laid out in attachment A to this letter. The Commission may consider producing GHG emissions intensity estimates for additional product categories, including at the subcategory level laid out in attachment B to this letter, as needed.

The GHG emissions intensity estimates presented in the report should include the following types of GHG emissions:

1. Scope 1 GHG emissions related to the production of steel and aluminum. Scope 1 GHG emissions are the direct emissions from the facility's owned or controlled sources. These include the facility's fuel combustion emissions, process emissions (emissions from industrial processes involving chemical or physical transformations other than fuel combustion), and emissions from the facility's own electricity generation. To the extent practicable, the Commission should collect and estimate scope 1 GHG emissions data using the following sources:
    a. Data reported by facilities to EPA in accordance with the GHGRP.
    b. Data from the Commission's survey for facilities that do not report their scope 1 GHG emissions data to EPA in accordance with the GHGRP.
2. Scope 2 GHG emissions related to the production of steel and aluminum. Scope 2 GHG emissions are the indirect emissions from the generation of the facility's purchased energy, including electricity, steam, heat, or cooling.
3. Certain scope 3 GHG emissions associated with material and resource inputs for the production of steel and aluminum. Scope 3 GHG emissions are indirect emissions not included in scope 2 that occur in the value chain of the reporting company. For purposes of this investigation, the Commission should analyze only a specific subset of upstream

scope 3 GHG emissions. To the extent practicable, the Commission should collect information that will be used to estimate upstream scope 3 GHG emissions associated with U.S. facilities' intermediate steel and aluminum inputs purchased from other sources and used in production (e.g., iron ore, coke, ore-based metallics, semi-finished steel and other steel substrate suitable for further processing, carbon anodes, unwrought aluminum, and wrought aluminum suitable for further processing). In particular, the Commission should collect information on the volume and origin of intermediates such as primary unwrought aluminum and semi-finished steel (ingots, blooms, semi-finished slabs, billets, or beams, etc.) and other steel substrate suitable for further processing purchased by producers of wrought aluminum and finished steel products, respectively. The origin of these intermediate goods should be established based on the following:

a. For a facility's purchases of primary unwrought aluminum, the origin is the country where the new aluminum metal is produced from alumina (or aluminum oxide) by the electrolytic Hall-Héroult process ("country of smelt").
b. For a facility's purchases of semi-finished steel and other steel substrate suitable for further processing, the origin is the country where the aforementioned products were first produced in a steel-making furnace in a liquid state and then poured into its first solid shape ("country of melt and pour").
c. For facilities purchasing wrought aluminum suitable for further processing, the Commission should consider collecting information pertaining to the "country of largest smelt" and "country of second largest smelt", as defined by the U.S. Department of Commerce, when relevant.

In addition to presenting GHG emissions intensity estimates, the report should describe the methodologies used to collect relevant information and to analyze product-specific GHG emissions intensity for the range of steel and aluminum products made in the United States. The report should also identify, to the extent practicable, the location, in the case of certain Scope 3 emissions, and stage at which GHG emissions occur within steel and aluminum production processes.

Since I intend that the report be made available to the public in its entirety, it should not include confidential business or national security classified information. I request delivery of the report no later than January 28, 2025. Similar requests will be made of the Commission in the future to account for developments in the domestic steel and aluminum industries.

Sincerely,

Ambassador Katherine Tai

# Attachments

Attachment A: List of steel and aluminum product categories for assessing GHG emissions intensity

Steel product categories include:

- Stainless
- Carbon and other alloy, with additional breakouts for:
  - Flat products
  - Pipe and tube products
  - Long products
  - Semi-finished products

Aluminum product categories include:

- Unwrought products
- Wrought products, with additional breakouts for:
  - Bars, rods, and profiles
  - Wire
  - Plates, sheets, and strip
  - Foil
  - Tubes, pipes, and tube/pipe fittings
  - Castings, to the extent practicable
  - Forgings, to the extent practicable

## ATTACHMENT B: STEEL AND ALUMINUM PRODUCT CATEGORIES

| Steel Category | Relevant Articles (HTSUS) |
|---|---|
| **FLAT PRODUCTS** | |
| Hot Rolled | |
| Hot Rolled Sheet | 7208.10.6000; 7208.26.0030; 7208.26.0060; 7208.27.0030; 7208.27.0040; 7208.27.0045; 7208.27.0060; 7208.38.0015; 7208.38.0030; 7208.38.0090; 7208.39.0015; 7208.39.0020; 7208.39.0025; 7208.39.0030; 7208.39.0090; 7208.40.6030; 7208.40.6060; 7208.53.0000; 7208.54.0000; 7208.90.0000; 7225.30.7000; 7225.40.7000 |
| Hot Rolled Strip | 7211.19.1500; 7211.19.2000; 7211.19.3000; 7211.19.4500; 7211.19.6000; 7211.19.7530; 7211.19.7560; 7211.19.7590; 7226.91.7000; 7226.91.8000 |
| Hot Rolled Plate in Coils | 7208.10.1500; 7208.10.3000; 7208.25.3000; 7208.25.6000; 7208.36.0030; 7208.36.0060; 7208.37.0030; 7208.37.0060; 7211.14.0090; 7225.30.3005; 7225.30.3050 |
| Cold Rolled | |
| Cold Rolled Sheet | 7209.15.0000; 7209.16.0030; 7209.16.0040; 7209.16.0045; 7209.16.0060; 7209.16.0070; 7209.16.0091; 7209.17.0030; 7209.17.0040; 7209.17.0045; 7209.17.0060; 7209.17.0070; 7209.17.0091; 7209.18.1530; 7209.18.1560; 7209.18.6020; 7209.18.6090; 7209.25.0000; 7209.26.0000; 7209.27.0000; 7209.28.0000; 7209.90.0000; 7210.70.3000; 7225.50.7000; 7225.50.8010; 7225.50.8080; 7225.99.0010; 7225.99.0090 |
| Cold Rolled Strip | 7211.23.1500; 7211.23.2000; 7211.23.3000; 7211.23.4500; 7211.23.6030; 7211.23.6060; 7211.23.6090; 7211.29.2030; 7211.29.2090; 7211.29.4500; 7211.29.6030; 7211.29.6080; 7211.90.0000; 7212.40.1000; 7212.40.5000; 7226.92.5000; 7226.92.7005; 7226.92.7050; 7226.92.8005; 7226.92.8050; 7226.99.0180 |
| Cold Rolled Black Plate | 7209.18.2520; 7209.18.2585 |
| Plate Cut Lengths | 7208.40.3030; 7208.40.3060; 7208.51.0030; 7208.51.0045; 7208.51.0060; 7208.52.0000; 7210.90.1000; 7211.13.0000; 7211.14.0030; 7211.14.0045; 7225.40.3005; 7225.40.3050; 7225.50.6000; 7226.91.5000 |

| Steel Category | Relevant Articles (HTSUS) |
|---|---|
| Hot-Dipped | 7210.41.0000; 7210.49.0030; 7210.49.0040; 7210.49.0045; 7210.49.0091; 7210.49.0095; 7210.70.6060; 7212.30.1030; 7212.30.1090; 7212.30.3000; 7212.30.5000; 7225.92.0000; 7226.99.0130 |
| All Other Metallic Coated | 7210.20.0000; 7210.61.0000; 7210.69.0000; 7210.70.6090; 7210.90.6000; 7210.90.9000; 7212.50.0000; 7212.60.0000 |
| Tin Products | |
| Tin Free Steel | 7210.50.0000; 7210.50.0020; 7210.50.0090 |
| Tin Plate | 7210.11.0000; 7210.12.0000; 7212.10.0000 |
| Sheets and Strip Electrical | 7225.11.0000; 7225.19.0000; 7226.11.1000; 7226.11.9030; 7226.11.9060; 7226.19.1000; 7226.19.9000 |
| Sheets & Strip Galv Electrolyt | 7210.30.0030; 7210.30.0060; 7210.70.6030; 7212.20.0000; 7225.91.0000; 7226.99.0110 |
| **PIPE AND TUBE PRODUCTS** | |
| Oil Country Goods | 7304.23.3000; 7304.23.6030; 7304.23.6045; 7304.23.6060; 7304.29.1010; 7304.29.1020; 7304.29.1030; 7304.29.1040; 7304.29.1050; 7304.29.1060; 7304.29.1080; 7304.29.2010; 7304.29.2020; 7304.29.2030; 7304.29.2040; 7304.29.2050; 7304.29.2060; 7304.29.2080; 7304.29.3110; 7304.29.3120; 7304.29.3130; 7304.29.3140; 7304.29.3150; 7304.29.3160; 7304.29.3180; 7304.29.4110; 7304.29.4120; 7304.29.4130; 7304.29.4140; 7304.29.4150; 7304.29.4160; 7304.29.4180; 7304.29.5015; 7304.29.5030; 7304.29.5045; 7304.29.5060; 7304.29.5075; 7304.29.6115; 7304.29.6130; 7304.29.6145; 7304.29.6160; 7304.29.6175; 7305.20.2000; 7305.20.4000; 7305.20.6000; 7305.20.8000; 7306.29.1030; 7306.29.1090; 7306.29.2000; 7306.29.3100; 7306.29.4100; 7306.29.6010; 7306.29.6050; 7306.29.8110; 7306.29.8150 |
| Line Pipe | |

| Steel Category | Relevant Articles (HTSUS) |
|---|---|
| < 16 in. diameter | 7304.19.1080; 7304.19.5080; 7305.11.1030; 7305.11.1060; 7305.11.5000; 7305.12.1030; 7305.12.1060; 7305.12.5000; 7305.19.1030; 7305.19.1060; 7305.19.5000 |
| > 16 in. diameter | 7304.19.1020; 7304.19.1030; 7304.19.1045; 7304.19.1060; 7304.19.5020; 7304.19.5050; 7306.19.1010; 7306.19.5110 |
| Not specified | 7306.19.1050; 7306.19.5150 |
| Standard Pipe | 7304.39.0016; 7304.39.0020; 7304.39.0024; 7304.39.0036; 7304.39.0048; 7304.39.0062; 7304.39.0076; 7304.39.0080; 7304.59.8010; 7304.59.8015; 7304.59.8030; 7304.59.8045; 7304.59.8060; 7304.59.8080; 7306.30.5025; 7306.30.5028; 7306.30.5032; 7306.30.5040; 7306.30.5055; 7306.30.5085; 7306.30.5090 |
| Structural Pipe & Tube | 7304.90.1000; 7304.90.3000; 7305.31.2000; 7305.31.4000; 7305.31.6090; 7306.30.3000; 7306.50.3000; 7306.61.1000; 7306.61.3000; 7306.69.1000; 7306.69.3000 |
| Mechanical Tubing | 7304.31.3000; 7304.31.6050; 7304.39.0028; 7304.39.0032; 7304.39.0040; 7304.39.0044; 7304.39.0052; 7304.39.0056; 7304.39.0068; 7304.39.0072; 7304.51.1000; 7304.51.5060; 7304.59.1000; 7304.59.6000; 7304.59.8020; 7304.59.8025; 7304.59.8035; 7304.59.8040; 7304.59.8050; 7304.59.8055; 7304.59.8065; 7304.59.8070; 7304.90.5000; 7304.90.7000; 7306.30.1000; 7306.30.5015; 7306.30.5020; 7306.30.5035; 7306.50.1000; 7306.50.5030; 7306.50.5050; 7306.50.5070; 7306.61.5000; 7306.61.7060; 7306.69.5000; 7306.69.7060 |
| Pressure Tubing | 7304.31.6010; 7304.39.0002; 7304.39.0004; 7304.39.0006; 7304.39.0008; 7304.51.5015; 7304.51.5045; 7304.59.2030; 7304.59.2040; 7304.59.2045; 7304.59.2055; 7304.59.2060; 7304.59.2070; 7304.59.2080; 7306.30.5010; 7306.50.5010 |
| Pipe for Piling | 7305.39.1000; 7305.39.5000 |
| Pipe and Tube Non-Classified | 7304.51.5005; 7305.90.1000; 7305.90.5000; 7306.90.1000; 7306.90.5000 |
| **STAINLESS** | |

| Steel Category | Relevant Articles (HTSUS) |
|---|---|
| Hot Rolled | |
| Hot Rolled Sheet | 7219.13.0002; 7219.13.0031; 7219.13.0051; 7219.13.0071; 7219.13.0081; 7219.14.0030; 7219.14.0065; 7219.14.0090; 7219.23.0030; 7219.23.0060; 7219.24.0030; 7219.24.0060 |
| Hot Rolled Strip | 7220.12.1000; 7220.12.5000 |
| Hot Rolled Plate in Coils | 7219.11.0030; 7219.11.0060; 7219.12.0002; 7219.12.0006; 7219.12.0021; 7219.12.0026; 7219.12.0051; 7219.12.0056; 7219.12.0066; 7219.12.0071; 7219.12.0081 |
| Cold Rolled | |
| Cold Rolled Sheet | 7219.32.0005; 7219.32.0020; 7219.32.0025; 7219.32.0035; 7219.32.0036; 7219.32.0038; 7219.32.0042; 7219.32.0044; 7219.32.0045; 7219.32.0060; 7219.33.0005; 7219.33.0020; 7219.33.0025; 7219.33.0035; 7219.33.0036; 7219.33.0038; 7219.33.0042; 7219.33.0044; 7219.33.0045; 7219.33.0070; 7219.33.0080; 7219.34.0005; 7219.34.0020; 7219.34.0025; 7219.34.0030; 7219.34.0035; 7219.34.0050; 7219.35.0005; 7219.35.0015; 7219.35.0030; 7219.35.0035; 7219.35.0050; 7219.90.0010; 7219.90.0020; 7219.90.0025; 7219.90.0060; 7219.90.0080 |
| Cold Rolled Strip | 7220.20.1010; 7220.20.1015; 7220.20.1060; 7220.20.1080; 7220.20.6005; 7220.20.6010; 7220.20.6015; 7220.20.6060; 7220.20.6080; 7220.20.7005; 7220.20.7010; 7220.20.7015; 7220.20.7060; 7220.20.7080; 7220.20.8000; 7220.20.9030; 7220.20.9060; 7220.90.0010; 7220.90.0015; 7220.90.0060; 7220.90.0080 |
| Cold Rolled Plate in Coils | 7219.31.0010 |
| Wire Drawn | 7223.00.1005; 7223.00.1016; 7223.00.1031; 7223.00.1046; 7223.00.1061; 7223.00.1076; 7223.00.5000; 7223.00.9000 |
| Stainless Pipe and Tube | 7304.41.3005; 7304.41.3015; 7304.41.3045; 7304.41.6005; 7304.41.6015; 7304.41.6045; 7304.49.0005; 7304.49.0015; 7304.49.0045; 7304.49.0060; 7305.31.6010; 7306.40.1010; 7306.40.1015; 7306.40.1090; 7306.40.5005; 7306.40.5015; 7306.40.5040; 7306.40.5042; 7306.40.5044; 7306.40.5062; |

| Steel Category | Relevant Articles (HTSUS) |
|---|---|
|  | 7306.40.5064; 7306.40.5080; 7306.40.5085; 7306.40.5090; 7306.61.7030; 7306.69.7030 |
| Line Pipe | 7304.11.0020; 7304.11.0050; 7304.11.0080; 7306.11.0010; 7306.11.0050 |
| Bars – Cold Finished | 7222.20.0001; 7222.20.0006; 7222.20.0041; 7222.20.0043; 7222.20.0062; 7222.20.0064; 7222.20.0067; 7222.20.0069; 7222.20.0071; 7222.20.0073; 7222.30.0001; 7222.30.0012; 7222.30.0022; 7222.30.0024; 7222.30.0082; 7222.30.0084 |
| Bars – Hot Rolled | 7221.00.0005; 7221.00.0045; 7221.00.0075; 7222.11.0001; 7222.11.0006; 7222.11.0057; 7222.11.0059; 7222.11.0082; 7222.11.0084; 7222.19.0001; 7222.19.0006; 7222.19.0052; 7222.19.0054; 7222.40.3065; 7222.40.3085 |
| Blooms, Billets & Slabs | 7218.91.0015; 7218.91.0030; 7218.91.0060; 7218.99.0015; 7218.99.0030; 7218.99.0045; 7218.99.0060; 7218.99.0090 |
| Oil Country Goods | 7304.22.0030; 7304.22.0045; 7304.22.0060; 7304.24.3010; 7304.24.3020; 7304.24.3030; 7304.24.3040; 7304.24.3045; 7304.24.3080; 7304.24.4010; 7304.24.4020; 7304.24.4030; 7304.24.4040; 7304.24.4050; 7304.24.4060; 7304.24.4080; 7304.24.6015; 7304.24.6030; 7304.24.6045; 7304.24.6060; 7304.24.6075; 7306.21.3000; 7306.21.4000; 7306.21.8010; 7306.21.8050 |
| Ingots for Steel and Castings | 7218.10.0000 |
| Plates Cut Lengths | 7219.21.0005; 7219.21.0020; 7219.21.0040; 7219.21.0060; 7219.22.0005; 7219.22.0015; 7219.22.0020; 7219.22.0025; 7219.22.0035; 7219.22.0040; 7219.22.0045; 7219.22.0070; 7219.22.0075; 7219.22.0080; 7219.31.0050; 7220.11.0000 |
| Wire Rods | 7221.00.0017; 7221.00.0018; 7221.00.0030 |
| Structural Shapes Heavy | 7222.40.3025; 7222.40.3045; 7222.40.6000 |
| **LONG PRODUCTS** |  |
| Structural Shapes Heavy | 7216.31.0000; 7216.32.0000; 7216.33.0030; 7216.33.0060; 7216.33.0090; 7216.40.0010; 7216.40.0050; 7216.50.0000; |

| Steel Category | Relevant Articles (HTSUS) |
|---|---|
| | 7216.99.0010; 7216.99.0090; 7228.70.3010; 7228.70.3020; 7228.70.3041; 7228.70.6000 |
| Wire Rods | 7213.91.3011; 7213.91.3015; 7213.91.3020; 7213.91.3093; 7213.91.4500; 7213.91.6000; 7213.99.0030; 7213.99.0090; 7227.20.0030; 7227.90.6020; 7227.90.6030; 7227.90.6035 |
| Wire Drawn | 7217.10.1000; 7217.10.2000; 7217.10.3000; 7217.10.4040; 7217.10.4045; 7217.10.4090; 7217.10.5030; 7217.10.5090; 7217.10.6000; 7217.10.7000; 7217.10.8010; 7217.10.8020; 7217.10.8025; 7217.10.8030; 7217.10.8045; 7217.10.8060; 7217.10.8075; 7217.10.8090; 7217.10.9000; 7217.20.1500; 7217.20.3000; 7217.20.4510; 7217.20.4520; 7217.20.4530; 7217.20.4540; 7217.20.4550; 7217.20.4560; 7217.20.4570; 7217.20.4580; 7217.20.6000; 7217.20.7500; 7217.30.1530; 7217.30.1560; 7217.30.3000; 7217.30.4504; 7217.30.4511; 7217.30.4520; 7217.30.4530; 7217.30.4541; 7217.30.4550; 7217.30.4560; 7217.30.4590; 7217.30.6000; 7217.30.7500; 7217.90.1000; 7217.90.5030; 7217.90.5060; 7217.90.5090; 7229.20.0010; 7229.20.0015; 7229.20.0090; 7229.90.1000; 7229.90.5006; 7229.90.5008; 7229.90.5016; 7229.90.5031; 7229.90.5051; 7229.90.9000 |
| Bars – Hot Rolled | 7213.20.0010; 7213.20.0080; 7213.99.0060; 7214.10.0000; 7214.30.0010; 7214.30.0080; 7214.91.0016; 7214.91.0020; 7214.91.0060; 7214.91.0090; 7214.99.0016; 7214.99.0021; 7214.99.0026; 7214.99.0031; 7214.99.0036; 7214.99.0040; 7214.99.0045; 7214.99.0060; 7214.99.0075; 7214.99.0090; 7215.90.1000; 7227.20.0080; 7227.90.6005; 7227.90.6010; 7227.90.6040; 7227.90.6090; 7228.20.1000; 7228.30.8005; 7228.30.8015; 7228.30.8041; 7228.30.8045; 7228.30.8070; 7228.40.0000; 7228.60.6000; 7228.80.0000 |
| Bars – Cold Finished | 7215.10.0010; 7215.10.0080; 7215.50.0016; 7215.50.0018; 7215.50.0020; 7215.50.0061; 7215.50.0063; 7215.50.0065; 7215.50.0090; 7215.90.3000; 7215.90.5000; 7228.20.5000; 7228.50.5005; 7228.50.5015; 7228.50.5040; 7228.50.5070; 7228.60.8000 |
| Bars – Light Shaped | 7216.10.0010; 7216.10.0050; 7216.21.0000; 7216.22.0000; 7228.70.3060; 7228.70.3081 |
| Bars - Reinforcing | 7213.10.0000; 7214.20.0000; 7228.30.8010 |

| Steel Category | Relevant Articles (HTSUS) |
|---|---|
| | |
| Steel Piling | 7301.10.0000 |
| Railroad Accessories | 7302.40.0000; 7302.90.1000; 7302.90.9000 |
| Rails All Other | 7302.10.1015; 7302.10.1025; 7302.10.1045; 7302.10.1055 |
| Rails Standard | 7302.10.1010; 7302.10.1035; 7302.10.1065; 7302.10.1075; 7302.10.5020; 7302.10.5040; 7302.10.5060 |
| Tool Steel | 7224.10.0045; 7224.90.0015; 7224.90.0025; 7224.90.0035; 7225.30.1110; 7225.30.1180; 7225.30.5110; 7225.30.5180; 7225.40.1110; 7225.40.1180; 7225.40.5110; 7225.40.5130; 7225.40.5160; 7225.50.1110; 7225.50.1130; 7225.50.1160; 7226.20.0000; 7226.91.0500; 7226.91.1530; 7226.91.1560; 7226.91.2530; 7226.91.2560; 7226.92.1030; 7226.92.1060; 7226.92.3030; 7226.92.3060; 7227.10.0000; 7227.90.1030; 7227.90.1060; 7227.90.2030; 7227.90.2060; 7228.10.0010; 7228.10.0030; 7228.10.0060; 7228.30.2000; 7228.30.4000; 7228.30.6000; 7228.50.1010; 7228.50.1020; 7228.50.1040; 7228.50.1060; 7228.50.1080; 7228.60.1030; 7228.60.1060; 7229.90.0500 |
| **SEMI-FINISHED PRODUCTS** | |
| Blooms, Billets and Slabs | 7207.11.0000; 7207.12.0010; 7207.12.0050; 7207.19.0030; 7207.19.0090; 7207.20.0025; 7207.20.0045; 7207.20.0075; 7207.20.0090; 7224.90.0005; 7224.90.0045; 7224.90.0055; 7224.90.0065; 7224.90.0075 |
| Ingots for Steel and Castings | 7206.10.0000; 7206.90.0000; 7224.10.0005; 7224.10.0075 |

Note: These are current as of June 5, 2023 and are subject to change with modifications of the HTSUS.

| _Aluminum Category | Relevant Articles (HTSUS) |
|---|---|
| **UNWROUGHT PRODUCTS** | |
| Not Alloyed | 7601.10 |
| Alloyed | 7601.20 |
| **WROUGHT PRODUCTS** | |
| Bars, Rods, and Profiles | 7604 |
| Wire | 7605 |
| Plates, Sheets, and Strip | 7606 |
| Foil | 7607 |
| Tubes and Pipes | 7608 |
| Tube and Pipe Fittings | 7609 |
| Castings | 7616.99.5160 |
| Forgings | 7616.99.5170 |

Note: These are current as of June 5, 2023 and are subject to change with modifications of the HTSUS.

# Appendix B
# *Federal Register* Notice

information technology, *e.g.,* permitting electronic submission of response.

Comments that you submit in response to this notice are a matter of public record. We will include or summarize each comment in our request to OMB to approve this ICR. Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

*Abstract.* This information collection is required under the Reclamation Reform Act of 1982 (RRA), Acreage Limitation Rules and Regulations, 43 CFR part 426, and Information Requirements for Certain Farm Operations In Excess of 960 Acres and the Eligibility of Certain Formerly Excess Land, 43 CFR part 428. The forms in this information collection are to be used by district offices to summarize individual landholder (direct or indirect landowner or lessee) and farm operator certification and reporting forms. This information allows us to establish water user compliance with Federal reclamation law.

*Title of Collection:* Certification Summary Form, Reporting Summary Form for Acreage Limitation, 43 CFR part 426 and 43 CFR part 428.

*OMB Control Number:* 1006–0006.

*Form Numbers:* Form 7–21SUMM–C and Form 7–21SUMM–R.

*Type of Review:* Extension of a currently approved collection.

*Respondents/Affected Public:* Contracting entities that are subject to the acreage limitation provisions of Federal reclamation law.

*Total Estimated Number of Annual Respondents:* 120.

*Total Estimated Number of Annual Responses:* 150.

*Estimated Completion Time per Respondent:* See table below.

*Total Estimated Number of Annual Burden Hours:* 6,000 hours.

*Respondent's Obligation:* Mandatory.

*Frequency of Collection:* Annually.

*Total Estimated Annual Nonhour Burden Cost:* None.

| Form No. | Burden estimate per form (in hours) | Number of respondents | Annual number of responses | Annual burden on respondents (in hours) |
|---|---|---|---|---|
| 7–21SUMM–C and associated tabulation sheets | 40 | 113 | 141 | 5,640 |
| 7–21SUMM–R and associated tabulation sheets | 40 | 7 | 9 | 360 |
| Totals | | 120 | 150 | 6,000 |

An agency may not conduct or sponsor and a person is not required to respond to a collection of information unless it displays a currently valid OMB control number.

The authority for this action is the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 *et seq.*).

**Christopher Beardsley,**

*Director, Policy and Programs.*

[FR Doc. 2023–14439 Filed 7–7–23; 8:45 am]

**BILLING CODE 4332–90–P**

---

## INTERNATIONAL TRADE COMMISSION

**[USITC SE–23–032]**

## Sunshine Act Meetings

**AGENCY HOLDING THE MEETING:** United States International Trade Commission.

**TIME AND DATE:** July 14, 2023 at 11:00 a.m.

**PLACE:** Room 101, 500 E Street SW, Washington, DC 20436, Telephone: (202) 205–2000.

**STATUS:** Open to the public.

**MATTERS TO BE CONSIDERED:**

1. *Agendas for future meetings:* none.
2. Minutes.
3. Ratification List.
4. Commission vote on Inv. Nos. 701–TA–690–691 and 731–TA–1619–1627 (Preliminary) (Paper Shopping Bags from Cambodia, China, Colombia, India, Malaysia, Portugal, Taiwan, Turkey, and Vietnam). The Commission currently is scheduled to complete and file its determinations on July 17, 2023; views of the Commission currently are scheduled to be completed and filed on July 24, 2023.
5. *Outstanding action jackets:* none.

**CONTACT PERSON FOR MORE INFORMATION:** Sharon Bellamy, Acting Supervisory Hearings and Information Officer, 202–205–2000.

The Commission is holding the meeting under the Government in the Sunshine Act, 5 U.S.C. 552(b). In accordance with Commission policy, subject matter listed above, not disposed of at the scheduled meeting, may be carried over to the agenda of the following meeting.

By order of the Commission.

Issued: July 6, 2023.

**Lisa Barton,**

*Secretary to the Commission.*

[FR Doc. 2023–14622 Filed 7–6–23; 4:15 pm]

**BILLING CODE 7020–02–P**

---

## INTERNATIONAL TRADE COMMISSION

**[Investigation No. 332–598]**

## Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level

**AGENCY:** United States International Trade Commission.

**ACTION:** Notice of investigation and scheduling of a public hearing.

**SUMMARY:** Following receipt on June 5, 2023, of a request from the U.S. Trade Representative (USTR), under section 332(g) of the Tariff Act of 1930, the U.S. International Trade Commission (Commission) instituted Investigation No. 332–598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level.* The USTR requested that the Commission conduct an investigation and prepare a report that assesses the greenhouse gas emissions intensity of steel and aluminum products produced in the United States.

**DATES:**

*November 17, 2023:* Deadline for filing requests to appear at the public hearing.

*November 21, 2023:* Deadline for filing prehearing briefs and statements.

*November 29, 2023:* Deadline for filing electronic copies of oral hearing statements.

*December 7, 2023:* Public hearing.

*December 21, 2023:* Deadline for filing posthearing briefs and statements.

*June 28, 2024:* Deadline for filing all other written submissions.

*January 28, 2025:* Transmittal of Commission report to the USTR.

**ADDRESSES:** All Commission offices, including the Commission's hearing rooms, are located in the U.S. International Trade Commission Building, 500 E Street SW, Washington, DC. All written submissions should be addressed to the Secretary, U.S. International Trade Commission, 500 E Street SW, Washington, DC 20436. The public record for this investigation may be viewed on the Commission's electronic docket (EDIS) at *https://edis.usitc.gov.*

**FOR FURTHER INFORMATION CONTACT:** Project Leader Caroline Peters (202–708–1443 or *caroline.peters@usitc.gov*), Deputy Project Leader Shova KC (202–205–2234 or *shova.kc@usitc.gov*) or Deputy Project Leader Alexander Melton (202–708–1665 or *alexander.melton@usitc.gov*) for information specific to this investigation. For information on the legal aspects of this investigation, contact Brian Allen (202–205–3034 or *brian.allen@usitc.gov*) or William Gearhart (202–205–3091 or *william.gearhart@usitc.gov*) of the Commission's Office of the General Counsel. The media should contact Jennifer Andberg, Office of External Relations (202–205–3404 or *jennifer.andberg@usitc.gov*).

Hearing-impaired individuals are advised that information on this matter can be obtained by contacting the Commission's TDD terminal on 202–205–1810. General information concerning the Commission may be obtained by accessing its internet address (*https://www.usitc.gov*). Persons with mobility impairments who will need special assistance in gaining access to the Commission should contact the Office of the Secretary at 202–205–2000.

**SUPPLEMENTARY INFORMATION:**

*Background:* As requested in the letter received from the USTR on June 5, 2023, the Commission has instituted an investigation under section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)) to prepare a report that assesses the greenhouse gas (GHG) emissions intensity of steel and aluminum produced in the United States, which the USTR states will help to inform discussions regarding the Global Arrangement on Sustainable Steel and Aluminum. To this end, the Commission intends to conduct a survey by issuing questionnaires to firms with facilities producing steel and aluminum in the United States, whether the firms are U.S.- or foreign-owned, to collect data on their production of these goods and associated GHG emissions. The Commission will post the draft questionnaire on its website for public comment and will post the final questionnaire on its website once the questionnaire is ready to be issued.

The GHG emissions intensity estimates presented in the report will include the following types of GHG emissions:

1. *Scope 1*—GHG emissions related to the production of steel and aluminum. Scope 1 GHG emissions are the direct emissions from the facility's owned or controlled sources. These include the facility's fuel combustion emissions, process emissions (emissions from industrial processes involving chemical or physical transformations other than fuel combustion), and emissions from the facility's own electricity generation.
2. *Scope 2*—GHG emissions related to the production of steel and aluminum. Scope 2 GHG emissions are the indirect emissions from the generation of the facility's purchased energy, including electricity, steam, heat, or cooling.
3. *Certain scope 3*—GHG emissions associated with material and resource inputs for the production of steel and aluminum. Scope 3 GHG emissions are indirect emissions not included in scope 2 that occur in the value chain of the reporting company. For purposes of this investigation, the Commission will analyze only a specific subset of upstream scope 3 GHG emissions associated with U.S. facilities' intermediate steel and aluminum inputs purchased from other sources and used in production. These intermediate inputs could include iron ore, coke, ore-based metallics, semi-finished steel and other steel substrate suitable for further processing, carbon anodes, unwrought aluminum, and wrought aluminum suitable for further processing.

In presenting the GHG emissions intensity estimates, the report will describe the methodologies used to collect relevant information and to analyze product-specific GHG emissions intensity for the range of steel and aluminum products made in the United States, and provide estimates for the highest and average GHG emissions intensities for the products analyzed. The report will also identify the stages within the steel and aluminum production processes at which associated GHG emissions occur and identify the locations (*i.e.,* originating countries) of scope 3 emissions associated with U.S. steel and aluminum products. Scope 3 emissions intensity estimates may be derived from the volume and origin of intermediate inputs from foreign and domestic sources as well as information regarding the emissions intensity of such inputs.

As requested by the USTR, the Commission will deliver the report no later than January 28, 2025. Since USTR has indicated that it intends to make this report available to the public in its entirety, the Commission will not include confidential business or national security classified information in its report. However, as detailed below, participants may submit confidential information to the Commission to inform its understanding of these issues, and such information will be protected in accordance with the Commission's *Rules of Practice and Procedure.* Participants are strongly encouraged to provide any supporting data and information along with their views.

*Public Hearing:* A public hearing in connection with this investigation will be held in person beginning at 9:30 a.m. on December 7, 2023, in the Main Hearing Room of the U.S. International Trade Commission, 500 E Street SW, Washington, DC 20436. The hearing can also be accessed remotely using the WebEx videoconference platform. A link to the hearing will be posted on the Commission's website at *https://www.usitc.gov/calendarpad/calendar.html.*

Requests to appear at the hearing should be filed with the Secretary to the Commission no later than 5:15 p.m., November 17, 2023, in accordance with the requirements in the ''Written Submissions'' section below. Any requests to appear as a witness via videoconference must be included with your request to appear. Requests to appear as a witness via videoconference must include a statement explaining why the witness cannot appear in person; the Chairman, or other person designated to conduct the investigation, may at their discretion for good cause shown, grant such requests. Requests to appear as a witness via videoconference due to illness or a positive COVID–19 test result may be submitted by 3 p.m. the business day prior to the hearing.

All prehearing briefs and statements should be filed no later than 5:15 p.m., November 21, 2023. To facilitate the hearing, including the preparation of an accurate written public transcript of the hearing, oral testimony to be presented at the hearing must be submitted to the Commission electronically no later than 5:15 p.m., November 29, 2023. All posthearing briefs and statements should be filed no later than 5:15 p.m., December 21, 2023. Posthearing briefs and statements should address matters raised at the hearing. For a description of the different types of written briefs and statements, see the ''Definitions'' section below.

In the event that, as of the close of business on November 17, 2023, no witnesses are scheduled to appear at the hearing, the hearing will be canceled. Any person interested in attending the hearing as an observer or nonparticipant should check the Commission website as indicated above for information concerning whether the hearing will be held.

*Written submissions:* In lieu of or in addition to participating in the hearing, interested persons are invited to file written submissions concerning this investigation. All written submissions should be addressed to the Secretary, and should be received no later than 5:15 p.m., June 28, 2024. All written submissions must conform to the provisions of section 201.8 of the Commission's *Rules of Practice and Procedure* (19 CFR 201.8), as temporarily amended by 85 FR 15798 (March 19, 2020). Under that rule waiver, the Office of the Secretary will accept only electronic filings at this time. Filings must be made through the Commission's Electronic Document Information System (EDIS, *https://edis.usitc.gov*). No in-person, paper-based filings or paper copies of any electronic filings will be accepted until further notice. Persons with questions regarding electronic filing should contact the Office of the Secretary, Docket Services Division (202–205–1802), or consult the Commission's Handbook on Filing Procedures.

*Definitions of types of documents that may be filed; Requirements:* In addition to requests to appear at the hearing, this notice provides for the possible filing of four types of documents: prehearing briefs, oral hearing statements, posthearing briefs, and other written submissions.

(1) *Prehearing briefs* refers to written materials relevant to the investigation and submitted in advance of the hearing, and includes written views on matters that are the subject of the investigation, supporting materials, and any other written materials that you consider will help the Commission in understanding your views. You should file a prehearing brief particularly if you plan to testify at the hearing on behalf of an industry group, company, or other organization, and wish to provide detailed views or information that will support or supplement your testimony.

(2) *Oral hearing statements (testimony)* refers to the actual oral statement that you intend to present at the hearing. Do not include any confidential business information (CBI) in that statement. If you plan to testify, you must file a copy of your oral statement by the date specified in this notice. This statement will allow Commissioners to understand your position in advance of the hearing and will also assist the court reporter in preparing an accurate transcript of the hearing (*e.g.,* names spelled correctly).

(3) *Posthearing briefs* refers to submissions filed after the hearing by persons who appeared at the hearing. Such briefs: (a) should be limited to matters that arose during the hearing; (b) should respond to any Commissioner and staff questions addressed to you at the hearing; (c) should clarify, amplify, or correct any statements you made at the hearing; and (d) may, at your option, address or rebut statements made by other participants in the hearing.

(4) *Other written submissions* refers to any other written submissions that interested persons wish to make, regardless of whether they appeared at the hearing, and may include new information or updates of information previously provided.

In accordance with the provisions of section 201.8 of the Commission's Rules of Practice and Procedure (19 CFR 201.8), the document must identify on its cover (1) the investigation number and title and the type of document filed (*i.e.,* prehearing brief, oral statement of (name), posthearing brief, or written submission), (2) the name and signature of the person filing it, (3) the name of the organization that the submission is filed on behalf of, and (4) whether it contains CBI. If it contains CBI, it must comply with the marking and other requirements set out below in this notice relating to CBI. Submitters of written documents (other than oral hearing statements) are encouraged to include a short summary of their position or interest at the beginning of the document, and a table of contents when the document addresses multiple issues.

*Confidential business information:* Any submissions that contain CBI must also conform to the requirements of section 201.6 of the Commission's Rules of Practice and Procedure (19 CFR 201.6). Section 201.6 of the rules requires that the cover of the document and the individual pages be clearly marked as to whether they are the ''confidential'' or ''nonconfidential'' version, and that the CBI is clearly identified by means of brackets. All written submissions, except for CBI, will be made available for inspection by interested persons.

As requested by the USTR, the Commission will not include any CBI in its report. However, all information, including CBI, submitted in this investigation may be disclosed to and used: (i) by the Commission, its employees and Offices, and contract personnel (a) for developing or maintaining the records of this or a related proceeding, or (b) in internal investigations, audits, reviews, and evaluations relating to the programs, personnel, and operations of the Commission, including under 5 U.S.C. appendix 3; or (ii) by U.S. Government employees and contract personnel for cybersecurity purposes. The Commission will not otherwise disclose any CBI in a way that would reveal the operations of the firm supplying the information.

*Summaries of written submissions:* Persons wishing to have a summary of their position included in the report should include a summary with their written submission no later than June 28, 2024, and should mark the summary as having been provided for that purpose. The summary should be clearly marked as ''summary for inclusion in the report'' at the top of the page. The summary may not exceed 500 words and should not include any CBI. The summary will be published as provided if it meets these requirements and is germane to the subject matter of the investigation. The Commission will list the name of the organization furnishing the summary and will include a link where the written submission can be found.

By order of the Commission.

Issued: July 5, 2023.

**Lisa Barton,**

*Secretary to the Commission.*

[FR Doc. 2023–14500 Filed 7–7–23; 8:45 am]

**BILLING CODE 7020–02–P**

---

## DEPARTMENT OF JUSTICE

## Foreign Claims Settlement Commission

### [F.C.S.C. Meeting and Hearing Notice No. 01–23]

## Sunshine Act Meeting

The Foreign Claims Settlement Commission, pursuant to its regulations (45 CFR part 503.25) and the Government in the Sunshine Act (5 U.S.C. 552b), hereby gives notice in regard to the scheduling of open meetings as follows:

**TIME AND DATE:** Tuesday, July 18, 2023, at 10:00 a.m. EST

**PLACE:** All meetings are held at the Foreign Claims Settlement Commission,

# Appendix C
# Hearing Witnesses

## CALENDAR OF PUBLIC HEARING

Those listed below appeared in the United States International Trade Commission's hearing:

| | |
|---|---|
| **Subject:** | Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level |
| **Inv. No.:** | 332-598 |
| **Dates and Times:** | Thursday, December 7, 2023 - 9:30 a.m. EST |

Sessions were held in connection with this investigation in the Main Hearing Room (Room 101), 500 E Street, SW., Washington, DC.

### FOREIGN GOVERNMENT WITNESS:

**European Union**
**Delegation to the United States of America**

**Vicente Hurtado Roa (remote witness), European Commission, Head of Unit CBAM, Energy and Green Taxation**

## PANEL 1:

### ORGANIZATION AND WITNESSES:

American Iron and Steel Institute
Washington, DC

**Kevin M. Dempsey**, President and Chief Executive Officer

Steel Manufacturers Association ("SMA")
Washington, DC

**Philip K. Bell**, President

The American Institute of Steel Construction (AISC)
Chicago, IL
**Max Puchtel**, Director of Government Relations and Sustainability

## PANEL 1 (continued):

### ORGANIZATION AND WITNESSES:

Specialty Steel Industry of North America ("SSINA")
Washington, DC

**Joseph J. Green**, Partner, Kelley Drye & Warren LLP
and Counsel to the Specialty Steel Industry of North America

United Steelworkers (USW)
Washington, DC

**Roxanne D. Brown**, International Vice President At-Large

Polsinelli PC
Washington, DC

United States Steel Corporation ("U. S. Steel")

**Jeffrey J. Becker**, Research Consultant – Sustainability & Strategy, U. S. Steel

**Benjamin Blase Caryl**, Associate General Counsel,
International Trade & Public Policy, U. S. Steel

**Deanna Tanner Okun** )
**Lydia Pardini** ) – OF COUNSEL
**Alissa Chase** )

Polsinelli PC
Washington, DC

Outokumpu Stainless USA, LLC ("Outokumpu")

**Tamara Weinert**, President and CEO, Business Area Americas, Outokumpu

**Camilla Kaplin**, Head of Sustainability Data, Outokumpu

**Deanna Tanner Okun** )
**Lydia Pardini** ) – OF COUNSEL
**Alissa Chase** )

## PANEL 1 (continued):

### ORGANIZATION AND WITNESSES:

King & Spalding LLP
Washington, DC

Cleveland-Cliffs Inc. (“Cleveland-Cliffs”)

**Patrick M. Bloom**, Vice President, Government Relations, Cleveland-Cliffs

**John R. Hill**, Senior Manager – Sustainability, Carbon Strategy, Cleveland-Cliffs

**Stephen P. Vaughn** ) OF COUNSEL

Schagrin Associates
Washington, DC

**Roger B. Schagrin** )
) – OF COUNSEL
**Jeffrey D. Gerrish** )

Schagrin Associates
Washington, DC

Steel Dynamics, Inc.

**Jeff Hansen**, Vice President of Human Resources,
Health and Safety and Environmental Sustainability, Steel Dynamics, Inc.

**Roger B. Schagrin** )
) – OF COUNSEL
**Jeffrey D. Gerrish** )

## PANEL 1 (continued):

### ORGANIZATION AND WITNESSES:

Schagrin Associates
Washington, DC

Committee on Pipe and Tube Imports

**Andrew Annakin**, Chairman, the Committee on Pipe and Tube Imports
and Executive Vice President and Chief Commercial Officer,
Bull Moose Tube Company

**Roger B. Schagrin** )
) – OF COUNSEL
**Jeffrey D. Gerrish** )

Wiley Rein
Washington, DC

Nucor Corporation (“Nucor”)

**David Miracle**, General Manager of Environmental Affairs, Nucor Corporation

**Alan H. Price** )
) – OF COUNSEL
**Theodore P. Brackemyre** )

## PANEL 2:

### ORGANIZATION AND WITNESSES:

Alcoa Corporation
Pittsburgh, PA

**Laura E. Chambers**, Director, Corporate Affairs, North America and Europe

**David M. Spooner** ) – OF COUNSEL

SAFE Foundation
Washington, DC

**Joe Quinn**, Director, Center for Strategic Industrial Materials
Vice President, SAFE

## PANEL 2 (continued):

### ORGANIZATION AND WITNESSES:

The Aluminum Association
Washington, DC

**Charles Johnson**, President and Chief Executive Officer

Institute of Scrap Recycling Industries, Inc.
Washington, DC

**Adam Shaffer**, Assistant Vice President of International Trade and Global Affairs

Forging Industry Association ("FIA")
Cleveland, OH

**James Warren**, President and Chief Executive Officer

**Omar Nashashibi**, Partner, The Franklin Partnership, LLP

Wiley Rein LLP
Washington, DC

Century Aluminum Company ("Century Aluminum")

**Matt Aboud**, Senior Vice President of Strategy and Business Development,
Century Aluminum

**Robert DeFrancesco** ) – OF COUNSEL

Novelis Corporation ("Novelis")
Atlanta, GA

**David Neuner**, Regional Environmental Manager

Roosevelt Institute
New York, NY

**Todd Tucker**, Director, Industrial Policy and Trade

Timothy Meyer

**Timothy Meyer**, Richard Allen/Cravath Distinguished Professor
In International Business Law, Duke University School of Law

## PANEL 3:

**ORGANIZATION AND WITNESSES:**

Sierra Club
Washington, DC

**Yong Kwon**, Senior Policy Advisor

Jan W. Mares

**Jan W. Mares**

The Climate Leadership Council
Washington, DC

**Matthew C. Porterfield**, Vice President, Policy & Research

Silverado Policy Accelerator, Inc.
Washington, DC

**Andrew S. David**, Senior Director of Research and Analysis

**- END -**

# Appendix D
# Summary of Views

Interested persons had the opportunity to file written submissions to the U.S. International Trade Commission (Commission) in the course of this investigation and to provide summaries of the positions they had expressed for inclusion in this report. This appendix contains these written summaries, provided that they meet certain requirements set out in the notice of investigation (see appendix B). The Commission has not edited these summaries. This appendix also contains the names of interested persons who filed written submissions during this investigation but did not provide written summaries. A copy of each written submission is available on the Commission's Electronic Document Information System (EDIS), at https://www.edis.usitc.gov, by searching for submissions related to Inv. No. 332-598. In addition, the Commission held a public hearing in connection with this investigation on December 7, 2023. The full transcript of the Commission's hearing is also available on EDIS.

# Summaries Included with Written Submissions

## Century Aluminum Company

Century Aluminum Company ("Century") is the largest primary aluminum producer in the United States, with three U.S. aluminum smelters that provide 1,260 good U.S. manufacturing jobs in economically disadvantaged communities. Sustainability is a fundamental component of Century's business operations, and Century has committed to reducing greenhouse gas ("GHG") emissions by 30 percent by 2030, and to creating zero carbon aluminum by 2050. The primary aluminum sector presents substantial opportunities for decarbonization. Accounting for approximately 2% of global GHG emissions, reducing emissions in the aluminum industry is necessary to achieve a net zero economy by 2050.

The pathway to decarbonization is multifaceted and requires commitment at all levels of the industry, and from both the public and private sector. It also requires continued trade protections, to shield the U.S. industry from cheap and dirty imports from countries like China and India, whose governments heavily subsidize carbon-intensive production. In this regard, U.S. trade policy measures need to be maintained, while climate and industrial policies evolve. Properly measuring GHG emissions is one essential component to develop policies and practices that promote the investment into and deployment of green aluminum production in the United States. This balance of policies and practices will foster a green and competitive American aluminum industry that serves as the backbone of U.S. infrastructure and provides thousands of U.S. manufacturing jobs.

In obtaining data, the U.S. International Trade Commission's (the "Commission") data collection should be consistent with the tariff schedule, as contemplated by the U.S. Trade Representative ("USTR"). Specifically, the product breakout for aluminum should begin with unwrought and wrought. This will help ensure that emissions data obtained for specific products more accurately matches the traded products at concern in the Global Arrangement. Additionally, gathering and measuring product-level GHG emissions should be based on the product's tariff classification for all products produced within the United States, not just those that are produced in the United States and then externally shipped.

Given the purposes of this investigation, the system boundaries for primary aluminum production scope 3 emissions associated with raw material inputs should be limited to carbon anodes. In particular, the Commission need not investigate the emissions associated with bauxite mining.

The Commission should collect data on imported carbon anodes. In the U.S. primary aluminum industry, carbon anodes are typically made onsite. However, it is possible for U.S. primary aluminum producers to import anodes, which may be more carbon intensive than domestically produced anodes. *For purposes of this investigation only*, for ease of reporting, Century does not disagree with assigning scrap a zero-carbon burden. The carbon attributable to that scrap should instead be assigned to the finished product produced.

Finally, the scope of producers reporting in this investigation should be limited to those that manufacture products subject to the Section 232 investigation and the USTR's letter.

## Nucor Corporation

Steel decarbonization is a serious and urgent challenge. As the largest American steel producer, Nucor Corporation (Nucor) is committed to this challenge and to producing low emissions, high-quality steel. Nucor pioneered the development and adoption of recycling- and scrap-based electric furnaces in the United States, which have per-ton Scope 1-3 emissions that are nearly 70% lower than traditional, integrated facilities. Indeed, the American steel industry is one of the lowest emitting in the world because of its unique focus on recycling and electric furnace-based production. This is the result of letting the market work. Nucor strives to continue lowering its emissions intensity, and it has recently announced even more ambitious emissions targets, pledging to reach near zero emissions by 2050.

By reporting comprehensive emissions data, the Commission can play a key role in providing the data necessary for policymakers and steel producers worldwide to reduce their emissions levels. However, it is imperative that complete and accurate emissions data be reported and that the same absolute emissions levels apply to all companies. While the scope of the Commission's investigation is necessarily limited to what was officially requested by the U.S. Trade Representative (USTR), the Commission's analysis implicates several broader policy issues related to steel decarbonization. Namely, throughout this investigation, some parties have argued for a dual standard or sliding scale approach that would apply different emissions requirements based on the type of production process or raw material mix. While this is not an issue the Commission should address as part of its investigation, the agency should be wary of misinformation surrounding claims about the need for a dual standard or a sliding scale.

A single emissions standard that applies equally to all companies, regardless of their production process, technology, or raw material mix, should be the starting point for any emissions policy. A single standard places the greatest incentive to decarbonize on the highest emitters and maximizes total emissions reductions. Dual standards and sliding scales are bad climate policies that result in far lower emissions reductions and are inconsistent with other carbon programs that use a single standard, such as the European Union's Emissions Trading System and Carbon Border Adjustment Mechanism. There is simply no need for a differentiated emissions policy that favors the highest emitters over low-emissions production.

A single standard is imperative because transitioning away from blast furnaces is the proven pathway for steel decarbonization. Many of the largest steel producers in the world are investing billions of dollars to shift from blast furnaces to electric furnaces and other green steelmaking technologies. Further, the justifications frequently given for a dual standard or sliding scale have been disproven and do not reflect the realities of the modern steel industry. For instance, electric furnaces can be used to produce the most advanced steel grades, such as those used for exposed automotive products. And there is more than enough scrap available in North America to support a transition towards greater scrap-based steelmaking in electric furnaces with reduced volumes of virgin metallic consumption.

## Outokumpu Stainless USA

As a global leader in sustainable steel production with substantial expertise and experience in calculating the emissions of stainless steel products, Outokumpu Stainless USA, LLC (”Outokumpu”) supports the International Trade Commission’s (“Commission”) collection of information on the greenhouse gas (“GHG”) emissions intensity of the U.S. steel industry to inform the United States Trade Representative’s negotiations with the European Union (“EU”) to establish an emissions-based tariff regime as part of the Global Arrangement on Sustainable Steel and Aluminum (“Global Arrangement”).

Global sustainable steel production is essential to a strong U.S. steel industry. As the U.S. and EU leaders recognized when they agreed to negotiate the Global Arrangement, steel excess capacity has a distortive effect on the U.S. and EU steel markets. Clean producers like Outokumpu require a level playing field to compete fairly in the global market. An emissions-based tariff regime will help level that playing field—but only if the emissions of steel products are fully captured and calculated to ensure fair and accurate comparisons.

To this end, Outokumpu urges the Commission to utilize a “cradle to gate” emissions calculation methodology that encompasses all Scope 1, Scope 2, and upstream Scope 3 GHG emissions on a product-specific basis, with steel product categories determined by the production stages that yield emissions, using the country of melt and pour as the basis for determining the emissions-based tariff associated with each traded steel product. These product categories should reflect the key processes that contribute to emissions, i.e., separating products at each stage of rolling (semifinished, hot-rolled, cold-rolled) and, within hot-rolled stainless steel, products that have been annealed and/or pickled from products that have undergone neither process. The Commission’s calculation need not, and should not, strive to be interoperable with foreign border measures such as the EU’s Carbon Border Adjustment Measure (CBAM). Instead, the Commission should close loopholes left open within CBAM – including the mining and processing of all alloy sources -- within the Commission’s proposed boundary. Finally, the Commission should strive to rely upon actual usage and factor data wherever possible – and, where actual factor data is not available, utilize a standard emission factor appropriate to the specific alloy source and the region in which an intermediate steel product was produced.

## Steel Manufacturers Association

Creating a lower carbon future is of utmost importance to the SMA. As the nation’s largest steel industry trade association, SMA is committed to producing low emission, high quality steel that embraces the circular economy. SMA members use an innovative, 21st century production process that is less energy-intensive and has lower carbon emissions than extractive, coal-based, blast furnace steelmaking. SMA members have emissions that are 70% lower than blast furnace facilities. The American steel industry is one of the lowest emitting in the world because of the dominance of electric furnace-based production that uses ferrous scrap as its primary raw material. Over 70% of the steel made in America is made via the electric furnace production route.

Collecting and reporting comprehensive emissions data is essential for policymakers and global steel producers to reduce their emissions levels. However, it is vital that complete and accurate emissions data be reported using one set of rules that apply equally to all companies. While the scope of the Commission's investigation is based on what is outlined in the formal request by the U.S. Trade Representative (USTR), the Commission's work brings into play several broader policy issues related to steel decarbonization.

A single emissions standard that applies equally to all companies, regardless of production route, steelmaking technology, or raw material mix, should be the starting point for any ambitious emissions policy. This type of approach offers the most expeditious pathway to decarbonize high emitters and increase total emissions reductions worldwide. Dual standards result in misguided climate policies that result in far lower emissions reductions and undermine America's carbon advantage. The approach unduly favors high emissions steel production over low-emissions production.

A single standard is imperative because the transition from blast furnaces can begin now using an existing, commercially viable, readily available and proven pathway to lower emissions. Many of the largest steel producers in the world are investing billions of dollars to make their steel industry look more like America's by shifting from blast furnaces to electric furnaces and other green steelmaking technologies. Further, the reasons used for justifying a dual standard have been disproven and have little to do with lowering emissions in today's modern, high-tech steel industry.

For instance, electric furnaces can be used to produce the most advanced steel grades, such as those used for automotive applications. In Europe, major steel producers such as ArcelorMittal and Saltzgetter who supply global automotive companies such as BMW and Mercedes-Benz are replacing antiquated blast furnaces with modern electric arc furnace and direct reduced iron (DRI) processes that are lower emission and can produce automotive grades including exposed automotive products. Additionally, as a net exporter of scrap, the United States has more than enough scrap available to support an immediate transition to circular economy steelmaking in electric furnaces with reduced reliance on extractive steelmaking in the United States and North America.

## United States Steel Corporation

As a domestic steel producer strategically focusing on decarbonization and sustainability, United States Steel Corporation ("U. S. Steel") supports the International Trade Commission's ("Commission") collection of information on the greenhouse gas ("GHG") emissions intensity of the U.S. steel industry to inform the United States Trade Representative's ("USTR") negotiations for a Global Arrangement on Sustainable Steel ("Global Arrangement") with the European Union ("EU") and/or other trading partners, or other trade negotiations.

U. S. Steel commends the Commission for collecting all of the necessary data to accurately, comprehensively and comparably calculate U.S. steel product emissions intensity based on production route and country of melt and pour, and U. S. Steel strongly recommends that the Commission include all of those calculations in its report so that USTR has maximum optionality for negotiations. Specifically, the Commission should use the emissions data it collected for steel products by production route (blast furnace/basic oxygen furnace (BF/BOF) and electric arc furnace (EAF)), including percentage scrap mix, to calculate emissions intensities by production route. The Commission should also use the emissions data it collected for steel products based on the country of melt and pour to calculate the emissions intensity of domestic steel products made from U.S. melted-and-poured steel by excluding domestic steel products made from foreign origin steel.

Throughout this investigation, U. S. Steel has provided technical and methodological recommendations for USTR to obtain as close to apples-to-apples comparisons to other steel industries as possible. Given the international and comparative nature of a potential Global Arrangement, the Commission should utilize all collected data and issue in its report emissions calculations allowing global product-to-product comparisons regardless of individual producers’ footprints for Scope 1, Scope 2, and upstream Scope 3 GHG emissions.

# Written Submissions Without Summaries

The following interested persons filed written submissions without summaries. Please see EDIS for full submissions.

**Table D.1** List of interested entities that submitted written submissions without summaries

| |
|---|
| Aluminum Extruders Council |
| Alcoa Corporation |
| Aluminum Association |
| American Institute of Steel Construction |
| American Iron and Steel Institute |
| Cleveland-Cliffs Inc. |
| Climate Leadership Council |
| Committee on Pipe and Tube Imports |
| European Commission |
| Forging Industry Association |
| Institute of Scrap Recycling Industries, Inc. |
| Mighty Earth |
| North American Die Casting Association |
| Novelis Corporation |
| Resources for the Future |
| Roger Schagrin, Schagrin Associates |
| SAFE |
| Sierra Club |
| Silverado Policy Accelerator |
| Specialty Steel Industry of North America |
| Steel Dynamics, Inc. |
| Timothy Meyer, Duke University |
| Todd Tucker, Roosevelt Institute |
| United Steelworkers |

Source: Compiled by the USITC.

# Appendix E
# Calculation Methods Appendix

This appendix details the Commission's methodology to calculate the emissions intensities of covered steel and aluminum produced in the United States by product category in 2022. To reach this set of estimates, the Commission calculated facility-level scope 1, 2, and 3 emissions within the system boundaries described in chapter 2. The Commission then allocated facility-level emissions to the facility's production processes, at which point they were then used to estimate product-level emissions inventories—the emissions associated with product themselves. Emissions intensities were calculated by dividing each product's emissions inventory by production output of that product.

The Trade Representative's letter specified many of the data collection methods and data sources to be used in this investigation as well as coverage in terms of the scope of emissions, product categories, and materials to be considered. In order to fulfill the elements of this request, the Commission reviewed existing standards and frameworks for GHG emissions accounting. This review provided the Commission with an understanding of the existing approaches for emissions accounting. The Commission then created an outline for its own methodology, generally following these accepted approaches within the confines of the data available and with an understanding of the end use for these measures (i.e., to inform international trade policy).[477] The Commission sought feedback on its proposed calculation methodology throughout the investigation via interviews, site visits, public hearing testimony, and investigation record submissions from industry, nongovernmental organizations, labor groups, U.S government agencies, think tanks, and academia. After receiving this feedback, the Commission worked to incorporate pertinent comments into its approach and continued to refine its methods based on further desk research on available data sources.

As mentioned in chapter 1 ("Guiding Principles for This Investigation"), the Commission strove to satisfy several guiding principles in the development of its methodology. In particular, the methodology was designed to achieve the principle of completeness, with consistent collection of the same set of emissions across all facilities within broad system boundaries. In addition, the methodology sought to maximize interoperability with existing data sources and government frameworks for emissions accounting. This orientation of the methodology in turn informed the development of the data collection strategy, which was designed around acquiring the level of precision needed to deliver measures responsive to trade policy while minimizing the reporting burden on the respondent and protecting confidential business information.

This appendix contains the detailed data sources and calculations for each step of the Commission's methodology, following the high-level descriptions in chapter 3. The appendix then provides an overview comparison of the different standards and frameworks the Commission consulted in the creation of its own methodology. The appendix closes with a tabular review of the data sources that the Commission used to develop and verify its emissions intensity estimates.

---

[477] Data availability was in large part determined by the development and execution of the Commission's data collection plan, which was developed in parallel with the Commission's methodology. A draft of this proposed calculation methodology was released alongside the Commission's draft questionnaires during the public comment period for the data collection plan to be reviewed by the Office of Management and Budget. For more information on the Commission's data collection, see appendix H ("Data Collection").

# I. Overview of Product-Level Emissions Intensity and Inventory Calculations

For all product categories ($category$), the Commission calculated emissions intensities ($GHGintensity_{category}$) by dividing the product-level emissions inventory ($GHG_{category}$) by production of that product ($Output_{category}$) (equation E.1). This approach was taken both for the industry-wide emissions intensities presented in this report and for the emissions intensities of products made by individual facilities.[478]

$$GHGintensity_{category} = \frac{GHG_{category}}{Output_{category}} \qquad (E.1)$$

$GHG_{category}$ includes the totality of emissions that occur during all processes within the system boundary that produce—or supply energy to the production of—the product category. The Commission developed a uniform approach to calculating $GHG_{category}$ for "reference products," a defined set of mutually exclusive product categories that include all covered steel and aluminum products and other upstream materials made by facilities producing covered products within the system boundaries of this investigation (see table E.1). These "reference products" are denoted throughout this appendix's equations with the $product$ subscript.[479] For each reference product, $GHG_{product}$ was calculated using equation E.2.

$$GHG_{product} = UGHG_{product} + \sum\nolimits_{material} ICGHG_{material,product} \qquad (E.2)$$

$UGHG_{product}$ refers to the "unit process emissions" directly attributed to the discrete production process (the "unit process") that makes the reference product and is calculated using equation E.3.

---

[478] Emissions intensity estimates for products made by individual facilities are used predominantly in two parts of the methodology. In the scope 3 analysis, they are sometimes used as emissions factors for other consuming facilities that received products from other facilities. In the calculation of industry-wide "highest" emissions intensity values, the emissions intensity values from individual facilities are used to determine each facility's position within the industry's distribution. The industry-wide highest emissions intensity is the average emissions intensity of the facilities with the highest emissions intensities that comprised 10 percent of the production of a product category or subcategory, unless otherwise noted. Once the emissions intensity estimates are computed at the facility level for each product category or subcategory, facilities are arranged in descending order of the emissions intensities, and cumulative production shares are calculated. Facilities are included until 10 percent of cumulative production is captured from the top end of the emissions intensity distribution. Finally, average emissions intensity is calculated using the same formula as the average national emissions intensity calculation in E.1 above. More information regarding the average and highest computation can be found in appendix H ("Computational Methods").

[479] Certain product categories that are either more or less granular than reference products require different approaches to calculating product-level emissions inventories. These include aggregate product categories (wrought and unwrought aluminum, and flat, long, tubular, and stainless steel). These also include several subcategories of steel product categories. The methods for calculating the product-level emissions inventories of these products are described in a later section of this appendix ("Additional Analysis for Aggregate Product Categories and Product Subcategories").

$$UGHG_{product} = S1P\ UGHG_{product} + S1FC\ UGHG_{product} + S2\ UGHG_{product} + S3\ UGHG_{product}\ (E.3)$$

Scope 1 process emissions ($S1P\ UGHG_{product}$) and scope 1 fuel combustion emissions ($S1FC\ UGHG_{product}$) are the direct emissions that occur in the unit process itself. Scope 2 emissions ($S2\ UGHG_{product}$) and scope 3 emissions ($S3\ UGHG_{product}$) are indirect emissions associated with the unit process due to that production process's direct use of purchased energy and material inputs.

The following sections of this appendix covering process emissions, energy-related emissions, and scope 3 emissions provide greater detail on how the Commission calculated each of these scope-specific unit process emissions terms. All these approaches, however, use the same process subdivision and physical allocation principles described in chapter 3 ("Allocation of Facility-Level Emissions to Unit Processes"), in particular, the allocation of facility-level emissions to "subprocesses." Subprocesses are defined facility processes for which facilities provided input and output data within the questionnaire and that correspond with emissions data reported under the GHGRP program.[480] Some subprocesses produce only a single reference product, in which case subprocess-level emissions serve without modification as unit process emissions for that reference product. Other subprocesses correspond with two or more reference products, in which case subprocess-level emissions are further allocated to the multiple unit processes corresponding with those reference products using physical allocation.[481] The list of subprocesses and corresponding reference products used in this investigation is provided in table E.1.

---

[480] EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024.

[481] All unit processes contain at least one subprocess related directly to the production of a reference product in addition to the subprocess "ambient heating, cooling, ventilation, and lighting supply," which is split using physical allocation across all production at a facility. In some cases, several subprocesses contribute to the same unit process. For example, both the "smelting of primary unwrought aluminum" and the "casting of primary unwrought aluminum" subprocesses contribute to the production of primary unwrought aluminum (a unit process). If a facility had emissions under multiple subprocesses contributing to the same unit process, then corresponding unit process emissions are aggregated. For example, if a facility had scope 1 fuel combustion emissions associated with both smelting and casting of unwrought aluminum, these would both be assigned to the production of primary unwrought aluminum and added together.

**Table E.1** List of facility subprocesses and corresponding reference products

| Subprocess | Corresponding reference products |
|---|---|
| Anode baking for primary unwrought aluminum production | Carbon anodes |
| Smelting of primary unwrought aluminum | Primary unwrought aluminum |
| Casting of primary unwrought aluminum | Primary unwrought aluminum |
| Secondary unwrought aluminum production | Secondary unwrought aluminum |
| Wrought aluminum production | Bars, rods, and profiles; plates, sheet, and strip; foil; wire; tubes, pipes, and tube or pipe fittings; castings; forgings |
| Lime and dolime production | Calcined lime; calcined dolime |
| Production of oxygen, nitrogen, argon, or hydrogen | Oxygen; nitrogen; argon; hydrogen |
| Metallurgical coke production (e.g., in a coke oven or coke battery) | Metallurgical coke |
| Iron sinter production | Iron sinter |
| Liquid pig iron production in a rotary hearth furnace | Pig iron |
| Blast furnace operations, including pig iron casting | Pig iron |
| Steelmaking, including BOF or EAF operations, preheating ferrous scrap, refining/ladle station, decarburization, and casting | Semifinished steel (carbon and alloy, stainless) |
| Remelting and further working of previously cast semifinished steel into different forms of semifinished steel (e.g., electroslag remelting, vacuum arc remelting) | Semifinished steel (carbon and alloy, stainless) |
| Hot-rolling flat steel products | Hot-rolled flat steel products (carbon and alloy, stainless) |
| Cold-rolling flat steel products | Cold-rolled flat steel products (carbon and alloy, stainless) |
| Production of seamless tubular products | Seamless steel tubular products (carbon and alloy, stainless) |
| Production of non-seamless tubular products | Non-seamless steel tubular products (carbon and alloy, stainless) |
| Hot-working long steel products | Hot-worked long steel products (carbon and alloy, stainless) |
| Cold-forming or cold finishing long steel products | Cold-formed long steel products (carbon and alloy, stainless) |
| Coating, cladding, or plating flat steel products | Carbon and alloy coated flat steel products |
| Ambient heating, cooling, ventilation, and lighting supply in facilities where production occurs, if measured separately from the process-specific fuel use reported above | All |
| Processes used to make products other than covered steel, covered aluminum, or their upstream material inputs | None |
| Activities of other producers operating on-site | None |
| Stationary equipment that shreds or sorts scrap | None |
| Ancillary (non-production) activities that are not associated with production floor operations | None |

Source: Compiled by the USITC.

Note: Each reference product made by a subprocess has a corresponding unit process (i.e., the unit process is the specific process covering the production of the reference product). Emissions associated with subprocesses that correspond to no reference products are out of the Commission's system boundary and are not allocated to any product-level inventories. The emissions associated with ambient heating, cooling, ventilation, and lighting supply are allocated to any reference products and any noncovered production using the physical allocation approach. The term "carbon and alloy, stainless" indicates that the subprocess makes stainless steel and carbon and alloy steel versions of that product type.

In addition to unit process emissions, equation E.2 includes the contributed emissions from upstream processes in the facility that do not directly produce the reference product but are still included in the product-level emissions inventory, captured in $ICGHG_{material,product}$. Specifically, $ICGHG_{material,product}$ is the inventory of emissions associated with a quantity of a material ($material$) that is made in the same facility and used in the production of the reference product. This term is summed across all materials made in the same facility that feed into production of the reference product. The methods for calculating $ICGHG_{material,product}$ are described below ("Computing Product-Level Emission Inventories").

# II. Compiling a Facility-Level Emissions Inventory and Allocating to Subprocesses and Unit Processes

This section sets out the data and calculation steps the Commission used to build a facility-level emissions inventory, and then the steps it took to allocate those emissions to different subprocesses and unit processes in preparation for computing a product-level emissions inventory. These calculations represent the steps described in stage 1 and the first part of stage 2 in chapter 3 (see "Stage 1: Compiling a Facility-Level Emissions Inventory" and "Allocation of Facility-Level Emissions to Unit Processes"). As described in chapter 3, the facility-level inventory is comprised of scope 1 process and fuel combustion emissions, scope 2 emissions associated with purchased energy, and scope 3 emissions associated with the material inputs into production of covered steel and aluminum products within the system boundary the Commission has established. The calculations the Commission uses to generate these emissions inventory data from activity data and emissions factors and the calculations that reporters to the U.S. Environmental Protection Agency's (EPA's) Greenhouse Gas Reporting Program (GHGRP) use to calculate their own emissions data are both described.[482]

## II.A. Process Emissions for Steel

This subsection provides more detail on how the Commission calculated scope 1 process emissions from the production of iron and steel. The Commission's scope 1 process emissions calculation for steel production applies to multiple subprocesses, including lime and dolime production, metallurgical coke production, iron sintering, and steelmaking, for the purposes of product-level allocation of emissions.

Scope 1 process emissions at steelmaking facilities can occur from the operation of a basic oxygen furnace (BOF), electric arc furnace (EAF), non-recovery coke oven battery, sinter plant, decarburization vessel, or direct reduction furnace (see chapter 2, "Steel Production," for more information on these processes). In this report, process emissions also include those from flaring of blast furnace gas and coke

---

[482] The request letter states that the Commission should collect data for the scope 1 emissions used in its emissions intensity calculations from facility GHGRP reports to EPA when available. For facilities that do not report to GHGRP, the request letter notes that the Commission should use survey data to determine scope 1 emissions. See appendix A of this report for a copy of the request letter.

oven gas.[483] There are other sources of process emissions from iron and steel facilities as well, including those that produce fugitive emissions in steelmaking facilities.[484]

To generate process emissions estimates for facilities producing covered steel products, the Commission relied on two data sources: (1) GHGRP data, which contains data for almost all steel producers with process emissions, and (2) data from the Commission's questionnaire for the few facilities that did not report to the GHGRP in 2022 but nonetheless had process emissions from steelmaking.

## II.A.1. Scope 1 Process Emissions Reported Under the GHGRP

Facility-level reports under EPA's GHGRP are the primary source of steel process emissions data for the Commission's investigation. The GHGRP subpart Q requires iron and steel-producing facilities with annual emissions of over 25,000 mt of $CO_2e$ to report their emissions to EPA under this program.[485] The EPA estimated that this threshold captures 100 percent of BOF producers and the vast majority of EAF producers in the United States.[486]

Of the steelmaking facilities (i.e., those facilities using an on-site BOF or EAF to make semifinished steel) that responded to the Commission's questionnaire, 95.6 percent of steelmaking facilities also reported to the GHGRP.

### II.A.1.a GHGRP Iron and Steel Production Calculations

The GHGRP regulation provides steelmaking facilities a variety of options to calculate their process emissions under subpart Q. These calculation options are broadly grouped into four techniques: default emissions factors, site-specific emissions factor, mass-balance equations approach, and continuous emissions monitoring systems (CEMS).

- *Default emissions factors:*[487] Default emissions factors are provided by the GHGRP and are based on the average emissions that occur per unit of consumption of raw material or per unit of

---

[483] The emissions from the use of these waste gases in on-site industrial processes are characterized as scope 1 fuel combustion emissions, as described in the energy emissions section below.

[484] Note that these fugitive emissions refer only to those emissions at steelmaking facilities and are distinct from those discussed in appendix F ("Fugitive Emissions Associated with Coal and Natural Gas Used in Steel and Aluminum Production"). The fugitive emissions referred to in the text above can occur during ladle metallurgy operations, desulfurization, hot metal transfer, sinter cooling, and the charging and tapping of furnaces. For example, fugitive emissions of blast furnace gas may be emitted during infrequent process upsets when gas is vented for a short time or from leaks in the ductwork through which these gases pass. EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 22.

[485] EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024. 40 C.F.R § 98.2(a)(2).

[486] EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 30.

[487] The GHGRP does not rely heavily on default emissions factors, an approach that differs considerably from other approaches that tend to rely heavily on default emissions factors. In the GHGRP proposed rule, the EPA argued that its low reliance on these default emissions factors was due to the very high uncertainty of these factors. It stated that default emissions factors would not provide site-specific estimates of emissions that reflect the differences in feedstocks, operating conditions, fuel combustion efficiency, variability in fuels, and other differences among facilities. It stated that a default emissions factor-based methodology is more widely used as a sector-wide or national total estimate and is not necessarily appropriate for facility-level estimates. EPA, OAR, "Technical Support Document for the Iron and Steel Sector," August 28, 2009, 32.

output. In the case of steel, a default emissions factor is used to determine fugitive $CO_2$ emissions from one process: coke pushing.[488]

- *Site-specific emissions factors*: Under the GHGRP, steel facilities can calculate GHG emissions from a particular process by using a site-specific emissions factor that they have calculated specific to that process. They can determine an emissions factor from a performance test that measures $CO_2$ emissions from all exhaust stacks for the process, and also measure either the feed rate of materials into the process or the production rate during the test in metric tons per hour. Under this approach, the site-specific emissions factor is multiplied by annual feedstock use or production to determine annual $CO_2$ emissions from the process.[489]
- *Mass-balance equations*: Mass-balance equations generally measure (1) the carbon entering a process through inputs or feedstocks (the product of the carbon content of inputs and the quantity of those inputs used in the process); and (2) the carbon exiting the same process through products and by-products. These equations then subtract the carbon outputs from the carbon inputs and assume the carbon difference is either directly released or oxidized and then released as $CO_2$.[490] Separate mass-balance equations are provided within the GHGRP regulations for various processes used to produce iron and steel (described in 40 C.F.R. Part 98 Subpart Q).[491]
- *Continuous emissions monitoring system (CEMS)*: A CEMS is a device that continually collects information on the quantity of a gas being emitted, including GHGs. CEMS devices will often collect GHG emissions information covering both process and fuel combustion emissions.[492]

Facilities report the specific methods they use to calculate subpart Q emissions associated with different production processes throughout their facilities. Facilities may report one or multiple quantities of emissions for each production process depending on the complexity of their operations. The Commission assigned these emissions to specific subprocesses used in this investigation ($S1P_{subproc}$) based on the methodology the facility used to calculate those emissions under subpart Q. Table E.2 shows the specific methods used by facilities to report process emissions and the subprocesses to which the Commission assigned those emissions.

---

[488] 40 C.F.R. § 98.173(c).

[489] 40 C.F.R § 98.173(b)(2), EPA, "Mandatory Reporting of Greenhouse Gases Iron and Steel (Final)," March 2012, 3.

[490] EPA, "Greenhouse Gas Reporting Program: Emission Calculation Methodologies," July 2015; EPA, "Mandatory Reporting of Greenhouse Gases Iron and Steel (Final)," March 2012; EPA, "Reporting of Greenhouse Gases for Aluminum Production," February 2018.

[491] 40 C.F.R. § 98.173(b)(1)(vi).

[492] EPA, "Mandatory Reporting of Greenhouse Gases Iron and Steel (Final)," March 2012, 3; 40 C.F.R. § 98.173(d).

**Table E.2** Steel process emissions data reported under the Greenhouse Gas Reporting Program (GHGRP) and associated subprocess

| GHGRP basis for calculating or measuring GHG emissions | Regulatory citation for calculation or measurement | Assigned subprocess |
|---|---|---|
| Carbon mass-balance method for a decarburization vessel | 40 C.F.R. § 98.173(b)(1)(vi) | Steelmaking |
| Carbon mass-balance method for an electric arc furnace (EAF) | 40 C.F.R. § 98.173(b)(1)(v) | Steelmaking |
| Carbon mass-balance method for basic oxygen process furnaces | 40 C.F.R. § 98.173(b)(1)(ii) | Steelmaking |
| Carbon mass-balance method for nonrecovery coke ovens | 40 C.F.R. § 98.173(b)(1)(iii) | Metallurgical coke production |
| Carbon mass-balance method for direct reduction furnace | 40 C.F.R. § 98.173(b)(1)(vii) | Rotary hearth furnace |
| Carbon mass-balance method for sinter processes | 40 C.F.R. § 98.173(b)(1)(iv) | Iron sinter production |
| Default emissions factor for coke pushing emissions | 40 C.F.R. § 98.173(c) | Metallurgical coke production |
| Continuous emissions monitoring system (CEMS), where a facility report includes reference to an EAF associated with the reported emissions | 40 C.F.R. § 98.173(d) | Steelmaking |
| CEMS, where facility report includes reference to iron sinter processes associated with the reported emissions | 40 C.F.R. § 98.173(d) | Iron sinter production |
| Site-specific factor, where facility report includes reference to EAF processes associated with the reported emissions | 40 C.F.R. § 98.173(b)(2) | Steelmaking |
| Site-specific factor, where the facility report includes reference to a decarburization vessel associated with the reported emissions | 40 C.F.R. § 98.173(b)(2) | Steelmaking |
| Site-specific factor, where the facility report includes reference to a basic oxygen process furnace process associated with the reported emissions | 40 C.F.R. § 98.173 (b)(2) | Steelmaking |
| Site-specific factor for flaring associated with blast furnace processes or blast furnace gas | 40 C.F.R. § 98.253(b)(1) | Blast furnace operations |
| Site-specific factor for flaring associated with coke oven processes or coke oven gas | 40 C.F.R. § 98.253(b)(1) | Metallurgical coke production |
| Carbon mass-balance method for lime production | 40 C.F.R § 98.193(b)(2) | Lime and dolime production |

Source: Compiled by the USITC.

Note: Any emissions using the carbon mass-balance method for direct reduction furnaces were allocated to the rotary hearth furnace subdivision. The carbon mass-balance method for lime and dolime production is used for GHG emissions data reported under Subpart S of the GHGRP.

Certain processes described above, particularly those associated with CEMS measurements, can include fuel combustion or the use of feedstock that could be reported under either the GHGRP subpart C (fuel combustion emissions) or the GHGRP subpart Q (process emissions). The GHGRP allows for emissions from certain stationary combustion processes that are difficult to distinguish from process emissions (e.g., from a common monitored stack) to be reported under subparts C or Q.[493] This can result in ambiguity between what is reported under subpart C and what is reported under subpart Q. Notwithstanding this ambiguity, this report refers to emissions reported under subpart C as "scope 1 fuel combustion emissions" and those reported under subpart Q as "scope 1 process emissions." The Commission considers both sets of emissions to be scope 1 emissions that can be linked to specific subprocesses for the purposes of product allocation, regardless of whether they are fuel combustion or process emissions.

The Commission used $S1P_{subproc}$ to calculate unit process-level process emissions ($S1P\ UGHG_{product}$) described in equation E.3 in the overview section of this appendix. For subprocesses that only produced a single reference product, $S1P\ UGHG_{product}$ was considered equivalent to $S1P_{subproc}$.[494] The steelmaking and production of calcined lime and dolime subprocesses produce multiple reference products, and the Commission calculated $S1P\ UGHG_{product}$ for products made from these subprocesses using equation E.4.

$$S1P\ UGHG_{product} = S1P_{subproc} * \frac{Output_{product}}{Output_{subproc}} \qquad (E.4)$$

## II.A.2. Use of Survey Data to Calculate Scope 1 Process Emissions for Certain EAF Facilities

For facilities reporting that they used EAFs to produce semifinished steel but did not have a corresponding GHGRP report for 2022, the Commission used equation E.5 to calculate process emissions associated with steelmaking for that facility. Equation E.5 is based on the GHGRP's mass-balance approach for EAFs and decarburization vessels. The Commission's main sources for the data used in this equation were questions in sections 5 and 6 of the questionnaire, which covered input and output data from EAFs and decarburization vessels as well as the carbon content of those materials.

---

[493] The GHGRP subpart Q regulation specifies that facilities must report under subpart C emissions from, among other facility units, byproduct recovery coke oven battery combustion stacks, blast furnace stoves, boilers, process heaters, reheat furnaces, annealing furnaces, flame suppression, ladle reheaters, and other miscellaneous combustion sources. Subpart C can also be used by facilities reporting combinations of fuel combustion and process emissions from common stacks that are monitored using CEMS. Subpart Q includes mass-balance based emissions reporting provisions that require facilities to include carbon from fuels used in EAFs, BOFs, decarburization vessels, direct reduction furnaces, taconite indurating furnaces, nonrecovery coke oven batteries, and iron sinter units. Some facilities also report subpart Q emissions using CEMS that includes a mix of fuel combustion and process emissions. 40 C.F.R. § 98.33; 40 C.F.R. § 98.172; 40 C.F.R. § 98.173; U.S. industry representatives, interviews by USITC staff; Subject matter expert, email message to USITC staff, December 21, 2023.

[494] The subprocesses with process emissions under subpart Q that produced only a single reference product were metallurgical coke production, iron sinter production, liquid pig iron in rotary hearth furnaces, and blast furnace operations. See also table E.2 for an exhaustive list of all subprocesses.

$$CO_2 = \frac{44}{12} * \big(Iron * C_{Iron} + Scrap * C_{Scrap} + Flux * C_{Flux} + Electrode * C_{Electrode} + Carbon * C_{Carbon} - Steel_{EAF} * C_{Steel} + Steel_{Decarb} * (C_{Steelin} - C_{Steelout}\big) + F_g * HHV * EF * 0.001 - Slag * C_{Slag} - R_{EAF} * C_{REAF} - R_{Decarb} * C_{RDecarb}) \qquad (E.5)$$

Table E.3 shows the mass-balance equations for EAFs, decarburization vessels, and for gaseous fuel combustion emissions from the GHGRP on which the Commission based its calculations in equation E.5.

**Table E.3** GHGRP equations used for the Commission's approach for calculating scope 1 process emissions from EAF facilities that do not report to the Greenhouse Gas Reporting Program (GHGRP)

| GHGRP calculation | Description | Source |
|---|---|---|
| $CO_2 = \frac{44}{12} * (Iron * C_{Iron} + Scrap * C_{Scrap} + Flux * C_{Flux} + Electrode * C_{Electrode} + Carbon * C_{Carbon} - Steel_{EAF} * C_{Steel} + F_g * C_{gf} * \frac{MW}{MVC} * 0.001 - Slag * C_{Slag} - R_{EAF} * C_{REAF})$ | Mass-balance equation for steel produced in EAFs. GHGRP Equation Q-5. | 40 C.F.R. § 98.173(b)(1)(v) |
| $CO_2 = \frac{44}{12} * (Steel_{Decarb} * (C_{Steelin} - C_{Steelout}) - R_{Decarb} * C_{RDecarb})$ | Mass-balance equation for decarburization vessels. GHGRP Equation Q-6. | 40 C.F.R. § 98.173(b)(1)(vi) |
| $CO_{2,Fg} = F_g * HHV * EF * 0.001$ | Subpart C gaseous fuel combustion equation (tier 1 approach). GHGRP Equation C-1. | 40 C.F.R. § 98.33(a)(1)(i) |
| $CO_{2,Fg} = \frac{44}{12} * (F_g * C_{gf} * \frac{MW}{MVC} * 0.001)$ | Subpart C gaseous fuel combustion equation (tier 3 approach). GHGRP Equation C-4 and portion of GHGRP Equation Q-5 shown above. | 40 C.F.R. § 98.33(a)(3)(iii);<br>40 C.F.R. § 98.173(b)(1)(v) |

Source: Compiled by the USITC.
Note: Variables used in the equations in this table are described in table E.4.

Equation E.5 consolidates GHGRP equations Q-5 and Q-6, allocating all process emissions from EAFs and decarburization vessels to the steelmaking subprocess. In order to reduce the burden on surveyed facilities, the Commission substituted the portion of GHGRP equation Q-5 that mirrored GHGRP equation C-4 (a more complex approach to calculating the $CO_2$ emissions from fuel combustion, $CO_{2,Fg}$) with the simpler GHGRP equation C-1 that is also used to calculate $CO_{2,Fg}$.[495] The question numbers in the Commission's questionnaire under which information on the above inputs was gathered and the variables they correspond to within equation E.5 are noted in Table E.4.

---

[495] The use of GHGRP equation C-1 to capture the fuel consumption portion of the Commission's equation E.5 allowed for surveyed facilities to report only their fuel consumption in questionnaire question 5.4 (if not otherwise captured in section 3 of the questionnaire). If equation E.5 had instead used GHGRP equation C-4 for the fuel consumption portion, facilities would have had to report the average annual carbon content and average annual molecular weight of fuel consumed in steelmaking in question 5.4. The Commission made this decision for the sake of simplification.

**Table E.4** USITC calculation variables, description, and questionnaire mapping for the process emission methodology for EAFs that do not report to the Greenhouse Gas Reporting Program (GHGRP)

| Process emissions formula variable | Variable description | USITC questionnaire question |
|---|---|---|
| Iron | Annual mass of direct reduced iron or pig iron (if any) charged to the furnace | 5.1.12a, 5.1.13a |
| $C_{Iron}$ | Carbon content of the direct reduced iron expressed as a decimal fraction | 5.1.12c, 5.1.13c |
| Scrap | Annual mass of ferrous scrap charged to the furnace | 5.1.14a |
| $C_{Scrap}$ | Carbon content of the ferrous scrap expressed as a decimal fraction | 5.1.14g |
| Flux | Annual mass of flux materials (i.e., limestone, dolomite) charged to the furnace | 5.1.8a |
| $C_{Flux}$ | Carbon content of the flux materials expressed as a decimal fraction | 5.1.8d |
| Electrode | Annual mass of carbon electrodes consumed | 5.1.15a |
| $C_{Electrode}$ | Carbon content of the flux materials expressed as a decimal fraction | 5.1.15c |
| Carbon | Annual mass of the carbonaceous materials expressed as a decimal fraction | 5.1.5b, 5.1.6a, 5.1.7a |
| $C_{Carbon}$ | Carbon content of the carbonaceous materials expressed as a decimal fraction | 5.1.5d, 5.1.6c, 5.1.7d |
| Steel | Annual mass of molten raw steel produced by the furnace | 6.1.1a |
| $C_{Steel}$ | Carbon content of the steel expressed as a decimal fraction | 6.1.1c |
| $Steel_{Decarb}$ | Annual mass of molten steel charged to the decarburization vessel | 6.1d |
| $C_{Steelin}$ | Carbon content of the molten steel before decarburization expressed as a decimal fraction | 6.1f |
| $C_{Steelout}$ | Carbon content of the molten steel after decarburization expressed as a decimal fraction | 6.1f |
| $F_g$ | Annual volume of the gaseous fuel used | 5.1.4b |
| HHV | Annual average high heating value (HHV) of the fuel | Natural Gas high heating value from table C-1 of 40 C.F.R. 98, subpart C (MMBtu/scf) |
| EF | Fuel specific default $CO_2$ emissions factor (EF) | Natural Gas Emissions factor from table C-1 of 40 C.F.R. 98, subpart C ($CO_2$/MMBtu) |
| Slag | Annual mass of slag produced by the furnace | 6.3a |
| $C_{Slag}$ | Carbon content of the slag produced by the furnace expressed as a decimal fraction | 6.3c |
| $R_{EAF}$ | Annual mass of air pollution control residue resulting from the EAF | 6.2b |
| $C_{REAF}$ | Carbon content of the air pollution control residue resulting from the EAF expressed as a decimal fraction | 6.2d |
| $R_{Decarb}$ | Annual mass of air pollution control residue resulting from the decarburization vessel | 6.2b |
| $C_{RDecarb}$ | Carbon content of the air pollution control residue resulting from the decarburization vessel expressed as a decimal fraction | 6.2d |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024.

When certain information on the carbon content of materials was not known by a facility, the Commission used publicly available factors (table E.5) in equation E.5 to calculate process emissions.

**Table E.5** Default carbon content values and sources
In metric tons of carbon dioxide equivalent per metric ton (mt $CO_2e$ /mt) of material.

| Formula variable | Default value (mt carbon/mt) | Sources |
|---|---|---|
| $C_{Iron}$ | 0.020 (direct reduced iron), 0.047 (pig iron) | IPCC, "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3," 4.31. |
| $C_{Scrap}$ | 0.01 | IPCC, "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3," 4.31. |
| $C_{Flux}$ | 0.13 (dolime), 0.121 (lime/limestone),<br>0.23 (other) | IPCC, "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3," 4.31. |
| $C_{Electrode}$ | 0.82 | EPA, OAR, "Inventory of U.S. Greenhouse Gas Emissions and Sinks," October 22, 2024, 4–87. |
| $C_{Carbon}$ | 0.91 (charcoal), 0.87 (petroleum coke) | IPCC, "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3," 4.31. |
| $C_{Carbon}$ | 0.73 (coking coal) | IPCC, "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3," 4.31. |
| $C_{Steel}$ | 0.04 | EPA, OAR, "Inventory of U.S. Greenhouse Gas Emissions and Sinks," October 22, 2024, 4–87. |
| $C_{Steelin}$ | 0.04 | EPA, OAR, "Inventory of U.S. Greenhouse Gas Emissions and Sinks," October 22, 2024, 4–87. |
| $C_{Steelout}$ | 0.01 | Sullivan and Olson, "Building a Decarbonized Steel Sector," July 7, 2023. |
| $C_{Slag}$ | 0.004 | Moras et al., "Carbon Dioxide Removal Efficiency of Iron and Steel Slag in Seawater via Ocean Alkalinity Enhancement," June 17, 2024. |
| $C_{REAF}$, $C_{RDecarb}$ | 0.15 | EPA, "Air Pollution Aspects of the Iron and Steel industry" 43. |

Source: Compiled by the USITC.

Because the Commission considered all emissions calculated using equation E.5 to be from the steelmaking subprocess, these were further allocated to the reference products produced from steelmaking using equation E.5

## II.B. Process Emissions for Aluminum

In line with the U.S. Environmental Protection Agency (EPA)'s Greenhouse Gas Reporting Program (GHGRP) methodology, the Commission considered process emissions associated with the production of covered aluminum products as emissions that "generally include emissions from chemical transformation of raw materials."[496] As defined in chapter 3 ("Aluminum Process Emissions"), the process emissions emitted by facilities producing covered aluminum products consist of $CO_2$ and perfluorocarbons (PFCs) and only occur in the production of primary aluminum. $CO_2$ process emissions are released during the baking of the carbon anode and the consumption of the anode during

---

[496] EPA, "Greenhouse Gas Reporting Program: Emission Calculation Methodologies," July 2015, 1. The GHGRP also considers fugitive emissions in its definition. See appendix F ("Fugitive Emissions Associated with Coal and Natural Gas Used in Steel and Aluminum Production") for more information on fugitive emissions.

electrolysis. PFCs are released when the levels of alumina within the pot fall below the level required for electrolysis, causing the voltage within the pot to spike ("anode effects").[497] The information in this section will cover the use of EPA's GHGRP data to estimate process emissions from primary unwrought aluminum production, and the steps taken to allocate these emissions to two subprocesses: anode baking and smelting of primary unwrought aluminum.

## II.B.1. Scope 1 Process Emissions Reported Under the GHGRP

This investigation used only publicly available data from facility-level reports under EPA's GHGRP to determine process emissions from primary aluminum production.[498] All operating U.S. aluminum smelters reported to the GHGRP in 2022.

The GHGRP provides calculation approaches to estimate process emissions using a number of techniques depending on which segment of process emissions are being measured. Like in the steel regulations explained above, these process emissions can be reported either through a mass-balance calculation method or by using a continuous emissions monitoring system (CEMS).[499] The Commission assigned emissions reported by facilities under subpart F to specific subprocesses used in this investigation ($S1P_{subproc}$). Table E.6 shows the possible methods facilities used to report process emissions and the subprocess to which the Commission assigned those emissions.

**Table E.6** Greenhouse Gas Reporting Program (GHGRP) emissions data reported under Subpart F and associated subprocess

| GHGRP basis for calculating or measuring GHG emissions | Regulatory citation for calculation or measurement | Assigned subprocess |
|---|---|---|
| Continuous emissions monitory system (CEMS) or mass-balance equations for pitch volatiles and bake furnace packing material | 40 C.F.R. § 98.63(d)(f) | Anode baking |
| CEMS or mass-balance equation for process emissions from anode consumption; calculations using measured and default values for anode effects | 40 C.F.R. § 98.63(a),(b),(d),(e) | Smelting of primary unwrought aluminum |

Source: Compiled by the USITC.

The Commission used ($S1P_{subproc}$) to calculate unit process-level process emissions ($S1P\ UGHG_{product}$) described in equation E.3 in the overview section of this appendix. The two subprocesses under which subpart F emissions were assigned each produced only a single reference product; therefore, $S1P\ UGHG_{product}$ was considered equivalent to $S1P_{subproc}$.[500] The below sections describe the specific ways in which GHGRP reporters are to calculate process emissions in aluminum production.

---

[497] IAI, "Perfluorocarbon (PFC) Emissions," 2024.

[498] EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024.

[499] Note that some facilities may vent emissions from anode consumption during electrolysis or anode baking of prebake cells (which are described under subpart F) through the same stack as emissions from any fuel combustion units (described under GHGRP subpart C). If these emissions are measured by a CEMS, the GHGRP regulation notes that emissions from this stack should be reported under subpart C. 40 C.F.R. § 98.63(g). Regardless of where they are reported, these emissions are still linked to specific processes for the purposes of product allocation.

[500] The subprocesses with process emissions under subpart F each correspond with a single reference product. Anode baking with carbon anodes (a material input for primary unwrought aluminum) and smelting of primary unwrought aluminum with primary unwrought aluminum (see also tables E.1 and E.6).

### II.B.1.a GHGRP Anode Baking Calculations

Anode baking of prebake carbon anodes releases $CO_2$ emissions both from pitch volatiles and bake furnace packing material.[501] For the baking of the carbon anodes, process emissions may be calculated by one of two approaches: either measurement by a CEMS monitoring system or the use of mass-balance equations.[502] The GHGRP regulation instructs that if these process emissions are measured by a CEMS on a stack with fuel combustion emissions from subpart C, those combined emissions must be reported under subpart F.[503] Under the Commission's methodology, these emissions are all considered to be scope 1 emissions linked to primary unwrought aluminum. The mass-balance equation for estimating emissions from pitch volatiles takes into account the initial weight of the green anodes, the mass of hydrogen in the green anodes, the mass of the baked anodes, and the mass of waste tar collected.[504] The mass-balance equation for estimating emissions from the bake furnace packing material takes into account the packing coke (calcined petroleum coke) consumption rate per ton of baked anode production as well as the sulfur and ash contents of the packing coke.[505] Some values in this mass-balance equation (e.g., sulfur, ash, and hydrogen contents) can either be smelter specific or a default value from Table F-2 of subpart F.[506]

### II.B.1.b GHGRP Primary Unwrought Aluminum Production Calculations

When primary aluminum is smelted, process emissions are generated both as the carbon anodes are consumed, and when anode effects occur. $CO_2$ emissions from anode consumption can be estimated using a mass-balance equation based on measurements of the net prebaked anode consumption rate per metric ton of aluminum produced, the ash and sulfur contents of the anodes, and the total mass of aluminum metal produced per year for all prebake cells.[507] Like in anode baking, process emissions for anode consumption during electrolysis may be calculated by either the use of this mass-balance equation or CEMS measurement. Similarly to anode baking, some values in this mass-balance equation for anode consumption (e.g., sulfur and ash contents) can either be smelter specific or a default value from Table F-2 of subpart F.[508]

Emission of PFCs resulting from anode effects are calculated by the GHGRP using given parameters on anode effect minutes and metal production, as well as a smelter specific or default slope coefficient for

---

[501] Prebake carbon anodes are anodes that are produced prior to being used in the smelting process, whereas Søderberg anodes are baked in the smelting pot during the smelting process. In the United States, all producers use prebake carbon anodes. Pitch volatiles, typically made from methane, tar, and hydrogen, are used to heat-treat green anodes during the anode baking process. For more information on anode baking, see chapter 2 ("Primary Unwrought Aluminum Production").

[502] A CEMS measures the concentration and rate of gas or particulate matter being emitted from a production facility. Analogous to steel, CEMS devices will often collect GHG emissions information covering both process and fuel combustion emissions.

[503] 40 C.F.R § 98.63(g); Table F-2 to Subpart F of Part 98, Title 40.

[504] Carbon anodes are called "green anodes" before they are baked. 40 C.F.R § 98.63(f).

[505] EPA, "Reporting of Greenhouse Gases for Aluminum Production," February 2018, 2. See also 40 C.F.R § 98.63(f).

[506] Table F-2 to Subpart F of Part 98, Title 40.

[507] 40 C.F.R § 98.63(e).

[508] Table F-2 to Subpart F of Part 98, Title 40.

perfluoromethane (also known as carbon tetrafluoride, or $CF_4$) emissions to anode effect minutes.[509] Monthly totals of anode effect minutes per cell-day, aluminum production, and a slope coefficient (either smelter specific or, under certain circumstances, a default value) relating $CF_4$ emissions to the prior two variables are used to estimate $CF_4$ from anode effects. This estimate of $CF_4$ is then combined with a mass ratio of perfluoroethane (also known as hexafluoroethane, or $C_2F_6$) to $CF_4$ to estimate $C_2F_6$ emissions.[510]

Beyond the sources of process emissions covered under the GHGRP, new research has revealed other potential sources of process emissions in the smelting of primary unwrought aluminum. While these other sources are not explicitly included in the GHGRP data the Commission uses for these estimates, these sources are described further in box E.1 for reference.

**Box E.1** Other Types of Aluminum Process Emissions not Incorporated in the Commission's Calculation

**Emissions from low voltage anode effects:** Depending on the level of the voltage change in the smelting pot, anode effects can be characterized as "low voltage" or "high voltage." Although Subpart F the U.S. Environmental Protection Agency's (EPA's) Greenhouse Gas Reporting Program (GHGRP) does not define what should constitute high- or low-voltage anode effects, it is commonly understood that low voltage anode effects occur below the 6–8 volt detection limit of most modern plant computers.[a] As low voltage anode effects and associated emissions are not currently detectable by most smelters, they were not required to be reported to the GHGRP in 2022 and are also not included within the estimates provided in this report.[b] A 2022 *Federal Register* notice on potential revisions to the GHGRP regulation noted that the EPA was considering an amendment to Subpart F to add reporting of emissions from low-voltage anode effects.[c] In April 2024, the EPA's final rule on amendments to the GHGRP regulation indicated that it would not be making changes to the measurement methodology at this time.[d]

**Cell startup emissions**: Emissions are also released when a new or refurbished smelting pot (or cell) is brought online and operated at a higher voltage to bring the pot up to operating temperature.[e] This increased voltage can produce additional perfluorocarbon (PFC) emissions, designated as "cell start-up emissions." As some operators do not begin measuring voltages and related emissions until the pot begins smelting aluminum, these emissions can go unrecorded.[f] As such, cell start-up emissions are also not explicitly included in the GHGRP reporting requirements and thus may often be excluded from the estimates provided in this report. Because no new potlines were built or old potlines restarted in 2022, cell start-up emissions were likely very small.[g] In 2022, the EPA requested comments on a potential amendment to Subpart F that would require the inclusion of cell startup emissions in future GHGRP reporting requirements.[h] As noted above, in April 2024, the EPA's final rule indicates it will not make changes to Subpart F calculations at this time.[i]

[a] Tabereaux, "Low Voltage Anode Effects and Unreported PFC Emissions," October 2016, 631.
[b] USITC, hearing transcript, December 7, 2023, 261 (testimony of Matt Aboud, Century Aluminum); Alcoa Corporation, written submission to the USITC, December 7, 2023, 8.
[c] 87 Fed. Reg. 36920, 37023 (June 21, 2022).
[d] 40 C.F.R. § 98; 89 Fed. Reg. 31802, 31822 (April 25, 2024).
[e] IAI, "IAI Good Practice Document on Measuring Perfluorocarbons," December 2020, 9.
[f] IAI, "IAI Good Practice Document on Measuring Perfluorocarbons," December 2020, 9.
[g] USGS, Mineral Commodity Summaries 2023: Aluminum, January 2023.
[h] 87 Fed. Reg. 118, 37023 (June 21, 2022).
[i] 40 C.F.R. § 98; 89 Fed. Reg. 31802, 31822 (April 25, 2024).

---

[509] Anode effects occur when an insufficient supply of alumina to the smelting pot causes a rapid spike in voltage in the pot, leading to the emission of gases containing PFCs. These effects are measured by duration in minutes. 40 C.F.R § 98.63(b).
[510] 40 C.F.R § 98.63(b).

# II.C. Energy-Related Emissions

This section provides more detail on how the Commission calculated scope 1 unit process emissions from fuel combustion ($S1FC\ UGHG_{product}$) and scope 2 unit process emissions from purchased energy ($S2\ UGHG_{product}$). The Commission's energy-related calculations incorporate facility-wide data and produce partial scope 1 and complete scope 2 emissions subprocess-specific estimates, further mapped to reference products' unit processes.[511] The scope 1 fuel combustion emissions described in this section are combined with the scope 1 process emissions to calculate total scope 1 estimates for each product category.

## II.C.1. Data Collected in the Questionnaire

As noted in chapter 3 ("Energy Emissions (Scopes 1 and 2)"), the Commission used a combination of data collected from section 3 (fuel combustion) and section 4 (purchased energy) of its questionnaire and public EPA data to calculate energy-related emissions. The types of data collected, where they were requested in the questionnaire, and whether they were used for scope 1 calculations, scope 2 calculations, or both are summarized in table E.7.

**Table E.7** Use of questionnaire data for scope 1 fuel combustion and scope 2 emissions calculations

| Data collected | Questionnaire questions | Used for scope 1 fuel combustion emissions | Used for scope 2 emissions |
|---|---|---|---|
| Fuel types and quantities combusted | 3.5, 3.6 | Yes | No |
| Quantity and sourcing of purchased electricity | 4.1, 4.2a, 4.4b, 4.5a | No | Yes |
| Quantity and sourcing of heat, steam, and hot water from third-party operated units | 3.2c–e, 3.3b, 4.7 | No | Yes |
| On-site generation of electricity, heat, steam, and hot water by the facility operator; use of fuels in these operations | 3.2c–e, 3.3c, 3.4c–e; 3.7 | Yes | No |
| Subprocess-specific use of fuels, electricity, steam, heat, and hot water | 3.8–3.12 | Yes | Yes |

Source: Compiled by the USITC; USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 3.1–4.7.

Note: Qualitative responses to additional questionnaire questions (such as 3.13 and 4.4e) were also used to inform data cleaning and the emissions calculations. The questionnaire sources list does not include filter questions. The Commission did not receive any relevant responses to questionnaire questions 4.4f or 4.5b.

For the main results presented in chapters 4 and 5, data from questions 4.4b and 4.5a were only used when the electricity was reported as supplied via a direct-line connection. The calculations used the 4.4b and 4.5a data, as well as data from questions 3.4b, 4.3c, and 4.3d for the market-based method sensitivity analysis presented in appendix F ("Market-Based Method").

The requests from the USTR letter to use available facility-level data and to measure product-specific emissions across the entire U.S. industry required development of a method to disaggregate the facility-level emissions data to product-specific data. For facilities that only produced one category of products or that already had energy meters on different production lines, these data were typically directly

---

[511] See "I. Overview of Product-Level Emissions Intensity and Inventory Calculations."

measured and could be pulled from company records.[512] However, for many other facilities, any product-specific allocations of energy use needed to be estimated.[513] During questionnaire development, industry representatives suggested that the methodology for estimating these allocations was best left to each facility respondent, rather than adopting a single methodology and applying it to a range of facilities making different products and using different manufacturing processes and equipment.[514] To make these allocations less burdensome for questionnaire respondents, the Commission designed the questionnaire to collect energy use allocations for a short list of subprocesses rather than each product category. As discussed further in "Computing Product-Level Emissions Inventories," when facilities used the same production subprocess to make multiple covered products, the Commission divided the subprocess-specific emissions proportionally among the product categories based on the relative tonnage of production.

The Commission's questionnaire asked respondents to estimate allocations of the amounts of fuel combustion (by each fuel type; question 3.8); electricity (question 3.9); and useful thermal outputs of steam, heat, and hot water (questions 3.10–3.12) used in different subprocesses. These subprocesses fell into one of four categories, listed below. Table E.8 then presents the categorization for each subprocess.

- Subprocesses associated with upstream material inputs for covered steel and aluminum production
- Subprocesses associated with different types of covered steel and aluminum production
- Subprocesses associated with building-wide energy use that may support multiple categories of production (including noncovered production)
- Subprocesses associated with noncovered production, activities unrelated to the facility's production of covered steel or aluminum, or activities that are otherwise outside of the Commission's system boundaries for covered steel and aluminum production

Categories A and B are both in-scope subprocesses whose emissions are ultimately allocated to this report's product-specific emissions for covered steel and aluminum. Category C only applies to one subprocess (energy use for ambient heating, cooling, ventilation, and lighting supply), whose emissions are redistributed among other subprocesses as the last step to arrive at unit process emissions for scope 1 fuel combustion and scope 2 energy emissions. Category D subprocesses are treated as out of scope; the energy use and the resulting emissions associated with these subprocesses are not included in the product-specific emissions estimates in this report.

---

[512] U.S. industry representative, interview by USITC staff, August 1, 2023.

[513] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 3.13; USITC, hearing transcript, December 7, 2023, 77–78 (testimony of Joe Green, SSINA).

[514] USITC, hearing transcript, December 7, 2023, 146 (testimony of Jeff Hansen, SDI); 147-148 (testimony of John Hill, Cleveland-Cliffs); 149–150 (testimony of Kevin Dempsey, AISI); 150-151 (testimony of Roger Schagrin, Schagrin Associates).

**Table E.8** Subprocesses used for energy allocations (as presented in questions 3.8–3.12) and their categorization and industry

Category A is for in-scope production of material inputs, Category B is for in-scope production of covered products, Category C is for a facility-wide subprocess that is reallocated among the facility's production subprocesses (both in scope and out of scope), and Category D is for out-of-scope subprocesses. BOF = blast oxygen furnace; EAF = electric arc furnace.

| Subprocess | **Category** | **Industry** |
|---|---|---|
| Stationary equipment that shreds or sorts scrap | D | Aluminum and Steel |
| Anode baking for primary unwrought aluminum production | A | Aluminum |
| Smelting of primary unwrought aluminum | B | Aluminum |
| Casting of primary unwrought aluminum | B | Aluminum |
| Secondary unwrought aluminum production | B | Aluminum |
| Wrought aluminum production | B | Aluminum |
| Metallurgical coke production | A | Steel |
| Lime and dolime production | A | Steel |
| Iron sinter production | A | Steel |
| Production of oxygen, nitrogen, argon, or hydrogen | A | Steel |
| Liquid pig iron production in a rotary hearth furnace | A | Steel |
| Blast furnace operations, including pig iron casting | A | Steel |
| Steelmaking, including BOF or EAF operations, preheating ferrous scrap, refining/ladle station, decarburization, and casting | B | Steel |
| Remelting and further working of previously cast semifinished steel into different forms of semifinished steel | B | Steel |
| Hot-rolling flat steel products | B | Steel |
| Cold-rolling flat steel products | B | Steel |
| Coating, cladding, or plating flat steel products | B | Steel |
| Production of seamless tubular products | B | Steel |
| Production of non-seamless tubular products | B | Steel |
| Hot-working long steel products | B | Steel |
| Cold-forming or cold-finishing long steel products | B | Steel |
| Processes used to make products other than covered steel, covered aluminum, or their upstream material inputs | D | Aluminum and Steel |
| Activities of other producers operating on-site | D | Aluminum and Steel |
| Ambient heating, cooling, ventilation, and lighting supply in facilities where production occurs, if measured separately from the process-specific fuel use reported above | C | Aluminum and Steel |
| Ancillary (non-production) activities that are not associated with production floor operations | D | Aluminum and Steel |

Source: Subprocesses listed in USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, section 3.

The energy calculations deliberately start with facility-wide emissions estimates derived from measured data points such as facility-wide natural gas combustion and total purchased electricity (both metered data points that can be obtained from billing records). This limits reliance on the less precise subprocess-specific estimates to calculations for facilities that use multiple types of production subprocesses (e.g., hot-rolling flat steel and cold-rolling flat steel) or have both in-scope and out-of-scope activities (e.g., have in-scope production and on-site wastewater treatment). The Commission conducted extensive checks for outliers, outreach to questionnaire respondents, and data cleaning to improve the accuracy of these allocations.

## II.C.2. Energy Calculations for Facilities with Less Complicated Energy Sourcing

The Commission’s calculations were designed to cover all types of energy sourcing situations, including situations that applied only to one facility or a handful of facilities in the survey population. Rather than present this full set of calculations at once, this section starts with an explanation of how the energy calculations worked for most facilities producing covered steel and aluminum products in 2022 (i.e., those without the uncommon sourcing situations). However, this set of calculations does not fully cover the calculations applied to some of the largest U.S. steel and aluminum producers. These more complicated calculations—applied to facilities that reported fuel combustion emissions from a continuous emissions monitoring system (CEMS); generated electricity on-site; or generated or purchased steam, heat, or hot water for their production operations—are covered later in the section.

The energy calculations start by measuring scope 1 fuel combustion emissions. First, the calculations estimate the facility’s total GHG emissions from fuel combustion for each fuel type combusted. For most facilities, this only consists of natural gas emissions. Second, the calculations use questionnaire data on how much fuel was used in each subprocess to estimate subprocess-specific shares of fuel use, for each fuel type combusted. The fuel combustion emissions are then multiplied by the subprocess-specific shares to calculate subprocess-specific fuel combustion emissions. When multiple fuel types are used, the calculations sum all fuel combustion emissions for each subprocess.

Next, the calculations pivot to scope 2 emissions. As with the scope 1 fuel combustion emissions, the scope 2 part of the energy calculations first estimates a facility-wide total. For the simple version of the scope 2 emission calculations, the calculations multiply total purchased electricity reported in the questionnaire by the emissions factor for the facility’s eGRID subregion (as discussed in chapter 3, “Scope 2 Emissions”). The calculations then use questionnaire data on how much electricity was used in each subprocess to estimate subprocess-specific shares of electricity use. After that, the calculations multiply the subprocess-specific shares by the facility-wide emissions from purchased electricity to obtain subprocess-specific scope 2 emissions estimates.

Finally, the calculations reallocate subprocess-specific fuel combustion and electricity estimates from the questionnaire for “ambient heating, cooling, ventilation, and lighting supply in facilities where production occurs, if measured separately from the other fuel use” among in-scope production subprocesses and out-of-scope production, using the physical allocation approach.[515] For example, a facility reporting 10 mt of production of aluminum castings and 20 mt of bronze castings would have one-third of its scope 1 fuel combustion emissions for ambient energy use added to its scope 1 fuel combustion emissions for the unit process “wrought aluminum production.”[516]

---

[515] USITC, *Greenhouse Gas (GHG) Emissions Intensity Questionnaire: Facility-Level*, 2024, section 3.

[516] Questionnaire respondents were provided the option of allocating their energy used for the general building temperature control, ventilation, and lighting directly to production subprocesses rather than reporting it separately. This flexibility was provided in recognition that a facility’s data on its energy use for specific subprocesses can vary considerably, may be measured directly for all subprocesses or for just some subprocesses, or may need to be estimated for anything below a facility-wide measure. Allocating ambient energy use based on relative tonnage may not always accurately capture the product category’s relative use of building space and

### II.C.2.a Calculating Facility-Wide Scope 1 Fuel Combustion Emissions

As a first step, the energy calculations total estimates for facility-wide fuel combustion, separated by fuel type. When facilities reported no on-site fuel combustion (questionnaire question 3.5), the calculations set scope 1 fuel combustion emissions to zero. For facilities that reported on-site fuel combustion, the calculation step follows two different paths, depending on whether the facility reported 2022 data to the EPA's GHGRP.

When a facility reported 2022 data to the GHGRP, the calculations use the public GHGRP ID to match the facility to its EPA data.[517] As noted in chapter 3 ("Scope 1 Fuel Combustion Emissions"), most of the GHGRP data in subpart C is available as fuel-specific and unit-specific values for $CO_2$, methane, and nitrous oxide (with the latter two gases measured in $CO_2e$). The calculations aggregate these values to fuel-specific, facility-wide GHG emission totals. For facilities producing covered steel products, GHGRP reporters comprised about 98 percent of total facility-wide fuel combustion emissions. For facilities producing covered aluminum products, GHGRP reporters comprised about 82 percent of total facility-wide fuel combustion emissions.[518]

When facility-specific 2022 GHGRP data are not available, the calculations instead apply fuel-specific direct emissions factors used by the GHGRP to the fuel type and quantity data reported in the questionnaire.[519] The calculations combine several different GHGRP factors for these estimates: gross heat content to convert fuel quantities from volume or mass to thermal energy; $CO_2$, methane, and nitrous oxide emissions factors to estimate the direct emissions from fuel combustion; and global warming potentials to convert the methane and nitrous oxide emissions to $CO_2e$ emissions.[520]

The first GHGRP factor used is the gross heat content for each fuel type (also referred to as high heating value or higher heating value), measured in million British thermal units (MMBtu) per unit of volume or weight. This is an estimate based on the average U.S. heat content of a given fuel type, so it is not as precise as conversions between units that are measuring the same thing (e.g., converting liters to gallons or short tons to kilograms). Because natural gas is sometimes billed and metered based on its heat content, the questionnaire allowed respondents to directly report natural gas quantities in MMBtu or therms (a different measure of heat content equivalent to approximately 0.1 MMBtu). More than half of the non-GHGRP reporting facilities reporting natural gas use reported natural gas in thermal energy units (MMBtu or therms). The calculations only applied the GHGRP's average gross heat content for U.S. natural gas to the non-GHGRP-reporting facilities that reported natural gas in standard cubic feet. The calculations also applied fuel-specific average heat content values to the 11 other fuel types that non-GHGRP facilities reported in their questionnaire responses, but these were a small minority of the fuel combustion emissions. Fewer than 50 non-GHGRP-reporting facilities reported combusting liquefied

---

impact on heating, cooling, lighting, and ventilation demand. However, it allows for an approximate allocation across all relevant production categories while relying on questionnaire data that was also used for other purposes (minimizing respondent burden).

[517] EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024.

[518] USITC estimates based on its calculation methodology. See appendix F ("Greenhouse Gas Reporting Program Reporters Only") for more analysis on how data for facilities reporting to the GHGRP compared to data for the Commission's full survey population.

[519] See table G.1 in appendix G for the fuel combustion emissions factors used for non-GHGRP reporters.

[520] Table A-1 to Subpart A and Tables C-1 and C-2 to Subpart C of Part 98, Title 40.

propane, and the 10 other fuel types (diesel, heavy gas oil, kerosene, liquefied petroleum gas, motor gasoline, propane gas, propylene, residual fuel oil, used oil, and other oil) were each rarely reported by non-GHGRP-reporting facilities.[521]

Second, the Commission constructed a fuel-specific GHG emissions factor, using the GHGRP's direct emissions factors (converted from kilograms to metric tons; $CO_2EF_{fuel}$, $CH_4EF_{fuel}$, and $N_2OEF_{fuel}$) and the global warming potentials for $CO_2$, methane, and nitrous oxide emissions.[522] For each fuel type, $CO_2EF_{fuel}$ determines nearly all of the constructed GHG emissions factors. The methane and nitrous oxide emissions factors were significantly smaller and were not as differentiated. The only distinction provided in the GHGRP's emissions factors for these GHGs is between the emissions factors for natural gas and the emissions factors to apply to all petroleum products (covering the 11 other fuel types mentioned above). Before adding the methane and nitrous oxide emissions factors to the $CO_2$ emissions factor, the calculations convert the emissions factors to a $CO_2e$ measure. This last conversion uses the global warming potential factors in GHGRP table A-1, which notes that methane emissions are 25 times as potent ($CH_4GWP$) and nitrous oxide emissions are 298 times as potent ($N_2OGWP$) as a metric ton of $CO_2$ emissions, respectively, based on a 100-year time horizon.[523]

Third, equation E.6 multiplied the fuel quantity in MMBtu ($use_{fuel}$) reported in question 3.6 by the fuel-specific $CO_2e$ emissions factor. The resulting estimates are facility-wide GHG emissions from each fuel type combusted ($facilityGHG_{fuel}$), effectively applying a GHGRP Tier 1 approach to the questionnaire data. These non-GHGRP reporter facility-wide fuel combustion emissions then follow the same energy calculation steps as the fuel combustion emissions for GHGRP-reporting facilities.

$$\begin{aligned} facilityGHG_{fuel} = use_{fuel} * [CO_2EF_{fuel} + \left(CH_4EF_{fuel} * CH_4GWP\right) \\ + (N_2OEF_{fuel} * N_2OGWP)] \end{aligned} \qquad (E.6)$$

---

[521] For non-GHGRP facilities producing covered steel products and for non-GHGRP facilities producing covered aluminum products, nearly all of the emissions associated with facility-wide fuel combustion came from natural gas. USITC estimates based on its calculation methodology.

[522] Table A-1 to Subpart A and Tables C-1 and C-2 to Subpart C of Part 98, Title 40.

[523] See chapter 1 ("Introduction to GHG Emissions") for more information on global warming potentials and time horizons. Table A-1 to Subpart A of Part 98, Title 40.

**Box E.2** Effects of Using Alternate Global Warming Potentials

This report uses a consistent set of global warming potential (GWP) factors from the U.S. Environmental Protection Agency's Greenhouse Gas Reporting Program (GHGRP) to convert emissions from methane ($CH_4$), nitrous oxide ($N_2O$), and perfluorocarbons ($C_2F_6$ and $CF_4$) into a single carbon dioxide equivalent value. These GHGRP factors match the factors published by The United Nations' Intergovernmental Panel on Climate Change (IPCC) in its 4th Assessment Report.[a] Box table 1 presents GHG-specific data aggregated across all facilities that responded to the Commission's questionnaire and reported to the GHGRP in 2022, before the GWP factors were applied.

**Box Table 1:** Total emissions from the GHGRP for facilities producing covered steel products and facilities producing covered aluminum products

In metric tons (mt), —(em dash)= not applicable.

| Facility type | $CO_2$ | $CH_4$ | $N_2O$ | $C_2F_6$ | $CF_4$ |
|---|---|---|---|---|---|
| Steel facilities | 49,380,294 | 288.8 | 41.5 | — | — |
| Aluminum facilities | 9,311,517 | 647.3 | 91.8 | 7.5 | 93.8 |

Source: EPA, OAP, GHGRP, 2022 Data Summary Spreadsheets, accessed October 2, 2024.

Note: Data in this table exclude GHGRP emissions from subpart TT (industrial waste landfills), which were outside of this report's system boundaries for steel and aluminum production. Otherwise, the data directly reflect a total of the GHGRP's emissions data across all facilities that reported to the GHGRP in 2022 and responded to the Commission's questionnaire for this investigation.

Box table 2 below presents a summary of these emissions data from steel and aluminum facilities after the data were converted to metric tons of carbon dioxide equivalent (mt $CO_2e$) using the GWP factors from the GHGRP, which are the factors used in the analysis in the main text of this report. For steel facilities, over 99.9 percent of the GHG emissions (in mt $CO_2e$) sourced from the GHGRP data came from $CO_2$. For aluminum facilities, about 91.8 percent of the GHG emissions sourced from the GHGRP data came from $CO_2$ and another 7.7 percent came from $C_2F_6$ and $CF_4$ at primary aluminum smelters.

**Box Table 2:** Total emissions from the GHGRP for facilities producing covered steel products and facilities producing covered aluminum products

In metric tons of carbon dioxide equivalent (mt $CO_2e$), and percentages (%);—(em dash)= not applicable.

| GHG | GHGRP GWPs used in the report | Steel facility emissions (mt $CO_2e$) | GHG share of steel facility emissions (%) | Aluminum facility emissions (mt $CO_2e$) | GHG share of aluminum facility emissions (%) |
|---|---|---|---|---|---|
| $CO_2$ | 1 | 49,380,294 | 99.96 | 9,311,517 | 91.8 |
| $CH_4$ | 25 | 7,221 | 0.01 | 16,183 | 0.2 |
| $N_2O$ | 298 | 12,360 | 0.03 | 27,344 | 0.3 |
| $C_2F_6$ | 12,200 | — | —. | 91,250 | 0.9 |
| $CF_4$ | 7,390 | — | — | 693,221 | 6.8 |
| Total | — | 49,399,875 | 100.0 | 10,139,515 | 100.0 |

Sources: EPA, OAP, GHGRP, 2022 Data Summary Spreadsheets, accessed October 2, 2024; 40 C.F.R., table A-1 to subpart A of part 98.

Note: Data in this table exclude GHGRP emissions from subpart TT (industrial waste landfills), which were outside of this report's system boundaries for steel and aluminum production. Otherwise, the data directly reflect the GHGRP's facility-wide totals across all facilities that reported to the GHGRP in 2022 and responded to the Commission's questionnaire for this investigation.

However, there is not a single, authoritative set of GWP factors to use. The United Nations' Intergovernmental Panel on Climate Change (IPCC) releases updated GWP factors in each of its Assessment Reports, adjusted to reflect more recent research on the impacts of these gases.[b] The IPCC's Assessment Reports also do not always provide a single GWP for each gas. For example, the 5th Assessment Report provides different GWP factors to use for $CH_4$ depending on the time horizon (20-year versus 100-year), whether the $CH_4$ comes from fossil fuel or biogenic sources, and whether certain indirect effects (referred to as climate-carbon feedbacks) are included. For the 20-year time horizon, these GWPs for $CH_4$ range from 84 to 87; for the 100-year time horizon, they range from 28 to 36.[c]

Because $CO_2$ comprises the vast majority of GHGs associated with these facilities in tonnage terms, applying a much higher GWP for $CH_4$ to the data above does not substantially affect the overall total of these emissions in carbon dioxide equivalent terms. For example, if a 20-year time-horizon GWP of 87 were used, $CH_4$ emissions across all GHGRP-reporting facilities that produced covered steel products would only increase by 17,907 mt $CO_2e$ (less than 0.1 percent of the total GHG emissions).[d] For GHGRP-reporting facilities that produced covered aluminum products, $CH_4$ emissions would increase by 40,134 mt $CO_2e$ (about 0.4 percent of the total GHG emissions).[e] For facilities that did not report to the GHGRP, natural gas was responsible for almost all the scope 1 fuel combustion emissions; applying the higher $CH_4$ GWP factor would have increased those natural gas combustion emissions by about 0.1 percent.[f]

---

[a] 40 C.F.R., table A-1 to subpart A of part 98 (2024); Solomon et al., Technical Summary of AR4, 2007, 33.

[b] One example of this is that the measurement of climate-carbon feedback in the $CH_4$ factors changed between two of the IPCC reports. Myhre et al., "Anthropogenic and Natural Radiative Forcing," 2013, 713–14; Forster et al., "The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity," 2021, 1013 and 1017.

[c] The IPCC released updated GWPs in 2021 in its 6th Assessment Report, but the 5th Assessment Report's 100-year time-horizon GWPs are being used by parties to the Paris Agreement (providing comparability with national inventory data from earlier years). UNFCCC, "National Inventory Reports," accessed October 15, 2024; UNFCCC, Report of the COP24, May 14, 2019, 25; Myhre et al., "Anthropogenic and Natural Radiative Forcing," 2013, 713 and 741; Forster et al., "The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity," 2021, 117.

[d] Total GHG emissions for these comparisons only apply a 20-year GWP to $CH_4$ and use the 100-year GHGRP GWPs for all other gases. While $CH_4$ has a lifetime of less than 20 years, $N_2O$, $C_2F_6$, and $CF_4$ all have lifetimes over 100 years. Therefore the 20-year GWPs for these other GHGs are lower than the 100-year GWPs. Solomon et al., Technical Summary of AR4, 2007, 33.

[e] Over 90 percent of the $CH_4$ emissions in the GHGRP data from aluminum facilities come from a single aluminum smelter's coal use. The coal is used in a utility-scale, coal-fired power plant that sells some excess electricity back to the grid, so these emissions overstate how much CH4 is allocated to U.S. aluminum production. EPA, OAP, GHGRP, 2022 Data Summary Spreadsheets, accessed October 2, 2024; EPA, OAP, GHGRP, FLIGHT database, "2022 Greenhouse Gas Emissions from Large Facilities," accessed October 2, 2024; FERC, "Order Granting in Part and Denying in Part Requests for Waiver, Docket No. ER20-1580-000," July 16, 2020, 3–4.

[f] Each MMBtu of natural gas combusted at a facility that did not report to the GHGRP was assumed to result in 5.306 x 10-2 mt $CO_2$, 10-6 mt $CH_4$, and 10-7 mt $N_2O$. When taken together, the GHGRP's Tier 1 default emissions factors and GWP factors that were used for non-GHGRP facilities assume that $CO_2$ is responsible for 99.9 percent of the GHG emissions from combusting natural gas. USITC estimates based on its calculation methodology; 40 C.F.R., tables C-1 and C-2 to subpart C of part 98.

## II.C.2.b Allocating Fuel Combustion Emissions to Subprocesses

For facilities with simple energy sourcing, facility-wide scope 1 fuel combustion emissions are allocated to subprocesses in two steps (equations E.7 and E.8). After estimating the facility-wide emissions from each type of fuel combusted ($facilityGHG_{fuel}$), the calculations use proportional shares of fuel use by subprocess from questionnaire question 3.8 ($\Sigma_{subproc}\left(use_{fuel,subproc}\right)$) to develop fuel-specific estimates for subprocess-specific fuel combustion emissions ($S1FC_{fuel,subproc}$) (equation E.7). Second, for each subprocess, the emissions are totaled across all fuel types ($\Sigma_{fuel}\left(S1FC_{fuel,subproc}\right)$), resulting in subprocess-specific emissions ($S1FC_{subproc}$) (equation E.8).

$$S1FC_{fuel,subproc} = facilityGHG_{fuel} * \frac{use_{fuel,subproc}}{\Sigma_{subproc}\left(use_{fuel,subproc}\right)} \qquad (E.7)$$

$$S1FC_{subproc} = \Sigma_{fuel}\left(S1FC_{fuel,subproc}\right) \qquad (E.8)$$

### II.C.2.c Calculating Facility-Wide Scope 2 Emissions

For facilities with simple energy sourcing, equation E.9 estimates scope 2 emissions by multiplying the total quantity of electricity purchased from question 4.1 ($purch_{elec}$) by the confirmed eGRID subregion for the facility from question 4.2a ($eGRID_{srl}$).[524]

$$facilityGHGS2 = purch_{elec} * \; eGRID_{srl} * \frac{1}{2{,}204.62} \qquad (E.9)$$

### II.C.2.d Allocating Scope 2 Emissions to Subprocesses

As with fuel combustion emissions, equation E.10 uses proportional shares of energy use—this time from questionnaire question 3.10—to develop subprocess-specific estimates for scope 2 ($S2_{subproc}$).

$$S2_{subproc} = facilityGHGS2 * \frac{use_{elec,subproc}}{\Sigma_{subproc}\left(use_{elec,subproc}\right)} \qquad (E.10)$$

### II.C.2.e Reallocating Emissions from Ambient Heating, Cooling, Ventilation, and Lighting Supply

As noted above, the Commission used a physical allocation to allocate any emissions from a subprocess that corresponds to multiple reference products (e.g., allocating scope 1 fuel combustion emissions from subprocess “wrought aluminum production” to reference products forgings and castings based on facility production tonnage). The approach to allocate scope 1 fuel combustion and scope 2 energy emissions from ambient heating varies slightly to ensure emissions are allocated to any out-of-scope production by dividing by a facility’s total production ($output$)(equation E.10).

$$S1FC_{ambient,product} = \left(S1FC_{ambient} * \frac{output_{product}}{output}\right) \qquad (E.11)$$

### II.C.2.f Unit Process Emissions from Scope 1 Fuel Combustion and Scope 2 Energy

To transform scope 1 fuel combustion and scope 2 energy emissions from all other subprocesses to the unit process level unique to each reference product, equations E.12.a and E.12.b multiply subprocess-specific emissions by the reference product’s share of total output corresponding to the subprocess.

$$S1FC_{subproc,product} = S1FC_{subproc} * \frac{output_{product}}{output_{subproc}} \qquad (E.12.a)$$

$$S2_{subproc,product} = S2_{subproc} * \frac{output_{product}}{output_{subproc}} \qquad (E.12.b)$$

Then, equations E.13.a and E.13.b add the emissions associated with energy use for ambient heating, cooling, ventilation, and lighting supply ($S1FC_{ambient,product}$, $S2_{ambient,product}$) to emissions from

---

[524] The calculations match the facility’s subregion to the 2022 default emissions factor for the subregion provided in eGRID, which is converted from pounds of $CO_2e$ per megawatt-hour (MWh) to metric tons of $CO_2e$ per MWh. The calculations use variable SRC2ERTA for the emissions factor, described as “eGRID subregion annual $CO_2$ equivalent total output emission rate (lb/MWh).” EPA, “SRL22,” January 30, 2024.

other subprocesses associated with on-site production activities for each reference product to arrive at scope 1 fuel combustion and scope 2 unit process emissions for the product-level inventories.[525]

$$S1FCUGHG_{product} = \sum_{subproc} S1FC_{subproc,product} \qquad (E.13.a)$$

$$S2UGHG_{product} = \sum_{subproc} S2_{subproc,product} \qquad (E.13.b)$$

## II.C.3. Energy Calculations for Facilities with More Complicated Energy Sourcing

### II.C.3.a Facility-Wide Fuel Combustion Emissions for GHGRP Reporters with CEMS Units

The EPA GHGRP's Subpart C data are available as fuel-specific and unit-specific emissions values for almost all the GHGRP-reporting U.S. steel and aluminum producers in the Commission's survey population. However, a few U.S. steel and aluminum producers have some fuel combustion emissions in Subpart C or D that are measured using a continuous emissions monitoring system (CEMS).[526] Unlike the rest of the subpart C and D emissions data, the $CO_2$ emissions from CEMS units are not separated out by fuel type.[527] When the CEMS unit combusted a single fuel type, all the CEMS unit emissions were allocated to that fuel type (equation E.14). When the unit used multiple fuels, the Commission used public data from the GHGRP on the annual heat input from natural gas ($CEMSheat_{natgas}$) and the GHGRP's direct $CO_2$ emissions factor for natural gas ($CO_2EF_{natgas}$) to estimate the unit's $CO_2$ emissions from natural gas combustion.[528] Equation E.15 subtracts this natural gas emissions value from the CEMS unit's total $CO_2$ emissions ($CEMSCO_2$) and assigns the remainder to the other fuel type used. These CEMS-specific emissions are combined with any Tier 1, 2, and 3 data from the facility for each fuel type ($facilityT1GHG_{fuel}, facilityT2GHG_{fuel}, facilityT3GHG_{fuel}$) as well as the fuel-specific $CH_4$ ($facilityT4CH_{4\,fuel}$) and $N_2O$ emissions ($facilityT4N_2O_{fuel}$) from the CEMS unit. This results in facility-wide, fuel-specific totals.

$$\begin{aligned} facilityGHG_{natgas} &= facilityT1GHG_{natgas} + facilityT2GHG_{natgas} + facilityT3GHG_{natgas} \\ &\quad + \left(CEMSheat_{natgas} * CO_2EF_{natgas}\right) + facilityT4CH_{4\,natgas} + facilityT4N_2O_{natgas} \qquad (E.14) \end{aligned}$$

---

[525] Table E.1 in the "I. Overview of Product-Level Emissions Intensity and Inventory Calculations" section in this appendix details the mapping of subprocesses to their corresponding reference products.

[526] Subpart D of the GHGRP is for certain electricity generating units; GHGRP-reporting facilities that use fuel combustion for electricity generation but do not meet subpart D reporting requirements instead report these emissions in subpart C. Only one facility producing covered steel or aluminum products reported subpart D emissions in 2022, and the facility reported all of these emissions using a CEMS unit. These subpart D emissions were included in the scope 1 fuel combustion emission calculations. 40 C.F.R. § 98.30(a), 98.30(b)(5), and 98.42; EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024.

[527] 40 C.F.R. § 98.36(b)(9).

[528] Table C-1 to Subpart C of Part 98, Title 40; EPA, OAP, "FLIGHT Database, 2022 Greenhouse Gas Emissions from Large Facilities," Accessed various dates.

$$facilityGHG_{otherfuel} = facilityT1GHG_{otherfuel} + facilityT2GHG_{otherfuel} + facilityT3GHG_{otherfuel} + CEMSCO_2 - \left(CEMSheat_{natgas} * CO_2EF_{natgas}\right) + facilityT4CH_{4_{natgas}} + facilityT4N_2O_{natgas} \qquad (E.15)$$

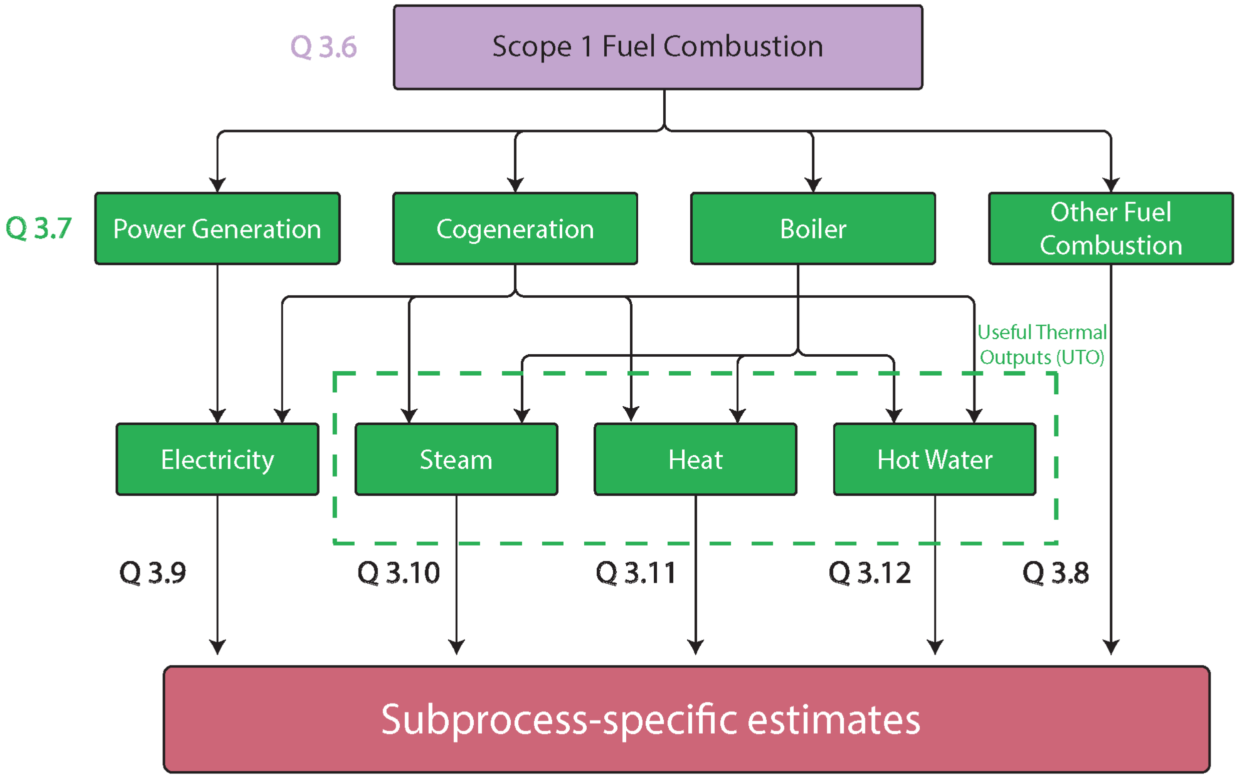
### II.C.3.b Fuel Combustion Emissions for Facilities with On-Site Generation or Boiler Units

Some facilities use on-site fuel combustion to run power generation, cogeneration, or boiler units, and then use the resulting electricity, steam, heat, and hot water in various subprocesses. These facilities may also source additional energy from off-site, particularly for electricity. Within the facility, however, there is no difference between consuming the portion of energy sourced from on-site units and consuming the portion of energy purchased from a third party.[529] For this reason, the calculations assume that the proportional use of each energy type is the same across all sources—e.g., that electricity from an on-site unit and electricity sourced from the grid was used in the same proportions as the facility-wide data in question 3.9 for each subprocess. The questionnaire required facilities that reported the use of on-site power generation, cogeneration, or multipurpose nonelectric boiler units to first allocate fuel use among these units and all other on-site fuel combustion in question 3.7. For these facilities, the subprocess-specific quantities of fuel use reported in question 3.8 only represented fuel that was not first combusted in the generation or boiler units, to avoid double counting. The calculations instead used data in questions 3.9 through 3.12 on subprocess-specific use of electricity, steam, heat, and hot water to allocate the emissions from the power generation, cogeneration, and boilers to subprocesses. This mapping of fuel combustion in power generation, cogeneration, boiler units, and all other fuel combustion to electricity, steam, heat, hot water, and question 3.8 fuel use to develop subprocess-specific emission estimates is shown in figure E.1, below.

---

[529] Subject matter expert, interview by USITC staff, August 24, 2023.

**Figure E.1** Mapping of facility-wide scope 1 fuel combustion emissions to subprocess-specific estimates



Source: Compiled by the USITC.
Note: The "Q" labels in the diagram above indicates the question number in the Commission's facility-level questionnaire gathering this information. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, section 3.

Calculating the subprocess-specific emissions for other fuel combustion (from question 3.7) is similar to the subprocess-specific fuel combustion calculation for facilities with less complicated energy sourcing. The only difference is that the facility-wide emissions are multiplied by an additional ratio to remove the fuel-specific emissions associated with generation and boiler units (equation E.16). This ratio is the amount of fuel used in all other on-site fuel combustion in question 3.7 ($use_{fuel,othercom}$) divided by the total fuel use reported in question 3.7 ($\Sigma_{unit}(use_{fuel,unit})$).

$$S1FC_{fuel,othercom,subproc} = facilityGHG_{fuel} * \frac{use_{fuel,othercom}}{\Sigma_{unit}(use_{fuel,unit})} * \frac{use_{fuel,subproc}}{\Sigma_{subproc}\,(use_{fuel,subproc})} \quad (E.16)$$

As shown in figure E.1, fuel combustion quantities from question 3.7 ($use_{fuel,power}$, $use_{fuel,cogen}$, $use_{fuel,boiler}$) determine the share of the facility-wide, fuel-specific emissions to apply to the facility's power generation, cogeneration, and boiler units, respectively. Cogeneration units produce a mix of electricity and useful thermal outputs (steam, heat, and hot water), and boilers may produce more than one type of useful thermal output. Equations E.17–E.19 first compute the fuel combustion emissions for each of these units ($S1FC_{fuel,power}$, $S1FC_{fuel,cogen}$, $S1FC_{fuel,boiler}$), before further allocating the unit emissions to their different energy outputs.

$$S1FC_{fuel,power} = facilityGHG_{fuel} * \frac{use_{fuel,power}}{\Sigma_{unit}(use_{fuel,unit})} \quad (E.17)$$

$$S1FC_{fuel,cogen} = facilityGHG_{fuel} * \frac{use_{fuel,cogen}}{\Sigma_{unit}\left(use_{fuel,unit}\right)} \qquad (E.18)$$

$$S1FC_{fuel,boiler} = facilityGHG_{fuel} * \frac{use_{fuel,boiler}}{\Sigma_{unit}\left(use_{fuel,unit}\right)} \qquad (E.19)$$

The fuel-specific emissions for each unit are then totaled across fuel types to estimate total fuel combustion emissions for each unit. The formula for power generation units is shown as an example in equation E.20.

$$S1FC_{power,elec} = \Sigma_{fuel}\left(S1FC_{fuel,power}\right) \qquad (E.20)$$

Before estimating subprocess-specific scope 1 emissions from electricity use, the calculations split apart emissions from cogeneration units between electricity $\left(S1FC_{cogen,elec}\right)$ and useful thermal outputs $\left(S1FC_{cogen,nonelec}\right)$. The DOE's identification number for the facility's cogeneration units, as reported in question 3.3c, is used to identify the unit's electric allocation factor ($elecfactor_{plant}$) in eGRID's plant-level data.[530] Equation E.21 uses this factor to estimate the share of the cogeneration unit's emissions associated with the unit's electric power output ($S1FC_{cogen,elec}$).

$$S1FC_{cogen,elec} = S1FC_{cogen} * elecfactor_{plant} \qquad (E.21)$$

For any facilities generating more electricity than they used at the facility, the questionnaire allowed a negative value to be reported in question 4.1 for electricity purchases. Equations E.22.a and E.22.b calculate scope 1 fuel combustion emissions associated with electricity for facilities with negative net purchases and positive net purchases, respectively. Equation E.22.a incorporates the ratio of electricity used on-site, where $purch_{elec}$ represents negative net purchases (electricity sold off-site) and ($gen_{power,elec} + gen_{cogen,elec}$) is the sum of on-site electricity generation reported in question 3.3.

$If\ purch_{elec} < 0$:

$$S1FC_{elec} = \frac{\left(gen_{power,elec} + gen_{cogen,elec} + purch_{elec}\right)}{gen_{power,elec} + gen_{cogen,elec}} \left(S1FC_{cogen,elec} + S1FC_{power,elec}\right) \quad (E.22.a)$$

*Else:*

$$S1FC_{elec} = S1FC_{cogen,elec} + S1FC_{power,elec} \qquad (E.22.b)$$

Then, equation E.23 allocates facility-wide scope 1 electricity generation emissions ($S1FC_{elec}$) to subprocesses ($S1FC_{elec,subproc}$).

$$S1FC_{elec,subproc} = S1FC_{elec} * \frac{use_{elec,subproc}}{\Sigma_{subproc}\left(use_{elec,subproc}\right)} \qquad (E.23)$$

The next set of equations split emissions from non-electric cogeneration ( $S1FC_{cogen,nonelec}$) and boiler units ($S1FC_{boiler}$) to develop emissions estimates for steam, heat, and hot water use. Non-electric cogeneration emissions are the total emissions associated with on-site generation of useful thermal outputs (equations E.24 and E.25):

---

[530] Variables ORISPL and ELCALLOC. EPA, "PLNT22," January 30, 2024.

$$S1FC_{cogen,nonelec} = S1FC_{cogen} - S1FC_{cogen,elec} \tag{E.24}$$

$$S1FC_{cogen,nonelec} = S1FC_{cogen,uto} = S1FC_{cogen,steam} + S1FC_{cogen,hwater} + S1FC_{cogen,heat} \tag{E.25}$$

First, if a facility reported net sales of these outputs ($sold_{uto} > purch_{uto}$), equations E.26.a and E.27.a applied a ratio of thermal outputs used on-site ($gen_{cogen,uto} + gen_{boiler,uto} - sold_{uto} + purch_{uto}$) to outputs generated on-site ($gen_{cogen,uto} + gen_{boiler,uto}$).[531] This ratio removes the emissions associated with thermal outputs that were sold from the facility and used instead by third parties. When a facility sells more thermal output than it purchases, no scope 2 emissions are estimated for the quantity of purchased output; the quantity purchased is instead treated as if it were sourced from the facility's on-site generation of that thermal output. This is consistent with how electricity was treated (using data on net electricity purchases) and with GHG Protocol guidance.[532] In addition to adjusting for any net sales of thermal outputs, equations E.26 and E.27 proportionally break out emissions for cogeneration and boiler units based on the relative quantities of each type of thermal output produced from each unit (e.g., ($GEN_{cogen,uto}/\Sigma_{uto}(GEN_{cogen,uto})$)). Equations E.26 and E.27 are calculated for each of the types of useful thermal output (steam, heat, and hot water). Equation E.28 combines the emissions for each useful thermal output from cogeneration units with the emissions for that output from boiler units.

$$If\ sold_{uto} > purch_{uto}:$$

$$S1FC_{cogen,uto} = S1FC_{cogen,nonelec} * \frac{\left(gen_{cogen,uto} + gen_{boiler,uto} - sold_{uto} + purch_{uto}\right)}{gen_{cogen,uto} + gen_{boiler,uto}} * \frac{gen_{cogen,uto}}{\Sigma_{uto}(gen_{cogen,uto})} \tag{E.26.a}$$

$$Else:$$

$$S1FC_{cogen,uto} = S1FC_{cogen,nonelec} * \frac{gen_{cogen,uto}}{\Sigma_{uto}(gen_{cogen,uto})} \tag{E.26.b}$$

$$If\ sold_{uto} > purch_{uto}:$$

$$S1FC_{boiler,uto} = S1FC_{boiler} * \frac{\left(gen_{cogen,uto} + gen_{boiler,uto} - sold_{uto} + purch_{uto}\right)}{gen_{cogen,uto} + gen_{boiler,uto}} * \frac{gen_{boiler,uto}}{\Sigma_{uto}(gen_{boiler,uto})} \tag{E.27.a}$$

$$Else: S1FC_{boiler,uto} = S1FC_{boiler} * \frac{gen_{boiler,uto}}{\Sigma_{uto}(gen_{boiler,uto})} \tag{E.27.b}$$

$$S1FC_{uto} = S1FC_{cogen,uto} + S1FC_{boiler,uto} \tag{E.28}$$

---

[531] Question 3.3 collected data on the quantities of thermal outputs generated from cogeneration and boiler units. Questions 3.4c-e and 3.3b collected data on sales and purchases of thermal outputs, respectively.

[532] WRI, *GHG Protocol Scope 2 Guidance*, 2015, 41. For a comparison of the GHG Protocol guidance and other methods, see "Other Standards Informing the Commission's Methodology Development."

Equation E.29 then allocates the estimates for scope 1 fuel combustion associated with the facility's generation of steam, heat, and hot water at on-site units ($S1FC_{uto}$) to each of the subprocesses. The allocations for steam, heat, and hot water were reported directly in questions 3.10–3.12 as estimated percentage shares ($useshare_{uto,subproc}$).[533]

$$S1FC_{uto,subproc} = S1FC_{uto} * useshare_{uto,subproc} \qquad (E.29)$$

Finally, equation E.30 totals the subprocess-specific estimates for scope 1 fuel combustion emissions ($S1FC_{subproc}$) from scope 1 electricity, steam, heat, hot water, and other fuel combustion. For fuel combustion not used in power generation, cogeneration, or boiler units, the subprocess-specific emissions are first totaled across all fuel types ($\Sigma_{fuel}\left(S1FC_{fuel,othercom,subproc}\right)$).

$$\begin{aligned} S1FC_{subproc} = \Sigma_{fuel}\left(S1FC_{fuel,othercom,subproc}\right) + S1FC_{elec,subproc} + S1FC_{steam,subproc} \\ + S1FC_{heat,subproc} + S1FC_{hwater,subproc} \end{aligned} \qquad (E.30)$$

From this point in the calculations, the allocation of any emissions from ambient heating and the aggregation of subprocesses to unit process emissions for scope 1 fuel combustion follow the same steps as with simpler facilities (equations E.11–E.13). These final steps yield scope 1 fuel combustion unit process emissions ($S1FCUGHG_{product}$) for the product-level emissions inventories.

## II.C.3.c Scope 2 Emissions for Facilities with Direct-Line Connections

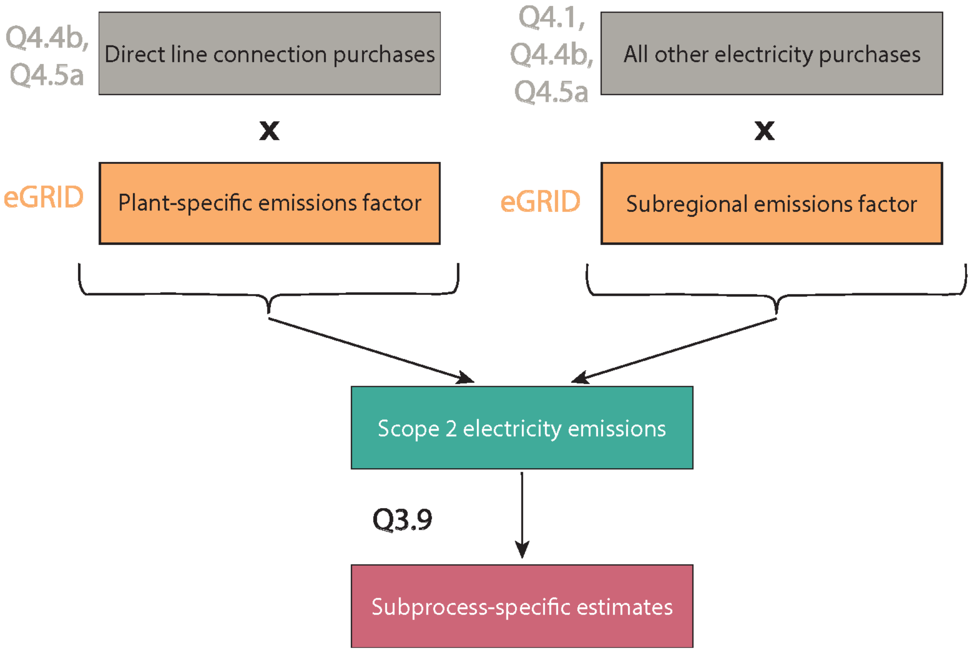
A small number of facilities reported purchasing electricity through a direct-line connection. As discussed in chapter 3 ("Scope 2 Emissions"), this is a rare sourcing arrangement where electricity can flow directly from the electricity generation unit to the facility without first flowing through the transmission and distribution grid.[534] Electricity sourced through a direct-line connection is the only time that the primary scope 2 calculations do not use eGRID subregional emissions factors for purchased electricity. These two pieces of the scope 2 electricity emissions calculations are shown in figure E.2 and described in more detail below.

---

[533] Use of steam, heat, and hot water is less common at U.S. facilities making covered steel and aluminum products than use of fuel combustion and electricity. While subprocess-specific data for fuel combustion and electricity was collected in absolute quantities to support data validation work, useful thermal output data collection was simplified to percentages to reduce burden and manage the complexity of the questionnaire's programming.

[534] One example of this is facilities that have an on-site power or cogeneration unit that is operated by a third party. WRI, *GHG Protocol Scope 2 Guidance*, 2015, 36.

**Figure E.2** Mapping of scope 2 electricity emissions to subprocess-specific estimates



Source: Compiled by the USITC.
Note: The "Q" labels in the diagram above indicate the question number in the Commission's facility-level questionnaire gathering this information. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, sections 3-4.

The questionnaire requested data on direct-line connections across two questions. Question 4.4b covered the quantity of energy attribute certificates (e.g., renewable energy certificates) associated with a zero-emission source of energy that were bundled with electricity supplied via a direct-line connection ($certificates_{dlc}$).[535] Question 4.5 covered plant-specific contractual arrangements with plants that did not receive energy attribute certificates and included data on the quantity of electricity that was supplied via a direct-line connection ($noncertplant_{dlc}$). Using the non-certificate electricity data from question 4.5 and an emissions factor specific to the plant in eGRID ($eGRID_{plant}$), equation E.31 estimates emissions associated with purchases made through direct-line connections ($S2_{elecdlc}$).[536]

$$S2_{elecdlc} = noncertplant_{dlc} * eGRID_{plant} \qquad (E.31)$$

To separate direct-line connection purchases from all other electricity purchases ($purch_{elecnondlc}$), equation E.32 removes electricity purchases $certificates_{dlc}$ and $noncertplant_{dlc}$ from total electricity purchases reported in question 4.1.[537]

---

[535] Question 4.4f covered the possibility of a facility purchasing additional electricity through a direct-line connection to a plant that issued certificates (more than the quantity of certificates reported in question 4.4b), but no facilities reported this. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level,* 2024, responses to questions 4.4f and 4.4b.

[536] The supplying plant's DOE identification number, as reported in the questionnaire, is used to retrieve the plant-specific emissions factor in eGRID. For the eGRID data, this step used variables ORISPL and PLC2ERTA. EPA, "PLNT22," January 30, 2024.

[537] No further calculations for the direct-line connection purchases were bundled with zero-emission certificates, because their direct-line emissions factor is zero.

$$purch_{elecnondlc} = purch_{elec} - certificates_{dlc} - noncertplant_{dlc} \tag{E.32}$$

Equation E.33 accounts for emissions from all other electricity purchases (applying the same subregional emissions factor covered in the simple version of the calculations).[538] Finally, equation E.34 combines the direct-line connection emissions with non-direct line (grid) purchase emissions and allocates them to associated subprocesses using electricity use quantities provided in question 3.9.

$$S2_{elecnondlc} = purch_{elecnondlc} * eGRID_{srl} \tag{E.33}$$

$$S2_{elec,subproc} = (S2_{elecdlc} + S2_{elecnondlc}) * \frac{use_{elec,subproc}}{\Sigma_{subproc}\left(use_{elec,subproc}\right)} \tag{E.34}$$

### II.C.3.d Scope 2 Emissions for Facilities with Purchases of Useful Thermal Outputs

For this investigation's survey population, purchases of steam, heat, or hot water (useful thermal outputs or UTO) from a third party were rare but sometimes associated with significant quantities of emissions.[539] The Commission collected data on these purchases of useful thermal outputs in question 4.7 and used eGRID data on cogeneration plants to determine how much of the supplying cogeneration plant's emissions to assign to the purchased useful thermal output. The key aspects of this calculation are shown in figure E.3, below. When useful thermal output was purchased from a boiler or a source that was otherwise unavailable in eGRID, facility contacts were requested to provide the emissions factor that their company used for the purchased useful thermal output in company-level emissions accounting.[540]

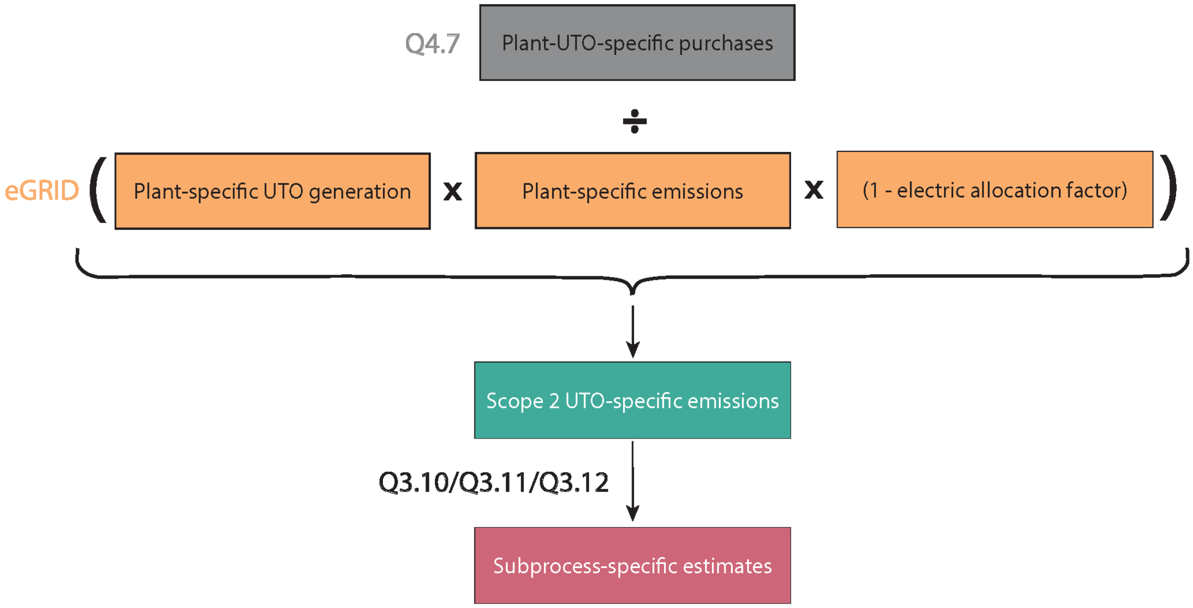
---

[538] See "Calculating Facility-Wide Scope 2 Emissions".

[539] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level,* 2024, responses to question 4.7; USITC estimates based on its calculation methodology.

[540] A boiler can only produce a type of useful thermal output, and therefore, no electricity is produced from these units, and the use of an electrical allocation factor is not necessary to determine the amount of emissions allocated to the use of the resulting useful thermal output. For more information on the cogeneration plant data in eGRID, see EPA, OAR, *eGRID2022 Technical Guide*, January 2024, 15.

**Figure E.3** Mapping of scope 2 useful thermal output emissions from cogeneration plants to subprocess-specific estimates



Source: Compiled by the USITC.
Note: The “Q” labels in the diagram above indicate the question number in the Commission’s facility-level questionnaire gathering this information. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility*-Level, 2024, sections 3-4.

The questionnaire allowed respondents to report purchases of useful thermal outputs in three different units: megawatt-hours (MWh) used to generate the output, in gigajoules of output, or in MMBtu of output. When these thermal outputs were purchased from a cogeneration plant in the eGRID database, the calculations converted the purchased quantities to MMBtu.[541] Equation E.35 uses the ratio of the purchased MMBtu of useful thermal output reported in question 4.7 ($purch_{plant,uto}$) to total useful thermal output from the plant in eGRID ($gen_{plant,uto}$) to estimate the share of the plant’s useful thermal outputs purchased by the facility ($purchshare_{plant,uto}$).[542] Equation E.36 separately estimates the scope 2 emissions associated with the facility’s purchased steam, heat, and hot water ($S2_{uto}$). To do this, the equation multiplies the share of useful thermal output purchased from the plant by the ratio of non-electric outputs to electric outputs(measured by dividing the complement of the plant’s electric allocation factor by the electric allocation factor) and by the plant’s total CO$_2$e emissions allocated to electricity generation in eGRID ($plantGHG$).[543] These calculations were run separately for each pairing of

---

[541] The Commission used an assumed 75 percent efficiency for generating useful thermal output and a 3.412 conversion rate for MWh to MMBtu, or a 0.947817 conversion rate for gigajoules to MMBtu.
[542] The calculations use variable USETHERMO, described as “CHP plant useful thermal output (MMBtu),” for the plant’s total useful thermal output. EPA, “PLNT22,” January 30, 2024; EPA, OAR, *eGRID2022 Technical Guide*, January 2024, 47.
[543] eGRID adjusts variables such as $plantGHG$ (PLCO2EQA in the eGRID database) by the electric allocation factor, to solely measure the emissions associated with the plant’s electricity generation. Dividing $plantGHG$ by $elecfactor_{plant}$ removes this adjustment; multiplying by $1 - elecfactor_{plant}$ then reduces the plant emissions to the quantity associated with non-electric outputs, i.e., useful thermal outputs. Variables ELCALLOC and PLCO2EQA. EPA, “PLNT22,” January 30, 2024; EPA, OAR, *eGRID2022 Technical Guide*, January 2024, 47, 49.

useful thermal output and source plant reported in question 4.7 and then totaled for each useful thermal output.

$$purchshare_{plant,uto} = \frac{purch_{plant,uto}}{gen_{plant,uto}} \qquad (E.35)$$

$$S2_{uto} = \sum_{plant} \left[ \left(1 - elecfactor_{plant}\right) * purchshare_{plant,uto} * plantGHG \right] \qquad (E.36)$$

Next, equations E.37.a and E.37.b determined what share of each thermal output was used on-site rather than sold. As denoted in equation E.37.a, if the facility sold more of a useful thermal output than it purchased, the scope 2 share was set to zero, and the scope 1 emissions associated with generating the useful thermal output were reduced by the share of net sales. Most facilities did not both purchase and sell useful thermal output, so the scope 2 share ($netpurchshare_{uto}$) often has a value of 1.

$$If\ sold_{uto} > purch_{uto}: netpurchshare_{uto} = 0 \qquad (E.37.a)$$

$$Else: netpurchshare_{uto} = \frac{purch_{uto} - sold_{uto}}{purch_{uto}} \qquad (E.37.b)$$

Equations E.38-E.40 applied this share and the thermal output-specific scope 2 emissions to subprocesses using the percent shares reported in questions 3.10, 3.11, and 3.12, respectively. Finally, equation E.41 combined these scope 2 emissions with the scope 2 emissions from purchased electricity to estimate scope 2 emissions for each subprocess ($S2_{subproc}$).

$$S2_{steam,subproc} = S2_{steam} * useshare_{steam,subproc} * netpurchshare_{steam} \qquad (E.38)$$

$$S2_{heat,subproc} = S2_{heat} * useshare_{heat,subproc} * netpurchshare_{heat} \qquad (E.39)$$

$$S2_{hwater,subproc} = S2_{hwater} * useshare_{hwater,subproc} * netpurchshare_{hwater} \qquad (E.40)$$

$$S2_{subproc} = S2_{elec,subproc} + S2_{steam,subproc} + S2_{heat,subproc} + S2_{hwater,subproc} \qquad (E.41)$$

From this point in the calculations, the allocation of any emissions from ambient heating and the aggregation of subprocesses to unit process emissions for scope 2 energy follow the same steps as with simpler facilities (equations E.11–E.13). These final steps yield scope 2 energy unit process emissions ($S2UGHG_{product}$) for the product-level emissions inventories.

## II.D. Emissions Embedded in Material Inputs

As described in chapter 3 (“Emissions Embedded in Material Inputs from External Sources (Scope 3)”), the Commission calculated each facility’s scope 3 emissions by multiplying certain activity data—material receipts or in some cases material use data—by scope 3 emissions factors specific to those materials. This section describes how scope 3 emissions were calculated for specific materials used by steel and aluminum producers. In addition, this section describes how scope 3 emissions were allocated to unit processes.

## II.D.1. Calculation of Facility-Level Scope 3 Emissions

At the most basic level, a facility's scope 3 emissions are calculated for each material ($material$) it received from external sources in 2022 based on equation E.42.

$$S3_{material} = Receipts_{material} * EF_{material} \qquad (E.42)$$

$S3_{material}$ refers to total GHG emissions, measured in mt of $CO_2$e, that occurred during the partial life cycle of that material in external upstream facilities.

$Receipts_{material}$ is the activity data covering external receipts or use of the material in 2022, generally measured in metric tons of material received or used for solid materials and in standard cubic feet for gaseous materials.[544]

$EF_{material}$ refers to the emissions factor, or the amount of GHG emissions, measured in metric tons of $CO_2$e, that occurred during the partial life cycle of that material in external upstream facilities for every unit that was produced.

Equation E.42 is more complex for certain materials depending on the amount of information available, whether a "multi-source approach" or "global approach" is used, the production pathways of those materials, and whether alternative emissions factors are available for performing those calculations.[545] Derivatives of equation E.42 and associated sources of information are described in greater detail below for all materials in the steel and aluminum system boundaries.

### II.D.1.a Approaches for Materials Used in the Steel System Boundary

The Commission calculated scope 3 emissions for facilities producing covered steel products for each material received from external sources by those facilities. Four different calculation approaches that were derivatives of equation E.42 were used, applying to four groups of materials. These groups are listed in table E.9.

---

[544] The sections below describe the materials for which the Commission always based its scope 3 emissions calculations on material use data instead of external receipts for calculating scope 3 emissions. Beyond those systematic incorporations of material use data into the scope 3 analysis, there were also isolated cases for individual facilities where the Commission decided during curing of the data that external receipt data were missing or incomplete and would be better replaced by material use data. In some cases, facilities that had significant buildups or drawdowns of externally sourced material inventories in 2022 adjusted the reported external receipts to better reflect actual use of those materials in order to avoid substantial overstatement or understatement of scope 3 emissions related to their production using those materials in that year.

[545] Chapter 3 ("Calculating Facility-Level Scope 3 Emissions") includes a description of the multi-source and global approaches to calculating facility-level scope 3 emissions.

**Table E.9** Material groups used for calculating scope 3 emissions for facilities producing covered steel products

| Material categories | Material group and equation index term |
|---|---|
| Metallurgical coke, calcined lime, calcined dolime, iron pellets, direct reduced iron, carbon electrodes, oxygen, nitrogen, argon, and hydrogen | Material group 1 ($material1$) |
| Non-calcined limestone and dolomite, ferroalloys and other alloying metals, and coating materials | Material group 2 ($material2$) |
| Pig iron | Material group 3 ($pig$) |
| All steel products used as materials | Material group 4 ($steel$) |

Source: Compiled by the USITC.

## II.D.1.a(1) Scope 3 Emissions for Steel Materials Group 1: Global Approach Using Receipts Data

Materials group 1 includes metallurgical coke, calcined lime, calcined dolime, iron pellets, direct reduced iron, carbon electrodes, oxygen, nitrogen, argon, and hydrogen.[546] Facilities reported external receipts for each of these materials in the questionnaire.[547] For each material in material group 1 ($material1$), the Commission used a global approach to calculate $S3_{material1}$ (see equation E.43) using total material receipts from all sources ($Receipts_{material1}$) as activity data and global emissions factors ($DefaultEF_{material1,global}$).

$$S3_{material1} = Receipts_{material1} * DefaultEF_{material1,global} \qquad (E.43)$$

## II.D.1.a(2) Scope 3 Emissions for Steel Materials Group 2: Global Approach Using Use Data

Materials group 2 includes limestone, ferroalloys and other alloying metals, and coating metals ($material2$). As with material group 1, the Commission used a global approach to calculate $S3_{material2}$ for each of these materials. Unlike the materials in group 1, the Commission assumed based on discussions with industry representatives that facilities producing covered steel products were unlikely

---

[546] Iron sinter is also included in material group 1; however, no facilities reported receipts of iron sinter in 2022.

[547] The Commission collected country-specific material receipts for iron pellets, DRI, and carbon electrodes in order to allow for a multisource approach to calculating scope 3 emissions for these materials. Although the Commission did not collect country-specific material receipts for the other materials in material group 1, a review of U.S. import data and information provided by an industry representative allowed for an assumption that most of these materials were sourced domestically in 2022. USITC DataWeb/Census, HTS statistical reporting numbers 2704.00.00.25, 2518.20.0000, 2522.10.0000, accessed September 27, 2023; U.S. industry representatives, email messages to USITC staff, October 10, 2023. However, the Commission did not locate country-specific emissions factors for any materials in the steel system boundary that were reliable or could be consistently applied across the various country sources for these materials. Although the Commission took steps to calculate country- and production-pathway emissions factors for pig iron and steel products (material groups 3 and 4) due to their substantial contribution to scope 3 emissions, it did not undertake such a detailed analysis for these other materials and instead relied on global emissions factors and a global approach to calculating scope 3 emissions for material groups 1 and 2. Appendix F (“Step 1 Emissions Factors Collected from Public Sources”) has more information about how global emissions factors were selected for upstream material other than pig iron and steel products.

to produce the materials in group 2.[548] Therefore, in lieu of external receipts, the Commission used the total quantity of material use ($\sum_{subproc} Use_{material2,subproc}$) as activity data in the calculation of $S3_{material2}$ in order to avoid asking facilities for the same type of data multiple times (see equation E.44).[549] Like group 1, $DefaultEF_{material2,global}$ was used.[550]

$$S3_{material2} = \sum_{subproc} Use_{material2,subproc} * DefaultEF_{material2,global} \qquad (E.44)$$

The metal products included in this group generally have high embodied emissions; however, the Commission used a global approach to calculating scope 3 emissions for these materials for several reasons. Although alloying or coating metals may have a substantial impact on the emissions intensity of stainless, high-alloy, or coated steel products, the use of each of these metals by steel facilities varied widely. Given the dozens of alloying and coating metals for which data were collected in the questionnaire, the Commission decided not to further increase the burden on facilities by also asking them to report the sources of these metals. However, the questionnaire requested facilities producing stainless steel products to provide data for a wide variety of ferroalloys and other alloying metals in order to better capture the impact of varying rates of use of each of those materials on the emissions intensities of stainless steel product categories (see box E.3).

**Box E.3** Measurement of Scope 3 Emissions for Ferroalloys and Other Alloying Metals

Facilities reported use of ferroalloys and other alloying metal inputs in the broad “steelmaking” subprocess. Primary alloy inclusion in steel production typically occurs during the refining process after the production of steel in an EAF or BOF. During refining, the liquid steel is stirred with an inert gas such as argon to clean the steel of impurities. From there, the chemistry of the steel is further fine-tuned by adding alloys and other additions as needed. After this process, the steel is sent to casting.[a]

Facilities reported all ferroalloy and other alloying metal use, but with different levels of specificity depending on the type of steel being produced at the facility. Where a facility produced stainless steel or a mix of stainless and carbon and alloy steels, it was asked to report material use quantities for 17 different categories of ferroalloys and other alloying metals.[b] Where a facility produced only carbon and alloy steel, it was asked to report material use quantities for three different categories of ferroalloys and other alloying metals.[c] In both cases, facilities were also asked to report use of all nonlisted ferroalloys and other alloying metals within a category called “all other ferroalloys and other alloying metals.”

---

[548] U.S. industry representatives, email messages to USITC staff, October 6 and 10, 2023; USITC, hearing transcript, December 7, 2023, 153–55, 167 (testimony of Jeff Becker, U. S. Steel); SSINA, written submission to the USITC, December 21, 2023, 3–4; AISI, written submission to the USITC, December 21, 2023, 4–5; U. S. Steel, written submission to the USITC, December 21, 2023, app. 1.

[549] As discussed in chapter 3 (“Allocation of Facility-Level Emissions to Unit Processes”) and in the section below (“Computing Product-Level Emissions Inventories”), material use data are also collected for product allocation purposes.

[550] The Commission included measures of scope 3 emissions even for facilities’ reported use of ferroalloys, other alloying metals, and coating metals that were not provided as selectable options in the questionnaire. Facilities reported quantities of material use for other forms of chromium, nickel, molybdenum, and coating, cladding, and plating metal. The Commission selected emissions factors that corresponded with textual descriptions provided by the facilities to accompany their reported use of these metals. These emissions factors are not reported since they are specific to individual facilities’ responses; however, the Commission selected these from the same sources used to develop default emissions factors reported in table G.4 of appendix G.

Using equation E.44, the quantity of each ferroalloy and other alloying metal used by the facility is multiplied by a default scope 3 emissions factor corresponding with that material. The alloying metals tracked under "all other ferroalloys and other alloying metals" are multiplied by the global default emissions factor associated with pig iron production. A pig iron emissions factor is used for this remainder category of alloying metals for three reasons:

- The emissions factor will assign a standardized emissions burden to activity data corresponding with use of unspecified alloying metals, which avoids systematic undercounting of the emissions associated with the use of these metals.[d]
- The use of a pig iron emissions factor (rather than a semifinished steel emissions factor) avoids double counting the emissions associated with the alloys themselves, and the electricity used to create steel that includes the alloys.
- This method is used by reputable third-party sources on emissions accounting.[e]

The decision to track a much higher number of ferroalloys for facilities with stainless steel production was based on the expectation of a higher alloy use, and thus higher contribution of alloys to the scope 3 emissions, by those facilities.[f] Stainless steels contain a higher share of ferroalloys and alloying metals due to the characteristics of the steel.[g] Therefore, greater specificity in data collection for facilities with stainless steel production captured the unique scope 3 emissions profile of these products which have a higher share of ferroalloys and other alloying metals by weight.

By contrast, most facilities with production of carbon and alloy steel will generally use only a small amount of ferroalloys and other alloying metals relative to other metallic inputs (i.e., scrap, pig iron, and direct reduced iron).[h] The Commission chose to use less specificity in data collection for these facilities, with concerns about the reporting burden on respondents outweighing any anticipated gains to the accuracy of accounting of the scope 3 emissions associated with inclusion of a greater variety of ferroalloys and other alloying metals. However, the low quantities of alloying metals used by facilities producing only carbon and alloy steel likely resulted in negligible effects on overall emissions intensities of products made by these facilities or across the industry.[i]

[a] AIST, "AIST Steel Wheel," accessed November 5, 2024.
[b] Ferroalloys and other alloying metals tracked for stainless steel are ferrochromium, chromium metal, other forms of chromium, ferronickel, nickel metal, nickel pig iron, other forms of nickel, ferromanganese, manganese metal, ferromolybdenum, molybdenum metal, other forms of molybdenum, ferrosilicon, silicomanganese, silicon metal, ferrovanadium, aluminum metal, and copper metal.
[c] The ferroalloy and other alloying metals tracked for carbon and alloy steels are ferrochromium, ferronickel, and ferromanganese, the same ferroalloys tracked by the European Union Carbon Boarder Adjustment Mechanism (CBAM) as precursor materials for semifinished steel and iron or steel products. EC, DG-TAXUD, *CBAM Guidance for Installations*, December 8, 2023, 57.
[d] If instead of a pig iron emissions factor no emissions factor was applied to this remainder category of alloying metals, the emissions intensity of steel products made by these facilities would be lower if they used more alloying metals rather than iron and scrap. The Commission elected to assign a default emissions factor to these inputs to ensure the Commission was accounting for embodied emissions associated with their inputs.
[e] ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024.
[f] SSINA, written submission to the USITC, December 21, 2023, 3; U. S. Steel, written submission to the USITC, December 21, 2023, 9; Outokumpu, written submission to the USITC, November 21, 2023, 27.
[g] Stainless steel is defined as steel containing majority iron, a chromium alloying element and other alloying elements (often chromium at 11 percent by weight or more). worldstainless, "Introduction to Stainless Steels," accessed November 8, 2024.
[h] USITC, hearing transcript, December 7, 2023, 154 (testimony of Jeff Becker, U. S. Steel); Remus et al., *Best Available Techniques (BAT) Reference Document*, January 24, 2013, 369, 429.
[i] For facilities making only high alloy types of carbon and alloy steel but not stainless steel, the effects on the overall emissions intensity calculations of lower specificity of data for alloying metals was likely more substantial. However, output from these high alloy producing facilities were likely substantially lower than for facilities producing other carbon steel products. Therefore, the effect on industry-wide emissions intensity of any inaccuracies associated with collecting data for only a few ferroalloys was likely minimal.

## II.D.1.a(3) Scope 3 Emissions for Steel Materials Group 3: Pig Iron

Pig iron ($pig$) receipts are one of the most substantial sources of scope 3 emissions for steel facilities, and the Commission therefore prioritized development of a multisource approach to estimating $S3_{pig}$. In addition to asking for external receipts of pig iron from specific countries ($Receipts_{pig,country}$), the questionnaire asked consuming facilities for their external receipts of pig iron from specific U.S. suppliers

($Receipts_{pig,supplier}$).[551] The Commission also developed corresponding country-specific emissions factors ($DefaultEF_{pig,country}$) and supplier-specific emissions factors ($EF_{pig,supplier}$) for pig iron. Country-specific emissions factors were based on the partial life cycle inventory (LCI) approach described in appendix F ("Development of Default Emissions Factors for Materials Used by Steel Facilities"). Supplier-specific emissions factors were calculated from emissions intensity estimates for pig iron from individual steel facilities producing this material.

If a consuming facility received pig iron from another U.S. facility that produced pig iron and responded to the questionnaire, the Commission used $EF_{pig,supplier}$ in lieu of a default emissions factor to calculate scope 3 emissions associated with receipts from that supplier facility ($S3_{pig,supplier}$) using equation E.45.

$$S3_{pig,supplier} = Receipts_{pig,supplier} * EF_{pig,supplier} \qquad (E.45)$$

For all other identified sources of pig iron, including from specified import partner countries, unidentified U.S. sources, or identified U.S. suppliers who did not respond to the questionnaire or indicate the production of pig iron, no supplier-specific emissions factor was available. The Commission calculated scope 3 emissions associated with those sources on a country-specific basis ($S3_{pig,country}$) using $DefaultEF_{pig,country}$ using equation E.46. Where the consuming facility reported receipts of pig iron from unknown sources or imports from unidentified countries, a global emissions factor was used.

$$S3_{pig,country} = Receipts_{pig,country} * DefaultEF_{pig,country} \qquad (E.46)$$

All country- and supplier-specific scope 3 emission calculations were summed to get total facility-level scope 3 emissions for pig iron ($S3_{pig}$) (see equation E.47).

$$S3_{pig} = \sum_{supplier} S3_{pig,supplier} + \sum_{country} S3_{pig,country} \qquad (E.47)$$

### II.D.1.a(4) Scope 3 Emissions for Steel Materials Group 4: Steel Products

As with pig iron, steel products ($steel$) used as materials in the production of other steel products are themselves substantial contributors to steel facilities' scope 3 emissions. To calculate $S3_{steel}$ for each steel product, the Commission used a similar multisource approach to that used for pig iron for materials group 5, combining supplier-specific and country-specific calculations. Also, because the emissions intensity of steel is substantially different depending on the production pathway used (i.e., whether steel is produced using an EAF versus a BOF), the Commission used information regarding the production pathway of steel from specific sources.

---

[551] The Commission selected the source countries identified in the questionnaire based on a review of 2022 U.S. import data. USITC DataWeb/Census, HTS heading 7201, accessed September 27, 2023. Facilities responding to the questionnaire identified their U.S. pig iron suppliers using a list developed by the Commission of steel producers based on GHGRP reports and a database published by AIST. AIST, *2022 Directory of Iron and Steel Plants*, 2022; EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024. Facilities were also given the opportunity to identify U.S. pig iron suppliers other than those pre-populated in the questionnaire.

As with pig iron, consuming facilities reported their receipts of steel products from other U.S. supplier facilities ($Receipts_{steel,supplier}$).[552] Where those U.S. supplier facilities themselves responded to the questionnaire and reported steel production, the Commission calculated a corresponding supplier-specific emissions factor ($EF_{steel,supplier}$). Scope 3 emissions associated with receipts of the steel material from that supplier ($S3_{steel,supplier}$) were based on equation E.48.

$$S3_{steel,supplier} = Receipts_{steel,supplier} * EF_{steel,supplier} \tag{E.48}$$

Facilities also reported quantities of receipts of steel products from specific countries ($Receipts_{steel,country}$), where the source country was defined as the country of melt and pour.[553] Facilities reported not only the source of these steel products based on the country of melt and pour, but also estimates of the shares of steel from each country based on whether the steel was melted and poured in an EAF facility ($EAFshare_{country}$) or a BOF facility ($BOFshare_{country}$). In order to use these production pathway specific activity data, the Commission calculated default emissions factors that were both pathway- and country-specific ($DefaultEF_{steel,eaf,country}$ and $DefaultEF_{steel,bof,country}$) using the partial LCI approach described in appendix F ("Development of Default Emissions Factors for Materials Used by Steel Facilities"). Equations E.49 and E.50 show how scope 3 emissions associated with receipts of steel melted and poured in EAF facilities ($S3_{steel,eaf,country}$) and BOF facilities ($S3_{steel,bof,country}$) were calculated.

$$S3_{steel,eaf,country} = Receipts_{steel,country} * EAFshare_{country} * DefaultEF_{steel,eaf,country} \tag{E.49}$$

$$S3_{steel,bof,country} = Receipts_{steel,bof,country} * BOFshare_{country} * DefaultEF_{steel,bof,country} \tag{E.50}$$

The equations above could not be used to calculate scope 3 emissions associated with receipts from import partner countries without accompanying estimates of the production pathway for that steel, unidentified U.S. sources, or identified U.S. suppliers who did not report production of the steel product ($Receipts_{steel,unk,country}$). The Commission calculated scope 3 emissions associated with those sources on a country-specific basis ($S3_{steel,unk,country}$) using a country-specific emissions factor that was not pathway specific ($DefaultEF_{steel,country}$) using equation E.51.[554] Where the consuming facility

---

[552] Facilities responding to the questionnaire identified their U.S. pig iron suppliers using a list developed by the Commission of pig iron suppliers based on GHGRP reports, a database published by the Association for Iron and Steel Technology (AIST), and information from industry representatives. AIST, *2022 Directory of Iron and Steel Plants*, 2022; EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024; U. S. Steel, written submission to the USITC, December 21, 2023, app. 3; CPTI, written submission to the USITC, November 21, 2023, app. 1. Facilities were also given the opportunity to identify U.S. steel suppliers other than those pre-populated in the questionnaire.

[553] A country of melt and pour for steel is the location where the raw steel is: (1) first produced in a steelmaking furnace in a liquid state; and (2) poured into its first solid shape. The first solid state can take the form of either a semifinished steel product (i.e. ingot, bloom, slab, billet, beam blank, etc.) or a finished steel mill product. The location of melt and pour is customarily identified on mill test certificates that are commonplace in steel production. Countries of melt and pour identified in the questionnaire were selected for each steel product based on a review of 2022 U.S. import data from the Steel Import Monitoring and Analysis System's Melt and Pour Dashboard. USDOC, ITA, "Melt and Pour Dashboard," accessed November 8, 2024.

[554] The Commission calculated $DefaultEF_{steel,country}$ using the partial LCI approach described in appendix F ("Development of Default Emissions Factors for Materials Used by Steel Facilities").

reported receipts of steel from unknown sources or imports from unidentified countries, a global emissions factor was used.

$$S3_{steel,unk,country} = Receipts_{steel,unk,country} * DefaultEF_{steel,country} \qquad (E.51)$$

$S3_{steel}$ was calculated as the sum of all parts described above using equation E.52.

$$S3_{steel} = \sum\nolimits_{supplier} (S3_{steel,supplier}) + \sum\nolimits_{country} (S3_{steel,eaf,country} + S3_{steel,bof,country} + S3_{steel,unk,country}) \qquad (E.52)$$

## II.D.1.b Approaches for Materials Used in Aluminum System Boundary

The aluminum scope 3 emissions in this investigation were calculated using four approaches covering different materials or groups of materials. Table E.10 summarizes the materials and which of the four approaches was used to estimate scope 3 emissions, which are described in further detail in the following section.

**Table E.10** Aluminum calculation methods used for scope 3 materials

| Material categories | Materials group allocation and equation index term |
|---|---|
| Primary unwrought aluminum (U.S.) | Materials group 1 ($aluminum$) |
| Secondary unwrought aluminum (U.S.), wrought aluminum (U.S.) | Materials group 2 ($material2$) |
| Alloys, calcined petroleum coke, coal tar pitch | Materials group 3 ($material3$) |
| Alumina, primary unwrought aluminum (rest of world) | Materials group 4 ($material4$) |

Source: Compiled by the USITC.

### II.D.1.b(1) Scope 3 Emissions for Aluminum Materials Group 1: U.S. Primary Unwrought Aluminum from Surveyed Facilities

Some primary unwrought aluminum covered in the investigation was produced by U.S. aluminum smelters and then consumed by different U.S. facilities in the production of other covered aluminum products. If a facility indicated that it sourced primary unwrought aluminum that was smelted in the United States, the questionnaire asked which of the six U.S. smelters were suppliers and the quantity of material received from that smelter ($Receipts_{aluminum,supplier}$), used as activity data. The relevant emissions intensity from the supplying smelter was then used as the scope 3 emissions factor ($EF_{aluminum,supplier}$) for that quantity of primary unwrought aluminum in the receiving facility in equation E.53.

$$S3_{aluminum,supplier} = Receipts_{aluminum,supplier} * EF_{aluminum,supplier} \qquad (E.53)$$

### II.D.1.b(2) Scope 3 Emissions for Aluminum Materials Group 2: Secondary and Wrought Product Inputs from U.S. Sources

Just as with primary unwrought aluminum inputs, survey respondents who indicated that they sourced secondary unwrought aluminum inputs from the United States were asked to select the specific facilities they sourced from and the quantity sourced from each facility ($Receipts_{material2,us}$). Some of these facilities both supplied and sourced secondary unwrought aluminum to and from various other U.S. facilities, making it difficult to trace the original supplier and apply an appropriate emissions factor. Facilities were also less likely to be able to specifically identify the source facility for these inputs than they were for primary aluminum. For these reasons, a supplying-facility-specific emissions factor approach was not used for secondary unwrought aluminum inputs.

Instead, the questionnaire data were used to generate a national estimate for scope 3 emissions from secondary unwrought aluminum inputs before they are used as inputs into other secondary unwrought aluminum. To do this, domestic secondary unwrought aluminum inputs were removed from the calculation at the national level. Thus, the national estimate for the “input” or “first-use” secondary unwrought aluminum trends slightly lower than the overall secondary unwrought aluminum estimate. Because the same circularity issue appears for wrought aluminum producers also using other wrought products as inputs, the same approach of calculating an emissions factor for wrought aluminum inputs using a national estimate rather than a supplying-facility-specific estimate was applied.

These national input estimates were then used as the scope 3 emissions factor ($EF_{material2,us}$) for all relevant inputs in equation E.54.

$$S3_{material2,us} = Receipts_{material2,us} * EF_{material2,us} \qquad (E.54)$$

### II.D.1.b(3) Scope 3 Emissions for Aluminum Materials Group 3: Materials Without Expected Source-Specific Emissions Factors

For materials in this group—alloys, purchased carbon anodes, calcined petroleum coke, and coal tar pitch—no regional-specific emissions factor was used in this investigation, and no sourcing information was collected. The Commission did not consider the benefit of greater source specificity for these materials to justify the greater burden on facilities associated with providing that detailed information.[555] Calcined petroleum coke and coal tar pitch, used in anode production, were assigned the same universal values that IAI uses in their 2022 Scope 3 Calculation Tool.[556] The quantities of material used ($Use_{material3}$) were collected in the questionnaire based on the assumption that these materials

---

[555] Alloying metals are assigned a primary unwrought aluminum emissions factor, rather than an emissions factor for the specific alloying material. As alloying elements typically have a lower emissions burden compared to that of primary aluminum, this method avoided undercounting the emissions burden from the inclusion of these alloying materials, as well as reduced the burden on facilities that consume a relatively negligible amount of this material and may not be able to allocate their alloy use by material type. AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 46.

[556] Sphera Solutions, *IAI Scope 3 Calculation Tool Guidance*, September 13, 2022, 32. While (green) petroleum coke can differ in emissions intensity depending on inputs and processes used, once it is further refined into calcined petroleum coke little information on its emissions intensity is published. Coal tar pitch similarly has an emissions factor value from the IAI Scope 3 guidance and little else to consider as regional alternatives.

were never produced on-site. Therefore, total receipts are calculated based on the sum of the facilities' various quantities of consumption of that material rather than an explicit "external receipts" variable. These are multiplied by the IAI default emissions factors to generate scope 3 emissions in equation E.55.

$$S3_{material3} = Use_{material3} * DefaultEF_{material3,global} \quad (E.55)$$

**Box E.4** Special Treatment of Alloys in Aluminum Emissions Calculation

The combined weight of alloying materials typically make up 1–15 percent of the weight of aluminum products.[a] In North America, the percentage weight of alloy content in aluminum is low. Therefore, the Commission assigned a primary aluminum emissions factor to the inclusion of all alloying materials. This method avoided undercounting the emissions burden from the inclusion of these alloying materials, as well as reduced burden on companies that consume a relatively negligible amount of this material and may not be able to separate their alloy use by material type.[b]

[a] AA, The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report, January 2022, 46.

[b] The Aluminum Association used this methodology of assigning a primary aluminum emissions factor to alloys in its 2022 report on The Environmental Footprint of Semifinished Aluminum Products in North America. The EU's Guidance Document for CBAM Implementation also suggests this methodology. EC, DG-TAXUD, CBAM Guidance for Installations, December 8, 2023, 60.

### II.D.1.b(4) Scope 3 Emissions for Aluminum Materials Group 4: Materials With Potential Source-Specific Emissions Factors

For materials in this group—alumina and primary aluminum (or primary aluminum metal content) from a country other than the United States—it was assumed that external receipts ($Receipts_{material4,region}$) could be sourced from multiple countries and that regional- or country-specific emissions factors might be used. Therefore, country source information was collected for facilities' receipts of these materials. Regional- or country-specific default emissions factors were then used where possible, or if a more specific default factor was not available, a global default factor was used ($DefaultEF_{material,region}$), as shown in equation E.56.

$$S3_{material4} = \left(\sum_{region} Receipts_{material4,region}\right) * DefaultEF_{material4,region} \quad (E.56)$$

## II.D.2. Selection of Default Emissions Factors

Each of the calculations of scope 3 emissions described above relied upon the use of emissions factors, particularly default country-specific or global emissions factors. This section provides greater detail on how emissions factors were selected for use in those calculations, including the criteria considered for selection, a full description of the approaches used to select emissions factors for use in calculating scope 3 emissions of facilities producing covered aluminum products, and an introduction to the approach taken for selecting emissions factors for use in steel product calculations (described in greater detail in appendix F, "Development of Default Emissions Factors for Materials Used by Steel Facilities").

Default emissions factors are meant to capture the emissions intensity of products across an industry and therefore are inherently subject to uncertainty. A consuming facility's suppliers may have production practices that are less or more emissions intensive than those represented within default emissions factors, which would cause calculated scope 3 emissions to be overstated or understated, respectively.

To improve the accuracy of scope 3 emissions results, the Commission selected default emissions factors based on the following criteria:

- **Representativeness:** Default emissions factors were selected based on whether they were representative of the emissions intensity of activity data collected in the questionnaires. In particular, default emissions factors were selected if they covered a material description that matched as closely as possible to that used in this investigation. The Commission selected default emissions factors that were recently published or corresponded to a recent time period in order to represent 2022 activity data. For certain emissions-intensive materials including pig iron, steel products, and primary unwrought aluminum, default emissions factors were selected that corresponded to the countries and production practices for which activity data were collected.[557]
- **Consistency with overall calculation approach:** To the extent possible, default emissions factors were selected that were developed using approaches that were as consistent as possible with the broader methodology used in this investigation. In particular, the Commission sought to use or develop default emissions factors that included direct and indirect emissions corresponding with all processes (or at least the most emissions-intensive processes) covered within the investigation's system boundaries. In addition, the Commission sought default emissions factors that included all GHG emissions covered in this investigation, including not only $CO_2$ but also $CH_4$, $N_2O$, and PFCs.
- **Reputation and widespread use of source:** Where possible, the Commission sought to use publications or databases with default emissions factors that were internationally recognized or widely used by other publications or by industry sources.
- **Transparency:** Where possible, default emissions factors were sought that were either based on well-documented methods or where the emissions factors themselves were publishable, or both.
- **Consistency across emissions factors:** For any given material, the Commission sought to use the same source of default emissions factors across countries.

For materials in the steel system boundary, the Commission selected emissions factors from an approach referred to in this report as the partial life cycle inventory (LCI) approach. The partial LCI approach used methods adapted from a study by the European Commission's Joint Research Centre (JRC) to construct country- and production pathway-specific emissions factors for all steel product categories and pig iron.

---

[557] Some secondary sources with default emissions factors publish factors that are systematically higher than industry average emissions intensity estimates in order to discourage reporting facilities from using default emissions factors in lieu of actual primary source information regarding scope 3 emissions. For example, ResponsibleSteel uses this approach and refers to this as the "burden of the doubt" approach to selecting default emissions factors. Likewise, the European Commission intends to use default emissions factors for goods subject to CBAM that "will be set at the average emission intensity for each exporting country, increased by a proportionately designed mark-up." ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 115; EC, DG-TAXUD, "Default Values for the CBAM Transitional Period," December 22, 2023, 5. By contrast, the purpose of the Commission's investigation was to calculate the average and highest emissions of steel products made in the United States as accurately as possible, not to encourage any kind of reporting technique. Therefore, default emissions factors were selected that were as representative as possible of typical or average emission intensities in a given industry. the Commission adjusted default emissions factors from ResponsibleSteel to remove the mark-up as described in greater detail in appendix F ("Step 1 Emissions Factors Collected from Public Sources").

This was supplemented by publicly available emissions factors covering global industries for upstream materials used in iron and steel production. The partial LCI approach is described in appendix F ("Development of Default Emissions Factors for Materials Used by Steel Facilities").

For materials in the aluminum system boundary, emissions factors from public sources were used, and these factors can be found in table G.2 of appendix G. The available list of public regional primary aluminum scope 3 emissions factors that match closely to the methodology of the aluminum calculations is not long.[558] The Commission uses data from a 2022 IAI report that released primary aluminum lifecycle inventory data to be used in modules for life cycle assessments.[559] The IAI report also demonstrated the use of this data with several examples of regional life cycle assessments for primary aluminum.[560] Of the public regional primary aluminum factors available, these example data most closely match the Commission's system boundaries, including the same production processes for primary aluminum. While not a perfect match, because the IAI data include emissions such as low-voltage anode effects and transportation emissions, it captures the important emissions variation in primary unwrought aluminum smelted in Canada from the global average. Since this small set of data includes this important factor, as well as a global factor, a similar system boundary to the Commission's investigation, and is unlikely to understate emissions, the Commission uses this set of factors to apply to primary unwrought aluminum smelted internationally.

For downstream aluminum products in the United States, most of the variation captured by regional scope 3 factors depends on whether imported primary aluminum was sourced from Canada, where the emissions factor of 5.4 mt $CO_2e$/mt aluminum is much lower than the 2019 global average of 16.8.[561] Because this situation had a public emissions factor, the aluminum calculations did not require regional emissions factors created using various sources of underlying data in the same way that the steel calculations did.

## II.D.3. Allocation of Scope 3 Emissions to Unit Processes

As described in the overview section at the beginning of this appendix, the Commission allocated all facility-level emissions to subprocesses (using process subdivision) and ultimately to unit processes (using physical allocation where necessary). This section describes how the Commission allocated scope 3 emissions to unit processes (i.e., how $S3\ UGHG_{product}$ was calculated).

---

[558] The "Statistics" section of the IAI website includes primary aluminum smelting intensity and power consumption by region, but not life cycle inventories for these regions that include all three scopes. Many regional estimates only include scopes 1 and 2. Others use different fuel mix assumptions. IAI, "Primary Aluminium Smelting Energy Intensity (2022)," September 21, 2024; European Aluminium Association, *Environmental Profile Report*, February 2018, 46; AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022, 108; Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 162.

[559] IAI, *Life Cycle Inventory Data and Environmental Metrics for the Primary Aluminium Industry*, November 2022, 23.

[560] IAI, *Life Cycle Inventory Data and Environmental Metrics for the Primary Aluminium Industry*, November 2022, 37.

[561] See appendix G, table G.2 for a list of these emissions factors.

### II.D.3.a Process Subdivision of Scope 3 Emissions to Subprocesses

Process subdivision in this investigation involved the division of facility-level emissions into "subprocesses", or predefined broad process categories that make one or more reference products. For some materials that only had one potential use by facilities producing covered products, the Commission allocated facility-level scope 3 emissions ($S3_{material}$) fully to a single subprocess ($subproc$) without any additional process subdivision calculations (i.e., $S3_{material} = S3_{material,subproc}$).[562] All other materials were potentially usable in multiple subprocesses. For each of these other materials ($material$), the Commission calculated subprocess-level scope 3 emissions ($S3_{material,subproc}$) by multiplying $S3_{material}$ by the material's use in each subprocess ($Use_{material,subproc}$) as a share of total use ($Use_{material}$) (equation E.57). This share is referred to as the subprocess's "material use share."

$$S3_{material,subproc} = S3_{material} * \frac{Use_{material,subproc}}{Use_{material}} \qquad (E.57)$$

The Commission's questionnaire collected material use data either covering material from external sources only or total material use. For some steel and aluminum materials, however, two sets of material use data were collected.[563]

1. The first set of material use data covers use of externally sourced material that is further processed into another form of the same product category (e.g., hot-rolled flat steel used to make a pickled hot-rolled flat steel product).
2. The second set covers use of that material from all sources (including external receipt and on-site production) to make other product categories (e.g., hot-rolled flat steel used to make cold-rolled flat steel).

If only one of these use datasets was reported by a facility, the Commission used equation E.57 based on that dataset alone. However, some facilities reported data under both sets when they further processed externally sourced material into another form of the same product category and then used that further processed product to make a downstream product. Where this was the case, the Commission allocated $S3_{material}$ to the subprocess corresponding to the same product category (e.g., scope 3 emissions associated with receipts of hot-rolled flat steel were allocated to the subprocess covering the production or further processing of hot-rolled flat steel). If the quantity of material receipts exceeded the quantity from the first material use dataset described above, the Commission allocated scope 3 emissions associated with the difference of these two values using material use share data from the second dataset.

---

[562] In the steel system boundary, scope 3 emissions associated with facilities' receipts of ferroalloys and other alloying metals as well as carbon electrodes were fully allocated to the steelmaking subprocess. In the aluminum system boundary, all scope 3 emissions were allocated to either primary or secondary unwrought aluminum production for facilities that only make those products. In addition, all alloys were allocated to secondary unwrought aluminum production for facilities that produce both secondary unwrought aluminum and wrought aluminum products.

[563] These materials include secondary unwrought aluminum and both stainless and carbon and alloy forms of semifinished steel, hot-rolled flat steel, cold-rolled flat steel, and hot-worked long steel.

### II.D.3.b Further Allocation of Subprocess-Level Scope 3 Emissions to Unit Processes

$S3_{material,subproc}$ was equivalent to material-specific unit process scope 3 emissions ($S3\ UGHG_{material,product}$) corresponding with a single reference product ($product$) where either of the following was true:

- The subprocess only corresponded with a single reference product (see table E.1 in the "I. Overview of Product-Level Emissions Intensity and Inventory Calculations" section of this appendix for a listing of subprocesses where this was the case); or
- The material was a steel product. In this case, the material itself was either stainless steel or carbon and alloy steel. If the Commission allocated scope 3 emissions associated with a stainless steel material to a steel production subprocess using equation E.57, it assumed that the material was used in production of the stainless version of that steel product. For example, scope 3 emissions receipts associated with stainless semifinished steel used in hot rolling flat steel products were assumed to be used in the production of stainless hot-rolled flat steel products, specifically. The same logic applied for carbon and alloy steel.

For all other material-subprocess combinations where scope 3 emissions associated with non-steel materials were allocated to subprocesses corresponding with multiple potential reference products, $S3_{material,subproc}$ was allocated to $S3\ UGHG_{material,product}$ using the physical allocation approach shown in equation E.58.

$$S3\ UGHG_{material,product} = S3_{material,subproc} * \frac{Output_{product}}{Output_{subproc}} \qquad (E.58)$$

Once all material-specific scope 3 emissions were allocated to unit process level emissions, they were aggregated across materials to calculate $S3\ UGHG_{product}$ (equation E.59).

$$S3\ UGHG_{product} = \sum\nolimits_{material} S3\ UGHG_{material,product} \qquad (E.59)$$

# III. Computing Product-Level Emissions Inventories

After the Commission has allocated the emissions data from facilities to subprocesses and unit processes as described above, it takes the following steps to prepare product-level emissions inventories. As shown in equation E.2 above, the product-level emissions inventory of each reference product ($GHG_{product}$) includes two main components: (1) unit process emissions encompassing all direct emissions that occur during the unit process as well as indirect emissions from energy and externally sourced materials used in that unit process ($UGHG_{product}$); and (2) the sum of all emissions associated with upstream materials made in the same facility and used in the production of the reference product ($\sum_{material} ICGHG_{material,product}$). The sections above describe the methods for calculating each scope's contribution to unit process emissions, which are summed to equal $UGHG_{product}$ in equation E.3. This section describes the Commission's calculation of $ICGHG_{material,product}$ and its incorporation of this term into $GHG_{product}$ using material flow analysis.

$ICGHG_{material,product}$ is a portion of the facility's product-level emissions inventory for its own on-site production of an upstream product used as a material ($material$) in the production of the reference product ($product$). The Commission calculated $ICGHG_{material,product}$ using equation E.60.

$$ICGHG_{material,product} = GHG_{material} * \frac{ICOutput_{material}}{Output_{material}} * \frac{Use_{material,product}}{Use_{material}} \qquad (E.60)$$

Equation E.60 is the product of:

- $GHG_{material}$: the facility's product-level emissions inventory for $material$.
- $ICOutput_{material}/Output_{material}$: the "internal consumption share" for $material$, or the share of the facility's output of $material$ that is used in on-site production as opposed to shipped off-site. Equation E.60's incorporation of the internal consumption share ensures that downstream product-level emissions inventories do not include emissions associated with quantities of $material$ that are shipped off-site.
- $Use_{material,product}/Use_{material}$: the facility's use of $material$ from all sources (including external receipts and on-site production) in the production of $product$ as a share of the facility's total use of $material$.

The material use data are from questionnaire data in which facilities reported their use of materials in specific subprocesses ($subproc$). Where a subprocess produces multiple reference products, material use data at the subprocess level ($Use_{material,subproc}$) are split using a similar physical allocation approach to that used above to allocate facility-level emissions to unit processes (see equation E.61).

$$Use_{material,product} = Use_{material,subproc} * \frac{Output_{product}}{Output_{subproc}} \qquad (E.61)$$

In effect, this approach uses emissions inventories for upstream products made at facilities for multiple purposes.[564] Because the upstream products made at a facility have a portion of their emissions inventories included within those of further downstream products, the term $GHG_{product}$ must be calculated sequentially starting with the furthest upstream reference products. This ordered approach is referred to in this report as "material flow analysis" and is based on a combination of Commission research into how unit processes relate to each other in steel and aluminum facilities as well as the information provided in questionnaire responses in which facilities identified how they used materials.

---

[564] Emissions associated with upstream materials sourced externally and used in the production of the reference product are captured within $UGHG_{product}$ based on methods described in the section covering scope 3 emissions. For example, if a facility receives semifinished steel slabs (denoted here as $semi$) from external sources and uses that product to produce hot-rolled flat steel products ($hr$), the scope 3 emissions associated with receipts of those slabs would be incorporated within $UGHG_{hr}$. However, if the facility produces its own slabs and uses that to produce hot-rolled flat steel products, the emissions associated with slabs used to make hot-rolled flat steel would be incorporated within $ICGHG_{semi,hr}$.

# III.A. Material Flow Analysis for the Steel System Boundary

For reference products in the steel system boundary, material flow analysis begins with calculation of $GHG_{product}$ for industrial gas products: oxygen, nitrogen, argon, and hydrogen. Industrial gas products are assumed not to use other products made at steel facilities as materials and are also potentially used to make most of the downstream reference products. Therefore, for these products (which are rarely made at steel facilities), $GHG_{product}$= $UGHG_{product}$ without the inclusion of any derivative of $ICGHG_{material,product}$.

Subsequent calculations of $GHG_{product}$ become more complex as they include additional derivatives of $ICGHG_{material,product}$. Table E.11 provides a list of all reference products ($product$) for which values of $GHG_{product}$ were calculated, ordered by the sequence in which these values were calculated. For each $product$, a list of materials ($material$) includes all upstream products that were—or potentially could be—produced by facilities and that could be used as materials in the production of $product$. Each $product$ and $material$ combination listed in table E.11 has a corresponding term for $ICGHG_{material,product}$ that is included in the calculation of $GHG_{product}$.[565] If a facility does not have production of $material$ or does not use $material$ in the production of the $product$, then $ICGHG_{material,product}$ corresponding with $material$ will not contribute any emissions to $GHG_{product}$.

---

[565] Materials in the system boundary other than those listed in table E.11 that are used in the production of the listed product categories. Examples include ferroalloys, direct reduced iron and hot briquetted iron (DRI), and iron pellets. However, none of those materials are made in U.S. steel facilities themselves, and therefore are not included in this material flow analysis, which focuses on relationships between products made within steel facilities. All materials in the system boundary that are sourced externally (including those that can also be made internally within steel facilities) are included within the scope 3 analysis. Scope 3 emissions associated with those externally sourced materials are allocated to the unit process emissions that use those materials.

**Table E.11** List of materials made at steel facilities that are used in the production of reference products
— (em dash) = not applicable.

| Reference products made at steel facilities (in calculation order) | Corresponding materials made on-site at steel facilities that could be used to produce the reference product |
|---|---|
| Oxygen | — |
| Nitrogen | — |
| Argon | — |
| Metallurgical coke | Oxygen, Nitrogen |
| Calcined lime | Oxygen, Nitrogen |
| Calcined dolime | Oxygen, Nitrogen |
| Iron sinter | Metallurgical coke, Calcined lime, Calcined dolime, Oxygen, Nitrogen |
| Pig iron | Iron sinter, Metallurgical coke, Calcined lime, Calcined dolime, Oxygen, Nitrogen |
| Semifinished steel products | Pig iron, Metallurgical coke, Calcined lime, Calcined dolime, Oxygen, Nitrogen, Hydrogen, Argon |
| Hot-rolled flat steel products | Semifinished steel products, Oxygen, Nitrogen, Hydrogen |
| Cold-rolled flat steel products | Hot-rolled flat steel products, Oxygen, Nitrogen, Hydrogen |
| Coated flat steel products | Hot-rolled flat steel products (if not cold rolled before being coated), Cold-rolled flat steel products, Oxygen, Nitrogen, Hydrogen, Argon |
| Hot-worked long steel products | Semifinished steel products, Oxygen, Nitrogen, Hydrogen |
| Cold-formed long steel products | Hot-worked long steel products, Oxygen, Nitrogen, Hydrogen, Argon |
| Seamless tubular steel products | Semifinished steel products, Hot-worked long steel products, Oxygen, Nitrogen, Hydrogen, Argon |
| Non-seamless tubular steel products | Hot-rolled flat steel products, Cold-rolled flat steel products, Coated flat steel products, Hot-worked long steel products, Oxygen, Nitrogen, Hydrogen, Argon |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.1.1, 5.1.6a, 5.1.8a, 5.1.9a, 5.1.10a, 5.1.10b, 5.1.10c, 5.1.13a, 5.1.17a, 5.1.18a, 5.1.19a, 5.1.20a, 5.1.23a.
Note: Where the upstream material is itself a steel product, only the emissions associated with that type of steel were included in the inventory. For example, if a facility produced both stainless steel and carbon and alloy steel types of semifinished steel and used those products to make both types of hot-worked long steel products, then only the emissions associated with the facility's production of stainless semifinished steel would be used within the emissions inventory for production of stainless hot-rolled flat steel products (and vice versa for carbon and alloy products).

An example of how $GHG_{product}$ is calculated is illustrated by the production of carbon and alloy semifinished steel in a hypothetical integrated steel facility (see figure E.4). In this example, the facility produces the following reference products and associated unit process emissions:

- 1.00 million metric tons (mmt) of metallurgical coke associated with unit process emissions ($UGHG_{mcoke}$) of 0.40 mmt $CO_2$e. Of this production, 0.50 mmt (50 percent) of this material is used on-site to produce other products. The facility reports that 80 percent of the metallurgical coke that it uses is used in blast furnace operations and 20 percent is used in iron sinter production.
- 1.00 mmt of semifinished steel in BOF steelmaking associated with unit process emissions ($UGHG_{car\ semi}$) of 0.40 mmt $CO_2$e.
- 1.20 mmt of pig iron associated with unit process emissions ($UGHG_{pig}$) of 1.80 mmt $CO_2$e. Of this production, 0.90 mmt (75 percent) is used on-site to produce other products and 0.30 mmt is shipped to other facilities. The facility reports that all of the pig iron that it uses is used in blast furnace operations (production of pig iron).

- 1.40 mmt of iron sinter associated with unit process emissions ($UGHG_{sinter}$) of 0.30 mmt $CO_2$e. All iron sinter is used to produce pig iron on-site.
- 1.20 mmt of pig iron associated with unit process emissions ($UGHG_{pig}$) of 2.00 mmt $CO_2$e. Of this production, 0.60 mmt (50 percent) is used on-site to produce other products. The facility reports that all of the pig iron that it uses is used in BOF steelmaking.
- 0.80 mmt of carbon and alloy semifinished steel in BOF steelmaking associated with unit process emissions ($UGHG_{car\ semi}$) of 0.40 mmt $CO_2$e.
- The facility does not report production of any other products.

First, $GHG_{mcoke}$ is calculated. No upstream materials made at this facility are included in the calculation of this product-level emissions inventory. Therefore, $GHG_{mcoke}$ is equal to $UGHG_{mcoke}$, or 0.40 mmt $CO_2$e. Of those emissions, 0.20 mmt $CO_2$e (corresponding with the share of production used on-site) are allocated to downstream products that use metallurgical coke. Based on the use of metallurgical coke in the facility, $ICGHG_{mcoke,sinter}$ is equal to 0.04 mmt $CO_2$e (corresponding with 20 percent of metallurgical coke use), and $ICGHG_{mcoke,pig}$ is equal to 0.16 mmt $CO_2$e (corresponding with 80 percent of metallurgical coke use).

Second, $GHG_{sinter}$ is calculated as the sum of $UGHG_{sinter}$ and $ICGHG_{mcoke,sinter}$. This sum is 0.34 mmt $CO_2$e. All sinter is used on-site in the production of pig iron. Therefore, $ICGHG_{sinter,pig}$ is also 0.34 mmt $CO_2$e.

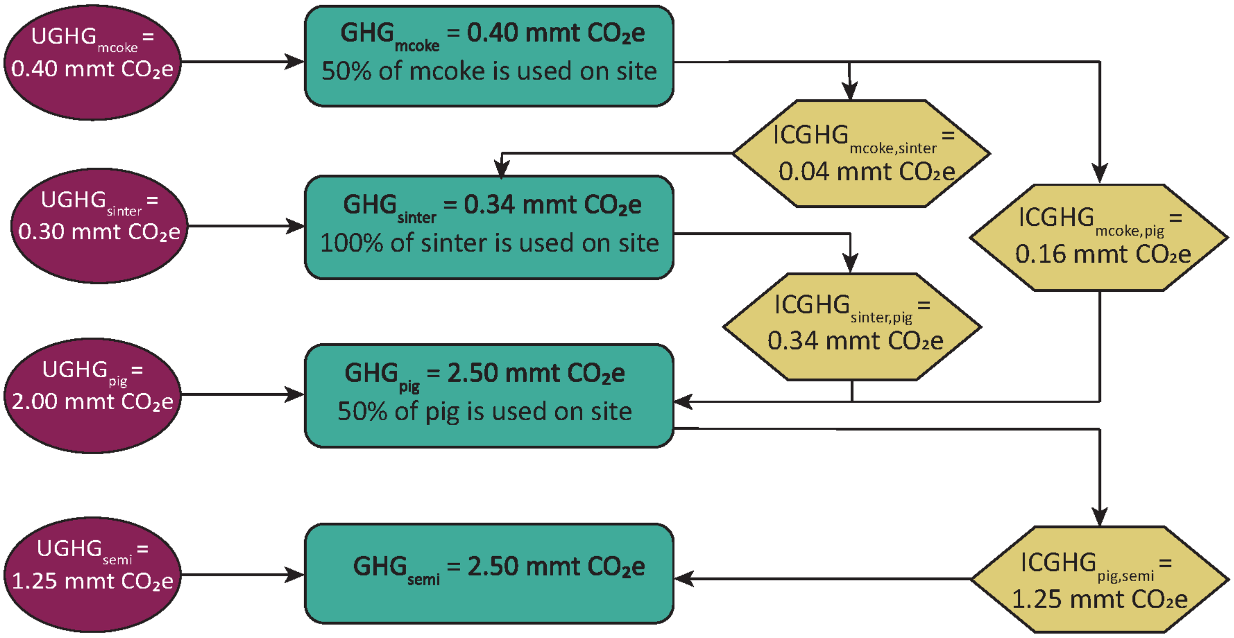
Third, $GHG_{pig}$ is calculated as the sum of $UGHG_{pig}$, $ICGHG_{mcoke,pig}$, and $ICGHG_{sinter,pig}$. This sum is 2.50 mmt $CO_2$e. Of those emissions, 1.25 mmt $CO_2$e (corresponding with the share of production used on-site) are allocated to the only downstream product made at the facility that uses pig iron, which is semifinished steel. Therefore, $ICGHG_{pig,car\ semi}$ is also equal to 1.25 mmt $CO_2$e.

Fourth, $GHG_{car\ semi}$ is calculated as the sum of $UGHG_{car\ semi}$ and $ICGHG_{pig,car\ semi}$, which is 2.50 mmt $CO_2$e.

In all four summations of $GHG_{product}$ described above, other derivatives of $ICGHG_{material,product}$ are also included based on the material and product relationships shown in table E.11. Because this facility has no material production or product use of that material, all those derivatives are equal to zero and are not depicted in the figure.

**Figure E.4** Example of how material flow analysis is used to calculate product-level emissions inventories in an integrated steel facility

mcoke = metallurgical coke; sinter = iron sinter; pig = pig iron; semi = carbon and alloy semifinished steel; $UGHG_{product}$ = unit process emissions from production of the reference product; $GHG_{product}$ = the product-level emissions inventory of the reference product; $ICGHG_{material,product}$ = emissions associated with upstream materials made in the same facility and used in the production of the reference product; mmt $CO_2e$ = million metric tons of carbon dioxide equivalent.



Source: Compiled by the USITC.

## III.B. Material Flow Analysis for the Aluminum System Boundary

In the United States, upstream materials used in the production of aluminum products are not typically produced in the same facility producing the aluminum products—with two exceptions. First, carbon anodes are typically produced in the same facility as primary unwrought aluminum. Incorporating emissions from the production of carbon anodes (i.e., anode baking) into the primary unwrought aluminum emissions estimate is straightforward as anode baking only maps to one product—primary unwrought aluminum. Thus, all upstream emissions from anode baking material ($material$) that is consumed on-site can be allocated to primary unwrought aluminum ($product$) and included in $GHG_{product}$. Second, secondary unwrought aluminum may be produced in the same facility as wrought aluminum products and other noncovered products. Therefore, upstream emissions from this on-site secondary unwrought aluminum production ($ICGHG_{material,product}$) are included in the emissions inventories ($GHG_{product}$) for all downstream wrought aluminum products (e.g., aluminum bars, rods, and profiles) that use secondary unwrought aluminum produced on-site.

# III.C. Additional Analysis for Aggregate Product Categories and Product Subcategories

The calculations in the sections above generate product-level emissions inventories for reference products that correspond directly with most product categories for which estimates are presented in this report.[566] This section describes how the Commission calculated product-level emissions inventories for products that are either aggregates or subcategories of reference products.

## III.C.1. Calculation of Product-Level Emissions Inventories for Product Subcategories

The Commission calculated emissions intensity estimates for certain steel products that are subcategories of reference products (see table E.12 for a list of these products). For each subcategory ($subcategory$), the Commission calculated the product-level emissions inventory ($GHG_{subcategory}$) using equation E.62.

$$GHG_{subcategory} = GHG_{product} * \frac{Output_{subcategory}}{Output_{product}} \qquad (E.62)$$

**Table E.12** List of reference products with associated subcategories

| Reference product(s) | Associated subcategories |
|---|---|
| Semifinished steel | Ingots and steel in other primary forms (carbon and alloy, stainless); slabs (carbon and alloy, stainless); and all other forms of semifinished steel (carbon and alloy, stainless) |
| Carbon and alloy hot-rolled flat steel | Hot-rolled plate; all other hot-rolled flat steel products |
| Carbon and alloy hot-worked long steel | Rebar; wire rod; heavy structural shapes and sheet piling; all other hot-worked long steel products |
| Cold-formed long steel | Wire (carbon and alloy, stainless); all other forms of cold-formed long steel products (carbon and alloy, stainless) |
| Carbon and alloy seamless steel tubular products | Seamless oil country tubular goods; all other seamless steel tubular products |
| Carbon and alloy non-seamless steel tubular products | Non-seamless oil country tubular goods; all other non-seamless steel tubular products |

Source: Compiled by the USITC.

Note: The term “carbon and alloy, stainless” indicates that both stainless steel and carbon and alloy steel types of that reference product have associated subcategories of the same type.

This approach meant that, for a given facility, there was no difference in the emissions intensities of the broader reference product and underlying subcategories of products. Emissions intensity estimates presented for different product subcategories do not reflect distinctions in production practices within individual facilities that may affect the emissions intensities of subcategories. For example, a facility that produces both rebar and steel wire rod would not have a different emissions intensity for those product subcategories, nor would those emissions intensities be distinct from carbon and alloy hot-worked long

---

[566] Table E.1 in the “I. Overview of Product-Level Emissions Intensity and Inventory Calculations” section of this appendix contains the full list of reference products.

products generally. However, for the industry-wide estimates presented in this report, the different production practices and efficiencies of facilities and the different concentration of product subcategories across all facilities is reflected in distinct estimates for each subcategory. Using the above example again, the industry-wide emissions intensity for rebar and wire rod will differ from each other based on the hot-worked long product emissions intensities of the facilities concentrated in either product subcategory.

## III.C.2. Calculation of Product-Level Emissions Inventories for Aggregate Product Categories

Certain product categories are aggregates of other product categories and therefore encompass multiple underlying reference products (see table E.13). Aggregate product categories are steel product categories specified in the Trade Representative's letter under attachment A.[567]

**Table E.13** List of aggregate product categories and underlying reference products

| Aggregate product categories | Underlying reference products |
|---|---|
| Unwrought aluminum | Primary unwrought aluminum; secondary unwrought aluminum |
| Wrought aluminum | Bars, rods, and profiles; wire; plates, sheets, and strip; foil; tubes, pipes, and tube or pipe fittings; castings; forgings |
| Carbon and alloy flat steel | Carbon and alloy hot-rolled flat steel; carbon and alloy cold-rolled flat steel; carbon and alloy coated flat steel |
| Carbon and alloy long steel | Carbon and alloy hot-worked long steel; carbon and alloy cold-formed long steel |
| Carbon and alloy tubular steel | Seamless steel tubular products; non-seamless steel tubular products |
| Stainless steel | Stainless semifinished steel; stainless hot-rolled flat steel; stainless cold-rolled flat steel; stainless hot-worked long steel; stainless cold-formed long steel; stainless seamless tubular steel products; stainless non-seamless tubular steel products |

Source: Compiled by the USITC.

The emissions inventories of unwrought aluminum, wrought aluminum, and carbon and alloy tubular steel are the sums of the product-level emissions inventories of underlying reference products. For stainless steel products ($ss\ all$), carbon and alloy flat steel products ($car\ flat$), and carbon and alloy long steel products ($car\ long$), the underlying reference products were vertically integrated. As a result, product-level emissions inventories for downstream underlying reference products (e.g., carbon and alloy cold-rolled flat steel products) included emissions associated with the production of upstream underlying reference products (e.g., carbon and alloy hot-rolled flat steel products). The Commission calculated the emissions inventories of each of these three aggregate product categories by summing

---

[567] See appendix A for the Trade Representative's request letter for this investigation.

$GHG_{product}$ for all underlying reference products and by subtracting all terms for $ICGHG_{material,product}$ where both $material$ and $product$ referred to underlying reference products.[568]

# IV. Standards Informing the Commission's Methodology Development

Across the steel and aluminum industries, dozens of different standards and approaches to emissions measurement exist. Approaches to measuring product-level GHG emissions within these standards differ across multiple dimensions, including system boundaries, the types of GHGs and emissions scopes covered, treatment of emissions embodied in waste gases and scrap, product allocation techniques, and measurement techniques allowed for direct and indirect emissions. The differences in these approaches are driven largely by the objectives of each standard, regulation, or study.

Many stakeholders have argued that the proliferation of different approaches can create burdens for firms providing data, increase trade compliance costs, and lead to confusion among the users of GHG emissions data (e.g., consumers and policymakers).[569] As a result, multiple organizations have called for new and existing measurement approaches to improve "interoperability": that is, the techniques and data derived from different methodologies should be maximally usable (even if not identical) across standards.[570] In particular, some organizations have argued that U.S. measurement approaches should maximize interoperability with the EU's approach to measurement under its Carbon Border Adjustment Mechanism (CBAM). Some suggested that with the EU's long-standing efforts to measure GHG emissions through its Emissions Trading System (ETS) and more recently CBAM, other countries should simply adopt similar accounting techniques.[571] Others suggested that the EU and the United States should harmonize reporting requirements, units of measure, system boundaries, covered gases and scopes of emissions, and acceptable methods for measuring or calculating emissions.[572]

Within the context of the U.S. Trade Representative's request, the Commission's objective was to provide a single-year snapshot of the emissions intensities of covered steel and aluminum products and to explain its methodology in doing so. In its development of an approach appropriate for these purposes, the Commission considered many existing approaches when developing its own methodology. To

---

[568] For similar reasons, emissions intensity calculations for these same three aggregate product categories did not include all production of all underlying reference products. Specifically, production of upstream underlying reference products used to make downstream underlying reference products was not included. As a result, the production of aggregate product categories used in emissions intensity calculations only include production for external shipment and production for use in the same facility used to make products other than those covered under the aggregate product category itself. The Commission estimated a facility's production of a material used to make specific downstream products by multiplying $ICOutput_{material}$ and $\frac{Use_{material,product}}{Use_{material}}$.

[569] Subject matter expert, interview by USITC staff, October 20, 2023; Subject matter expert, interview by USITC staff, August 2, 2023.

[570] USTR, "USTR Issues Communication to WTO Members," April 4, 2024; WTO, "Steel Standards Principles," accessed September 20, 2024.

[571] Benson, *Transatlantic Trade and Climate*, December 18, 2023.

[572] Porterfield, Hoenig, and Rooper, "An Approach to Interoperability of U.S. and EU Systems for Determining GHG Emissions Intensity of Steel," April 2024; Rasool, Reinsch, and Denamiel, "Crafting a Robust U.S. Carbon Border Adjustment Mechanism," July 2024.

facilitate the use and ease of interpretation of the emissions intensity estimates it developed, the Commission planned its data collection strategy and calculation methodology strategy with consideration for interoperability with other commonly used standards when possible and borrowed existing approaches when appropriate. However, the Commission did not adhere to any single existing methodology for calculating product-level GHG emissions, particularly since many of these frameworks (e.g., CBAM, ResponsibleSteel 2.1) were in draft form or undergoing revisions throughout this investigation.

Given the Trade Representative's request that data to generate product-level emissions intensities estimates be collected via a survey at the firm level, the Commission consulted both corporate and product-level accounting frameworks. The level of specificity of the measurement output of these frameworks varied. On the end with the greatest detail, the Commission reviewed life cycle inventories (LCIs) and environmental product declarations (EPDs), some of which were developed to describe the embedded environmental burden for a specific material or product produced at a particular facility. The Commission also reviewed the broader frameworks upon which several more industry- and product-specific standards are built, including the GHG Protocol's Corporate and Product Life Cycle and Accounting Standards, and the various product-level standards from the International Organization for Standardization (ISO).[573]

Tables E.14 and E.15 present a summary of the approaches the Commission focused on most closely in its review and how they compare to the Commission's methodology across several key metrics. These methodologies represent approaches used under mandatory government reporting (CBAM), voluntary industry-derived standards (worldsteel/ISO 14404, Responsible Steel 2.1, Global Steel Climate Council (GSCC), and the International Aluminium Institute (IAI)), and life cycle analysis studies with actual data (Aluminum Association and Sphera/Aluminum Extruders Council (AEC)). While several other insightful and thoroughly researched calculation frameworks have been released by industry researchers and life cycle analysis practitioners, the Commission hewed most closely to those standards and frameworks cited by steel and aluminum industry representatives in their own carbon accounting work.[574]

---

[573] WRI and WBCSD, *GHG Protocol Product Life Cycle Accounting and Reporting Standard*, accessed August 3, 2023; WRI and WBCSD, *The Greenhouse Gas Protocol*, March 2004; ISO, *ISO 14067*, April 22, 2022; ISO, *ISO 14044*, August 12, 2014; ISO, *ISO 14404-1*, 2013; ISO, *ISO 14404-2*, 2013.

[574] Examples of such additional calculation approaches include the Greenhouse Gas Index (GGI) developed by researchers at Resources for the Future and RMI's Steel and Aluminum GHG Emissions Reporting Guidance. Flannery and Mares, Greenhouse Gas Emissions Intensities of the Steel and Aluminum Industries at the Product Level, August 2024; Wright et al., Steel GHG Emissions Reporting Guidance, June 2023; Chalasani, Liu, and Wu, Aluminum GHG Emissions Reporting Guidance, December 2023.

**Table E.14** Comparison of the USITC's methodology to commonly referenced approaches to measuring product-level emissions for steel

CBAM = Carbon Border Adjustment Mechanism; ETS = Emissions Trading System; GSCC = Global Steel Climate Council; ISO = International Organization of Standards; $N_2O$ = nitrous oxide; $CH_4$ = methane; $NF_3$ = nitrogen trifluoride; HFCs = hydrofluorocarbons; PFCs = perfluorocarbons; $SF_6$ = sulfur hexafluoride.

| Factor | USITC Methodology: Steel | CBAM: Iron and Steel | worldsteel $CO_2$ Data Collection User Guide/ISO 14404 | GSCC Steel Climate Standard | ResponsibleSteel 2.1 |
|---|---|---|---|---|---|
| Measurement purpose | Generating an average nationwide product-level GHG emissions intensity estimate collected across all U.S. facilities. | Generating a product-level embedded emissions estimate for individual importers' imports, covering a scope consistent with ETS coverage of European industrial installations. | Generating site-specific emissions intensity estimates for the production of crude steel. The ISO 14404 series includes standards that are specific to production technology; worldsteel's approach is not. | Generating site-specific emissions intensity estimates for the production of crude steel. Estimates are used for low-carbon certification program, company target-setting, and steel customer awareness. | Generating site-specific emissions and emissions intensity estimates for the production of crude steel. Estimates are part of a broader voluntary sustainability certification standard. |
| Emissions covered | GHGs include $CO_2$, $N_2O$, and $CH_4$. All scope 1 and scope 2 emissions are included. Scope 3 covers emissions embedded in externally sourced upstream material inputs. | GHGs include $CO_2$ only. Covers "direct embedded emissions" which include scope 1 emissions other than those associated with electricity generation and scope 2 emissions associated with heat received from other sources; and "indirect embedded emissions" which include emissions related to electricity consumption (which can be scope 1 or scope 2 depending on point of generation). Emissions embedded in externally sourced upstream material inputs (scope 3) are similarly divided and aggregated with the above. | GHGs include $CO_2$ only. All scope 1 and scope 2 emissions are included. Scope 3 covers emissions embedded in externally sourced upstream material inputs. | GHGs include $CO_2$, $CH_4$, $NF_3$, $N_2O$, HFCs, PFCs, and $SF_6$. All scope 1 and scope 2 emissions are included. Scope 3 covers emissions embedded in externally sourced upstream material inputs and those associated with downstream toll processing of finished steel mill products. | GHGs include $CO_2$, $CH_4$, $NF_3$, $N_2O$, HFCs, PFCs, and $SF_6$. All scope 1 and scope 2 emissions are included. Scope 3 covers emissions embedded in externally sourced upstream material inputs. |

| Factor | USITC Methodology: Steel | CBAM: Iron and Steel | worldsteel $CO_2$ Data Collection User Guide/ISO 14404 | GSCC Steel Climate Standard | ResponsibleSteel 2.1 |
|---|---|---|---|---|---|
| System boundaries (upstream materials covered) | Boundary includes emissions associated with extraction and processing of most upstream raw materials. Excludes emissions associated with transport. See figures 2.4 and 2.5 of this report for full coverage of processes covered under this investigation's system boundaries. | Boundary includes emissions associated with processing of some key material inputs, but excludes emissions associated with mining and the processing of coke, flux materials, carbon electrodes, industrial gases other than hydrogen, all but three ferroalloys and alloying metals, and coating metals. Excludes emissions associated with transport. | Boundary includes emissions associated with processing of most upstream raw materials. Excludes emissions associated with extraction of materials and transport. The ISO 14404 series has slightly different boundaries depending on the production technology. | Boundary includes emissions associated with extraction, processing, and transport of materials. | Boundary includes emissions associated with extraction, processing, and transport of materials. |
| System boundaries (downstream products) | Covers emissions from all production of finished mill products. This includes products such as coated flat steel, tubular products, and wire. See investigation request letter in appendix A of this report for a full list and chapter 2 ("Covered Steel Products") for a list of all product categories for which emissions intensity estimates were generated in this report. | Covers emissions from production of crude steel products and "iron or steel products," a broad category of finished downstream steel mill products that is more expansive than the covered products under the USITC investigation. | Covers emissions from a facility's production of crude steel. Does not cover downstream processes. | Covers emissions from a facility's production through the hot-rolling stage. | Covers emissions from a facility's production of crude steel. Does not cover downstream processes. |

| Factor | USITC Methodology: Steel | CBAM: Iron and Steel | worldsteel $CO_2$ Data Collection User Guide/ISO 14404 | GSCC Steel Climate Standard | ResponsibleSteel 2.1 |
|---|---|---|---|---|---|
| Allocation of emissions from waste gases | Emissions from waste gas combustion are fully allocated to the processes where that combustion occurs (or the processes that use energy generated on-site from waste gases). For more information see box 3.1 in chapter 3 of this report. | Emissions from waste gas combustion are allocated to the facility and process that created the gas. Exports of waste gas for use in another process or facility receive a credit based on displacement of natural gas use. Similarly, production processes that use waste gas sourced from a different process or facility use a lower natural gas emissions factor for that combustion of waste gas imports. This effectively shifts some of the waste gas combustion emissions from processes using the gas to the processes creating it. | Emissions from waste gas combustion are included in facility-wide scope 1 emissions. Exports of waste gas are assumed to displace alternative sources for electricity; they receive a scope 2 emissions credit based on the 2006 IEA world average $CO_2$ intensity of electricity. | Emissions from waste gas combustion are included in facility-wide scope 1 emissions. Exports of waste gas (including on-site use outside the system boundary) receive credits based on displacement of natural gas use or electricity generation using the local average mix of generation sources. | Emissions from waste gas combustion are included in facility-wide scope 1 emissions. Exports of waste gases (including on-site use outside of the system boundary) receive credits based on displacement of natural gas use or electricity generation using a global average mix of generation sources. |
| Allocation of facility-level emissions to products | Facility-level emissions are subdivided into subprocesses and further divided into unit-process level emissions based on “physical allocation” (i.e., by mass of output); unit-process-level emissions are then combined with emissions associated with upstream products internally consumed within the same facility. | Emissions are allocated using a similar approach to the USITC method, although product categories are broader. For facilities that do not externally ship any upstream products made on-site, a “bubble” approach can be used that avoids allocation of facility-level emissions into specific processes. | Emissions embedded in intermediate products shipped off-site are excluded. Because the estimation involves crude steel only, no allocation steps are needed to determine product-level emissions for crude steel or any downstream goods. | Emissions burden of intermediate products is not explicitly discussed. Standard notes that a product’s embedded carbon estimates should be determined in conformance with GHG Protocol Product Life Cycle and Accounting Standard, which forms the basis for the USITC’s allocation approach. | Emissions embedded in intermediate products shipped off-site are excluded. Because the estimation involves crude steel only, no allocation steps are needed to determine product-level emissions for crude steel or any downstream goods. |

| Factor | USITC Methodology: Steel | CBAM: Iron and Steel | worldsteel $CO_2$ Data Collection User Guide/ISO 14404 | GSCC Steel Climate Standard | ResponsibleSteel 2.1 |
|---|---|---|---|---|---|
| Scrap treatment | Scrap does not have embedded scope 3 emissions. The Commission’s questionnaire asked for data on the quantity and characteristics of scrap used in steelmaking (i.e., share of scrap that is post-consumer, home scrap, and carbon content) for supplemental analysis. | Scrap does not have embedded scope 3 emissions. Post-consumer scrap used as an input is presumed to have zero emissions burden, whereas carbon in pre-consumer scrap is considered under mass-balance calculations. Importers provide source installation’s quantity of scrap used in production, including the share of scrap that is pre-consumer. | Scrap does not have embedded scope 3 emissions. Standards do not call for gathering data on scrap receipts from external sources for any other reason. | Scrap does not have embedded scope 3 emissions from original steel production, but emissions from scrap collection and processing are explicitly included. | Scrap does not have embedded scope 3 emissions from original steel production, but emissions from transportation of scrap to the steel producer’s gate is included. The quantity of scrap used in crude steel production is required reporting to be able sell products as ResponsibleSteel certified. |
| Scope 3 emission requirements | Scope 3 emissions are calculated by multiplying activity data by emissions factors from two sources: (1) product-level emissions intensities of U.S. supplier facilities estimated by the Commission; or (2) default emissions factors collected or developed by the Commission (see appendix F in this report for more details). | Installations producing iron and steel products are required to report data on the emissions intensities of inputs (“precursors”) produced off-site. These data may be collected directly from the precursor producers. If these emission data were not available, installations were also allowed to use default values provided under CBAM until July 2024. After July 2024, installations may use those default values for 20 percent or less of their total embedded emissions. | Calculation of scope 3 emissions from primary data is highly recommended, though calculation methodologies are flexible, and could include a mix of primary source or local and regional secondary source information. worldsteel also supplies industry average upstream factors in the event primary data are not available. (ISO 14404 also has an upstream emissions factor table, with similar rules applied). | Scope 3 emissions are determined either based on primary source data (conforming to certain reporting requirements) OR unspecified “industry average data” with proper citation. Scope 3 emissions from purchased billets and slabs must be determined based on primary source data. The share of scope 3 emissions based on primary source data is also reported as a qualitative factor. | Scope 3 emissions are determined either based on primary source data provided by the supplier of upstream materials (conforming to certain reporting requirements) or on ResponsibleSteel default emissions factors (“embodied GHG values”). Many of these default emissions factors are taken from industry sources and multiplied by a factor of 1.2 or 1.6 to be purposely higher than industry averages. |

Sources: EC, DG-TAXUD, *CBAM Guidance for Installations*, December 8, 2023; European Parliament and the Council of the European Union, “CBAM Regulation 2023/956,” May 17, 2023; GSCC, *The Steel Climate Standard*, August 2023; Janjua and Maciel, *$CO_2$ Data Collection User Guide, Version 11*, May 30, 2024; ISO, *ISO 14404-1:2013*, 2013; ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024.

**Table E.15** Comparison of USITC's methodology to commonly referenced approaches to measuring product-level emissions for aluminum

IAI = International Aluminum Institute; CBAM = Carbon Border Adjustment Mechanism; ETS = Emissions Trading System; ISO = International Organization of Standards; $N_2O$ = nitrous oxide; $CH_4$ = methane; $NF_3$ = nitrogen trifluoride; HFCs = hydrofluorocarbons; PFCs = perfluorocarbons; $SF_6$ = sulfur hexfluoride.

| Factor | USITC Methodology: Aluminum | CBAM: Aluminum | IAI | Aluminum Association LCA Semi-Fabricated | Sphera/AEC Assessment for Aluminum Extrusions |
|---|---|---|---|---|---|
| Measurement purpose | Generating an average nationwide product-level GHG emissions intensity estimate collected across all U.S. facilities. | Generating product-level embedded emissions intensity estimates for individual importers' imports, covering a scope consistent with ETS coverage of European industrial installations. | Establishing standardized guidance on the calculation of product-level GHG emissions, primarily in the primary unwrought aluminum segment and precursor segments. | Creating a North American lifecycle analysis of semi-fabricated aluminum products to improve understanding of the environmental implications of aluminum production. Also serves as a resource for development of EPDs and other sustainability reports, strategic planning, and sustainable development. | Creating North American industry average lifecycle analyses for aluminum extrusions with various finishes, to serve as a resource for the development of future EPDs. |
| Emissions covered | GHGs include $CO_2$, $N_2O$, $CH_4$, and PFCs ($CF_4$ and $C_2F_6$). Scope 1 process and fuel combustion emissions are included. Scope 2 emissions from purchased electricity, heat, and steam are included. Scope 3 emissions are from emissions embedded in externally sourced upstream material inputs. | GHGs include $CO_2$ and PFCs ($CF_4$ and $C_2F_6$). Covered "direct embedded emissions" which include scope 1 emissions other than those associated with electricity generation and scope 2 emissions associated with heat received from other sources; and "indirect embedded emissions" which include emissions related to electricity consumption (which can be scope 1 or scope 2 depending on point of generation). Emissions embedded in externally sourced upstream material inputs (scope 3) are similarly divided and aggregated with the above. | GHGs include $CO_2$, $N_2O$, $CH_4$, and PFCs ($CF_4$ and $C_2F_6$). Scope 1 process and fuel combustion emissions are included. Scope 2 emissions from purchased electricity, heat, and steam are included. Scope 3 emissions are from emissions embedded in externally sourced upstream material inputs. | GHGs include $CO_2$, $N_2O$, $CH_4$, and PFCs ($CF_4$ and $C_2F_6$). Scope 1 process and3 fuel combustion emissions are included. Scope 2 indirect electricity and thermal energy emissions are included. Scope 3 indirect emissions from sources not controlled by the company are included. | GHG inclusion corresponds with IPCC AR 5, which includes $CO_2$, $N_2O$, $CH_4$, $SF_6$, and PFCs ($CF_4$ and $C_2F_6$) and HFCs. Scope 1 process and fuel combustion emissions are included. Scope 2 indirect electricity and thermal energy emissions are included. Scope 3 emissions from externally sourced upstream inputs are included. |

| Factor | USITC Methodology: Aluminum | CBAM: Aluminum | IAI | Aluminum Association LCA Semi-Fabricated | Sphera/AEC Assessment for Aluminum Extrusions |
|---|---|---|---|---|---|
| System boundaries (upstream materials covered ) | Includes emissions associated with extraction and processing or production of most upstream materials including bauxite mining, alumina refining, and production of anode materials and carbon anodes.<br>Excludes emissions associated with transportation, where possible. | Excludes emissions associated with extraction and processing of raw materials. Excludes alumina refining and production of pre-baked carbon anodes (whether baked on- or off-site).<br>Excludes emissions associated with transportation. | Includes emissions associated with extraction and processing or production of upstream materials including bauxite or other ores mining, alumina refining, and production of anode materials and carbon anodes.<br>Includes emissions associated with transportation.<br>Older versions of IAI guidance had more narrowly defined system boundaries. | Includes emissions associated with extraction and processing of raw materials and production of metal.<br>Includes emissions associated with transportation. | Includes emission associated with extraction and processing of raw materials and production of metal.<br>Includes emissions associated with transportation. |
| System boundaries (downstream products) | Primary aluminum, secondary aluminum, and certain downstream aluminum products. See investigation request letter in appendix A of this report for a full list. | Primary aluminum, secondary aluminum, and aluminum products. CBAM has more expansive coverage of downstream aluminum products than the USITC investigation. | The Good Practice Document only covers primary aluminum and its precursor products. Additional draft guidance on reporting carbon footprints of aluminum products when scrap or recycled material are incorporated would apply to both semifinished (e.g., sheet) and finished (e.g., cans) aluminum products. | Primary aluminum, secondary aluminum, generic and automotive extrusions, generic and automotive sheet, foil, and die castings. | Aluminum extrusions of varying finishes including mill finished, painted, anodized, thermally improved and painted, and thermally improved and anodized. |

| Factor | USITC Methodology: Aluminum | CBAM: Aluminum | IAI | Aluminum Association LCA Semi-Fabricated | Sphera/AEC Assessment for Aluminum Extrusions |
|---|---|---|---|---|---|
| Allocation of facility-level emissions to products | USITC subdivides facility-level emissions into subprocesses; further divides subprocess-level emissions into unit-process level emissions based on “physical allocation” (i.e., by mass of output); and includes unit-process-level emissions within downstream emissions calculations where upstream products are internally consumed within the same facility. | Emissions are allocated using a similar approach to the USITC method, although product categories are broader. For facilities that do not externally ship any upstream products made on-site, a “bubble” approach can be used that avoids allocation of facility-level emissions into specific processes. | IAI guidelines rely on ISO 14044 / ISO 14067 allocation approaches. IAI recommends collecting input and output data separately at the subprocess level for different products. When this approach cannot be used, a physical allocation approach based on mass is generally the preferred way to allocate emissions across products. | Relies on ISO 14040/14044 standards. The approach attempts to avoid allocation by expanding system boundaries where possible. | Facility-level emissions are subdivided between product types using questionnaire data. |
| Scrap treatment | Scrap does not have embedded scope 3 emissions. The Commission’s questionnaire asked for data on the quantity and characteristics of scrap used in aluminum production (i.e., share of scrap that is post-consumer, runaround scrap) for supplemental analysis. | Scrap does not have embedded scope 3 emissions. Importers provide source installation’s quantity of scrap used in production, including the share of scrap that is pre-consumer. | No single approach recommended for determining scrap emissions, but treatment across different ISO standards Is described. Under all approaches, post-consumer scrap has no embedded scope 3 emissions. Disclosing the calculation for pre-consumer scrap emissions, and shares of pre- and post-consumer scrap used in production is good practice. | Scrap does not have embedded scope 3 emissions in the cradle-to-gate approach. The cradle-to-grave approach uses a modified substitution method, which allows for a scrap “credit” or “burden” depending on recycling rates. The questionnaire asked for information on the amount of scrap used that was pre- or post-consumer. | Scrap does not have embedded emissions in the cradle-to-gate approach. The cradle-to-grave approach allows for a scrap “credit” or “burden” based on net scrap output. The questionnaire asked for information on the amount of scrap used that was pre- or post-consumer. |

| Factor | USITC Methodology: Aluminum | CBAM: Aluminum | IAI | Aluminum Association LCA Semi-Fabricated | Sphera/AEC Assessment for Aluminum Extrusions |
|---|---|---|---|---|---|
| Scope 3 emission requirements | Scope 3 emissions are generally calculated by multiplying activity data by emissions factors from default emissions factors collected by Commission (see appendix F in this report for more details). In the case of inputs of domestic primary aluminum, the supplier facility's emissions data are used where possible. | Scope 3 emissions are generally calculated by multiplying activity data by emissions factors. Installations producing aluminum products are required to report emissions factors of inputs ("precursors") produced off-site. These data may be collected directly from the precursor producers. If these emission data were not available, installations were also allowed to use default values provided under CBAM until July 2024. After July 2024, installations may only use those default values for 20 percent or less of their total embedded emissions. | Follows the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard. User-defined "specific and verified" scope 3 emissions factors are recommended, though default emissions factors can be used in the event this information is not available. IAI provides a list of default emissions factors for material inputs in the aluminum value chain, gathered from various public sources. | The breakdown of scopes is done in compliance with the ISO 14044 standard. Scope 3 emissions are generally calculated by multiplying activity data by regional emissions factors. The LCA model uses aggregated survey results of inputs and outputs to find the average metal composition by product category. | Scope 3 emissions are generally calculated by multiplying activity data by emissions factors from default emissions factors mainly provided by Sphera and other sources. Where possible, location-specific emissions factors were used. |

Sources: EC, DG-TAXUD, *CBAM Guidance for Installations*, December 8, 2023; EU, European Parliament and the Council of the European Union, "CBAM Implementing Legislation 2023/1773," August 17, 2023; European Parliament and the Council of the European Union, "CBAM Regulation 2023/956," May 17, 2023; IAI, "Good Practice Guidance for Calculation of Primary Aluminium," August 2021; Biberman, Toledano, and Ram Mohan, "GHG Accounting Methods in the Aluminum Industry," February 2023; Sphera Solutions, *IAI Scope 3 Calculation Tool Guidance*, September 13, 2022, 3; IAI, "Reference Document on How to Treat Scrap Flows in Carbon Footprint Calculations for Aluminium Products," January 2023; ISO, *ISO 14040:2006*, 2006; ISO, *ISO 14067*, April 22, 2022, 14067; IAI, "Guidelines on Transparency – Aluminum Scrap," September 2022; WRI and WBCSD, *GHG Protocol Product Life Cycle Accounting and Reporting Standard*, accessed August 3, 2024; AA, The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report, January 2022; Sphera Solutions, *Aluminum Extrusion EPD Background Report*, November 4, 2022.

# V. Data Sources Used to Generate and Validate the Commission's Emissions Intensities

In addition to the primary data collected through questionnaire responses, the Commission drew from public and proprietary databases to generate and validate emissions intensity estimates for covered steel and aluminum product categories. As described in table E.16, the Commission used several data sources for publicly available emissions factors and emissions data to verify certain primary data received through questionnaire responses. Proprietary databases were used only to validate public and primary data collected, or to generate alternate scope 3 emissions intensities, presented in the sensitivity analyses in appendix F.

**Table E.16** Data sources used to generate and validate emissions intensity estimates
— (em dash) = not applicable.

| Data source | Description | Use in emissions intensity estimates generation | Use in emissions intensity estimates validation | Year(s) of data coverage used in this report | Data maintained by |
|---|---|---|---|---|---|
| U.S. steel and aluminum facility-level questionnaire data | Survey of facilities producing covered steel and aluminum products in the United States, requesting information on production, energy use, and inputs | Primary data used to generate emissions intensity estimates at the process and product level | Section 7 optional responses used to validate certain average and facility-specific emissions intensities at the product level | 2022 | USITC |
| Greenhouse Gas Reporting Program (GHGRP) | Database of facility and unit-level emissions data from large GHG emission sources, fuel and industrial gas suppliers, and $CO_2$ injection sites in the iron and steel and aluminum sectors the United States | Process and fuel combustion emissions data used to allocate facility- and unit-level emissions estimates for facilities emitting more than 25,000 tons of $CO_2e$ annually | Process and combustion emissions and fuel data used to validate primary data for facilities emitting more than 25,000 tons of $CO_2e$ annually | 2022 | U.S. Environmental Protection Agency (EPA) |
| Emissions and Generation Resource Integrated Database (eGRID) | Database including emissions, emission rates, generation, heat input, and resource mixes of electric power generation in the United States | Subregional and plant-specific emissions and energy data used to generate emissions estimates related to generation and purchases of electricity and useful thermal output | Plant-level data and zip code subregion crosswalk used to validate primary data on facility grid purchases and plant-specific contracts | 2022 | EPA |

| Data source | Description | Use in emissions intensity estimates generation | Use in emissions intensity estimates validation | Year(s) of data coverage used in this report | Data maintained by |
|---|---|---|---|---|---|
| Joint Research Centre Technical Reports | 2023 technical report measuring the GHG emissions intensities of steel, aluminum, cement, and fertilizer products from industries in the EU and its trading partners; and 2013 technical report providing information and data on specific industrial processes within the iron and steel sector | Fuel, energy, and material input intensity data for iron and steel production processes used to generate certain iron and steel product-level emissions factors for use in scope 3 emissions estimates | — | 2022 | European Commission, Joint Research Centre |
| Sphera Managed Life Cycle Analysis Content (MLC) Database | Proprietary database of product-level life cycle inventories and assessments | Emissions factors for material and energy inputs used to generate alternate scope 3 emission estimates | Emissions factors for material and energy inputs used to validate USITC-generated scope 3 emissions factors used in scope 3 emissions estimates | Varies by emissions factor | Sphera Solutions, Inc. (Sphera) |
| International Energy Agency (IEA) Extended Energy Balances Data and Emissions Factors Database | Databases containing quantities of fuel and energy inputs and outputs across the iron and steel industry and country-specific emissions factors for electricity and heat generation | Fuel and energy quantities and emissions factors used to generate country-specific scope 3 emissions factors for certain material inputs in the partial LCI approach | — | 2017–22 | IEA |
| CRU Emissions Analysis Tool | Web-based portal for benchmark data of GHG emissions and emissions intensities in steel and aluminum plants | — | Facility-level production data to validate primary production data collection and emissions intensity and emissions factor estimates | 2022 | CRU |
| ResponsibleSteel International Production Standard 2.1 Annex 5 | Dataset of default embodied emissions factors for use as standard in site-level semifinished steel emission intensity performance determinations | Certain upstream material input emissions factors for steel production used to generate scope 3 emissions in the partial LCI approach | — | Varies by emissions factor | ResponsibleSteel |
| worldsteel Statistical Yearbook | Statistical yearbook on semifinished steel production by product, country, and process | Production data used to generate scope 3 emissions factors in the partial LCI approach | Production data used to validate primary data collected from domestic steel facilities | 2021 | World Steel Association |

| Data source | Description | Use in emissions intensity estimates generation | Use in emissions intensity estimates validation | Year(s) of data coverage used in this report | Data maintained by |
|---|---|---|---|---|---|
| wordsteel 2020 Life Cycle Inventory (LCI) and worldsteel $CO_2$ Data Collection User Guide | Documents containing direct and upstream emissions factors related to the production of steel | Used upstream material input emissions factors for steel production used to generate scope 3 emissions in the partial LCI approach | — | 2020, 2022 | World Steel Association |
| Aluminum Association (AA) Environmental Footprint of Semi-Fabricated Products Report | Cradle-to-gate life cycle inventory assessment of primary aluminum, secondary aluminum, and semi-fabricated aluminum products | — | Public emissions factors for secondary unwrought aluminum and wrought aluminum used to validate USITC's emissions factors | 2016 | AA |
| Aluminum Extruders Council (AEC) | Cradle-to-gate life cycle assessments and environmental product declarations for various types of aluminum extrusions | — | Public emissions factors for aluminum extrusions used to validate USITC's emissions intensity for bars, rods, and profiles | 2020–21 | AEC |
| International Aluminium Institute (IAI) Life Cycle Inventory Data | LCI database and accompanying report on cradle-to-gate environmental metrics for primary aluminum production | Public emissions factors for upstream inputs to primary unwrought aluminum used to generate scope 3 emissions for primary unwrought aluminum; public emissions factors for primary unwrought aluminum production used to generate scope 3 emissions for secondary unwrought and wrought aluminum products with primary unwrought aluminum input | Public emissions factors for primary unwrought aluminum used to validate USITC's emissions intensity estimates | 2019 | IAI |

Sources: EPA, "Greenhouse Gas Reporting Program (GHGRP)," June 10, 2014; EPA, "eGRID with 2022 Data," January 30, 2024; Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023; Remus et al., *Best Available Techniques (BAT) Reference Document*, January 24, 2013; Sphera Solutions, "LCA Database," 2024; IEA, "World Energy Balances," July 2024; IEA, "Emissions Factors 2023," September 2023; CRU, "CRU Emissions Analysis Tool," 2024; ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024; worldsteel, *Steel Statistical Yearbook 2023*, accessed September 21, 2024; Janjua and Maciel, *$CO_2$ Data Collection User Guide, Version 11*, May 30, 2024; worldsteel, *2020 LCI Study*, May 2021; AA, *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*, January 2022; Sphera Solutions, *Aluminum Extrusion EPD Background Report*, November 4, 2022; IAI, *Life Cycle Inventory Data and Environmental Metrics for the Primary Aluminium Industry*, November 2022.

# Bibliography

Alcoa Corporation. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 7, 2023. https://edis.usitc.gov/external/search/document/809502.

Aluminum Association (AA). *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A LifeCycle Assessment Report*. January 2022. https://www.aluminum.org/sites/default/files/2022-01/2022_Semi-Fab_LCA_Report.pdf.

American Iron and Steel Institute (AISI). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810875.

Association for Iron & Steel Technology (AIST). “AIST Steel Wheel.” In *The Making, Shaping and Treating of Steel*. Accessed November 5, 2024. https://apps.aist.org/steelwheel/index.html.

Association of Iron & Steel Technology (AIST). *2022 Directory of Iron and Steel Plants*. Warrendale, PA, 2022. https://www.aist.org/publications-advertising/directory-iron-and-steel-plants.

Benson, Emily. *Transatlantic Trade and Climate: Evaluating Differences and Commonalities in Mutual Approaches*. December 18, 2023. https://www.csis.org/analysis/transatlantic-trade-and-climate-evaluating-differences-and-commonalities-mutual-approaches.

Biberman, John, Perrine Toledano, and Rohini Ram Mohan. “GHG Accounting Methods in the Aluminum Industry.” *SSRN Electronic Journal* (February 2023). https://doi.org/10.2139/ssrn.4407422.

Chalasani, Sravan, Wenjuan Liu, and Iris Wu. *Aluminum GHG Emissions Reporting Guidance*. Rocky Mountain Institute (RMI), December 2023. https://rmi.org/wp-content/uploads/2023/11/aluminum_guidance.pdf.

Committee on Pipe and Tube Imports (CPTI). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 21, 2023. https://edis.usitc.gov/external/search/document/809092.

CRU Group (CRU). “CRU Emissions Analysis Tool.” Emissions Analysis Tool, 2024. https://www.crugroup.com/emissions-analysis-tool/.

European Aluminium Association. *Environmental Profile Report: Life-Cycle Inventory Data for Aluminium Production and Transformation Processes in Europe*. February 2018. https://european-aluminium.eu/wp-content/uploads/2022/10/european-aluminium-environmental-profile-report-2018-executive-summary.pdf.

European Commission (EC). Directorate-General Taxation and Customs Union (DG TAXUD). *Guidance Document on CBAM Implementation for Installation Operators Outside the EU*. Brussels, Belgium: European Commission, December 8, 2023. https://taxation-customs.ec.europa.eu/document/download/2980287c-dca2-4a4b-aff3-db6374806cf7_en?filename=Guidance%20document%20on%20CBAM%20implementation%20for%20installation%20operators%20outside%20the%20EU.pdf.

European Commission (EC). Directorate-General Taxation and Customs Union (DG-TAXUD). "Default Values for the Transitional Period of the CBAM Between 1 October 2023 and 31 December 2025." December 22, 2023. https://taxation-customs.ec.europa.eu/system/files/2023-12/Default%20values%20transitional%20period.pdf.

European Union (EU). European Parliament and the Council of the European Union. "Regulation 2023/1773 of European Union (EU)." August 17, 2023. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1773.

Flannery, Brian, and Jan Mares. Greenhouse Gas Emissions Intensities of the Steel and Aluminum Industries at the Product Level. 24–13. Resources for the Future, August 2024, Updated November 2024. https://media.rff.org/documents/Flannery_and_Mares_-_ITC_Version_11.2024_Update.pdf.

Global Steel Climate Council (GSCC). *The Steel Climate Standard: Framework for Steel Product Certification and Corporate Science-Based Emissions Targets*. August 2023. https://globalsteelclimatecouncil.org/the-standard/.

International Aluminium Institute (IAI). "IAI Good Practice Document on Measuring Perfluorocarbons." December 2020. https://international-aluminium.org/resource/good-practice-guidance-measuring-perfluorocarbons/.

International Aluminium Institute (IAI). "Good Practice Guidance for Calculation of Primary Aluminium and Precursor Product Carbon Footprints." August 2021. https://international-aluminium.org/wp-content/uploads/2021/08/CF-Good-Guidance-v2_final-2021.pdf.

International Aluminium Institute (IAI). "Guidelines on Transparency – Aluminum Scrap." IAI, September 2022. https://international-aluminium.org/wp-content/uploads/2022/09/IAI-Guidelines-Transparency-Final_Sept-2022.pdf.

International Aluminium Institute (IAI). *Life Cycle Inventory Data and Environmental Metrics for the Primary Aluminium Industry*. November 2022. https://international-aluminium.org/resource/2019-life-cycle-inventory-lci-data-and-environmental-metrics/.

International Aluminium Institute (IAI). "Reference Document on How to Treat Scrap Flows in Carbon Footprint Calculations for Aluminium Products (Draft for Public Review)." January 2023. https://international-aluminium.org/resource/public-review-guidelines-on-transparency-aluminium-scrap/.

International Aluminium Institute (IAI). "Perfluorocarbon (PFC) Emissions." 2024. https://international-aluminium.org/statistics/perfluorocarbon-pfc-emissions/?publication=perfluorocarbon-pfc-emissions.

International Aluminium Institute (IAI). “Primary Aluminium Smelting Energy Intensity (2022).” IAI Statistical System, September 21, 2024. https://archive.international-aluminium.org/statistics/primary-aluminium-smelting-energy-intensity/.

International Energy Agency (IEA). “Emissions Factors 2023.” September 2023. https://www.iea.org/data-and-statistics/data-product/emissions-factors-2023.

International Energy Agency (IEA). “World Energy Balances.” July 2024. https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

International Organization for Standardization (ISO). *ISO 14040:2006*. 2006. https://www.iso.org/standard/37456.html.

International Organization for Standardization (ISO). *ISO 14404-1:2013: Calculation Method of Carbon Dioxide Emission Intensity from Iron and Steel Production — Part 1: Steel Plant with Blast Furnace*. 2013. https://www.iso.org/standard/57298.html.

International Organization for Standardization (ISO). *ISO 14404-2:2013: Calculation Method of Carbon Dioxide Emission Intensity from Iron and Steel Production — Part 2: Steel Plant with EAF*. 2013. https://www.iso.org/standard/57299.html.

International Organization for Standardization (ISO). *ISO 14044:2006*. August 12, 2014. https://www.iso.org/standard/38498.html.

International Organization for Standardization (ISO). *ISO 14067:2018 Greenhouse Gases — Carbon Footprint of Products — Requirements and Guidelines for Quantification*. April 22, 2022. https://www.iso.org/standard/71206.html.International Organization for Standardization (ISO). *ISO 14067:2018*. April 22, 2022. https://www.iso.org/standard/71206.html.

International Panel on Climate Change. “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3.”

Janjua, Rizwan, and Felipe Maciel. *$CO_2$ Data Collection User Guide, Version 11*. V11, 30/05/2024. World Steel Association, May 30, 2024. https://worldsteel.org/wp-content/uploads/CO2_User_Guide_V11.pdf.

Moras, Charly A., Renaud Joannes-Boyau, Lennart T. Bach, Tyler Cyronak, and Kai G. Schulz. “Carbon Dioxide Removal Efficiency of Iron and Steel Slag in Seawater via Ocean Alkalinity Enhancement.” *Frontiers in Climate* 6 (June 17, 2024): 1396487. https://doi.org/10.3389/fclim.2024.1396487.

Outokumpu Stainless USA, LLC. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 21, 2023. https://edis.usitc.gov/external/search/document/809124.

Porterfield, Matthew C, Daniel Hoenig, and Holly Rooper. “An Approach to Interoperability of U.S. and EU Systems for Determining GHG Emissions Intensity of Steel.” Climate Leadership Council, April 2024. https://clcouncil.org/media/2024/04/Interoperability-of-Carbon-Accounting-for-GASSA_Final-1.pdf.

Rasool, Sanam, William Alan Reinsch, and Thibault Denamiel. “Crafting a Robust U.S. Carbon Border Adjustment Mechanism.” *CSIS Briefs*, July 2024. https://www.csis.org/analysis/crafting-robust-us-carbon-border-adjustment-mechanism.

Remus, Rainer, Miguel A. Aguado-Monsonet, Serge Roudier, and Luis Delgado Sancho. *Best Available Techniques (BAT) Reference Document for Iron and Steel Production*. January 24, 2013. https://doi.org/10.2791/98516.

ResponsibleSteel. *ResponsibleSteel International Production Standard: Version 2.1*. May 21, 2024. https://www.responsiblesteel.org/standards.

Specialty Steel Industry of North America (SSINA). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810863.

Sphera Solutions, Inc. *IAI Scope 3 Calculation Tool Guidance*. International Aluminium Institute (IAI), September 13, 2022. https://international-aluminium.org/resource/iai-scope3-calcuation-tool-and-guidance/.

Sphera Solutions, Inc. *Aluminum Extrusion EPD Background Report*. Version 1.1. Aluminum Extruders Council (AEC), November 4, 2022. https://aec.org/sites/default/files/2022-11/AEC_EPDs_Background_Report_20221107_signed.pdf.

Sphera Solutions, Inc. “LCA Database.” Life Cycle Assessment Datasets, 2024. https://lcadatabase.sphera.com/.

Sullivan, Kate, and Grace Olson. “Building a Decarbonized Steel Sector.” (July 7, 2023). https://www.wri.org/update/building-decarbonized-steel-sector.

Tabereaux, Alton. “Low Voltage Anode Effects and Unreported PFC Emissions.” Presentation presented at the ICSOBA 2016: 34th conference and exhibition, Quebec City, Quebec, Canada, October 2016. https://icsoba.org/proceedings/34th-conference-and-exhibition-icsoba-2016/?doc=63.

U.S. Department of Commerce (USDOC). International Trade Administration (ITA). “Melt and Pour Dashboard.” Accessed November 8, 2024. https://www.trade.gov/data-visualization/melt-and-pour-dashboard.

U.S. Environmental Protection Agency (EPA). “Iron and Steel Production Final Rule: Mandatory Reporting of Greenhouse Gases.” 40 CFR 98, subpart Q, March 2012. https://www.epa.gov/sites/default/files/2015-02/documents/infosheetqironandsteelproduction.pdf.

U.S. Environmental Protection Agency (EPA). “Greenhouse Gas Reporting Program (GHGRP).” Other Policies and Guidance, June 10, 2014. https://www.epa.gov/ghgreporting.

U.S. Environmental Protection Agency (EPA). “Greenhouse Gas Reporting Program: Emission Calculation Methodologies.” July 2015. https://www.epa.gov/sites/default/files/2015-07/documents/ghgrp_methodology_factsheet.pdf.

U.S. Environmental Protection Agency (EPA). "Aluminum Production Subpart F, Greenhouse Gas Reporting Program." 40 CFR Part 98 Subpart F, February 2018. https://www.epa.gov/sites/default/files/2018-02/documents/f_infosheet_2018.pdf.

U.S. Environmental Protection Agency (EPA). "eGRID Subregion Year 2022 Data (SRL22)." Emissions and Generation Resource Integrated Database (eGRID), January 30, 2024. https://www.epa.gov/egrid/download-data.

U.S. Environmental Protection Agency (EPA). "eGRID with 2022 Data." Emissions and Generation Resource Integrated Database (eGRID), January 30, 2024. https://www.epa.gov/egrid/download-data.

U.S. Environmental Protection Agency (EPA). "Plant Year 2022 Data (PLNT22)." Emissions and Generation Resource Integrated Database (eGRID), January 30, 2024. https://www.epa.gov/egrid/download-data.

U.S. Environmental Protection Agency (EPA). "Greenhouse Gas Reporting Program (GHGRP). Envirofacts GHG Query Builder." Accessed September 18, 2024. https://enviro.epa.gov/query-builder/ghg.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). "Technical Support Document for the Iron and Steel Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases." August 28, 2009. https://www.epa.gov/sites/default/files/2015-02/documents/tsd_iron_and_steel_epa_9-8-08.pdf.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). *The Emissions and Generation Resource Integrated Database: eGRID Technical Guide with Year 2022 Data*. Clean Air Markets Division (CAMD), January 2024. https://www.epa.gov/system/files/documents/2024-01/egrid2022_technical_guide.pdf.

U.S. Environmental Protection Agency (EPA). Office of Air and Radiation (OAR). "Inventory of U.S. Greenhouse Gas Emissions and Sinks." Reports and Assessments, October 22, 2024. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

U.S. Environmental Protection Agency (EPA). Office of Atmospheric Protection (OAP). "Greenhouse Gas Reporting Program (GHGRP). Facility-Level Information on Greenhouse Gases Tool (FLIGHT) Database." Accessed various dates. https://ghgdata.epa.gov/ghgp/main.do?site_preference=normal.

U.S. Geological Survey (USGS). *Mineral Commodity Summaries 2023: Aluminum*. USGS, January 2023. https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-aluminum.pdf.

U.S. International Trade Commission (USITC). *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_facility-level_questionnaire_aluminum_and_steel_combined.pdf.

U.S. International Trade Commission (USITC). Hearing Transcript in Connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 7, 2023. https://edis.usitc.gov/external/search/document/810108.

U.S. Trade Representative (USTR). "USTR Issues Communication to WTO Members on Climate and Trade." Press Release, Office of the United States Trade Representative, April 4, 2024. https://ustr.gov/about-us/policy-offices/press-office/press-releases/2024/april/ustr-issues-communication-wto-members-climate-and-trade.

United States Steel Corporation (U. S. Steel). Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810840.

Vidovic, Danko, Alain Marmier, Lovro Zore, and Jose A. Moya. *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries in the EU and Its Main Trading Partners*. European Commission. Joint Research Centre (JRC), 2023. https://data.europa.eu/doi/10.2760/359533.

World Resources Institute (WRI). *GHG Protocol Scope 2 Guidance*. 2015. https://ghgprotocol.org/sites/default/files/2023-03/Scope%202%20Guidance.pdf.

World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). *GHG Protocol Product Life Cycle Accounting and Reporting Standard*. Accessed August 3, 2023. https://ghgprotocol.org/sites/default/files/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf.

World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*. March 2004. https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf.

World Steel Association (worldsteel). *Life Cycle Inventory (LCI) Study: 2020 Data Release*. May 2021. https://worldsteel.org/wp-content/uploads/Life-cycle-inventory-LCI-study-2020-data-release.pdf.

World Steel Association (worldsteel). *Steel Statistical Yearbook 2023*. Accessed September 21, 2024. https://worldsteel.org/publications/bookshop/ssy_subscription-2023/.

World Trade Organization (WTO). "Steel Standards Principles." Accessed September 20, 2024. https://www.wto.org/english/tratop_e/envir_e/steel_standards_principles_e.pdf.

worldstainless. "Introduction to Stainless Steels." Accessed November 8, 2024. https://www.worldstainless.org/about-stainless/what-are-stainless-steels/introduction-to-stainless-steels/.

Wright, Lachlan, Xiyuan Liu, Iris Wu, and Sravan Chalasani. *Steel GHG Emissions Reporting Guidance*. Rocky Mountain Institute (RMI), June 2023. https://rmi.org/wp-content/uploads/2022/09/steel_emissions_reporting_guidance.pdf.

# Appendix F
# Development of Default Emissions Factors and Sensitivity Analyses

This appendix is divided into two primary sections. The first section outlines the Commission's approach to generating default emissions factors for use in the Commission's calculation of the emissions intensity estimates of covered steel products. The emissions factors calculated using this approach were used as default global and country-specific emissions factors and were multiplied by activity data (i.e., quantities of inputs into the production of steel) to generate upstream scope 3 emissions for reporting facilities.[575] The steps of the approach to develop these factors and the data sources used to do so are described.

The second section of this appendix presents the results of sensitivity analyses that explore the impact that modifications to the Commission's methods, respondent population, and input parameters have on the overall emissions intensity estimates.

# Development of Default Emissions Factors for Materials Used by Steel Facilities

As described in chapter 3, this investigation collected default emissions factors for use in calculating consuming facilities' scope 3 emissions. This appendix details how default emissions factors were developed that cover materials within the steel system boundary using a methodology referred to in this report as the partial life cycle inventory (LCI) approach ("partial LCI approach"). The partial LCI approach used public source information and LCI analysis principles to create a database of (1) global emissions factors for upstream products used as material inputs by steel-producing facilities and (2) country- and production pathway-specific default emissions factors that capture distinctions in how international industries produce pig iron and steel. In particular, this approach sought to account for the following factors that drive differences between countries' steel product emissions intensities:

- Mixes of electricity generation sources: many processes in the steel production life cycle are electricity intensive, particularly steelmaking in electric arc furnaces.
- Apparent efficiency of steel production processes.
- Types of fuel used predominantly in each country's steel industries.
- Use rates of alloying materials in stainless steel production (specifically nickel and chromium).

In addition to providing a mechanism for capturing greenhouse gas (GHG) emissions intensity differences between countries and production pathways, the partial LCI approach also allowed for the development of default emissions factors that adhered as closely as possible to the methodologies and system boundary that governed the broader approach used to calculate each facility's product-level emissions intensity values. In addition, the Commission's calculation of its own default emissions factors for use in this investigation allowed for the publication of these emissions factors. These emissions factors are presented in appendix G.

---

[575] For more information on how scope 3 emissions are calculated using default emissions factors, see chapter 3 ("Emissions Embedded in Material Inputs from External Sources (Scope 3)") and appendix E ("II.D.1 Calculation of Facility-Level Scope 3 Emissions").

# Overview of Partial LCI Approach

For each product used as a material input ($material$) in the steel system boundary, the goal of the partial LCI approach was to collect or calculate one or more default emissions factors ($DefaultEF_{material}$) covering the amount of GHG emissions that occur in the production of one unit of that product from cradle (i.e., far-upstream production practices) to product gate (i.e., the end point of the production process for the product).[576] This term is designed to capture the inventory of direct emissions that occur in the manufacturing of that product as well as indirect emissions that occur in the generation of energy and the production of upstream material inputs (referred to throughout this section as "inputs") used to produce that product.

For many of the nonsteel products included in the steel system boundary, the Commission calculated global emissions factors ($DefaultEF_{material}$) using publicly available emissions factors (see step 1 below, which also contains of a list of these products). No country-specific emissions factors were calculated for these products.

The Commission also calculated country-specific emissions factors ($DefaultEF_{material,country}$) for iron sinter, pig iron, and all steel products.[577] The methods for calculating country-specific emissions factors are described in greater detail in steps 2 and 3 and are summarized in equation F.1 below. Equation F.1 sums the emissions intensity of specific production processes used to directly produce $material$ as well as the emissions associated with the use of inputs (including both emissions embedded in upstream inputs and direct emissions that occur when using those inputs).

$$DefaultEF_{material,country} =$$

$$UEF_{material,country} + \sum_{input} \left( Intensity_{input,material} * \left( DefaultEF_{input,country} + DirectEF_{input} \right) \right) (F.1)$$

For each product ($material$):

- $UEF_{material,country}$ refers to the unit process emissions factor for $material$, or the amount of emissions from fuel and energy consumption that is attributed to the discrete production process used to make that product in a particular country (the "unit process"). This term covers direct emissions from consumption of fuels during the unit process, as well as indirect emissions

---

[576] Under this approach, default emissions factors are calculated for all products used as materials in the system boundary even if U.S. steel facilities do not receive those materials from external sources. Examples of such products include iron ore, iron sinter, and nickel pig iron. As described in greater detail in step 3, default emissions factors for upstream inputs contribute to the calculation of default emissions factors for downstream products.

[577] Because of the complexity associated with developing country-specific emissions factors, the Commission prioritized development of country-specific emissions factors only for pig iron and steel products because of the potential for variations in the emissions factors of those products to substantially affect the emissions intensity estimates of U.S. steel products overall. The partial LCI approach also calculated country-specific emissions factors for iron sinter because of that material's close relationship with pig iron production, although no iron sinter default emissions factors were used to calculate scope 3 emissions because this product is generally consumed on-site and is not shipped between U.S. steel facilities. Chapter 3 ("Calculating Facility-Level Scope 3 Emissions") and appendix E ("II.D.1 Calculation of Facility-Level Scope 3 Emissions") contain additional detail on the reasons for why global emissions factors and approaches were used for certain materials.

from the generation of energy used in the unit process.[578] $UEF_{material,country}$ is expressed as metric tons of carbon dioxide-equivalent (mt $CO_2e$) per metric ton of production of $material$.

- $Intensity_{input,material}$ refers to the rate at which a specific input ($input$) is used in the unit process that produces $material$ (i.e., the "intensity" of the input in the product's unit process). $Intensity_{input,material}$ is expressed as the quantity of $input$ used (generally metric tons, except for gases, which are standard cubic feet), per metric ton of $material$ produced. $Intensity_{input,material}$ is the same for all countries under this approach.
- $DefaultEF_{input,country}$ refers to the default emissions factor of $input$. $DefaultEF_{input,country}$ is equivalent to the value of $DefaultEF_{material}$ for the input product itself, and is expressed as mt $CO_2e$ per unit of input used. This term differs by country if the upstream input's own default emissions factors was calculated at the country level; otherwise, that emissions factor was global.
- $DirectEF_{input}$ refers to the amount of direct emissions that occurs from the use of $input$ in production of other products. For example, $DirectEF_{lstone}$ refers to the amount of emissions that occurs when a quantity of limestone is consumed in the production of another product.[579] $DirectEF_{input}$ is expressed as mt $CO_2e$ per unit of input used. $DirectEF_{input}$ is the same for all countries under this approach.

The methods and sources for calculating $UEF_{material}$ and $Intensity_{input,material}$ were adapted from parts of the methodology used in a 2023 study by the European Commission's Joint Research Centre, *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries in the EU and its Main Trading Partners* (JRC 2023). JRC 2023 estimated the emissions intensities of steel and other products made by the EU's largest trading partners for these products.[580] In particular, the partial LCI approach uses JRC's technique of dividing GHG emissions from fuel and energy consumption in the iron and steel sector among specific unit processes that correspond with product categories (see the

---

[578] In contrast to the main allocation approach used to develop product-level emissions intensity estimates (described in chapter 3, "Allocation of Facility-Level Emissions to Unit Processes"), unit process emissions factors used in the partial LCI approach do not include any emissions associated with use of inputs, as these are captured using the subsequent terms in equation F.1.

[579] As shown in tables G.3 and G.4 in appendix G, some inputs have a direct emissions factor of zero, wherein use of the input in a process does not contribute direct emissions. Products with direct emissions factors of zero include industrial gases, pure alloying metals such as nickel, and calcined lime and dolime.

[580] JRC 2023 has been used in the implementation of the Carbon Border Adjustment Mechanism (CBAM). The estimates produced in that study formed the basis of default values published by the European Commission for use by importers in their reporting of GHG emissions under CBAM. EC, DG-TAXUD, "Default Values for the CBAM Transitional Period," December 22, 2023, 5; Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 6.

description of step 2 below).[581] In addition, the partial LCI approach uses multiple data sources. These include:

- Default and direct emissions factors for upstream inputs from the World Steel Association's *$CO_2$ Data Collection User Guide* and Annex 5 of the *ResponsibleSteel International Production Standard Version 2.1* (*RS Standard 2.1*).[582]
- The International Energy Agency's (IEA's) Extended Energy Balances data, which include quantities of fuel and energy inputs and outputs within different industrial sectors including blast furnaces and the broader iron and steel industry.[583]
- The IEA's Emissions Factors 2023 data, which include emissions factors for electricity generation by country.[584]
- Direct emissions factors for fuel combustion produced by the *2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, Volume 2* (2006 IPCC Guidelines).[585]
- Fuel, energy, and input intensity data produced by JRC, both in its 2023 report (JRC 2023) and in a 2013 JRC study that included surveys of the European steel industries (JRC 2013).[586]
- Production data from the World Steel Association's (worldsteel) *Steel Statistical Yearbook* (worldsteel Statistical Yearbook), the European Foundry Association, and EUROFORGE.[587]

The following sections, organized into steps, describe in greater detail how these data were used in equation F.1 to calculate default emissions factors. Step 1 describes how default emissions factors and direct emissions factors for certain materials were collected from public sources. Step 2 describes how $UEF_{material,country}$ was calculated for iron sinter, pig iron, and all steel products. Step 3 describes in practical terms how equation F.1 was used to calculate $DefaultEF_{material,country}$ for those products. The emissions factors themselves are available in appendix G.

---

[581] Step 1 of the partial LCI approach differs from the JRC 2023 study's approach in the use of published default emissions factors for a wider range of upstream materials than those covered in JRC 2023's system boundary. Step 3 of the partial LCI approach differs from the JRC 2023 study's approach in the use of intensity data for upstream inputs as a basis for the material flow analysis in that section. JRC 2023 focused on different product categories than those covered in the partial LCI approach. For each country and product category, JRC 2023 also limited the presentation of emissions intensity results to the production pathway with the highest GHG emissions intensity, whereas the partial LCI approach calculated default emissions factors covering both electric arc furnace (EAF) and blast furnace-basic oxygen furnace (BF-BOF) production pathways as well as providing country-level emissions factors that combined both production pathways. Many other more minor distinctions between the partial LCI approach and the JRC 2023 report are discussed throughout this appendix. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 12, 13–14, 16, 18–46.

[582] Janjua and Maciel, *$CO_2$ Data Collection User Guide, Version 11*, May 30, 2024, 17; ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 112–15.

[583] IEA, "World Energy Balances," July 2024; IEA, *World Energy Balances Documentation*, July 2024.

[584] IEA, "Emissions Factors 2023," September 2023; IEA, *Emission Factors 2023: Database Documentation*, September 2023.

[585] IPCC, *2006 IPCC Guidelines, Volume 2*, 2006, 2.16-19.

[586] Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 15, 46–47, 50; Remus et al., *Best Available Techniques (BAT) Reference Document*, January 24, 2013, 95, 304, 369, 429.

[587] worldsteel, *Steel Statistical Yearbook 2023*, accessed September 21, 2024; CAEF, "The European Foundry Industry 2022," November 2023; EUROFORGE, *International Statistics 2022*, accessed April 18, 2024.

# Step 1 Emissions Factors Collected from Public Sources

The Commission collected two types of emissions factors directly from public sources for use in scope 3 analysis and in the partial LCI approach. These were:

- $DirectEF_{input}$ collected from the World Steel Association's *CO₂ Data Collection User Guide* for all inputs for which emissions occur from the use of those inputs.[588] These inputs include non-calcined limestone and dolomite, pig iron, direct reduced iron, ferroalloys, and carbon electrodes.[589] The Commission used all values for $DirectEF_{input}$ without additional modifications.
- $DefaultEF_{material}$ (or $DefaultEF_{input}$ where such products are used as inputs in the calculation of a downstream product's value for $DefaultEF_{material}$) collected for all products other than iron sinter, pig iron, and steel products.[590] The specific sources for each of these emissions factors are described below.

The Commission assigned $DefaultEF_{material}$ for most materials based on emissions factors from *RS Standard 2.1*. These include emissions factors assigned to oxygen, argon, nitrogen, hydrogen, iron ore, iron pellets, metallurgical coke, non-calcined limestone and dolomite, calcined lime, calcined dolime, aluminum metal, copper metal, nickel pig iron, ferromanganese, manganese, ferromolybdenum, molybdenum metal, ferrosilicon, silicon, ferrovanadium, silicomanganese, tin metal, carbon electrodes, and direct reduced iron.[591] The Commission selected *RS Standard 2.1* as the source of most emissions factors for upstream materials for several reasons. First, this standard is one of only a small number of resources that publicly reports a comprehensive set of default emissions factors for most materials used by the steel sector. Second, *RS Standard 2.1* reports emissions factors derived from data provided by CRU and Sphera Solutions, Inc. (Sphera), private organizations that are commonly used by U.S. companies to provide reputable sources of emissions factor data.[592] Third, reported emissions factors from *RS Standard 2.1* are generally consistent with the broader methodology used by the Commission in this investigation. The emissions factors are based on cradle-to-gate processes within a system boundary that extends far upstream to processes such as mining.[593] The emissions factors are also expressed as mt $CO_2e$/unit of material used in steel production. Therefore, the Commission's selection of emissions

---

[588] Janjua and Maciel, *CO₂ Data Collection User Guide, Version 11*, May 30, 2024, 17.

[589] When metallurgical coke is used, it generates direct emissions; however, the direct emissions from metallurgical coke use are reflected in the unit process emissions calculations for pig iron, using calculations covered in step 2, as explained in greater detail below. Therefore, no direct emissions factors were used for metallurgical coke.

[590] Specifically, these include industrial gases, iron ore, iron pellets, metallurgical coke, non-calcined limestone and dolomite, calcined lime, calcined dolime, direct reduced iron, coating metals, ferroalloys and other alloying metals (other than "other ferroalloys and alloying metals"), and carbon electrodes. As described in box E.3 of appendix E, the global emissions factor for pig iron was used as the default emissions factor for other ferroalloys and alloying metals.

[591] ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 112–14.

[592] Industry representatives, email messages to USITC staff, February 19–24, 2024; ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 112–14.

[593] ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 83, 112–14.

factors for upstream materials from *RS Standard 2.1* satisfied many of the criteria for selecting default emissions factors described in appendix E ("II.D.2. Selection of Default Emissions Factors").

The Commission made several modifications to the emissions factors from *RS Standard 2.1* for use in its own investigation. *RS Standard 2.1* increases certain default emissions factors by 20–60 percent over source data in order to encourage reporters under the standard to use primary data in lieu of default emissions factors.[594] Because that incentive does not apply to the Commission's methodology, the Commission divided the *RS Standard 2.1* default emissions factors with these add-ons applied by 1.2 or 1.6, depending on the material.[595]

The Commission calculated the default emissions factors for direct reduced iron ($DefaultEF_{dri}$) using the natural gas- and coal-based emissions factors from *RS Standard 2.1*. Although direct reduced iron can be made using both fuel types, $DefaultEF_{dri,global}$ was derived directly from the natural gas-based emissions factors after the reduction of the add-on described above.[596] Although U.S. facilities producing covered steel products did not report external receipts of direct reduced iron from India, a separate term $DefaultEF_{dri,India}$ was calculated for use in calculating downstream values of $DefaultEF_{material,India}$ in step 3 using equation F.1. India is one of the world's largest producers of direct reduced iron and is also unique in its widespread use of the coal-based method for producing this material.[597] The direct reduced iron emissions factors for India is the weighted average of coal- and natural gas-based direct reduced iron emissions factors from *RS Standard 2.1* (with the add-on removed), weighted on the basis of 77.8 percent of India's direct reduced iron production being coal based and 22.2 percent being natural gas based.[598]

Emissions factors for zinc, chromium, ferrochromium, nickel, and ferronickel were derived from other sources. The Commission selected the emissions factor for zinc from the World Steel Association's 2020 *Life Cycle Inventory (LCI) Study*.[599] The Commission also sought emissions factors for ferronickel and ferrochromium that took into account assumed grades of these ferroalloys. For ferrochromium, the Commission used an estimate from a report published by the International Chromium Development Association (ICDA) that found that each kilogram of chromium metal in ferrochromium has embedded emissions of 10 kilograms of carbon dioxide equivalent ($CO_2e$).[600] For ferronickel, the Commission used an estimate from a 2023 report published by the Nickel Institute that found that each kilogram of nickel

---

[594] ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 114–15.

[595] Emissions factors for oxygen, argon, and nitrogen were converted to mt of $CO_2e$ per thousand cubic feet by multiplying those in *RS Standard 2.1* (expressed in thousands of normal cubic meters) by 0.02628, and then further dividing that value by 1.2. The emissions factor for hydrogen was converted to mt of $CO_2e$ per thousand cubic feet by dividing the hydrogen emissions factor in *RS Standard 2.1* (expressed in kg) by 423,288 and then dividing that value by 1.2. ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 113–15; UIG, "Oxygen Quantity Conversions Calculator," accessed November 12, 2024; Air Products, "Hydrogen Weight and Volume Equivalents," accessed November 12, 2024.

[596] Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 9, 13.

[597] Nduagu et al., "Comparative LCA of Natural Gas and Coal-Based DRI Production," May 1, 2022, 1–2; worldsteel, *Steel Statistical Yearbook 2023*, accessed September 21, 2024.

[598] Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 13.

[599] *RS Standard 2.1* does not report an emissions factor for zinc. worldsteel, *2020 LCI Study*, May 2021, 57; ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024, 112–14.

[600] ICDA, *Quantifying the Improvement in the Environmental Impact of the Production of High Carbon Ferrochromium (HC FeCr)*, April 2022, 2.

metal within ferronickel has embedded emissions of 45 kilograms of $CO_2e$.[601] Both of these reports were based on analysis provided to those institutions by Sphera.[602] The Commission calculated emissions factors for ferrochromium and ferronickel using these estimates and assumed chromium and nickel content for each of these ferroalloys of 53 percent and 30 percent, respectively.[603] The Commission also used the reported emissions factor for nickel metal from the 2023 Nickel Institute report.[604] The Commission used the calculated default emissions factor for ferrochromium for chromium metal as well, as no emissions factor for chromium metal was identified.

# Step 2 Unit Process Emissions Calculations for Iron and Steel Products

The partial LCI approach uses an approach adapted from JRC 2023 to calculate unit process emissions factors ($UEF_{material,country}$) for each iron sinter, pig iron, and steel production process in each country.[605] Unless otherwise stated, all equations and variables described in the discussion of step 2 include both country-specific and global derivatives without those being explicitly noted. $UEF_{material}$ (in mt $CO_2e$/mt) is calculated in equation F.2 using the total GHG emissions (in mt $CO_2e$) from fuel and

---

[601] Nickel Institute, *Life Cycle Data*, January 2023, 2.

[602] ICDA, *Quantifying the Improvement in the Environmental Impact of the Production of High Carbon Ferrochromium (HC FeCr)*, April 2022, 1; Nickel Institute, *Life Cycle Data*, January 2023, 1.

[603] The assumed grades of ferronickel and ferrochromium were from JRC 2023. The chromium content of ferrochromium was rounded to 53 percent (from 52.5 percent) in order to be consistent with a study by Gyllenram and Wei that is used extensively in step 3.4 described below. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 15; Gyllenram and Wei, *304 Stainless Steel Carbon Footprint Comparison: EU, Indonesia and China*, October 2022, 7.

[604] Nickel Institute, *Life Cycle Data*, January 2023, 2.

[605] $UEF_{material}$ covers unit process emissions in 2021 given the availability of data across multiple sources.

energy use associated with the unit process that produces the material ($UGHG_{material}$) and the total output of the material ($Output_{material}$).[606]

$$UEF_{material} = \frac{UGHG_{material}}{Output_{material}} \qquad (F.2)$$

$UGHG_{material}$is calculated using equation F.3, which divides total emissions from fuel and energy use within a country's iron and steel sector proportionally across the sector.

$$UGHG_{material} = \sum_{fuel} (GHG_{fuel} * Share_{fuel,material}) + \sum_{energy} (GHG_{energy} * Share_{energy,material}) (F.3)$$

Total GHG emissions (in mt $CO_2e$) from the iron and steel sector's consumption of a specific fuel type (i.e., the iron and steel sector's direct emissions from use of that $fuel$ type, or $GHG_{fuel}$) and total GHG emissions from energy (electricity or purchased heat) consumed by the iron and steel sector (i.e., the iron and steel sector's indirect emissions from use of that $energy$ type, or $GHG_{energy}$) are calculated using the methods described in step 2.1. The consumption of a fuel or energy type in the material's unit process as a share of total consumption of that fuel or energy type ($Share_{fuel,material}$ or $Share_{energy,material}$, respectively) is calculated using the methods described in step 2.2.

## Step 2.1 Calculating GHG Emissions for Each Fuel and Energy Type in the Iron and Steel Sector

In the partial LCI approach, equations F.4 and F.5 calculate $GG_{fuel}$ and $GHG_{energy}$ (in mt $CO_2e$/terajoules [TJ]) by multiplying the total quantity of fuel and energy use in blast furnaces and the iron and steel

---

[606] The Commission compiled a database covering each country's 2021 production of iron sinter, pig iron, and all steel material categories based primarily on data from the worldsteel Statistical Yearbook. The worldsteel Statistical Yearbook provides annual production quantities of various steel materials and some upstream materials such as pig iron. Where the worldsteel Statistical Yearbook indicated that data covering production of a material from a country was missing for 2021 but not for earlier years, the Commission used the quantity from the most recent year for that country as the quantity for 2021. Where all country-specific production data were missing for a specific material, the Commission estimated production for that country based on the global ratio of production of that material to the production of an upstream material (e.g., semifinished steel, hot-rolled flat steel). The quantity of cold-rolled flat steel produced by each country was assumed to be 49 percent of the quantity of hot-rolled flat steel produced by that country, consistent with the assumption used for this purpose in JRC 2023. The Commission calculated the quantity of cold-formed long steel produced by each country by multiplying the quantity of hot-worked long steel produced by that country by 6 percent (the ratio of 2022 U.S. cold-formed bar shipments to total bar shipments as reported by the American Iron and Steel Institute). Production data for all steel materials (other than coated flat steel) were split between carbon and alloy steel and stainless steel types of that material category using each country's ratio of stainless steel production (based on data from a 2020 report by International Stainless Steel Forum) to total semifinished steel production (using data from the worldsteel Statistical Yearbook) for the most recent year for which data from both sources was available (2019 for most countries). Production data for iron sinter was calculated by multiplying each country's pig iron production by the iron sinter use rate in blast furnaces from JRC 2013. worldsteel, *Steel Statistical Yearbook 2023*, accessed September 21, 2024; Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 13; AISI, "Net Shipments of Steel Mill Products," January 31, 2023; worldstainless, "Stainless Steel in Figures 2020," 2020, 7; Remus et al., *Best Available Techniques (BAT) Reference Document*, January 24, 2013, 304.

sector more broadly ($IndustryUse_{fuel}, IndustryUse_{energy}$) by emissions factors ($DirectEF_{fuel}, IndirectEF_{energy}$).

$$GHG_{fuel} = IndustryUse_{fuel} * DirectEF_{fuel} \tag{F.4}$$

$$GHG_{energy} = IndustryUse_{energy} * IndirectEF_{energy} \tag{F.5}$$

### Step 2.1.1 Calculating Fuel and Energy Use in the Iron and Steel Sector

$IndustryUse_{fuel}$and $IndustryUse_{energy}$ are based on data from the IEA Extended Energy Balances database, which quantifies (in TJ) fuel and energy use and generation by year, country, type of fuel or energy, and "flow." Dozens of fuel types and two energy types—electricity and heat—are covered in this database.[607] A flow refers to a sector or activity that uses or generates fuel or energy. Certain flows are unique to the iron and steel sector and are used to calculate $IndustryUse_{fuel}$ and $IndustryUse_{energy}$ for the sector. These include:

- **Transformation Processes in Blast Furnaces:** These data include fuel inputs used directly in blast furnaces as well as blast furnace gas (BFG) and basic oxygen furnace gas (BOFG) outputs. The fuel inputs reported within this flow include the portion of the feedstock coke and other fuels (e.g., coal, natural gas, and oil) used in blast furnaces that contribute calorific energy to BFG and BOFG.[608]
- **Energy Sector Own Use in Blast Furnaces:** These data include fuel and energy inputs used primarily for auxiliary purposes to support blast furnaces.[609] Country reporting within this flow is uneven, and some of this fuel and energy use may be reflected in the other two flows listed here (Final Consumption in the Iron and Steel Sector or Transformation Processes in Blast Furnaces).[610]

---

[607] IEA, *World Energy Balances Documentation*, July 2024, 25–33. Electricity use includes electricity produced on and off-site. Within the IEA Extended Energy Balances database, heat only includes: (1) heat generated by heat plants and combined heat and power (CHP) facilities where the main activity is production of energy (i.e., "main heat plants" and "main CHP plants"); and (2) the heat sold to third parties by facilities that produce energy as a secondary activity (i.e., "autoproducer heat plants" and "autoproducer CHP plants"). (Note: the IEA describes "autoproduction" as generation of energy wholly or partly for their own use as an activity which supports their main activity). Therefore, a sector's use of heat within this database excludes any heat generated and used by the same facility. IEA, *World Energy Balances Documentation*, July 2024, 8–9, 33. See chapter 3 ("Energy Emissions (Scopes 1 and 2)") and appendix E ("II.C.3 Energy Calculations for Facilities with More Complicated Energy Sourcing") for information on the Commission's treatment of CHP facilities.

[608] In measuring the fuel use within this flow, IEA seeks to only include the calorific contribution of those fuels that is captured within BFG and BOFG outputs. IEA takes steps to assign the remaining calorific contribution of fuel inputs (i.e., that which generates heat) to Final Consumption in the Iron and Steel Sector flow. IEA, *World Energy Balances Documentation*, July 2024, 9.

[609] IEA, *World Energy Balances Documentation*, July 2024, 10.

[610] Subject matter expert, email message to USITC staff, July 12, 2024.

- **Final Consumption in the Iron and Steel Sector:** These data include fuel and energy inputs used in the iron and steel sector.[611] As noted above, data under this flow may include fuel and energy use in blast furnaces that is not covered under either of the two flows described above.[612]

To avoid double counting emissions, no fuel use or output data are used for the BFG or BOFG fuel types. This is the first of several steps taken to avoid double counting associated with the use of fuels to generate BFG and BOFG, which are themselves fuels used in the iron and steel sector (see box F.1).

---

[611] The iron and steel sector is defined broadly within the IEA Extended Energy Balances database, covering all production under International Standard Industrial Classification (ISIC) Group 241 (Manufacture of basic iron and steel) and Class 2431 (Casting of iron and steel). This sector includes all of the steel production practices in the steel system boundary of this investigation, pig iron production in blast furnaces, and production of direct reduced iron. In addition, this sector includes several processes outside of the system boundary of this investigation, including production of cast-iron products, production of steel castings, and production of forgings. Fuel use in iron mining is covered in a different flow within the IEA Extended Energy Balances database (Final Consumption in Mining and Quarrying). Iron pelletization and iron sintering technically are also covered in the flow related to mining, as they are classified under ISIC Group 0710 (Mining of iron ores). The partial LCI approach assumed that fuel and energy use in iron sintering was actually covered under Final Consumption in the Iron and Steel Sector because of the likelihood that most iron sintering occurs on-site at steel and pig iron production facilities. By contrast, the partial LCI approach assumed that fuel and energy use in iron pelletization was accounted for in the Final Consumption in Mining and Quarrying flow given that iron pelletization frequently occurs in different locations. IEA, *World Energy Balances Documentation*, July 2024, 12; United Nations, *ISIC Rev.4*, *Rev. 4*, 2008, 81–82, 121–23.

[612] JRC 2023 also sums fuel and energy use in the iron and steel sector using the same flow data; however, in that study, use of fuel and energy in the blast furnace is separated from use of fuel and energy in the broader iron and steel sector. The JRC study allocates emissions associated with fuel and energy use under the blast furnace-specific flows directly to blast furnace processes and assumes that certain fuel types used in the "Final Consumption in the Iron and Steel Sector" flow (most notably metallurgical coke) cannot be allocated to blast furnaces. However, as described above for each flow, fuel use directly in blast furnaces as well as for auxiliary use in support of blast furnaces is covered unevenly across all three flows. Because of this, for any given country, it is not apparent how much of each fuel type within the "Final Consumption in the Iron and Steel Sector" flow should actually be allocated to blast furnaces. For this reason, the partial LCI approach does not directly allocate the blast furnace-specific flows described above to the blast furnace process. In a subsequent step under the JRC 2023 methodology and in step 2.2 of this method, emissions associated with aggregate fuel use are allocated using a uniform approach to each unit process within the iron and steel sector, including blast furnaces. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 12, 13–14, 47–48. See also Koolen and Vidovic, *Greenhouse Gas Intensities of the EU Steel Industry and Its Trading Partners*, June 22, 2022, 10, 13.

**Box F.1** Use of Fuel Consumption Data to Calculate Emissions from Blast Furnaces

In step 2.1, emissions associated with blast furnace gas (BFG) generation and combustion are calculated using data covering fuel use in blast furnaces. This approach captures emissions from blast furnace operations indirectly by multiplying fuel consumption in blast furnaces by direct emissions factors for those fuels. Similarly, emissions associated with generation of basic oxygen furnace gas (BOFG) (which are not uniformly captured for further use by national industries or measured within the International Energy Agency Extended Energy Balances database across countries) are implicitly measured using fuel consumption and material input data into basic oxygen furnaces (BOFs).[a] Using this approach, any additional inclusion of emissions from combustion of BFG or BOFG would result in double counting of emissions.[b] For this reason, fuel use and output quantities for BFG and BOFG are not included in the equations in step 2.1.

Another approach to measuring emissions from blast furnaces and BOFs would involve multiplying BFG and BOFG outputs by direct emissions factors for those gases. This is a more direct method for measuring emissions associated with these gases than use of a fuel consumption-based approach. However, in step 2.2, emissions associated with fuel consumption are allocated to unit processes based in part on fuel intensity (i.e., the rate at which a fuel is used) within each unit process. For example, emissions associated with coke, coal, oil, and natural gas consumption within the iron and steel sector are allocated to blast furnaces using data covering the typical use of each of those fuels in blast furnaces. Because allocation to unit processes uses assumptions about fuel intensities, the use of emissions estimates linked to fuel use data rather than those linked with BFG or BOFG outputs follows logically.

The effect on emissions in the iron and steel sector using an input-based versus output-based approach to measuring blast furnace emissions is likely negligible. Globally, the calculated emissions from combustion of all fuel inputs within the “Transformation Processes in Blast Furnaces” flow in the IEA Extended Energy Balances database are only slightly lower than the calculated emissions from combustion of BFG and BOFG outputs from that flow (which constitute national output of those gases).[c] Calculated emissions from the combustion of fuel inputs in that flow do not include carbon from material inputs, which are incorporated in step 3.

Reliance on fuel inputs and allocation of associated emissions to the points of generation (blast furnaces and BOFs) may appear to run counter to the “point of combustion” approach used elsewhere in this investigation (see box 3.1 in chapter 3). However, this inconsistency is minor. BFG generated in U.S. integrated facilities is combusted either by those facilities themselves or by third-party energy generation facilities that then transfer that energy back to the integrated facilities. Therefore, facility-wide emissions for U.S. integrated steel facilities include all or almost all emissions from combustion of BFG. The inconsistency with the point of combustion approach is also important to maintain in order to calculate comparable estimated emissions factors for pig iron and steel products across countries. BFG-related emissions are allocated to the unit process unique to integrated facilities—blast furnaces—and therefore are not included in unit process emissions for downstream products that may be made using electric arc furnaces (EAFs).

[a] Only a few countries report production of “other recovered gas” within the Transformation Processes in Blast Furnaces flow, which covers BOFG. IEA, “World Energy Balances,” July 2024.

[b] Koolen and Vidovic, *Greenhouse Gas Intensities of the EU Steel Industry and Its Trading Partners*, June 22, 2022, 10.

[c] This comparison uses emissions that were calculated using a modified version of equation F.4, relying only on fuel inputs and outputs in the Transformation Processes in Blast Furnaces flow as opposed to total fuel consumption by the iron and steel sector.

### Step 2.1.2 Selection of Direct and Indirect Emissions Factors for Fuel and Energy Types

Emissions factors for fuel ($DirectEF_{fuel}$) and energy ($IndirectEF_{energy}$) are from the following sources:

**Direct emissions factors for fuel types**: All direct emissions factors for fuels (not electricity or heat) are from the *2006 IPCC Guidelines*.[613] The Commission used the same default emissions factors from this source for all countries.[614]

**Indirect emissions factors for energy types**: Indirect emissions factors for electricity are from the IEA Emissions Factors 2023 database.[615] These indirect emissions factors are country-specific measures of the amount of $CO_2e$ (in grams) for each kilowatt-hour of electricity produced across each country's mix of generation sources.[616] The Commission averaged indirect emissions factors from this database over the 2017–21 period.[617] The IEA calculated the indirect emissions factors for electricity using the same data sources used in the partial LCI approach to calculate sector-level emissions: the IEA World Energy Balances database (which provides information on fuel use and energy generation by country and flow) and the *2006 IPCC Guidelines*.[618]

Indirect emissions factors for heat are derived using an adaptation of the equation that IEA uses to calculate emissions factors for electricity within the Emissions Factors 2023 database.[619] For each

---

[613] IPCC, *2006 IPCC Guidelines, Volume 2*, 2006, 2.18–2.19. The emissions factors selected from the IPCC report are those for stationary combustion in manufacturing industries and construction. They are available in terms of kilograms of GHG emissions per TJ of fuel input combusted. Emissions factors for methane ($CH_4$) and nitrous oxide ($N_2O$) are converted to carbon dioxide-equivalent ($CO_2e$) using the global warming potential (GWP) conversion factors from the 4th Assessment of the IPCC (these factors also used by the GHGRP and elsewhere in this investigation): 25 for $CH_4$ and 298 for $N_2O$. Table A-1 to Subpart A of Part 98, Title 40. Emissions factors for $CO_2$ are replaced with zero for biofuel types (e.g., biodiesels, biogasoline, charcoal, gas biomass, municipal wastes [biomass fraction], other liquid biofuels, and other primary solid biomass) that generate biogenic $CO_2$ emissions, consistent with the approach taken for scope 1 fuel combustion and scope 2 emissions described in chapter 3.

[614] Metallurgical coke is included in the partial LCI approach as a fuel rather than as a material input, and $DirectEF_{mcoke}$ is calculated for this fuel type along with similar terms for all other fuel types. Unlike all other fuel types included in this approach, metallurgical coke is a material input in the steel system boundary and has its own $DefaultEF_{mcoke}$ term associated with coke production. Each unit process's use of metallurgical coke is captured in the equations in step 2 rather than in the material flow analysis of step 3 (where it would be allocated using material intensity estimates representing typical use of inputs). To ensure that $DefaultEF_{mcoke}$ is incorporated into $DefaultEF_{material}$ for downstream product categories, $DirectEF_{mcoke}$ incorporates $DefaultEF_{mcoke}$ along with the IPCC-derived direct emissions factors for metallurgical coke described in this section. The Commission converted $DefaultEF_{mcoke}$(shown in table G.4 of appendix G) to mt $CO_2e$ per TJ using a conversion factor derived from the IEA World Conversion Factors database. IEA, "World Energy Balances," July 2024.

[615] IEA, "Emissions Factors 2023," September 2023.

[616] The Commission converted the IEA indirect emissions factors to mt of $CO_2e$ per TJ of electricity generated by multiplying these factors by 0.2778. The IEA provides emissions factors for $CH_4$ and $N_2O$ in a format that is already converted to $CO_2e$ using GWPs from the Fourth Assessment of the IPCC. IEA, *Emission Factors 2023: Database Documentation*, September 2023, 10.

[617] JRC 2023 also used a recent five-year average when using these data. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 12.

[618] IEA, *Emission Factors 2023: Database Documentation*, September 2023, 39.

[619] IEA, *Emission Factors 2023: Database Documentation*, September 2023, 40–41.

country and year, equation F.6 calculates the emissions factors for heat (in mt $CO_2e$/TJ) by summing across fuel types the product of total fuel use to generate heat $\left(Heatplant\ Use_{fuel,heat} + CHP\ Use_{fuel,heat} + Plant\ OwnUse_{fuel,heat}\right)$ and a direct emissions factor for each fuel type $(DirectEF_{fuel})$, and dividing by total heat output from all sources $(Output_{heat})$.[620] For more information on how fuel inputs are allocated in facilities with combined heat and power, see box F.2.

$$IndirectEF_{heat} = \frac{\sum_{fuel}\left((Heatplant\ Use_{ful,heat}+CHP\ Use_{fuel,heat}+Plant\ OwnUse_{fuel,heat})*DirectEF_{fuel}\right)}{Output_{heat}} \quad (F.6)$$

---

[620] $Heatplant\ Use_{fuel,heat}$ is the sum of fuel use from the IEA Extended Energy Balances database flows for "Transformation Processes in Main Activity Producer Heat Plants" and "Transformation Processes in Autoproducer Heat Plants." As described in greater detail in box F.2, $CHP\ Use_{fuel,heat}$ is derived from the sum of fuel use from the flows for "Transformation Processes in Main Activity Producer CHP Plants" and "Transformation Processes in Autoproducer CHP Plants." IEA, *World Energy Balances Documentation*, July 2024, 8–9. $Plant\ OwnUse_{fuel,heat}$, the quantity of fuel used for heat generation by all energy generation plants for their own operations, is derived from the flow for "Energy Industry Own Use in Electricity, CHP and Heat Plants." IEA, *World Energy Balances Documentation*, July 2024, 11. To calculate $Plant\ OwnUse_{fuel,heat}$, the Commission allocated total fuel use by energy generation plants between heat and electricity according to the relative output of each type of energy across all generation sources in a country. See also IEA, *Emission Factors 2023: Database Documentation*, September 2023, 41. For $DirectEF_{fuel}$, IPCC emissions factors for stationary combustion in the energy sector are used rather than those for the manufacturing and construction sector. Differences between these emissions factors are minor. As with direct emissions factors for fuel types used in equation F.4, the Commission replaced emissions factors for $CO_2$ emissions from biogenic fuels with zero. IPCC, *2006 IPCC Guidelines, Volume 2*, 2006, 2.16–2.17. $Output_{heat}$ is the sum of heat output from the IEA Extended Energy Balances database flows for Heat Output from all sources. IEA, *World Energy Balances Documentation*, July 2024, 16.

**Box F.2** Allocating Combined Heat and Power Fuel Inputs in the Partial LCI Approach

Equation F.6 requires fuel use to be allocated to either generation of electricity or generation of heat. For each fuel type, the IEA Extended Energy Balances database contains data covering the amount of heat and electricity generated by combined heat and power (CHP) facilities from that fuel type ($CHP\ Output_{fuel,heat}$) and ($CHP\ Output_{fuel,electricity}$) as well as the quantities of each fuel type used as inputs in CHP facilities ($CHP\ Use_{fuel}$), all expressed in terajoules (TJ). However, this database does not allocate fuel used in CHP facilities depending on whether they were used to generate heat or electricity ($CHP\ Use_{fuel,electricity}$ and $CHP\ Use_{fuel,heat}$, respectively).

To allocate fuel used in CHP facilities, the partial LCI approach uses the same assumptions used by the IEA Emission Factors 2023 database in developing the indirect emissions factors for electricity.[a] The IEA first assumes that heat generation efficiency in CHP facilities is fixed at 90 percent (i.e., 100 TJ of fuel generate 90 TJ of heat), as reflected in equation box F.2.1.

$$CHP\ Use_{fuel,heat} = \frac{CHP\ Output_{fuel,heat}}{0.9} \qquad (Box\ F.2.1)$$

However, if overall cogeneration efficiency is over 90 percent (i.e., if CHPs in a country generate more than 90 TJ of combined heat and electricity for every 100 TJ of the fuel type used), then fuel use should be allocated proportionally to each type of energy generated using that fuel. In this case, the fuel use dedicated to heat would be calculated as the total quantity of fuel used in CHP facilities multiplied by the amount of heat generated in CHP facilities as a share of total energy generated (equation box F.2.2).

$$CHP\ Use_{fuel,heat} = CHP\ Use_{fuel} * \frac{CHP\ Output_{fuel,heat}}{\left(CHP\ Output_{fuel,heat} + CHP\ Output_{fuel,electricity}\right)} \qquad (Box\ F.2.2)$$

Under both approaches, the fuel use allocated to electricity generation within CHP facilities is then equal to the total fuel use in CHP facilities minus the fuel use for heat generation in those facilities.

$$CHP\ Use_{fuel,electricity} = CHP\ Use_{fuel} - CHP\ Use_{fuel,heat} \qquad (Box\ F.2.3)$$

[a] IEA, Emission Factors 2023: Database Documentation, September 2023, 40–41.

## Step 2.1.3 Calculation and Aggregation of Energy- and Fuel-Specific Emissions from the Iron and Steel Sector

The Commission calculated $GHG_{energy}$ for both heat ($GHG_{heat}$) and electricity ($GHG_{electricity}$) using equation F.5. In addition, the Commission calculated $GHG_{fuel}$ for narrow categories of fuels that adhere to the specificity of IPCC emissions factors and data from the IEA Extended Energy Balances database. $GHG_{fuel}$ is then aggregated into broader fuel types corresponding with fuel intensity values discussed in step 2.2. These broader fuel types, and the specific fuels as classified under IPCC included within each, are based on a similar mapping provided by Joint Research Centre (JRC) 2023.[621] Specifically:

- $GHG_{COG}$ solely includes the industry's emissions from use of coke oven gas.
- $GHG_{mcoke}$ covers the industry's emissions from use of metallurgical coke, including lignite coke and coke oven coke (i.e., coke produced in coke ovens).
- $GHG_{natgas}$ solely includes the industry's emissions from use of natural gas.

---

[621] Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 49.

- $GHG_{coal}$ covers the industry's emissions from use of coal, including anthracite, charcoal, coking coal, lignite, other bituminous coal, patent fuel, and sub-bituminous coal.[622]
- $GHG_{oil}$ covers the industry's emissions from use of oil products, including gas or diesel oil, naphtha, and residual fuel oil.
- $GHG_{otherfuel}$ covers the industry's emissions from use of all other fuels, including biodiesels, biogasoline, brown coal briquettes, crude oil, ethane, gas biomass, gas coke, gas works gas, industrial wastes, jet kerosene, liquified petroleum gases, lubricants, motor gasoline, municipal wastes (biomass fraction), municipal wastes (non-biomass fraction), natural gas liquids, other kerosene, other liquid biofuels, other petroleum products, other primary solid biomass, peat, petroleum coke, refinery gas, shale oil, and white spirit and special boiling point industrial spirits.

As described above in box F.1, the partial LCI approach does not calculate emissions for use of BFG or BOFG in the iron and steel sector.

## Step 2.2: Calculating the Share of Fuel and Energy Used in Specific Unit Processes

The aggregated $GHG_{fuel}$ and $GHG_{energy}$ terms from step 2.1.3 are then allocated between unit processes associated with the production of individual materials using $Share_{fuel,material}$ and $Share_{energy,material}$ (equation F.7).[623] These terms cover use of a fuel or energy type in the material's unit process as a share of total use of that fuel or energy type, by country.[624]

$$Share_{fuel,material} = \frac{Output_{material} * Intensity_{fuel,material}}{\sum_{material}(Output_{material} * Intensity_{fuel,material})} \quad (F.7)$$

$Output_{material}$refers to the sector's total quantity of production for that material in metric tons.[625]

---

[622] The JRC 2023 report does not allocate charcoal to the coal grouping. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 49.

[623] Equation F.7 follows an approach and uses data similar to that used in JRC 2023. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 13–14. See also Koolen and Vidovic, *Greenhouse Gas Intensities of the EU Steel Industry and Its Trading Partners*, June 22, 2022, 12–13.

[624] $Share_{energy,material}$ is calculated using the same methods described for $Share_{fuel,material}$ in equation F.7.

[625] In addition to the production database covering each country's 2021 production of iron sinter, pig iron, and all steel material categories based primarily on data from the worldsteel Statistical Yearbook, described above, the following data sources were used to generate country-specific output data for use in equation F.7: (1) production data on iron and steel castings from the European Foundry Industry Association, (2) production data on forgings from EUROFORGE, and (3) production data on direct reduced iron from the worldsteel Statistical Yearbook. Using the same approach as was used in JRC 2023, production data for direct reduced iron were separated into direct reduced iron produced using a natural gas-based method (assumed to account for 22.2 percent of India's production and 100 percent of all other countries' production) and direct reduced iron produced using a coal-based method (assumed to account for 77.8 percent of India's production). CAEF, "The European Foundry Industry 2022," November 2023, 113; EUROFORGE, *International Statistics 2022*, accessed April 18, 2024, 1–2; worldsteel, *Steel Statistical Yearbook 2023*, accessed September 21, 2024. See also Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 13.

$Intensity_{fuel,material}$ refers to the typical intensity (use rate) of that fuel in the unit process for the material, measured as gigajoules (GJ) of fuel used per metric ton of material output.[626] Data for each fuel type and material combination are presented in tables F.1 and F.2.[627]

In effect, equation F.7 determines the proportional fuel use for unit processes corresponding with materials, using two scaling factors: (1) the relative output of each material and (2) measures of the typical use of that fuel type in the production of each material. If a country produces a large quantity of a material or the material typically uses a lot of a specific fuel type in its associated unit process, then $Share_{fuel,material}$ will be higher.[628] Nonetheless, $Share_{fuel,material}$ may be overstated or understated for countries that use disproportionately high or low quantities of specific fuel types relative to use in other countries. For these countries, allocation of emissions associated with those specific fuel types to unit processes using the fuel intensity data from JRC 2023 (which is based primarily on production practices in Europe) is subject to higher levels of uncertainty.[629]

---

[626] $Intensity_{otherfuel,material}$ uses total fuel and energy intensity data corresponding with that material's unit process. This means that a unit process's overall fuel and energy use is the basis for calculating $Share_{otherfuel,material}$ and allocating $GHG_{otherfuel}$ into various unit processes.

[627] Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 46–47. The partial LCI approach used unit processes producing individual materials that differed from the processes covered in JRC 2023. The relationship between JRC 2023 fuel intensity data based on that study's process definitions and the partial LCI approach's unit processes is also shown in tables F.1 and F.2. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 46–47.

[628] All terms for $Share_{fuel,material}$ sum to 100 percent across all products that use a given fuel type in their production. For this reason, it is necessary to calculate terms for products that are not covered under the partial LCI approach or in this investigation more broadly (e.g., cast-iron products). This ensures that terms for $Share_{fuel,material}$ that correspond with covered products such as steel products, pig iron, and iron sinter are not overstated due to a lack of consideration of other and iron and steel production processes.

[629] For example, South Africa's iron and steel sector has far higher quantities of coal consumption (relative to the quantities of steel produced in that country) compared to most other countries. Although coal is more emissions intensive than many other fuels, JRC 2023 reports that coal is a comparatively minor source of fuel inputs in blast furnaces (where metallurgical coke is the main fuel input) and EAFs (where electricity and natural gas are more substantial). For most countries that have relatively low quantities of coal consumption, the emissions associated with coal consumption are divided between blast furnaces and EAFs based on the relative output from each of those unit processes with relatively limited impact on the overall emissions intensity estimates of products made from those unit processes. By contrast, South Africa's emissions from coal consumption account for most of the emissions allocated to the blast furnace (BF) and EAF unit processes, contributing to far higher emissions intensities for South African pig iron and steel products than for most other countries. Although it is likely reasonable to find that South Africa's emissions intensities for these products are relatively high given the extensive use of coal, this country's emissions may nonetheless be misallocated between the blast furnace and EAF unit processes given the clear disparity in South Africa's use of coal compared to those presented in JRC 2023. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 46–47; IEA, "World Energy Balances," July 2024.

**Table F.1** Fuel and energy intensities for unit processes that produce iron and semifinished steel products, by fuel and energy type and by product

In gigajoules per metric ton (gj/mt). BOF = basic oxygen furnace; DRI = direct reduced iron; EAF = electric arc furnace.

| Product | Mapping with Joint Research Centre 2023 process | Metallurgical coke intensity | Coal intensity | Oil intensity | Electricity intensity | Heat intensity | Natural gas intensity | Coke oven gas intensity | Total fuel and energy intensity |
|---|---|---|---|---|---|---|---|---|---|
| Iron sinter | Sinter plant | 1.28 | 0.00 | 0.00 | 0.16 | 0.00 | 0.02 | 0.02 | 1.51 |
| Pig iron | Blast furnace | 10.81 | 1.00 | 1.27 | 0.27 | 0.16 | 0.17 | 0.28 | 11.18 |
| Carbon and alloy semifinished steel (BOF method) | BOF, continuous casting (carbon steel) | 0.01 | 0.00 | 0.00 | 0.16 | 0.00 | 0.27 | 0.00 | 0.44 |
| Carbon and alloy semifinished steel (EAF method) | EAF, continuous casting (carbon steel) | 0.00 | 0.52 | 0.00 | 2.22 | 0.71 | 0.86 | 0.00 | 4.31 |
| Stainless semifinished steel | EAF, continuous casting (high alloy steel) | 0.00 | 0.52 | 0.00 | 2.22 | 0.71 | 0.86 | 0.00 | 4.31 |
| DRI (natural gas method) | DRI-EAF (natural gas-based) | 0.00 | 0.00 | 0.00 | 0.35 | 0.00 | 9.40 | 0.00 | 9.74 |
| DRI (coal method) | DRI-EAF (coal-based) | 0.00 | 23.93 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 24.17 |
| Iron castings | Cast iron melting, foundry casting (iron) | 3.42 | 0.00 | 0.00 | 0.36 | 5.84 | 0.00 | 0.00 | 9.62 |
| Steel castings | Steel melting, foundry casting (steel) | 0.00 | 0.00 | 0.00 | 2.34 | 0.00 | 10.49 | 0.00 | 12.83 |
| Iron and steel forgings | Forging (carbon steel, iron) | 0.00 | 0.00 | 0.00 | 2.06 | 0.00 | 27.03 | 0.00 | 29.09 |

Sources: USITC compiled from Vidovic et al., *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries in the EU and Its Main Trading Partners*, September 18, 2023, 46–47.

Note: A fuel intensity value of 0 indicates that the Commission assumed—for purposes of calculating scope 3 emissions factors—that the unit process corresponding with the product specified in the row did not use the fuel specified in the column. "Total fuel and energy intensity" is measured as the total use of energy and fuel by each product's unit process. Total use of fuel and energy includes use of all of the specified fuel and energy types in this table as well as blast furnace gas and basic oxygen furnace gas. The sum of all underlying intensity values may differ slightly from total fuel and energy intensity due to rounding. Total fuel and energy intensity is used as a proxy value for "other fuel intensity." The partial life cycle inventory (LCI) approach used fuel and energy intensity values for DRI derived from Joint Research Centre (JRC) 2023 intensities that include both EAF and DRI processes combined, with EAF intensity data subtracted from the JRC data. The partial LCI approach used fuel and energy intensity values for semifinished steel unit processes that produce solid semifinished steel products. JRC 2023 separated the processes used to produce semifinished steel products into EAF and BOF operations that produced liquid steel in addition to a continuous casting process that produced solid semifinished steel products. JRC 2023 also assumes that 1.06 mt of liquid steel are used to produce solid semifinished steel products. JRC 2023 converted JRC 2023's fuel and energy intensity data for these processes into consolidated unit processes for EAF and BOF production. In the partial LCI approach, JRC 2023 fuel and energy intensity data for EAFs and BOFs were multiplied by a factor of 1.06 and added to the intensity data for continuous casting.

**Table F.2** Fuel and energy intensities for unit processes that produce finished steel mill products, by fuel and energy type and by product

In gigajoules per metric ton (gj/mt).

| Product | Mapping with Joint Research Centre 2023 process | Electricity intensity | Natural gas intensity | Total fuel and energy intensity |
|---|---|---|---|---|
| Stainless hot-rolled flat steel | Hot rolled mill (high alloy steel) | 0.35 | 2.33 | 2.68 |
| Carbon and alloy hot-rolled flat steel | Hot rolled mill (carbon steel) | 0.18 | 1.40 | 1.59 |
| Cold-rolled flat steel (carbon and alloy, stainless) | Cold rolled mill, annealing (carbon and high alloy steel) | 0.30 | 1.06 | 1.36 |
| Carbon and alloy coated flat steel | Finishing flat products | 0.10 | 1.07 | 1.17 |
| Stainless hot-worked long steel | Bars and rods mills (high alloy steel) | 0.86 | 3.49 | 4.35 |
| Carbon and alloy hot-worked long steel | Bars and rods mills (carbon steel) | 0.31 | 1.21 | 1.52 |
| Cold-formed long steel (carbon and alloy, stainless) | Wire mill (carbon and high alloy steel) | 0.53 | 0.00 | 0.53 |
| Seamless tubular steel products (carbon and alloy, stainless) | Beams, billets, rails and tubes mills (carbon and high alloy steel), annealing | 0.18 | 2.77 | 2.96 |
| Non-seamless tubular steel products (carbon and alloy, stainless) | Cold rolled mill, annealing (carbon and high alloy steel) | 0.30 | 1.06 | 1.36 |

Source: USITC compiled from Vidovic et al., *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries in the EU and Its Main Trading Partners*, September 18, 2023, 47.

Note: A fuel intensity value of 0 indicates that the Commission assumed—for purposes of calculating scope 3 emissions factors—that the unit process corresponding with the product specified in the row did not use the fuel specified in the column. “Total fuel and energy intensity” is measured as the total use of energy and fuel by each product’s unit process. Total use of fuel and energy includes use of all of the specified fuel and energy types in this table as well as blast furnace gas and blast oxygen furnace gas. The sum of all underlying intensity values may differ slightly from total fuel and energy intensity due to rounding. Total fuel and energy intensity is used as a proxy for “other fuel intensity.” Where a product category is modified with “carbon and alloy, stainless,” the fuel and energy intensities apply to both the carbon and alloy steel and stainless steel types of that product.

## Step 2.3 Final Calculation of Unit Process Emissions Factors for Iron Sinter Plants, Blast Furnaces, and Steel Production Processes

Step 2.1 generated the terms $GHG_{cog}$, $GHG_{mcoke}$, $GHG_{coal}$, $GHG_{oil}$, $GHG_{natgas}$, $GHG_{otherfuel}$, $GHG_{electricity}$, and $GHG_{heat}$ covering total emissions from use of each type of fuel by the iron and steel sector. Under equation F.3, these terms are multiplied by corresponding terms for $Share_{fuel,material}$ and $Share_{energy,material}$ and subsequently summed to calculate unit process emissions associated with fuel and energy use in the production of specific materials ($UGHG_{material}$).

An additional step adjusts emissions associated with electricity use in $UGHG_{pig}$ (unit process emissions for pig iron production in blast furnaces). As described in box F.1, all emissions associated with BFG and BOFG generation and combustion are implicitly allocated to blast furnaces and BOFs. If a country’s integrated facilities self-generate electricity using the waste gases generated from blast furnaces and BOFs (BFG and BOFG), those facilities should not also have positive contributions to $UGHG_{pig}$ from indirect emissions from the national grid for that electricity. To correct for this, after $GHG_{electricity}$ is allocated to the pig iron unit process using $Share_{electricity,pig}$, $UGHG_{pig}$ is reduced by the amount of electricity that the iron and steel industry self-generated from BFG and BOFG multiplied by the indirect emissions factors for electricity.[630]

Using equation F.2, the partial LCI approach calculates unit process emissions factors ($UEF_{material}$) for production of iron sinter, pig iron, and every steel product listed in tables F.1 and F.2. These unit process emissions factors are then incorporated into equation F.1, which generates country-specific emissions factors for these materials, as described in step 3.

## Step 3 Material Flow Analysis and Calculation of Default Scope 3 Emissions Factors for Iron Sinter, Pig Iron, and Steel Products

As described in step 1, many of the furthest upstream materials included in the steel system boundary have assigned default emissions factors using publicly available data. However, for iron sinter, pig iron, and each steel product, equation F.1 is used to calculate country-specific emissions factors for that material.[631] For each material, $UEF_{material}$ is added to a sum of emissions associated with upstream inputs that are used to produce the material to calculate $DefaultEF_{material}$. The amount of emissions associated with upstream inputs is based on a combination of upstream emissions factors associated with those inputs ($DirectEF_{input}$ and $DefaultEF_{input}$) and input intensity data ($Intensity_{input,material}$), which captures the rate at which inputs are used to make downstream materials.[632]

Step 3 describes how $DefaultEF_{material}$ is calculated for each material type and provides values for $Intensity_{input,material}$ using material-specific derivatives of equation F.1. These calculations occur sequentially: for example, the default emissions factor for iron sinter ($DefaultEF_{sinter}$) is used in the calculation of the default emissions factor for pig iron ($DeaultEF_{pig}$), which in turn is used in the calculation of the default emissions factor for carbon and alloy semifinished steel. All values of

---

[631] Values for $DefaultEF_{material}$ were calculated in step 3 for each country and globally. In some cases where a country did not produce a specific material or where data was unavailable to allow for the calculation of $UEF_{material}$ for that country using the methods described above for step 2, the country-specific emissions factor was assigned the same value as the global emissions factor for that material. For brevity, the subscript $country$ is not used in the equations in this section except in cases where a specific country-specific or global variable is explicitly referenced.

[632] With the exception of certain ferroalloys used in stainless steelmaking (see “Step 3.4: Default Emissions Factors for Stainless Semifinished Steel”), values for $Intensity_{input,material}$ were generally not calculated for individual countries’ industries and were assumed to represent typical input intensities globally that could be used in each country’s material flow analyses. The partial LCI approach’s use of this assumption reduces the precision of scope 3 emissions factors, as different countries’ iron and steel industries use different quantities of specific inputs. For example, an analysis by SMA found that different countries rely on alternative sources of iron ore to varying extents. SMA, *Steelmaking Emissions Report 2022*, June 14, 2022, 8. Notwithstanding this uncertainty, the Commission collected input intensity values that represent the key groups of inputs used in all unit processes covered in these analyses in order to avoid any consistent understatement or overstatement of calculated emissions factors across countries.

$DirectEF_{input}$ and $DefaultEF_{input}$ other than those values of $DefaultEF_{input}$ generated in step 3 itself are from tables G.3 and G.4 in appendix G.[633]

## Step 3.1 Default Emissions Factors for Iron Sinter

U.S. steel-producing facilities do not receive iron sinter from other sources. Therefore, use of iron sinter is not a source of scope 3 emissions when calculating the emissions intensity of U.S. steel products. However, iron sinter is an important input in pig iron production. Therefore, country-specific measures of $DefaultEF_{sinter}$ (equation F.8) are calculated that are subsequently used in the calculation of country-specific measures of $DefaultEF_{pig.}$

$$\begin{aligned} DefaultEF_{sinter} = UEF_{sinter} + (Intensity_{ore,sinter} * DefaultEF_{ore}) \\ + \left(Intensity_{lstone,sinter} * (DefaultEF_{lstone} + DirectEF_{lstone})\right) \\ + (Intensity_{lime,sinter} * DefaultEF_{lime}) \end{aligned} \qquad (F.8)$$

$Intensity_{ore,sinter}$ is set at 0.813 metric tons of iron ore; $Intensity_{lstone,sinter}$ is set at 0.131 metric tons of non-calcined limestone and dolomite; and $Intensity_{lime,sinter}$ is set at 0.010 metric tons of calcined lime.[634]

## Step 3.2 Default Emissions Factors for Pig Iron

$DefaultEF_{pig}$ is calculated using equation F.9.

$$\begin{aligned} DefaultEF_{pig} = UEF_{pig} + (Intensity_{oxygen,pig} * DefaultEF_{oxygen}) \\ +(Intensity_{ore,pig} * DefaultEF_{ore}) + (Intensity_{sinter,pig} * DefaultEF_{sinter}) \\ +(Intensity_{pellets,pig} * DefaultEF_{pellets}) + \left(Intensity_{lime,pig} * DefaultEF_{lime}\right) \end{aligned} \qquad (F.9)$$

Values for $Intensity_{input,pig}$ are shown for each input in table F.3.

---

[633] In the equations below, no term for $DirectEF_{input}$ is shown where direct emissions from use of that input are set at zero in tables G.3 and G.4 of appendix G.

[634] Values for $Intensity_{input,sinter}$ and for several other material flow analyses elsewhere in step 3 are derived from a 2013 JRC study titled *Best Available Techniques (BAT) Reference Document for Iron and Steel Production* (JRC 2013). This study's material flow data also form the foundation of several input and fuel intensity measures within JRC 2023. Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023; Remus et al., *Best Available Techniques (BAT) Reference Document*, January 24, 2013, 95.

**Table F.3** Input intensity of inputs in the production of pig iron, by input category
In metric tons of inputs used per metric ton of material produced (mt input/mt material) for solid materials and thousand cubic feet per metric ton of material produced for gases (Mcf/mt material).

| Input category | Variable name | Unit of measure | Input intensity value |
|---|---|---|---|
| Oxygen | $Intensity_{oxygen,pig}$ | Mcf/mt material | 1.598 |
| Iron ore | $Intensity_{ore,pig}$ | mt input/mt material | 0.180 |
| Iron sinter | $Intensity_{sinter,pig}$ | mt input/mt material | 1.088 |
| Iron pellets | $Intensity_{pellets,pig}$ | mt input/mt material | 0.358 |
| Calcined lime | $Intensity_{lime,pig}$ | mt input/mt material | 0.026 |

Source: USITC compiled from Drnevich, Messina, and Selines, “Production and Use of Industrial Gases for Iron and Steelmaking,” 1998, 292; Remus et al., *Best Available Techniques (BAT) Reference Document*, January 24, 2013, 304.
Note: “Input intensity value” refers to the quantity of inputs used to produce one metric ton of pig iron.

## Step 3.3 Default Emissions Factors for Carbon and Alloy Semifinished Steel

Carbon and alloy semifinished steel is the foundation of all other carbon and alloy steel products within the steel system boundary of this investigation. To capture differences in production methods that have substantial impacts on the emissions intensities of steel products, the partial LCI approach calculates three separate types of default emissions factors covering carbon and alloy semifinished steel:

- $DefaultEF_{car\ semi,bof}$ refers to default emissions factors for carbon and alloy steel produced using BOFs.
- $DefaultEF_{car\ semi,eaf,long}$ refers to default emissions factors for carbon and alloy steel produced using EAFs that is then used to make long steel products and seamless tubular steel products. These values are also used for the default emissions factors for $DefaultEF_{carsemi,eaf}$ generally, assuming that most receipts of carbon and alloy semifinished steel from EAF facilities are billets and ingots rather than slabs.
- $DefaultEF_{car\ semi,eaf,flat}$ refers to default emissions factors for carbon and alloy steel produced using EAFs that is subsequently used to make flat steel products. The partial LCI approach did not use these emissions factors directly to calculate scope 3 emissions for U.S. steel facilities. These emissions factors were used only to determine the upstream emissions contribution for carbon and alloy semifinished steel in the calculation of default emissions factors for flat steel mill products (e.g., hot-rolled flat steel) produced using an EAF production pathway (these are calculated in step 3.5).

Each type of carbon and alloy steel described above is calculated using equation F.10 below.

$$
\begin{aligned}
DefaultEF_{car\ semi} \\
= {} & UEF_{car\ semi} + \left(Intensity_{oxygen,car\ semi} * DefaultEF_{oxygen}\right) \\
& + \left(Intensity_{nitrogen,car\ semi} * DefaultEF_{nitrogen}\right) \\
& + \left(Intensity_{argon,car\ semi} * DefaultEF_{argon}\right) \\
& + \left(Intensity_{hydrogen,car\ semi} * DefaultEF_{hydrogen}\right) \\
& + \left(Intensity_{lstone,car\ semi} * (DefaultEF_{lstone} + DirectEF_{lstone})\right) \\
& + \left(Intensity_{lime,car\ semi} * DefafultEF_{lime}\right) \\
& + \left(Intensity_{alloys,car\ semi} * \left(DefaultEF_{alloys} + DirectEF_{alloys}\right)\right) \\
& + \left(Intensity_{electrode,car\ semi} * (DefaultEF_{electrode} + DirectEF_{electrode})\right) \\
& + \left(Intensity_{pig,car\ semi} * \left(DefaultEF_{pig} + DirectEF_{pig}\right)\right) \\
& + (Intensity_{dri,car\ semi} * (DefaultEF_{dri} + DirectEF_{dri})) \qquad (F.10)
\end{aligned}
$$

Values for $Intensity_{input,carsemi}$ are shown for each input and for each production pathway in table F.4. The main differences between each production pathway involve the use of pig iron and direct reduced iron. BOF steelmaking uses considerably more pig iron than EAF steelmaking.[635] Although they do not use as much pig iron as BOFs, EAF facilities that produce flat steel products use considerably more pig iron and direct reduced iron than those that produce long steel products.[636] When production pathway cannot be determined for a steel product input, the Commission use the steps explained in box F.3 to generate an emissions factor.

---

[635] When calculating $DefaultEF_{car\ semi,bof}$, equation F.10 uses the country-specific emissions factors for pig iron, assuming that most pig iron is sourced from the same country where BF-BOF steel is produced because of the vertically connected nature of integrated steelmaking. Based on a related assumption that most EAF steel producers do not necessarily have access to domestic sources of pig iron, both the long and flat steel derivatives of $DefaultEF_{car\ semi,eaf}$ are calculated using the global emissions factors for pig iron.

[636] SMA, *Steelmaking Emissions Report 2022*, June 14, 2022. The input intensity values selected for $Intensity_{pig,carsemi,eaf}$ for semifinished steel used to make flat products and long products represent the extreme high and low values, respectively, of a range of pig iron and direct reduced iron use rates by EAFs reported in JRC 2013. Remus et al., *Best Available Techniques (BAT) Reference Document*, January 24, 2013, 429.

**Table F.4** Input intensity of upstream inputs in the production of carbon and alloy semifinished steel, by input category

In metric tons of inputs used per metric ton of material produced (mt input/mt material) for solid materials and thousand cubic feet per metric ton of material produced for gases (Mcf/mt material). BF-BOF = blast furnace and basic oxygen furnace; EAF = electric arc furnace.

| Input category | Variable name | Unit of measure | Input intensity value (BF-BOF pathway) | Input intensity value (EAF pathway) |
|---|---|---|---:|---:|
| Oxygen | $Intensity_{oxygen,car\ semi}$ | Mcf/mt material | 2.375 | 1.620 |
| Nitrogen | $Intensity_{nitrogen,car\ semi}$ | Mcf/mt material | 2.298 | 0.134 |
| Argon | $Intensity_{argon,car\ semi}$ | Mcf/mt material | 0.027 | 0.024 |
| Hydrogen | $Intensity_{hydrogen,car\ semi}$ | Mcf/mt material | 0.010 | 0.010 |
| Calcined lime | $Intensity_{lime,car\ semi}$ | mt input/mt material | 0.051 | 0.087 |
| Non-calcined limestone and dolomite | $Intensity_{lstone,car\ semi}$ | mt input/mt material | 0.015 | 0.000 |
| Ferroalloys and alloying metals | $Intensity_{alloys,car\ semi}$ | mt input/mt material | 0.018 | 0.027 |
| Carbon electrodes | $Intensity_{electrodes,car\ semi}$ | mt input/mt material | 0.000 | 0.004 |
| Pig iron | $Intensity_{pig,car\ semi}$ | mt input/mt material | 0.943 | 0.000–0.162 |
| Direct reduced iron and hot briquetted iron | $Intensity_{dri,car\ semi}$ | mt input/mt material | 0.000 | 0.000–0.228 |

Source: USITC compiled from Remus et al., *Best Available Techniques (BAT) Reference Document*, January 24, 2013, 369, 429.

Note: “Input intensity value” refers to the quantity of inputs used to produce one metric ton of carbon and alloy semifinished steel. An input intensity value of 0 indicates that the Commission assumed—for purposes of calculating scope 3 emissions factors—that steel producers using the production pathway specified in the column did not use the material specified in the row.

**Box F.3** Calculation of Non-Pathway-Specific Emissions Factors for Steel Materials

As discussed in appendix E (“II.D.1.a(4) Scope 3 Emissions for Steel Materials Group 4: Steel Products”), this investigation calculates facility-level scope 3 emissions for steel products using production pathway-specific emissions factors where facilities identify their external receipts as being from sources associated with electric arc furnace (EAF) facilities or facilities with blast furnaces and basic oxygen furnaces (BF-BOF). However, in cases where the production pathway for external receipts is unknown, a non-pathway-specific emissions factors is used to calculate scope 3 emissions.

Non-pathway-specific steel emissions factors for non-U.S. source countries are calculated by measuring the weighted average of the EAF- and BF-BOF-specific emissions factors for each steel product. The EAF- and BF-BOF-specific emissions factors are weighted by the quantity of semifinished steel production by production pathway using data from the worldsteel Statistical Yearbook.[a] The same approach applies for all carbon and alloy steel products, including downstream steel mill products. (Stainless steel products are assumed to be produced using only the EAF production pathway, as discussed in Step 3.4, “Default Emissions Factors for Stainless Semifinished Steel,” which follows this text box.) This approach also applies for U.S. non-pathway-specific emissions factors for carbon and alloy semifinished steel.

The United States produces long steel products and seamless steel tubular products using the EAF production pathway, while both pathways are used to make flat steel products and by extension non-seamless tubular steel products.[b] Because of this, the U.S. non-pathway-specific emissions factors for carbon and alloy hot-worked long steel, cold-formed long steel, and seamless tubular steel products are the same as the EAF-specific emissions factors for those products.

The U.S. non-pathway-specific emissions factors for flat steel products and non-seamless tubular steel products (which are generally made using a flat steel substrate) are weighted using a similar approach to that of other countries. However, for these products, only the quantity of carbon and alloy semifinished steel produced in EAFs that is not used to produce long and seamless tubular steel products is considered when weighting the contribution of the EAF-specific emissions factor.

[a] worldsteel, *Steel Statistical Yearbook 2023*, accessed September 21, 2024.
[b] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 1.2.2 and 2.1.1.

## Step 3.4 Default Emissions Factors for Stainless Semifinished Steel

Stainless steel encompasses a highly diverse family of steels with a wide range of alloy mixtures, sources of alloying metal, production processes, scrap intensities, and corresponding grades of stainless steel produced. In seeking to develop standard default emissions factors for stainless semifinished steel, the partial LCI approach made the following simplifying assumptions:

1. The default emissions factors for all stainless semifinished steel would be based on an EAF production pathway based on the prevailing method for global production of stainless steel.[637]
2. The default emissions factors would be based on a grade that captures the essential characteristics of stainless steel—at least 10.5 percent chromium content and a generally high percent of nickel content. ASTM Grade 304 was selected because it is the most common grade of

---

[637] Norgate, Jahanshahi, and Rankin, “Alternative Routes to Stainless Steel - A Life Cycle Approach,” January 2004, 695; Total Materia, “Production of Stainless Steel: Part Two,” March 2008.

stainless steel produced globally at the time of this investigation. Grade 304 is defined in this investigation as having 19 percent chromium and 9.3 percent nickel.[638]

3. The input intensities of nickel and chromium were dictated by the amount of stainless steel scrap used.[639] The amount of scrap used for the production of stainless steel was assumed to be 58 percent of total metallic inputs. This percentage represents a mid-point between relatively high scrap use in the United States and Europe—the main sources of most of the U.S. industry's external receipts of stainless steel products—and lower scrap use globally.[640] This use of scrap led the Commission to assume that the input intensities of nickel and chromium provided by ferroalloys and other alloying metals (i.e., not from scrap) were 0.048 mt nickel and 0.095 mt chromium per metric ton of stainless semifinished steel produced.[641]
4. Ferrochromium was the source of all chromium needed to produce stainless semifinished steel not supplied by scrap. Ferronickel and nickel metal were the sources of all nickel not supplied by scrap, accounting for 66.9 percent and 33.1 percent of the remaining nickel needed, respectively.[642] The metallic content of these materials was 53 percent chromium content for ferrochromium and 30 percent nickel content for ferronickel, consistent with the assumptions used to calculate the default emissions factors for these materials described in step 1.[643]

The assumptions described above allowed the Commission to calculate broad approximations of the input intensities of ferronickel, nickel metal, and ferrochromium in the production of stainless semifinished steel (see table F.5). For China and Indonesia, however, the assumptions described above do not adequately capture a significant difference in production practices in these two countries that results in far higher emissions intensities for stainless steel produced in these countries than in other countries. Both countries rely to a lesser extent on scrap and to a greater extent on ferroalloys and other

---

[638] Norgate, Jahanshahi, and Rankin, "Alternative Routes to Stainless Steel - A Life Cycle Approach," January 2004; Outokumpu, written submission to the USITC, December 21, 2023, 7. For similar reasons, another recent life cycle analysis study by Gyllenram and Wei focused on Grade 304 in order to compare the stainless steel carbon footprints of the European Union, Indonesia, and China. Gyllenram and Wei, *304 Stainless Steel Carbon Footprint Comparison: EU, Indonesia and China*, October 2022, 6.

[639] worldstainless, "Stainless Steel $CO_2$ Emissions Report," August 2023.

[640] The Commission used the average of (1) stainless steel scrap share for EU plants from the Gyllenram and Wei study (79 percent) and (2) the global stainless steel scrap ratio from a worldstainless study (37 percent). Gyllenram and Wei, *304 Stainless Steel Carbon Footprint Comparison: EU, Indonesia and China*, October 2022, 17; worldstainless, *Global Life Cycle of Stainless Steel*, June 26, 2023.

[641] The Commission assumed that stainless steel scrap contains 7.75 percent nickel and 16.3 percent chromium by weight, derived from the Gyllenram and Wei study. Gyllenram and Wei, *304 Stainless Steel Carbon Footprint Comparison: EU, Indonesia and China*, October 2022, 13. The Commission then multiplied the 58 percent stainless steel scrap share by each of those contained weight shares to find that the contribution of nickel and chromium from this scrap equated to 4.5 percent and 9.5 percent of metallic inputs into stainless semifinished steel, respectively. Therefore, the remaining 4.8 percent nickel and 9.5 percent chromium needed to produce ASTM Grade 308 stainless semifinished steel were assumed to come from ferroalloys and other alloying metals.

[642] The assumed proportional contributions of ferronickel and nickel metal to the remaining nickel needed were based on the proportional contributions of those inputs to the supply of nickel for EU plants in the Gyllenram and Wei study. Gyllenram and Wei, *304 Stainless Steel Carbon Footprint Comparison: EU, Indonesia and China*, October 2022, 13,15.

[643] Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 15.

alloying metals as a source of alloying metals. In particular, these two countries produce stainless steel using nickel pig iron, a highly emissions-intensive form of nickel used in stainless steel production.[644]

**Table F.5** Input intensity of ferroalloy and other alloying metal inputs in the production of stainless semifinished steel for China, Indonesia, and the rest of the world, by input category

In metric tons of inputs used per metric ton of material (mt input/mt material).

| Input category | Variable name | Input intensity value (China) | Input intensity value (Indonesia) | Input intensity value (rest of world) |
|---|---|---|---|---|
| Ferrochromium | $Intensity_{fecr,ss\ semi}$ | 0.268 | 0.312 | 0.180 |
| Ferronickel | $Intensity_{feni,ss\ semi}$ | 0.000 | 0.000 | 0.107 |
| Nickel | $Intensity_{nimetal,ss\ semi}$ | 0.013 | 0.000 | 0.016 |
| Nickel pig iron | $Intensity_{nipig,ss\ semi}$ | 0.505 | 0.717 | 0.000 |

Sources: USITC estimates based on partial life cycle inventory (LCI) approach using data compiled from Gyllenram and Wei, *304 Stainless Steel Carbon Footprint Comparison: EU, Indonesia and China*, October 2022; Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023; worldstainless, *Global Life Cycle of Stainless Steel*, June 26, 2023.

Note: "Input intensity value" refers to the quantity of inputs used to produce one metric ton of stainless semifinished steel. An input intensity value of 0 indicates that the Commission assumed—for purposes of calculating scope 3 emissions factors—that steel producers in the country specified in the column did not use the material specified in the row.

To capture the clear distinction in China and Indonesia's sourcing of the nickel and chromium content in stainless semifinished steel production, assumptions 3 and 4 described above were modified in order to estimate different ferroalloy input intensities for these countries. Specifically, the Commission used a study by Gyllenram and Wei for its estimated contributions of nickel and chromium from scrap and ferroalloys from these countries. This study assumed the Chinese and Indonesian steel industries use lower quantities of stainless scrap, ferronickel, and nickel metal but higher quantities of ferrochromium and high quantities of nickel pig iron in the production of stainless semifinished steel (see table F.5).[645]

The Commission used equation F.11 to calculate the default emissions factor for stainless semifinished steel ($DefaultEF_{ss\ semi}$) for each country. Different $Intensity_{input,ss\ semi}$ values for China, Indonesia, and the rest of the world are shown for each alloying metal input in table F.5. For non-alloying metal inputs (industrial gases, calcined lime, and carbon electrodes), values for $Intensity_{input,ss\ semi}$ are the same as the EAF-specific values for $Intensity_{input,car\ semi}$ shown in table F.4 above.

---

[644] Outokumpu, written submission to the USITC, December 21, 2023, 7.

[645] As with the selection of ferronickel and ferrochromium grades from the JRC 2023 report, the Commission relied on that study for its assumption that nickel pig iron from all sources contained 12.5 percent nickel. Based on this assumption, the Commission re-calculated the quantities of nickel pig iron used by the Chinese and Indonesian industries, as those quantities were based on use of nickel pig iron with slightly different nickel contents. Input intensity data for the Chinese industry was based on the weighted average of three types of facilities with different input use rates. Gyllenram and Wei, *304 Stainless Steel Carbon Footprint Comparison: EU, Indonesia and China*, October 2022, 10,13,15; Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023.

$$\begin{aligned}
DefaultEF_{ss\ semi} \\
&= UEF_{ss\ semi} + \left(Intensity_{oxygen,ss\ semi} * DefaultEF_{oxygen}\right) \\
&+ \left(Intensity_{nitrogen,ss\ semi} * DefaultEF_{nitrogen}\right) \\
&+ \left(Intensity_{argon,ss\ semi} * DefaultEF_{argon}\right) \\
&+ \left(Intensity_{hydrogen,ss\ semi} * DefaultEF_{hydrogen}\right) \\
&+ (Intensity_{ss\ semi} * DefaultEF_{lime}) \\
&+ \left(Intensity_{electrode,ss\ semi} * (DefaultEF_{electrode} + DirectEF_{electrodes})\right) \\
&+ \left(Intensity_{feni,ss\ semi} * \left(DefaultEF_{feni} + DirectEF_{feni}\right)\right) \\
&+ \left(Intensity_{nimetal,ss\ semi} * (DefaultEF_{nimetal} + DirectEF_{nimetal})\right) \\
&+ \left(Intensity_{nipig,ss\ semi} * \left(DefaultEF_{nipig} + DirectEF_{nipig}\right)\right) \\
&+ \left(Intensity_{fecr,ss\ semi} * \left(DefaultEF_{fecr} + DirectEF_{fecr}\right)\right) \qquad (F.11)
\end{aligned}$$

## Step 3.5 Default Emissions Factors for Steel Mill Products

For both stainless steel and carbon and alloy steel mill products, default emissions factors generally are calculated as the sum of the unit process emissions for that product and the upstream emissions associated with the use of a corresponding steel substrate that would typically be used to produce the steel mill product. For example, in equation F.12 below, the default emissions factors for carbon and alloy hot-rolled flat steel are calculated using the emissions that occur during hot-rolling and upstream emissions associated with carbon and alloy semifinished steel.[646]

$$DefaultEF_{car\ hr} = UEF_{car\ hr} + (Intensity_{car\ semi,car\ hr} * DefaultEF_{car\ semi}) \qquad (F.12)$$

The partial LCI approach uses the following input intensity measures derived from JRC 2023 to determine the quantities of steel inputs used to make other forms of steel:

- Production of 1 mt of hot-rolled flat steel, hot-worked long steel, or seamless tubular steel requires 1.03 mt of semifinished steel.[647]
- Production of 1 mt of cold-rolled flat steel requires 1.04 mt of hot-rolled flat steel.
- Production of 1 mt of cold-formed long steel requires 1.04 mt of hot-worked long steel.[648]
- Production of 1 mt of non-seamless tubular steel products requires 1 mt of hot-rolled flat steel.

---

[646] In this investigation's facility-level scope 3 calculations, the activity data for steel mill products only identify the country of melt-and-pour, not the country where additional production steps occurred. For example, a facility's receipts of carbon and alloy hot-rolled flat steel from Canada would identify Canada as the country of melt-and-pour but would not identify whether hot-rolling occurred in Canada. However, the partial life cycle inventory (LCI) approach calculates country-specific emissions factors for downstream steel products under the assumption that additional processing steps also occurred in the country of melt-and-pour. In equation F.12, both the unit process emissions factors for hot-rolled flat steel and the upstream semifinished steel emissions factors would be specific to Canada using the example above.

[647] Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 15.

[648] JRC 2023 does not have a separate product category for cold-formed long steel. The Commission used the intensity of hot-rolled flat steel in the production of cold-rolled flat steel as a proxy for the intensity of hot-worked long steel in the production of cold-formed long steel.

Default emissions factors for carbon and alloy coated flat steel includes upstream emissions from cold-rolled flat steel ($car\ cr$) as well as from three commonly used metallic coating materials: zinc, tin, and aluminum (equation F.13).

$$\begin{aligned} DefaultEF_{car\ coat} \\ &= UEF_{car\ coat} + \left(Intensity_{car\ cr,car\ coat} * DefaultEF_{car\ cr}\right) \\ &+ \left(Intensity_{zinc,car\ coat} * DefaultEF_{zinc}\right) \\ &+ \left(Intensity_{tin,car\ coat} * DefaultEF_{tin}\right) \\ &+ \left(Intensity_{aluminumcar\ coat} * DefaultEF_{aluminum}\right) \end{aligned} \qquad (F.13)$$

Production of 1 mt of carbon and alloy coated flat steel requires 1 mt of cold-rolled flat steel.[649] The input intensity of coating metals used to produce coated flat steel products is assumed to be 0.069 mt of coating metal used to produce 1 mt of coated flat steel.[650] The input intensity of coating metals is divided into three coating metal types, with 0.047 mt of zinc, 0.016 mt of tin, and 0.005 mt of aluminum assumed to be used in the production of 1 mt of coated flat steel.[651]

# Sensitivity Analyses

To explore the effects that certain parameters, methods, and respondents had on the overall emissions intensity estimates, the Commission ran sensitivity analyses of its emissions intensity calculations. The results of these analyses are presented here to provide insight into the aspects of the calculations that are driving the emissions intensity estimates, which may help inform future efforts to produce similar calculations. In its sensitivity analyses, the Commission recalculated its emissions intensity results using four alternative methods: (1) using the market-based method for generating scope 2 emissions, (2) incorporating fugitive methane emissions associated with coal and natural gas used in the production of covered steel and aluminum products, (3) restricting the population of responses only to those firms reporting to the Greenhouse Gas Reporting Program (GHGRP), and (4) using only default emissions factors to generate emissions intensities. Compared to the presentation of results in the chapters and in appendix I, results under method 1 represent a change to the methodology and input data, results under method 2 represent a change to the methodology and input data via an expansion of the Commission's

---

[649] Vidovic et al., *GHG Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries*, 2023, 15.

[650] The assumption underlying the aggregate input intensity of coating metals is from a 2021 life cycle assessment by Arguillarena et al., in which the authors found that two plants used 58.9 kilograms and 79.2 kilograms, respectively, of zinc per metric ton of galvanized steel produced. The partial LCI approach averaged these two use rates and used that value as the input intensity for coating metals overall. As with other products analyzed in the partial LCI approach, these intensity values represent broad approximations of how materials are used to produce steel products and do not capture the wide variation in how coating metals are used to produce coated flat steel products. Arguillarena et al., "Life-Cycle Assessment as a Tool to Evaluate the Environmental Impact of Hot-Dip Galvanisation," March 25, 2021, 5.

[651] The input intensity for each coating metal used in the production of coated flat steel products is calculated by dividing the aggregate input intensity of coating metals by a coating metal share meant to capture each coating metal's prevalence in steel coating globally. In the absence of global coating metal use data, coating metal shares were calculated using 2022 U.S. import data, which separates carbon and alloy coated flat steel products by coating metal type. USITC DataWeb/Census, HTS subheadings 7210.11, 7210.12, 7210.30, 7210.41, 7210.49, 7210.61, 7210.69, 7212.10, 7212.20, 7212.30, 7225.91, 7225.92 and HTS statistical reporting numbers 7210.70.6030, 7210.70.6060, and 7226.99.0110.

system boundaries, results under method 3 represent a change in the population, and results under method 4 represent a change to the scope 3 emissions factors that the Commission uses to calculate emissions intensities.

## Market-Based Method

As summarized in box 1.2 in chapter 1, the GHG Protocol has two recommended methods for estimating emissions from purchased electricity: the location-based method and the market-based method. These methods are also each covered in the U.S. Environmental Protection Agency (EPA) guidance on calculating scope 2 emissions.[652] The market-based method is often used for company-level emissions reporting as it allows for instances where companies take actions, such as purchasing renewable energy certificates, to reduce their scope 2 emissions. Because the Commission's calculations are U.S.-wide averages rather than company-specific calculations and because of challenges with occasional double-counting of emissions attributes under the market-based method, the main calculations used to generate the results in chapters 4 and 5 use the location-based method. However, the questionnaire collected the information needed to apply the market-based method. This section presents the approach for calculating these market-based method emissions and the results of that analysis.

The EPA guidance identifies six different electricity emissions factors in order of preference that may be used for the market-based method. The first three are for emissions factors that are not always relevant to the facility, but should be used when relevant and available. The Commission's questionnaire collected data for each of these factors: energy attribute certificates, contracts to purchase electricity from specific generating facilities, and emissions factors specific to the utility or retail energy supplier from which the facility sourced their electricity. After these three emissions factors are applied, any remaining purchased electricity receives a default emissions factor. In order of preference, these default factors should use a residual mix, regional, or national factor. The residual mix factor represents the average emissions from electricity generation for a geographic area after excluding the attributes of electric generation in that area that are already counted in the certificates, contracts, and utility or retail supplier-specific factors. Residual mix emissions factors are not widely available. As such, the calculations use the same subregional emissions factors that were used in the location-based method.

The Green-e certification program publishes U.S. residual mix emissions factors for subregions in the EPA's Emissions and Generation Resource Integrated Database (eGRID) that exclude the attributes of all Green-e certified renewable energy generation. However, these data were not available for the year 2022 in time for inclusion in this report. According to the 2021 residual mix data, the differences compared to the eGRID subregional emissions factors were small—less than 1 percent and sometimes less than 0.1 percent—in many of the subregions where electricity use was most concentrated. One exception is the eGRID SRMW subregion (which spans parts of Missouri, Illinois, and Iowa), where Green-e's residual mix emissions factor was 1.66 percent higher in 2021 than the eGRID emissions factor.[653]

---

[652] WRI, *GHG Protocol Scope 2 Guidance*, 2015; EPA, *GHG Inventory Guidance*, December 2023.

[653] See figures 3.9 and 4.8 for maps of where electricity purchases were concentrated for U.S. steel and aluminum producers, respectively. Green-e, "2023 Residual Mix Emissions Rates (2021 Data)," December 12, 2023.

### Steel

For steel produced in the United States, using the market-based method results in slightly different average emissions intensities than those generated by using the location-based method. The differences between the intensities calculated under either method were not statistically significant for any product category. On a facility-by-facility basis, emissions intensities calculated using the market-based method could be higher than those under the location-based method if facilities reported an emissions factor for their purchased electricity from their utility or retail energy supplier that was higher than the eGRID subregional emissions factor. By contrast, zero-emission energy attribute certificates, as were reported by multiple facilities with EAF steelmaking, served to decrease a facility's emissions intensity under the market-based method relative to the location-based method. These certificates reduced the scope 2 emissions for those facilities and reduced the scope 3 emissions for U.S. facilities that sourced steel inputs from them.

### Aluminum

As with the steel product categories, the average emissions intensities for aluminum product categories did not significantly differ between those generated by the market-based method and those generated by the location-based method. Purchases of zero-emission energy attribute certificates were much more common among facilities producing covered steel products, particularly electric arc furnaces, than among facilities producing covered unwrought aluminum products.[654] Unlike semifinished steel, many facilities producing unwrought aluminum can manufacture a relatively low emissions intensity product (secondary aluminum) without using large quantities of electricity, which may explain why the use of certificates was not as common.

## Fugitive Emissions Associated with Coal and Natural Gas Used in Steel and Aluminum Production

In the main calculation methodology for product-level emissions intensities, the Commission assigns direct emissions factors that capture combustion emissions related to scope 1 and 2 coal and natural gas use. Coal and natural gas production generates additional emissions upstream of the point of combustion, which include fugitive methane emissions.[655] This section presents alternative results of average emission intensities for covered steel and aluminum product categories that incorporate estimates of fugitive methane emissions from cradle-to-gate coal and natural gas production activities.

---

[654] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 4.4b.

[655] The GHGRP includes some measures of fugitive emissions as part of the process emissions reported in subpart Q; however, as described in Appendix E ("II.A. Process Emissions for Steel"), these are specific to emissions that occur on-site at steelmaking facilities. This analysis focuses on fugitive emissions associated with the coal and natural gas before it is sent to steel and aluminum producers.

The Intergovernmental Panel on Climate Change (IPCC) defines fugitive emissions as an intentional or unintentional release of gases from anthropogenic sources, excluding fuel combustion.[656] These emissions are mostly methane, and in fossil fuel production they are often released from pipeline leaks, venting and flaring in mining and drilling activities, and storage.[657] The EPA estimates that in 2022 fugitive methane emissions from U.S. natural gas production and processing were 104.1 million metric tons of $CO_2e$, while fugitive methane emissions from coal mining were 43.6 million metric tons of $CO_2e$.[658]

Fugitive emissions, often disperse or resulting from accidental leaks, are inherently difficult to measure, leading to higher degrees of uncertainty in emissions reporting.[659] Research has shown that national emissions inventories likely vastly undercount fugitive methane emissions associated with fossil fuel production, particularly oil and gas systems.[660] Advancements in emissions measurement—such as methane detection technologies using satellites, airplanes, and vehicles—have led to estimates of fugitive methane emissions from natural gas production and processing that are up to eight times higher than the amount reported in the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks (GHGI).[661] Increased ability to measure these data has encouraged federal government efforts toward updating methane emissions monitoring and reporting.[662]

---

[656] The Commission has adopted the IPCC definition, which the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks (GHGI) also uses, for the purpose of this analysis. Characterization of fugitive emissions by government agencies and research institutions have not fully converged and remain a topic of discussion in standard-setting. Often, emissions from flaring and venting are inconsistently reported as both encompassed by fugitive emissions and separate from fugitive emissions (largely because of intentionality). IPCC, “Glossary,” June 19, 2019, G.8; Laconde, *Fugitive Emissions: A Blind Spot in the Fight Against Climate Change*, 2018.

[657] Laconde, *Fugitive Emissions: A Blind Spot in the Fight Against Climate Change*, 2018, 107–8.

[658] The value for natural gas is a sum of methane emissions from several production segments: onshore production, gathering and boosting, and processing in table 3-73 of the EPA GHG inventory. The value for coal is the sum of methane emissions from underground and surface mining and post-mining activities in table 3-34. Post-mining activities include processing, transport, and storage, but those activities are not itemized. While emissions from transportation are generally not included in the Commission’s system boundary, research suggests coal storage is a significant source of fugitive emissions and as such, fugitive emissions from post-mining activities are included in this analysis. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2022*, 2024, 3-63, 3-97.

[659] Bussewitz, “Difficulty Measuring Methane Slows Plan to Slash Emissions,” January 31, 2023; Myers, “Methane Emissions from Major U.S. Oil and Gas Operations,” March 13, 2024.

[660] For example, analysis of methane emissions in the U.S. oil and gas supply chain found that EPA GHGI estimates are likely undercounting methane emissions in the natural gas production segment by 60 to 100 percent, largely because of unintentional emissions from storage tanks, equipment leaks, and other abnormal emission events from large emitters, sometimes known as “super-emitters”. Alvarez et al., “Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain,” July 13, 2018; Rutherford et al., “Closing the Methane Gap in US Oil and Natural Gas Production Emissions Inventories,” August 5, 2021; Denis-Ryan, *Gross Under-Reporting of Fugitive Methane Emissions Has Big Implications for Industry*, July 2023; Riddick and Mauzerall, “Likely Substantial Underestimation of Reported Methane Emission,” 2023; Myers, “Methane Emissions from Major U.S. Oil and Gas Operations,” March 13, 2024.

[661] McVay, *Methane Emissions from U.S. Gas Pipeline Leaks*, August 2023, 6.

[662] In one example of these efforts, the EPA released a final rule in May 2024 that updates and expands methane emissions subpart W reporting requirements in the GHGRP for oil and gas producers. EPA, “Methane Emissions Reduction Program,” accessed October 21, 2024.

The Commission conducted desk research and interviews with subject matter experts to inform its development of U.S.-specific fugitive emissions factors for coal and natural gas.[663] The Commission applied four sets of natural gas and coal emissions factors to capture uncertainty in fugitive methane emissions accounting, using factors with both a 20-year and 100-year global warming potential (GWP).[664] The factors use natural gas and coal production data from U.S. Department of Energy (USDOE) and EPA, respectively.[665] The main sets of factors use EPA GHGI data on methane emissions for coal and natural gas, while the upper-bound sets incorporate the USDOE Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) model's estimates of fugitive emissions in natural gas production and processing along with the EPA's high estimate for fugitive emissions from coal mining. The GREET model estimates fugitive methane emissions from natural gas production and natural gas processing to be 44–47 percent and 60 percent higher than what EPA reports, respectively.[666] Fugitive emissions factors used in the analysis presented below are reported in table G.21 of appendix G.

The calculations that incorporate fugitive emissions in the average product-level emissions intensity estimates largely follow the same allocation steps as scope 1 and scope 2 emissions associated with coal and natural gas combustion presented in appendix E. In this analysis, a separate subprocess-specific total of scope 3 fugitive emissions approximated from activity data on scope 1 and scope 2 coal and natural gas use ($S3FGHG_{subproc}$) is added to the unit process emissions totals calculated in the main approach (equations F.14 and F.15).

$$S3FUGHG_{product} = S3FGHG_{subproc} * \frac{Output_{product}}{Output_{subproc}} \qquad (F.14)$$

$$\begin{aligned} UGHG_{product} = {} & S1P\ UGHG_{product} + S1FC\ UGHG_{product} + S2\ UGHG_{product} + S3\ UGHG_{product} \\ & + S3FUGHG_{product} \qquad (F.15) \end{aligned}$$

---

[663] Consistent with the Commission's system boundary, this analysis excluded fugitive methane emissions associated with the transportation of natural gas (transmission and distribution losses). U.S. government officials, interview by USITC staff, November 16, 2023; U.S. government official, interview by USITC staff, February 21, 2023; U.S. industry representative, interview by USITC staff, December 21, 2023; Subject matter expert, interview by USITC staff, March 18, 2024.

[664] The Commission applied a 20-year GWP of 87 for methane, the high-end of the IPCC's indicated GWP range of 84–87. IEA, "Methane and Climate Change," 2021.

[665] The natural gas fugitive emissions factors use the dry natural gas production volume (33.9 billion MMBtu) reported in the GREET 2023 model. Burnham, "Updated Natural Gas Pathways in GREET 2023," October 1, 2023, 5. In 2022, reported U.S. coal production was 538,515 kilotons. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2022*, 2024, 3-62,3-66.

[666] Burnham, "Updated Natural Gas Pathways in GREET 2023," October 1, 2023, 6.

For fugitive emissions associated with scope 1 coal and natural gas use, the approach applies a fugitive emissions factor to quantities of natural gas and bituminous coal reported in section 3 and section 5 of the Commission questionnaire.[667]

Estimation of the coal and natural gas use embedded in a facility's purchases required several additional calculation steps to the scope 2 emissions calculations presented in appendix E.[668] Natural gas and coal use associated with a facility's plant-specific electricity purchase are calculated using plant-specific data on total plant generation and fuel mix from EPA's eGRID.[669] The Commission used a similar approach to obtain the coal and natural gas use associated with plant-specific purchases of useful thermal output (UTO). The main calculation approach yielded total annual heat input from combustion and associated emissions from UTO purchases, which are further split in this analysis according to the coal and natural gas generation mix at the cogeneration plant.

The approach uses plant-level and subregional data in the eGRID database to assign coal and natural gas use to a respondent's facility-level electricity purchases from the grid.[670] The sum of fuel-specific purchases from the grid and via direct-line connection yield total coal and natural gas quantity activity data. The Commission then multiplied these fuel quantities by their respective fugitive emissions factors to generate facility-level estimates of scope 3 coal and natural gas fugitive emissions from scope 2 purchases.

## Marginal Aluminum and Steel Emissions Intensities from Fugitive Methane Emissions Associated with Coal and Natural Gas Use

Table F.6 presents the additional marginal emissions intensities from fugitive methane associated with coal and natural gas use for steel and aluminum aggregate product categories. The Commission calculated additional emissions intensity estimates from fugitive methane using a base and high-end

---

[667] A single fuel-specific emissions factor was applied to the quantity of fuel used in both direct fuel combustion (section 3 of the questionnaire) and feedstock material (section 5 of the questionnaire). For example, an EAF facility using natural gas for both facility heating and feedstock in steelmaking has the same scope 3 fugitive emissions factor applied per MMBtu.

[668] These calculation steps use the location-based method to estimate fugitive emissions from coal and natural gas purchases. As such, all natural gas and coal use associated with a facility's energy purchases through a direct-line connection or the regional grid are assigned fugitive emissions.

[669] The calculations use several columns of data from the PLNT22 tab in eGRID and primary data from question 4.5 of the questionnaire to yield gas and coal-specific quantities from plant-specific purchases. The share of the plant's electricity purchased by the reporting facility is calculated using PLNGENAN. This share is multiplied by the quantity of natural gas and coal (in MMBtu) used in each plant's electricity generation, calculated as (PLCLPR/PLCYPR)*ELCALLOC*UNHTI and (PLGSPR/PLCYPR)*ELCALLOC*UNHTI, respectively.

[670] In the SRL22 tab in eGRID, SRNGENAN is used to calculate the share of the subregion's net electricity generation that the facility purchases. Then, the SUBRGN column in the PLNT22 tab is used to sum the plant-level data calculated in the last footnote for all plants in each subregion, yielding total natural gas and coal use behind electricity generation in each subregion. Those totals are multiplied by the share of total subregional electricity generation that a facility purchases.

estimate of total fugitive methane emissions associated with coal and natural gas production in the United States in 2022, applying both a 100-year GWP and 20-year GWP to methane.[671]

Higher relative coal use for certain product categories, an increased share of emissions intensity attributed to on-site fuel combustion and process emissions, and a lower baseline emissions intensity all contribute to a higher relative impact of fugitive methane emissions on the total emissions intensity.[672] Inclusion of Commission estimates of fugitive methane emissions associated with coal and natural gas use have the largest relative impact on the average emissions intensity of carbon semifinished steel among all product categories (increasing average emissions intensity by 6.1–23.9 percent). Primary unwrought aluminum has the highest absolute increase in its average emissions intensity when accounting for fugitive methane. A higher share of product-level emissions intensity attributed to use of coal and natural gas (through on-site activities and purchased energy) increases the marginal emissions intensities contribution of fugitive methane. On-site coal use was most prevalent in primary unwrought aluminum production and stainless steel and carbon semifinished production.

**Table F.6** Steel and aluminum production: marginal product-level emissions intensities due to fugitive emissions from scope 1 and scope 2 coal and natural gas use

In metric tons of $CO_2$ equivalent per metric ton (mt $CO_2e$/mt) of steel. GWP = Global warming potential.

| Product category | Average emissions intensity, main method | Marginal emissions intensities, fugitive 100-year GWP | Marginal emissions intensities, fugitive 20-year GWP | Percent increase to the average emissions intensity due to inclusion of fugitive emissions, 100-year GWP to high-end 20-year GWP |
|---|---:|---:|---:|---:|
| Primary unwrought aluminum | 14.52 | 0.23 | 0.87 | 1.6–6.0 |
| Secondary unwrought aluminum | 2.46 | 0.02 | 0.09 | 0.7–3.5 |
| Wrought aluminum | 6.23 | 0.04 | 0.16 | 0.6–2.6 |
| Carbon and alloy semifinished steel | 1.02 | 0.06 | 0.24 | 6.1–23.9 |
| Carbon and alloy flat steel | 1.83 | 0.06 | 0.25 | 3.4–13.5 |
| Carbon and alloy long steel | 0.75 | 0.04 | 0.14 | 4.8–19.1 |
| Carbon and alloy tube | 1.50 | 0.01 | 0.04 | 0.6–2.8 |
| Stainless steel | 2.78 | 0.01 | 0.06 | 0.5–2.0 |

Source: USITC estimates based on its calculation methodology, see appendix E.

Note: The rightmost column provides the range in percent increase of product categories' average emissions intensities when including marginal fugitive emissions from scope 1 and 2 natural gas and coal use. For example, the addition of marginal fugitive emissions from coal and natural gas increases the U.S. primary unwrought aluminum average emissions intensity of 14.52 mt $CO_2e$/mt by 1.6 to 6.0 percent, depending on the GWP and source estimates for total fugitive emissions from coal and natural gas production in the U.S. in 2022.

---

[671] Results in table F.19 reflect base GHGI fugitive emissions estimates using the 100-year GWP and the high GREET and GHGI fugitive emissions estimates using the 20-year GWP. The Commission calculated marginal emissions intensities from the high GREET and GHGI fugitive emissions estimates using the 100-year GWP and the base GHGI fugitive emissions estimates using the 20-year GWP, which fell between the two sets of emissions intensities presented, respectively.

[672] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 3.6, 3.7, 3.8, 5.1.4b, and 5.1.5b.

# Greenhouse Gas Reporting Program Reporters Only

During the development of the data collection and analysis plan for this investigation, several industry stakeholders echoed the Trade Representative's request for the Commission to avail themselves of public emissions data sources. Some stakeholders even urged the Commission to limit its analysis to only established, publicly available data, with the idea that these data would be more reliable and lead to the production of a more replicable and transparent methodology.[673]

Using this perspective, this sensitivity analysis compares production totals and average emissions intensities of covered products made by a well-identified group of facilities—those reporting to the EPA's Greenhouse Gas Reporting Program (GHGRP)—to production totals and emissions intensities of covered products made by all facilities in the Commission's survey population.[674] Both sets of emissions intensities were calculated using the same methods described throughout this report, including a combination of data from the GHGRP, the Commission's questionnaire responses, and other data sources to cover direct and indirect emissions.[675] The only difference between the approaches is the population of facilities in each set. The results of this analysis show the impact on average emissions intensity of restricting the sample of facilities to only those reporting to the GHGRP. The results also provide a sense of how much production in a given product category is produced by GHGRP reporters, and where additional responses from the Commission's survey population frame (that were incorporated as a result of the Commission's additional research to develop a population list) contributed most to filling out the population coverage. There are no restrictions on what products may be produced by GHGRP reporters, however, the program's annual reporting requirement thresholds means that GHGRP reporters are well-represented among the surveyed facilities that produce of emission-intensive intermediate products (i.e., those from steel mills and aluminum smelters) as shown in table F.7 and F.8.

## Steel

The average emissions intensities of GHGRP reporters only were not significantly different than those from all facilities for any product category shown in table F.7.[676] As described in chapter 2, steelmaking and upstream on-site production processes are significant sources of direct emissions; as a result, most facilities with EAFs and all facilities with BF-BOFs are GHGRP reporters. Table F.7 shows that most production of semifinished and flat steel categories, as well as carbon and alloy hot-worked long steel products and carbon and alloy seamless tubular products, occurred at facilities that were GHGRP reporters. Most production of further downstream product categories was performed by non-GHGRP reporters.

---

[673] Silverado Policy Accelerator, written submission to the USITC, November 17, 2023, 3–5.

[674] See chapter 1 of this report for an overview of the GHGRP and chapter 3 for details on how and what emissions are reported to EPA under the program.

[675] The Commission is not presenting analysis of the differences in emissions intensities for GHGRP reporting facilities calculated using only GHGRP reported emission vs. using the Commission's direct and indirect emissions data, as that information in combination—especially when presented at the facility-level— could pose confidentiality concerns.

[676] Among GHGRP reporters producing covered steel products in the survey population, the facility-level questionnaire response rate was over 95 percent.

**Table F.7** Number and share of surveyed facilities reporting to the GHGRP that produced covered steel products and their share of overall production, by product category

In number and percentages (%).

| Product category | Surveyed facilities reporting to the GHGRP (number) | Share of surveyed facilities reporting to the GHGRP (%) | Share of total production of surveyed facilities comprised by facilities reporting to the GHGRP (%) |
|---|---|---|---|
| Carbon and alloy semifinished | 84 | 96.6 | 100.0 |
| Carbon and alloy hot-rolled flat | 41 | 87.2 | 99.4 |
| Carbon and alloy cold-rolled flat | 29 | 70.7 | 97.9 |
| Carbon and alloy coated flat | 33 | 73.3 | 86.5 |
| Carbon and alloy hot-worked long | 50 | 71.4 | 97.0 |
| Carbon and alloy cold-formed long | 8 | 8.1 | 30.6 |
| Carbon and alloy seamless tubular | 10 | 47.6 | 85.4 |
| Carbon and alloy non-seamless tubular | 3 | 3.1 | 5.8 |
| Stainless semifinished | 10 | 58.8 | 96.4 |
| Stainless hot-rolled flat | 10 | 71.4 | 98.9 |
| Stainless cold-rolled flat | 8 | 53.3 | 98.2 |

Sources: EPA, OAP, "FLIGHT Database, 2022 Greenhouse Gas Emissions from Large Facilities," accessed various dates. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 2.1.1.

Note: The number of GHGRP reporters in the stainless hot-worked long, cold-formed long, seamless tubular, and non-seamless tubular product categories was small enough to require data suppression, so these rows are not included above.

## Aluminum

The average emissions intensities of only GHGRP reporters producing covered aluminum products were not significantly different than the averages from all facilities for any product category shown in table 5.8. Only 56 facilities producing covered aluminum products reported to the GHGRP, and some of the GHGRP reporters made both secondary and wrought products so they are included in both totals in table F.8. [677] All (100 percent) facilities producing primary unwrought aluminum reported to GHGRP, while only a third of facilities producing secondary unwrought aluminum, and less than 10 percent of wrought aluminum-producing facilities were GHGRP reporters.[678] Although few facilities producing secondary unwrought and wrought aluminum reported to GHGRP, these reporters' production accounted for a large share of total domestic aluminum production for each of these product categories (table F.8).

---

[677] Among GHGRP reporters producing covered aluminum products in the survey population, the facility-level questionnaire response rate was 100 percent.

[678] Primary unwrought aluminum producers are required to report process emissions associated with aluminum production as described in Subpart F of the GHGRP regulation. Other types of aluminum producers typically only report to GHGRP under subpart C, which requires facilities to report their fuel combustion emissions if they exceed 25,000 mt of $CO_2e$ emissions annually. 40 C.F.R. § 98.30–38 and 98.60–68 (Subparts C and F).

**Table F.8** Number and share of surveyed facilities reporting to the GHGRP that produced covered aluminum products and their share of overall production, by product category
In number and percentages (%).

| Product category | Surveyed facilities reporting to the GHGRP (number) | Share of surveyed facilities reporting to the GHGRP (%) | Share of total production of surveyed facilities comprised by facilities reporting to the GHGRP (%) |
|---|---|---|---|
| Unwrought | 41 | 37.3 | 72.1 |
| Primary unwrought | 6 | 100.0 | 100.0 |
| Secondary unwrought | 35 | 33.7 | 69.5 |
| Wrought | 39 | 9.4 | 64.1 |

Sources: EPA, OAP, “FLIGHT Database, 2022 Greenhouse Gas Emissions from Large Facilities,” accessed various dates. USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.2.1, 2.2.2, and 2.2.3.
Note: Facility counts may not sum to total because facilities may produce more than one product category.

# Default Emissions Factors Only

Default emissions factors used in scope 3 analysis are inherently subject to uncertainty. For example, as described in this report, U.S. facilities producing covered steel and aluminum products operate under a wide range of energy efficiencies, purchase electricity from providers with different emissions profiles, have multiple production pathways, and use varying quantities of material inputs from a variety of sources. As a result, the emissions intensity of each U.S. supplier facility’s production of a given material can differ significantly from U.S.-specific or global default emissions factors for that material.

As described in chapter 3 and appendix E, the Commission calculated scope 3 emissions estimates using U.S. supplier-specific activity data (external receipts) and emissions factors for consuming facilities’ receipts of pig iron, steel products, and primary unwrought aluminum. For consuming facilities’ other receipts of these materials, the Commission used default emissions factors that were country specific or in some cases (for steel materials) product pathway specific. The Commission also used a country-specific emissions factor for alumina sourced from the United States. For all other materials in the system boundaries of this investigation, the Commission used global emissions factors. This approach is referred to here as the “main method” for calculating scope 3 emissions. In this section, a sensitivity analysis is conducted to examine the effects of data specificity and the choice of default emissions factors in calculating industry-wide emissions intensity estimates.

Under this analysis, referred to as the “default factors only method,” the Commission used country-specific and global default emissions factors in lieu of supplier-specific emissions factors to calculate scope 3 emissions for receipts from specific suppliers.[679] Specifically, equations E.45 (for pig iron), E.48

---

[679] In its research on potential emissions factors, the Commission evaluated other sources of country-specific, region-specific, and global emissions factor data. One source frequently cited by industry were the factors provided under Sphera Solutions’ proprietary Managed LCA Content (Sphera MLC) database. The Commission found that concordance between the Sphera MLC database product categories and the Commission’s product categories was possible using extrapolation techniques based on emissions factors for other steel product categories. With regard to transparency considerations however, the Commission elected to use only publicly available emissions factors in its main method and sensitivity analyses. Sphera Solutions, “LCA Database,” 2024.

(for steel products), and E.53 (for primary unwrought aluminum) are replaced with equation F.15 below for each material ($material$) received from a specific U.S. supplier facility ($supplier$).[680]

$$S3_{material,supplier} = Receipts_{material,supplier} * DefaultEF_{material,us} \qquad (F.15)$$

## Steel

Except for a few product categories, emissions intensity estimates of steel product categories are largely unaffected by the approach used to calculate scope 3 emissions when comparing the results of the main method to the default factors method (see tables F.9 and F.10). Under the main method, the total scope 3 emissions associated with receipts from specific U.S. suppliers accounts for over half of all facility-level scope 3 emissions for the steel sector.[681] Because most scope 3 emissions were calculated using supplier-specific emissions factors under the main method, use of a default factors-only method (i.e., not using supplier-specific emissions factors) will increase or decrease the emissions intensities of products depending on whether suppliers are more or less emissions intensive than default emissions factors. The use of these default emissions factors did not have a significant impact on the resulting emissions intensity estimates for carbon and alloy semifinished, flat, or long product categories (table F.9), or for 6 out of the 7 stainless steel product subcategories (table F.10). By contrast, the average emissions intensity estimates of carbon and alloy non-seamless steel tubular products and stainless hot-rolled steel products are significantly less using the main method than using the default factors only method. This means that facilities making non-seamless steel tubular products receive flat steel products from U.S. suppliers that are less emissions intensive than default emissions factors for those substrate products.

---

[680] As described in appendix E ("II.D.1.a(4) Scope 3 Emissions for Steel Materials Group 4: Steel Products"), consuming facilities reported estimates of the shares of steel from each import source country based on whether the steel was melted and poured in an EAF facility or a BF-BOF facility. Because consuming facilities listed individual U.S. suppliers, they did not provide similar estimates of whether their steel receipts from U.S. sources were produced in EAF or BF-BOF facilities. Under the default-factors-only-method, the Commission used information from third-party databases (including the GHGRP database and AIST) to estimate whether steel sourced from identified U.S. suppliers was originally produced in a semifinished form using an EAF or BOF. Based on this information, a pathway-specific U.S. emissions factor was used for the consuming facility's receipts from each supplier. AIST, *2022 Directory of Iron and Steel Plants*, 2022; EPA, "GHGRP, Envirofacts GHG Query Builder," accessed September 18, 2024.

[681] USITC estimates based on its calculation methodology.

**Table F.9** Carbon and alloy: average product-level emissions intensity under the main method and the default-factors-only-method

In metric tons of carbon dioxide-equivalent per metric ton (mt $CO_2e$/mt) of steel. ** = rounds to zero (less than 0.005); * indicates the averages for each method are statistically significantly different at the 0.05 significance level.

| Product category | Average emissions intensity, main method | Average emissions intensity, default factors only | Difference, main-default |
|---|---:|---:|---:|
| Semifinished | 1.02 | 1.03 | ** |
| Flat | 1.83 | 1.75 | 0.08 |
| Hot-rolled flat | 1.59 | 1.54 | 0.05 |
| Cold-rolled flat | 1.91 | 1.79 | 0.12 |
| Coated flat | 2.17 | 2.00 | 0.18 |
| Long | 0.75 | 0.76 | ** |
| Hot-worked long | 0.67 | 0.70 | −0.02 |
| Cold-formed long | 1.25 | 1.16 | 0.09 |
| Tubular | 1.50 | 1.67 | −0.17* |
| Seamless tubular | 1.09 | 1.12 | −0.03 |
| Non-seamless tubular | 1.71 | 1.96 | −0.24* |
| Non-seamless OCTG | 1.52 | 2.01 | −0.49* |
| All other non-seamless | 1.74 | 1.96 | −0.21* |

Source: USITC estimates based on its calculation methodology, see appendix E.

**Table F.10** Stainless steel: average product-level emissions intensity under the main method and the default-factors-only-method

In metric tons of carbon dioxide equivalent per metric ton (mt $CO_2e$/mt) of steel. * indicates the averages for each method are statistically significantly different at the 0.05 significance level.

| Product category | Average emissions intensity, main method | Average emissions intensity, default factors only | Difference, main-default |
|---|---:|---:|---:|
| Stainless steel | 2.78 | 3.02 | −0.24* |
| Semifinished | 2.23 | 2.22 | 0.01 |
| Hot-rolled flat | 2.31 | 2.75 | −0.44* |
| Cold-rolled flat | 3.08 | 3.26 | −0.18 |
| Hot-worked long | 2.93 | 2.77 | 0.16 |
| Cold-formed long | 3.55 | 3.61 | −0.06 |
| Seamless tubular | 4.07 | 4.04 | 0.04 |
| Non-seamless tubular | 3.16 | 3.42 | −0.26 |

Source: USITC estimates based on its calculation methodology, see appendix E.

## Aluminum

The emissions intensity for secondary unwrought and wrought aluminum product categories calculated using a global default primary aluminum factor were not found to be significantly different from those calculated using the U.S. supplying-smelter-specific emissions factors under the main method. This similarity of estimates under either method is in part explained by the input sourcing of surveyed facilities. Only about a quarter of input primary aluminum was reported as being sourced domestically by these facilities, and less than that was identified as being produced at a specific U.S. smelter.[682] Given the high share of non-U.S. primary aluminum as inputs into covered secondary unwrought and wrought aluminum production, the additional data granularity of U.S. smelter-specific emissions factors had a relatively small impact on the final emissions intensity.

---

[682] USITC, *Greenhouse Gas (GHG) Emissions Questionnaire: Facility-Level*, 2024, responses to questions 5.2.5b, c.

# Bibliography

Air Products. "Hydrogen Weight and Volume Equivalents." Accessed November 12, 2024. https://microsites.airproducts.com/gasfacts/hydrogen.html?_ga=2.155415035.177972454.1662132901-582580380.1649040173.

Alvarez, Ramón A., Daniel Zavala-Araiza, David R. Lyon, David T. Allen, Zachary R. Barkley, Adam R. Brandt, Kenneth J. Davis, et al. "Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain." *Science* 361, no. 6398 (July 13, 2018): 186–88. https://doi.org/10.1126/science.aar7204.

American Iron and Steel Institute (AISI). "AIS-10 Net Shipments of Steel Mill Products, All Grades Including Carbon, Alloy, and Stainless, December 2022." January 31, 2023. https://www.steel.org/.

Arguillarena, Andrea, María Margallo, Ane Urtiaga, and Angel Irabien. "Life-Cycle Assessment as a Tool to Evaluate the Environmental Impact of Hot-Dip Galvanisation." *Journal of Cleaner Production* 290 (March 25, 2021): 125676. https://doi.org/10.1016/j.jclepro.2020.125676.

Association of Iron & Steel Technology (AIST). *2022 Directory of Iron and Steel Plants*. Warrendale, PA, 2022. https://www.aist.org/publications-advertising/directory%E2%80%94iron-and-steel-plants.

Burnham, Andrew. "Updated Natural Gas Pathways in GREET 2023." Argonne National Laboratory (ANL), October 1, 2023. https://greet.anl.gov/publication-update_ng_2023.

Bussewitz, Cathy. "Difficulty Measuring Methane Slows Plan to Slash Emissions." AP News, January 31, 2023. https://apnews.com/article/drones-business-climate-and-environment-0a1ab9be3427818cfe5f33521b9b05c2.

Denis-Ryan, Amandine. *Gross Under-Reporting of Fugitive Methane Emissions Has Big Implications for Industry*. Institute for Energy Economics and Financial Analysis, July 2023. https://ieefa.org/sites/default/files/2023-07/Gross%20under-reporting%20of%20fugitive%20methane%20emissions%20has%20big%20implications%20for%20industry_2.pdf.

Drnevich, R. F., C. J. Messina, and R. J. Selines. "Production and Use of Industrial Gases for Iron and Steelmaking." In *The Making, Shaping and Treating of Steel, 11th Edition: Steelmaking and Refining Volume*. The AISE Steel Foundation, 1998. https://www.academia.edu/37434608/Steelmaking_and_Refining_Volume_AISE_1998.

EUROFORGE. *International Statistics 2022*. Accessed April 18, 2024. https://www.euroforge.org/wp-content/uploads/2022/11/International-Statistics-2022.pdf.

European Commission (EC). Directorate-General Taxation and Customs Union (DG-TAXUD). "Default Values for the Transitional Period of the CBAM Between 1 October 2023 and 31 December 2025." December 22, 2023. https://taxation-customs.ec.europa.eu/system/files/2023-12/Default%20values%20transitional%20period.pdf.

European Foundry Association (CAEF). “The European Foundry Industry 2022.” November 2023. https://www.caef.eu/downloads-links/.

Green-e. “2023 Residual Mix Emissions Rates (2021 Data).” December 12, 2023. https://www.green-e.org/2023-residual-mix.

Gyllenram, Rutger, and Wenjing Wei. *304 Stainless Steel Carbon Footprint Comparison: EU, Indonesia and China*. October 2022. https://www.researchgate.net/publication/370214813_304_Stainless_steel_Carbon_Footprint_Comparision-EU_Indonesia_and_China?enrichId=rgreq-4eff9998d6374d7572d847c96ac31524-XXX&enrichSource=Y292ZXJQYWdlOzM3MDIxNDgxMztBUzoxMTQzMTI4MTE1MzA4NTk0NEAxNjgyMzI3MDY2NjEz&el=1_x_2&_esc=publicationCoverPdf.

Intergovernmental Panel on Climate Change (IPCC). *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2*. 2006. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html.

Intergovernmental Panel on Climate Change (IPCC). “Glossary- 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.” June 19, 2019. https://www.ipcc.ch/site/assets/uploads/2019/06/19R_V0_02_Glossary_advance.pdf.

International Chromium Development Association (ICDA). *Quantifying the Improvement in the Environmental Impact of the Production of High Carbon Ferrochromium (HC FeCr)*. April 2022. https://www.icdacr.com/wp-content/uploads/2022/10/ICDA-HC-FeCr-LCA-summary-2022.pdf.

International Energy Agency (IEA). “Methane and Climate Change.” Methane Tracker, 2021. https://www.iea.org/reports/methane-tracker-2021/methane-and-climate-change.

International Energy Agency (IEA). *Emission Factors 2023: Database Documentation*. September 2023. https://iea.blob.core.windows.net/assets/bf862218-7fd8-4637-aca6-5a347b6ca4f1/IEA_Methodology_Emission_Factors_2023.pdf.

International Energy Agency (IEA). “Emissions Factors 2023.” September 2023. https://www.iea.org/data-and-statistics/data-product/emissions-factors-2023.

International Energy Agency (IEA). “World Energy Balances.” July 2024. https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

International Energy Agency (IEA). *World Energy Balances, 2024 Edition: Database Documentation*. July 2024. https://iea.blob.core.windows.net/assets/feea6879-1796-41c1-b8a1-2da8c181cba0/WORLDBAL_Documentation.pdf.

Janjua, Rizwan, and Felipe Maciel. *$CO_2$ Data Collection User Guide, Version 11*. World Steel Association, May 30, 2024. https://worldsteel.org/wp-content/uploads/CO2_User_Guide_V11.pdf.

Koolen, Derck, and Danko Vidovic. *Greenhouse Gas Intensities of the EU Steel Industry and Its Trading Partners*. June 22, 2022. https://doi.org/10.2760/170198.

Laconde, Thibault. *Fugitive Emissions: A Blind Spot in the Fight Against Climate Change*. Global Observatory on Non-State Climate Action, 2018. https://www.climate-chance.org/wp-content/uploads/2019/03/new-fugitive-emissions-a-blind-spot-in-the-fight-against-climate-change.pdf.

McVay, Renee. *Methane Emissions from U.S. Gas Pipeline Leaks*. Environmental Defense Fund, August 2023. https://www.edf.org/sites/default/files/documents/Pipeline%20Methane%20Leaks%20Report.pdf.

Myers, Andrew. "Methane Emissions from Major U.S. Oil and Gas Operations Higher than Government Predictions." Stanford Report, March 13, 2024. https://news.stanford.edu/stories/2024/03/methane-emissions-major-u-s-oil-gas-operations-higher-government-predictions.

Nduagu, Experience I., Deepak Yadav, Nishant Bhardwaj, Sabarish Elango, Tirtha Biswas, Rangan Banerjee, and Srinivasan Rajagopalan. "Comparative Life Cycle Assessment of Natural Gas and Coal-Based Directly Reduced Iron (DRI) Production: A Case Study for India." *Journal of Cleaner Production* 347 (May 1, 2022): 131196. https://doi.org/10.1016/j.jclepro.2022.131196.

Nickel Institute. *Life Cycle Data: Executive Summary*. January 2023. https://nickelinstitute.org/media/fbmdel4y/lifecycledata-summary-updatejan2023.pdf.

Norgate, T. E., S. Jahanshahi, and W. J. Rankin. "Alternative Routes to Stainless Steel - A Life Cycle Approach." *Tenth International Ferroalloys Congress* 7, no. 3 (January 2004): R126. https://www.researchgate.net/publication/242689888_Alternative_routes_to_stainless_steel-a_life_cycle_approach.

Outokumpu Stainless USA, LLC. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. December 21, 2023. https://edis.usitc.gov/external/search/document/810868.

Remus, Rainer, Miguel A. Aguado-Monsonet, Serge Roudier, and Luis Delgado Sancho. *Best Available Techniques (BAT) Reference Document for Iron and Steel Production*. January 24, 2013. https://doi.org/10.2791/98516.

ResponsibleSteel. *ResponsibleSteel International Production Standard: Version 2.1*. May 21, 2024. https://www.responsiblesteel.org/standards.

Riddick, Stuart, and Denise Mauzerall. "Likely Substantial Underestimation of Reported Methane Emissions from United Kingdom Upstream Oil and Gas Activities." *Energy & Environmental Science* 16, no. 1 (2023): 295–304. https://doi.org/10.1039/D2EE03072A.

Rutherford, Jeffrey S., Evan D. Sherwin, Arvind P. Ravikumar, Garvin A. Heath, Jacob Englander, Daniel Cooley, David Lyon, Mark Omara, Quinn Langfitt, and Adam R. Brandt. "Closing the Methane Gap in US Oil and Natural Gas Production Emissions Inventories." *Nature Communications* 12, no. 1 (August 5, 2021): 4715. https://doi.org/10.1038/s41467-021-25017-4.

Silverado Policy Accelerator. Written submission to the U.S. International Trade Commission in connection with Inv. No. 332-598, *Greenhouse Gas Emissions Intensities of the U.S. Steel and Aluminum Industries at the Product Level*. November 17, 2023. https://edis.usitc.gov/external/search/document/808917.

Sphera Solutions, Inc. "LCA Database." Life Cycle Assessment Datasets, 2024. https://lcadatabase.sphera.com/.

Steel Manufacturers Association (SMA). *Steelmaking Emissions Report 2022*. June 14, 2022. https://steelnet.org/steelmaking-emissions-report-2022/.

Total Materia. "Production of Stainless Steel: Part Two." March 2008. https://www.totalmateria.com/page.aspx?ID=CheckArticle&site=kts&NM=220.

United Nations, ed. *International Standard Industrial Classification of All Economic Activities (ISIC), Rev. 4*. Statistical papers. Series M. New York: United Nations, 2008. https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf.

Universal Industrial Gases, LLC (UIG). "Oxygen Quantity Conversions Calculator." Universal Industrial Gases. Accessed November 12, 2024. https://www.uigi.com/calculators/oxygen-quantity-conversions-calculator/.

U.S. Environmental Protection Agency (EPA). *Greenhouse Gas Inventory Guidance: Indirect Emissions from Purchased Electricity*. December 2023. https://www.epa.gov/sites/default/files/2020-12/documents/electricityemissions.pdf.

U.S. Environmental Protection Agency (EPA). *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2022*. EPA 430-R-24-004. 2024. https://www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-main-text_04-18-2024.pdf.

U.S. Environmental Protection Agency (EPA). "Greenhouse Gas Reporting Program (GHGRP). Envirofacts GHG Query Builder." Accessed September 18, 2024. https://enviro.epa.gov/query-builder/ghg.

U.S. Environmental Protection Agency (EPA). "Methane Emissions Reduction Program and GHGRP Subpart W (Petroleum and Natural Gas Systems)." Accessed October 21, 2024. https://www.epa.gov/inflation-reduction-act/methane-emissions-reduction-program-and-ghgrp-subpart-w-petroleum-and.

U.S. Environmental Protection Agency (EPA). Office of Atmospheric Protection (OAP). "Greenhouse Gas Reporting Program (GHGRP). Facility-Level Information on Greenhouse Gases Tool (FLIGHT) Database." Accessed various dates. https://ghgdata.epa.gov/ghgp/main.do?site_preference=normal.

U.S. International Trade Commission (USITC). *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_facility-level_questionnaire_aluminum_and_steel_combined.pdf.

Vidovic, Danko, Alain Marmier, Lovro Zore, and Jose A. Moya. *Greenhouse Gas Emission Intensities of the Steel, Fertilisers, Aluminium and Cement Industries in the EU and Its Main Trading Partners*. European Commission. Joint Research Centre (JRC), 2023. https://data.europa.eu/doi/10.2760/359533.

World Resources Institute (WRI). *GHG Protocol Scope 2 Guidance*. 2015. https://ghgprotocol.org/sites/default/files/2023-03/Scope%202%20Guidance.pdf.

World Steel Association (worldsteel). *Life Cycle Inventory (LCI) Study: 2020 Data Release*. May 2021. https://worldsteel.org/wp-content/uploads/Life-cycle-inventory-LCI-study-2020-data-release.pdf.

World Steel Association (worldsteel). *Steel Statistical Yearbook 2023*. Accessed September 21, 2024. https://worldsteel.org/publications/bookshop/ssy_subscription-2023/.

worldstainless. “Stainless Steel in Figures 2020.” (2020). https://www.worldstainless.org/Files/issf/non-image-files/PDF/ISSF_Stainless_Steel_in_Figures_2020_English_public_version.pdf.

worldstainless. *Global Life Cycle of Stainless Steel*. June 26, 2023. https://www.worldstainless.org/news/global-life-cycle-of-stainless-steel/.

worldstainless. “Stainless Steel $CO_2$ Emissions Report.” (August 2023). https://www.worldstainless.org/files/issf/non-image-files/PDF/worldstainless_CO2_Emissions_Report.pdf.

# Appendix G

# Emissions Factors Used in the Commission’s Calculations

This appendix contains the emissions factors that the Commission used in its emissions calculations. These factors are primarily used as default emissions factors in the calculation of scope 3 emissions. However, some emissions factors are direct emissions factors used to calculate direct emissions associated with a specific fuel or input (like those in table G.1) or used as an intermediate step in estimating the default factors for these calculations under the Commission’s partial life cycle inventory approach (see appendix F for an explanation).

**Table G.1** Default fuel combustion emissions factors for non-Greenhouse Gas Reporting Program (GHGRP) reporting facilities, by fuel source

In metric tons of carbon dioxide equivalent per unit (mt $CO_2$e/unit). mt = metric tons; MMBtu = million British thermal units; scf = standard cubic feet; therms = 100,000 British thermal units.

| Fuel | Unit | Value (mt $CO_2$e/unit) |
|---|---:|---:|
| Natural gas | scf | 0.0000545 |
| Natural gas | therms | 0.005311 |
| Natural gas | MMBtu | 0.4531 |
| Bituminous coal | mt | 2.584 |
| Coal coke | mt | 3.128 |
| Distillate fuel oil no. 2 | gallon | 0.01024 |
| Heavy gas oil | gallon | 0.01113 |
| Kerosene | gallon | 0.01019 |
| Liquid petroleum gas | gallon | 0.005701 |
| Motor gasoline | gallon | 0.008809 |
| Other oil | gallon | 0.01063 |
| Propane gas | scf | 0.0001553 |
| Liquefied propane | gallon | 0.005807 |
| Propylene | gallon | 0.00619 |
| Residual fuel oil no. 6 | gallon | 0.0113 |
| Used oil | gallon | 0.01025 |
| Blast furnace gas | scf | 0.00002524 |
| Coke oven gas | scf | 0.00002809 |

Sources: 40 C.F.R. § 98, Subpart A, Table A-1; 40 C.F.R. § 98, Subpart C, Tables C-1, C-2.

Notes: Values include default factors for $CO_2$, nitrous oxide ($N_2O$), and methane ($CH_4$) converted to carbon dioxide equivalent using table C-1, table C-2, and table A-1. See appendix E for details on the use of default fuel combustion emissions factors in calculations.

**Table G.2** Default emissions factors for aluminum material inputs, by economy

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2$e/mt).

| Material | Economy | Default emissions factor |
|---|---|---:|
| Alumina | United States | 1.46 |
| Alumina | All other economies | 1.26 |
| Calcined petroleum coke | Global | 1.88 |
| Coal tar pitch | Global | 2.62 |
| Carbon anode | Global | 1.75 |
| Alloys | Global | 16.8 |
| Primary unwrought aluminum | Global | 16.8 |
| Primary unwrought aluminum | Bahrain | 11.3 |
| Primary unwrought aluminum | Canada | 5.4 |
| Primary unwrought aluminum | Qatar | 11.3 |
| Primary unwrought aluminum | United Arab Emirates | 11.3 |
| Primary unwrought aluminum | United States | 14.52 |
| Secondary unwrought aluminum inputs | United States | 2.33 |
| Wrought aluminum inputs | United States | 5.75 |

Sources: IAI and Sphera Solutions, *IAI Scope 3 Calculation Tool & Guidance*, September 13, 2022; IAI, *Life Cycle Inventory Data and Environmental Metrics for the Primary Aluminium Industry*, November 2022; IAI, “IAI Good Practice Document on Measuring Perfluorocarbons,” December 2020; Atmolite Consulting Pty Ltd, *Analysis of Implementation of Greenhouse Gas (GHG) Emissions Reporting from ASI Certified Entities: March 2020–March 2021 Update*, October 12, 2021.USITC estimates based on its calculation methodology, see appendix E.

Notes: U.S. smelter-specific primary unwrought aluminum factors were used where known. U.S. secondary and wrought input factors were calculated for materials before they were used as inputs into other products, see appendix E for further details.

**Table G.3** Default global emissions factors for industrial gases

In metric tons of carbon dioxide equivalent per thousand cubic feet (mt $CO_2$e/Mcf).

| Gas | Direct emissions factor | Default emissions factor |
|---|---:|---:|
| Oxygen | 0 | 0.00933 |
| Argon | 0 | 0.00534 |
| Nitrogen | 0 | 0.00272 |
| Hydrogen | 0 | 0.02740 |

Source: Janjua and Maciel, *$CO_2$ Data Collection User Guide, Version 11*, May 30, 2024.

Note: The inputs above have direct emissions factors set to zero as they do not contain any carbon (i.e., all the emissions associated with their use come from the indirect emissions associated with their production).

**Table G.4** Default global emissions factors for material inputs

In metric tons of carbon dioxide equivalent per metric ton (mt $CO_2e$/mt). — (em dash) = not applicable.

| Material input | Direct emissions factor | Default emissions factor |
|---|---:|---:|
| Iron ore | 0.000 | 0.021 |
| Iron pellets | 0.000 | 0.196 |
| Metallurgical coke | — | 0.639 |
| Non-calcined limestone and dolomite | 0.458 | 0.004 |
| Calcined lime | 0.000 | 1.232 |
| Calcined dolime | 0.000 | 1.232 |
| Pig iron | 0.172 | — |
| Direct reduced iron | 0.073 | 1.016 |
| Zinc | 0.000 | 2.612 |
| Aluminum | 0.000 | 16.719 |
| Tin | 0.000 | 5.774 |
| Copper | 0.000 | 3.873 |
| Nickel metal | 0.000 | 13.0 |
| Ferronickel | 0.037 | 13.5 |
| Nickel pig iron | 0.018 | 5.200 |
| Chromium metal | 0.000 | 5.300 |
| Ferrochromium | 0.275 | 5.300 |
| Manganese | 0.000 | 13.329 |
| Ferromanganese | 0.183 | 4.700 |
| Molybdenum | 0.000 | 5.000 |
| Ferromolybdenum | 0.018 | 8.040 |
| Silicomanganese | 0.000 | 5.903 |
| Silicon Metal | 0.000 | 9.748 |
| Ferrosilicon | 0.004 | 10.915 |
| Ferrovanadium | 0.000 | 75.161 |
| Other ferroalloys and alloying metals | 0.172 | 2.391 |
| Carbon electrodes | 3.663 | 0.650 |

Sources: Janjua and Maciel, *$CO_2$ Data Collection User Guide, Version 11*, May 30, 2024; worldsteel, *2020 LCI Study*, May 2021; ResponsibleSteel, *ResponsibleSteel International Production Standard: Version 2.1*, May 21, 2024.

Notes: Not applicable (—) indicates where emissions are incorporated within the analysis using other approaches. As described in appendix F, the global emissions factors for downstream steel products (which have zero assumed direct emissions factors when used to make other steel), as well as iron sinter and pig iron are calculated separately under the partial life cycle inventory approach rather than public emissions factors. The default emissions factor for other ferroalloys and alloying metals is equal to the calculated global emissions factor for pig iron. When metallurgical coke is used, it generates direct emissions; however, these direct emissions are reflected in the unit process emissions calculations for pig iron based on different mechanisms as explained in greater detail in appendix F. Therefore, no direct emissions factor was used for metallurgical coke. Appendix F describes how global default emissions factors were collected and developed from public sources.

**Table G.5** Default emissions factors for pig iron calculated using partial life cycle inventory approach

In metric tons of carbon dioxide equivalent per metric ton (mt $CO_2e$/mt) of pig iron.

| Source economy | Default emissions factor |
|---|---:|
| Brazil | 2.0960 |
| Canada | 1.8954 |
| China | 2.2063 |
| India | 2.7280 |
| Poland | 2.3215 |
| Qatar | 2.3915 |
| Russia | 3.9757 |
| South Africa | 5.0814 |
| Ukraine | 2.2837 |
| United States | 1.9044 |
| Vietnam | 2.6997 |
| World | 2.3915 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.6** Default emissions factors for carbon and alloy semifinished steel products calculated using partial life cycle inventory approach, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace.

| Source economy | Default emissions factor for BOF pathway | Default emissions factor for EAF pathway | Default emissions factor for all pathways |
|---|---:|---:|---:|
| Australia | 2.468 | 0.975 | 2.073 |
| Austria | 2.214 | 0.584 | 2.072 |
| Brazil | 2.303 | 0.543 | 1.889 |
| Canada | 2.119 | 0.395 | 1.338 |
| China | 2.453 | 1.209 | 2.335 |
| Czechia | 2.817 | 0.862 | 2.741 |
| Denmark | 2.607 | 0.967 | 0.967 |
| France | 2.607 | 0.967 | 2.063 |
| Germany | 2.384 | 0.824 | 1.915 |
| India | 2.932 | 0.979 | 1.854 |
| Italy | 2.326 | 0.512 | 0.801 |
| Japan | 2.662 | 1.048 | 2.254 |
| Mexico | 2.846 | 0.363 | 0.757 |
| Romania | 2.317 | 0.782 | 1.835 |
| Russia | 4.131 | 1.161 | 2.972 |
| Spain | 1.957 | 0.501 | 0.962 |
| Sweden | 2.239 | 0.401 | 1.586 |
| Taiwan | 2.479 | 0.914 | 1.861 |
| United Kingdom | 2.545 | 0.610 | 2.192 |
| United States | 2.136 | 0.555 | 1.043 |
| World | 2.607 | 0.967 | 2.148 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.7** Default emissions factors for carbon and alloy hot-rolled flat steel products calculated using partial life cycle inventory approach, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace.

| Source economy | Default emissions factor for BOF pathway | Default emissions factor for EAF pathway | Default emissions factor for all pathways |
|---|---:|---:|---:|
| Austria | 2.359 | 1.354 | 2.271 |
| Belgium | 2.562 | 1.460 | 2.196 |
| Brazil | 2.429 | 1.291 | 2.162 |
| Canada | 2.279 | 1.179 | 1.781 |
| China | 2.609 | 2.015 | 2.553 |
| Finland | 2.312 | 1.330 | 1.922 |
| France | 2.760 | 1.754 | 2.426 |
| Germany | 2.527 | 1.596 | 2.248 |
| Indonesia | 6.446 | 3.951 | 5.670 |
| Japan | 2.816 | 1.836 | 2.568 |
| Mexico | 3.018 | 1.151 | 1.447 |
| Netherlands | 2.531 | 1.744 | 2.531 |
| Russia | 4.479 | 2.134 | 3.564 |
| Serbia | 3.322 | 3.006 | 3.256 |
| South Korea | 2.432 | 1.673 | 2.190 |
| Sweden | 2.327 | 1.107 | 1.893 |
| Türkiye | 2.526 | 1.431 | 1.742 |
| Ukraine | 2.788 | 2.519 | 2.769 |
| United States | 2.285 | 1.335 | 1.776 |
| Vietnam | 3.108 | 2.108 | 2.897 |
| World | 2.760 | 1.754 | 2.478 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.8** Default emissions factors for carbon and alloy cold-rolled flat steel products calculated using partial life cycle inventory approach, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace.

| Source economy | Default emissions factor for BOF pathway | Default emissions factor for EAF pathway | Default emissions factor for all pathways |
|---|---:|---:|---:|
| Argentina | 3.113 | 1.783 | 2.512 |
| Australia | 2.941 | 2.058 | 2.708 |
| Austria | 2.524 | 1.479 | 2.433 |
| Belgium | 2.739 | 1.593 | 2.357 |
| Brazil | 2.580 | 1.397 | 2.302 |
| Canada | 2.451 | 1.306 | 1.932 |
| Germany | 2.707 | 1.738 | 2.416 |
| India | 3.298 | 2.150 | 2.665 |
| Indonesia | 6.720 | 4.125 | 5.944 |
| Japan | 3.026 | 2.006 | 2.768 |
| Mexico | 3.212 | 1.270 | 1.578 |
| Netherlands | 2.715 | 1.896 | 2.715 |
| Russia | 4.861 | 2.422 | 3.909 |
| Serbia | 3.697 | 3.368 | 3.628 |
| Slovenia | 2.968 | 1.403 | 1.403 |
| South Korea | 2.610 | 1.820 | 2.359 |
| Sweden | 2.437 | 1.169 | 1.987 |
| Taiwan | 2.811 | 1.844 | 2.429 |
| Thailand | 3.066 | 1.952 | 1.952 |
| United States | 2.462 | 1.473 | 1.932 |
| Vietnam | 3.372 | 2.332 | 3.153 |
| World | 2.965 | 1.919 | 2.672 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.9** Default emissions factors for carbon and alloy coated flat steel products calculated using partial life cycle inventory approach, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2$e/mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace.

| Source economy | Default emissions factor for BOF pathway | Default emissions factor for EAF pathway | Default emissions factor for all pathways |
|---|---:|---:|---:|
| Australia | 3.332 | 2.449 | 3.099 |
| Austria | 2.881 | 1.835 | 2.789 |
| Brazil | 2.920 | 1.737 | 2.642 |
| Canada | 2.822 | 1.678 | 2.304 |
| China | 3.187 | 2.568 | 3.128 |
| France | 3.312 | 2.266 | 2.965 |
| Germany | 3.055 | 2.087 | 2.764 |
| India | 3.632 | 2.484 | 2.999 |
| Indonesia | 7.035 | 4.440 | 6.259 |
| Japan | 3.373 | 2.353 | 3.115 |
| Mexico | 3.575 | 1.633 | 1.942 |
| Netherlands | 3.068 | 2.249 | 3.068 |
| Russia | 5.323 | 2.884 | 4.371 |
| South Korea | 2.948 | 2.158 | 2.697 |
| Spain | 2.559 | 1.697 | 1.970 |
| Taiwan | 3.149 | 2.182 | 2.768 |
| Türkiye | 3.058 | 1.919 | 2.243 |
| United Kingdom | 3.194 | 1.825 | 2.943 |
| United States | 2.821 | 1.833 | 2.291 |
| Vietnam | 3.727 | 2.686 | 3.508 |
| World | 3.312 | 2.266 | 3.019 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.10** Default emissions factors for carbon and alloy hot-worked long steel products calculated using partial life cycle inventory approach, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace.

| Source economy | Default emissions factor for BOF pathway | Default emissions factor for EAF pathway | Default emissions factor for all pathways |
|---|---:|---:|---:|
| Algeria | 6.336 | 0.928 | 1.703 |
| Brazil | 2.431 | 0.618 | 2.005 |
| Canada | 2.273 | 0.497 | 1.468 |
| China | 2.657 | 1.376 | 2.535 |
| Czechia | 2.977 | 0.962 | 2.898 |
| Dominican Republic | 2.786 | 1.096 | 1.096 |
| Egypt | 2.740 | 0.311 | 0.311 |
| Germany | 2.540 | 0.934 | 2.057 |
| India | 3.118 | 1.106 | 2.008 |
| Japan | 2.845 | 1.182 | 2.768 |
| Luxembourg | 2.780 | 0.499 | 0.499 |
| Malaysia | 2.248 | 1.095 | 1.958 |
| Mexico | 3.013 | 0.456 | 0.862 |
| South Korea | 2.455 | 1.021 | 1.999 |
| Spain | 2.080 | 0.581 | 1.055 |
| Türkiye | 2.538 | 0.762 | 1.266 |
| United Arab Emirates | 2.786 | 1.096 | 1.096 |
| United Kingdom | 2.684 | 0.691 | 2.320 |
| United States | 2.293 | 0.665 | 0.665 |
| Vietnam | 3.160 | 1.464 | 2.803 |
| World | 2.786 | 1.096 | 2.313 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.11** Default emissions factors for carbon and alloy cold-formed long steel products calculated using partial life cycle inventory approach, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace.

| Source economy | Default emissions factor for BOF pathway | Default emissions factor for EAF pathway | Default emissions factor for all pathways |
|---|---:|---:|---:|
| Austria | 2.395 | 0.716 | 2.248 |
| Brazil | 2.464 | 0.651 | 2.038 |
| Canada | 2.295 | 0.519 | 1.490 |
| China | 2.857 | 1.576 | 2.735 |
| Germany | 2.617 | 1.011 | 2.135 |
| India | 3.275 | 1.264 | 2.166 |
| Italy | 2.508 | 0.639 | 0.937 |
| Japan | 2.975 | 1.312 | 2.554 |
| Malaysia | 2.371 | 1.219 | 2.082 |
| Mexico | 3.038 | 0.480 | 0.886 |
| Slovenia | 2.832 | 0.643 | 0.643 |
| South Korea | 2.565 | 1.130 | 2.109 |
| Spain | 2.124 | 0.624 | 1.099 |
| Sweden | 2.332 | 0.439 | 1.660 |
| Türkiye | 2.616 | 0.840 | 1.344 |
| Taiwan | 2.774 | 1.162 | 2.138 |
| United Arab Emirates | 2.910 | 1.220 | 1.220 |
| United Kingdom | 2.713 | 0.719 | 2.348 |
| United States | 2.360 | 0.732 | 0.732 |
| Vietnam | 3.382 | 1.686 | 3.024 |
| World | 2.910 | 1.220 | 2.440 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.12** Default emissions factors for carbon and alloy non-seamless tubular steel products calculated using partial life cycle inventory approach, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace.

| Source economy | Default emissions factor for BOF pathway | Default emissions factor for EAF pathway | Default emissions factor for all pathways |
|---|---:|---:|---:|
| Brazil | 2.524 | 1.386 | 2.257 |
| Canada | 2.360 | 1.259 | 1.861 |
| China | 2.734 | 2.139 | 2.678 |
| Germany | 2.606 | 1.674 | 2.326 |
| Greece | 2.798 | 1.335 | 1.335 |
| India | 3.175 | 2.071 | 2.566 |
| Italy | 2.511 | 1.321 | 1.511 |
| Japan | 2.914 | 1.933 | 2.665 |
| Mexico | 3.091 | 1.224 | 1.520 |
| Russia | 4.681 | 2.336 | 3.766 |
| Saudi Arabia | 2.743 | 1.228 | 1.228 |
| South Korea | 2.512 | 1.753 | 2.271 |
| Taiwan | 2.706 | 1.776 | 2.339 |
| Thailand | 2.906 | 1.835 | 1.835 |
| Türkiye | 2.621 | 1.526 | 1.837 |
| Ukraine | 2.970 | 2.702 | 2.952 |
| United Arab Emirates | 2.855 | 1.849 | 1.849 |
| United Kingdom | 2.741 | 1.425 | 2.501 |
| United States | 2.371 | 1.420 | 1.861 |
| Vietnam | 3.248 | 2.247 | 3.037 |
| World | 2.855 | 1.849 | 2.573 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.13** Default emissions factors for carbon and alloy seamless tubular steel products calculated using partial life cycle inventory approach, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace.

| Source economy | Default emissions factor for BOF pathway | Default emissions factor for EAF pathway | Default emissions factor for all pathways |
|---|---:|---:|---:|
| Argentina | 2.958 | 0.990 | 2.069 |
| Austria | 2.424 | 0.746 | 2.278 |
| Brazil | 2.475 | 0.662 | 2.048 |
| China | 2.624 | 1.343 | 2.503 |
| Czechia | 2.978 | 0.964 | 2.900 |
| France | 2.792 | 1.103 | 2.231 |
| Germany | 2.572 | 0.966 | 2.090 |
| India | 3.088 | 1.076 | 1.978 |
| Italy | 2.493 | 0.624 | 0.922 |
| Japan | 2.847 | 1.184 | 2.426 |
| Mexico | 3.095 | 0.537 | 0.943 |
| Oman | 2.882 | 0.476 | 0.476 |
| Romania | 2.576 | 0.995 | 2.080 |
| Russia | 4.663 | 1.604 | 3.469 |
| Saudi Arabia | 2.707 | 0.509 | 0.509 |
| South Africa | 5.726 | 6.224 | 5.936 |
| South Korea | 2.456 | 1.021 | 2.000 |
| Spain | 2.120 | 0.620 | 1.095 |
| Thailand | 2.792 | 1.037 | 1.037 |
| Ukraine | 2.913 | 1.962 | 2.846 |
| United States | 2.347 | 0.719 | 0.719 |
| World | 2.792 | 1.103 | 2.319 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.14** Default emissions factors for stainless semifinished steel products calculated using partial life cycle inventory approach

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel).

| Source economy | Default emissions factor |
|---|---:|
| Australia | 3.350 |
| Austria | 2.969 |
| Canada | 3.350 |
| China | 6.441 |
| Germany | 3.208 |
| India | 3.360 |
| Indonesia | 9.610 |
| Italy | 2.895 |
| Malaysia | 3.350 |
| South Korea | 3.292 |
| Spain | 2.886 |
| Sweden | 2.785 |
| Taiwan | 3.297 |
| United Kingdom | 2.993 |
| United States | 2.939 |
| World | 3.350 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.15** Default emissions factors for stainless hot-rolled flat steel products calculated using partial life cycle inventory approach

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel).

| Source economy | Default emissions factor |
|---|---:|
| Austria | 3.192 |
| Belgium | 3.302 |
| Brazil | 3.113 |
| Canada | 3.586 |
| China | 6.792 |
| France | 3.586 |
| Germany | 3.432 |
| India | 3.577 |
| Indonesia | 9.934 |
| Italy | 3.082 |
| Japan | 3.671 |
| Mexico | 3.586 |
| Netherlands | 3.586 |
| Slovenia | 3.586 |
| South Africa | 9.400 |
| South Korea | 3.504 |
| Sweden | 2.904 |
| Taiwan | 3.515 |
| United Kingdom | 3.191 |
| United States | 3.175 |
| World | 3.586 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.16** Default emissions factors for stainless cold-rolled flat steel products calculated using partial life cycle inventory approach

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel).

| Source economy | Default emissions factor |
|---|---:|
| Belgium | 3.508 |
| China | 7.188 |
| Finland | 3.319 |
| France | 3.824 |
| Germany | 3.647 |
| India | 3.814 |
| Indonesia | 10.347 |
| Italy | 3.264 |
| Japan | 3.914 |
| Malaysia | 3.824 |
| Mexico | 3.824 |
| Slovenia | 3.824 |
| South Africa | 10.454 |
| South Korea | 3.725 |
| Spain | 3.258 |
| Sweden | 3.037 |
| Taiwan | 3.744 |
| Thailand | 3.824 |
| United States | 3.388 |
| Vietnam | 3.824 |
| World | 3.824 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.17** Default emissions factors for stainless hot-worked long steel products calculated using partial life cycle inventory approach

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel).

| Source economy | Default emissions factor |
|---|---|
| Austria | 3.282 |
| Belgium | 3.395 |
| Brazil | 3.183 |
| Canada | 3.732 |
| China | 6.997 |
| France | 3.732 |
| Germany | 3.544 |
| India | 3.734 |
| Indonesia | 9.952 |
| Italy | 3.163 |
| Japan | 3.821 |
| Poland | 3.732 |
| Slovenia | 3.732 |
| Spain | 3.155 |
| Sweden | 2.925 |
| Switzerland | 3.732 |
| Taiwan | 3.656 |
| Ukraine | 3.732 |
| United Kingdom | 3.263 |
| United States | 3.291 |
| World | 3.732 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.18** Default emissions factors for stainless cold-formed long steel products calculated using partial life cycle inventory approach

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel).

| Source economy | Default emissions factor |
|---|---:|
| Austria | 3.317 |
| Canada | 3.855 |
| China | 7.197 |
| Czechia | 3.855 |
| France | 3.855 |
| Germany | 3.621 |
| India | 3.891 |
| Indonesia | 10.075 |
| Italy | 3.211 |
| Japan | 3.952 |
| Mexico | 3.855 |
| Slovakia | 3.855 |
| Slovenia | 3.855 |
| South Korea | 3.739 |
| Spain | 3.199 |
| Sweden | 2.931 |
| Taiwan | 3.784 |
| United Arab Emirates | 3.855 |
| United Kingdom | 3.291 |
| United States | 3.358 |
| World | 3.855 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.19** Default emissions factors for stainless non-seamless tubular steel products calculated using partial life cycle inventory approach

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel).

| Source economy | Default emissions factor |
|---|---:|
| Austria | 3.263 |
| Belgium | 3.397 |
| Brazil | 3.208 |
| Canada | 3.681 |
| China | 6.917 |
| Costa Rica | 3.681 |
| Finland | 3.193 |
| Germany | 3.510 |
| Guatemala | 3.681 |
| India | 3.671 |
| Indonesia | 9.950 |
| Italy | 3.140 |
| Japan | 3.767 |
| Mexico | 3.681 |
| Russia | 4.230 |
| South Korea | 3.585 |
| Taiwan | 3.604 |
| Türkiye | 3.681 |
| United States | 3.261 |
| Vietnam | 3.681 |
| World | 3.681 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.20** Default emissions factors for stainless seamless tubular steel products calculated using partial life cycle inventory approach

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel).

| Source economy | Default emissions factor |
|---|---|
| Austria | 3.201 |
| Canada | 3.557 |
| China | 6.732 |
| Czechia | 3.557 |
| France | 3.557 |
| Germany | 3.421 |
| India | 3.528 |
| Indonesia | 9.941 |
| Italy | 3.079 |
| Japan | 3.638 |
| Mexico | 3.557 |
| South Korea | 3.477 |
| Spain | 3.076 |
| Sweden | 2.907 |
| Taiwan | 3.503 |
| Thailand | 3.557 |
| Ukraine | 3.557 |
| United Kingdom | 3.190 |
| United States | 3.174 |
| Vietnam | 3.557 |
| World | 3.557 |

Source: Calculated using the USITC partial life cycle inventory approach.

Note: See appendix F for details on underlying sources used in the development of factors using the partial life cycle inventory approach.

**Table G.21** Default emissions factors for fugitive methane emissions from coal and natural gas

In metric tons of carbon dioxide equivalent per million British thermal units of coal and natural gas (mt $CO_2e$/MMBtu fuel). GWP = global warming potential.

| Fuel | Scenario | Default fugitive methane emissions factor |
|---|---|---|
| Natural gas | 20-year GWP | 0.0108 |
| Natural gas | 20-year GWP-high | 0.0158 |
| Natural gas | 100-year GWP | 0.0031 |
| Natural gas | 100-year GWP-high | 0.0045 |
| Coal | 20-year GWP | 6.128 |
| Coal | 20-year GWP-high | 6.718 |
| Coal | 100-year GWP | 1.761 |
| Coal | 100-year GWP-high | 1.930 |

Sources: Burnham, "Updated Natural Gas Pathways in GREET 2023," October 2023, 5-6; EPA, *Inventory of U.S. Greenhouse Gas Emissions*, 2024, pp.3-62–3-66.

Notes: In the scenarios above, the 20-year GWP of methane is 87 mt of carbon dioxide equivalent and the 100-year GWP of methane is 25 mt of carbon dioxide equivalent. "High" denotes use of upper-bound estimates for fugitive methane emissions from U.S. natural gas and coal production in 2022.

# Bibliography

Atmolite Consulting Pty Ltd. Analysis of Implementation of Greenhouse Gas (GHG) Emissions Reporting from ASI Certified Entities: March 2020 – March 2021 Update. Version 2.0. Aluminium Stewardship Initiative (ASI), October 12, 2021. https://aluminium-stewardship.org/wp-content/uploads/2021/10/20211012-ASI-GHG-Validation-Report_v2.0_GENERIC.pdf.

Burnham, Andrew. "Updated Natural Gas Pathways in GREET 2023." Argonne National Laboratory (ANL), October 1, 2023. https://greet.anl.gov/publication-update_ng_2023.

International Aluminium Institute (IAI). "IAI Good Practice Document on Measuring Perfluorocarbons." December 2020. https://international-aluminium.org/resource/good-practice-guidance-measuring-perfluorocarbons/.

International Aluminium Institute (IAI). Life Cycle Inventory Data and Environmental Metrics for the Primary Aluminium Industry. November 2022. https://international-aluminium.org/resource/2019-life-cycle-inventory-lci-data-and-environmental-metrics/.

International Aluminium Institute (IAI) and Sphera Solutions, Inc. IAI Scope 3 Calculation Tool & Guidance 2022. September 13, 2022. https://international-aluminium.org/wp-content/uploads/2022/11/IAI-Scope-3-Calculation-Guidance-Document.pdf.

Janjua, Rizwan, and Felipe Maciel. $CO_2$ Data Collection User Guide, Version 11. V11, 30/05/2024. WorldSteel Association, May 30, 2024. https://worldsteel.org/wp-content/uploads/CO2_User_Guide_V11.pdf.

ResponsibleSteel. ResponsibleSteel International Production Standard: Version 2.1. May 21, 2024. https://www.responsiblesteel.org/standards.

U.S. Environmental Protection Agency (EPA). Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2022. EPA 430-R-24-004. 2024. https://www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-main-text_04-18-2024.pdf.

World Steel Association (worldsteel). Life Cycle Inventory (LCI) Study: 2020 Data Release. May 2021. https://worldsteel.org/wp-content/uploads/Life-cycle-inventory-LCI-study-2020-data-release.pdf.

# Appendix H

# Description of the Commission's Survey Methodology

The U.S. Trade Representative (Trade Representative) requested the U.S. International Trade Commission (Commission) conduct a survey of firms with facilities producing covered steel and aluminum products (covered products) in the United States to collect information pertinent to the estimation of greenhouse gas (GHG) emissions intensities by product category in 2022. The request asked that the survey collect data from these firms to the extent the data were not already publicly available via reporting to the U.S. Environmental Protection Agency’s Greenhouse Gas Reporting Program (GHGRP) or other sources. To address this request, the Commission issued questionnaires to companies with facilities producing covered steel and aluminum products. Using the data collected via the questionnaire in combination with data from external sources, the Commission estimated GHG emissions intensities at the product-category level. This appendix discusses the Commission’s approach to compiling the survey population, drafting its questionnaire, collecting data, analyzing questionnaire responses, and presenting findings in this report.

# Survey Process

The survey process for this investigation consisted of three major steps. First, the Commission compiled the survey population. To identify the companies and their associated U.S. facilities that likely produced covered products in 2022, the Commission used various steel and aluminum association membership lists and other sources.

Second, the Commission developed questionnaires and collected data from companies and facilities. To facilitate the data collection process and to reduce the burden on facilities, the Commission conducted a two-part data collection. In the first part, the Commission sent a company-level questionnaire to companies that were identified as possibly producing covered products in 2022. After companies submitted the company-level questionnaire, the Commission initiated the second part of the data collection, sending facility-level questionnaires to each individual facility indicated in the company-level response. The facility-level questionnaire collected information on the production quantity of covered products, fuel usage, inputs, and sources of those inputs in the production process.

Finally, the Commission developed estimation calculations that combined information from facility-level questionnaire responses with other publicly available data, including data from the GHGRP and Emissions and Generation Resource Integrated Database (eGRID), to estimate production-weighted national averages and highest measures of emissions intensities of covered products in 2022 at the product-category level as described in chapter 3 of the report.

# Survey Population Development

The survey population for this investigation is composed of companies and their associated facilities that produced covered products in 2022. Because this list of companies is not readily available from any one source, the Commission used a variety of sources to generate a comprehensive list of possible producers of covered products. The Commission then verified the companies on this list for inclusion in or exclusion from the survey population as described below.

Industry association lists were a major source used by the Commission to identify relevant companies and facilities. For steel, these included the Association for Iron & Steel Technology directory, Steel Manufacturers Association membership list, the Specialty Steel Industry of North America membership list, the American Wire Producers Association membership list, information from pipe and tube market research firm Preston Pipe, and the Committee on Pipe & Tube Imports membership list. For aluminum, industry association lists included those from the Aluminum Association, Forging Industry Association, American Foundry Society, and North American Die Casting Association. The Commission received several of these lists (which may not be publicly available) directly from industry contacts.

Additional sources the Commission used to build its comprehensive list of companies producing covered products included the EPA's National Emissions Inventory and the GHGRP.[683] All companies with facilities reporting GHG emissions to the GHGRP in 2022 under subparts F (aluminum production) and Q (iron and steel production) were included in the population.[684]

The Commission closely reviewed companies and their associated facilities from each of these sources to determine their inclusion in the population. Cumulatively, the initial list of companies that possibly produced covered steel and aluminum product categories included more than 1,700 companies.

The Commission sent a prenotification letter to all companies on this initial list in January 2024. The letter asked companies to confirm whether they owned at least one facility that produced covered products in the United States in 2022 and to verify their company-level contact information. The letter also instructed companies to contact the Commission if none of their facilities produced any covered products in 2022 so that they could be removed from the list after confirmation of their claim. For companies that did not respond to the prenotification letter, the Commission used proprietary search tools to find potential company contacts and conducted further research to determine if these companies could be removed from the population.[685]

The final count of companies that the Commission identified as eligible for the company-level questionnaire totaled 948. The Commission was aware that this number would likely change after data collection began because some companies included in the population had not yet been verified as producers of covered products.

---

[683] The Commission received 2021 National Emissions Inventory data—the most recent data available at the time the Commission's lists were being compiled—from EPA staff. National Emissions Inventory data are released publicly in a three-year cycle; these 2021 data are not available on the EPA website but resemble the latest publicly available data from 2020. https://www.epa.gov/enviro/nei-overview. EPA, "National Emissions Inventory (NEI)," June 2, 2015; EPA, "Find and Use GHGRP Data," July 30, 2021.

[684] Overlapping with the aforementioned industry association lists, several companies with facilities reporting emissions exclusively under the GHGRP's subpart C (stationary fuel combustion) were also determined to be within the investigation's scope and included in the Commission's comprehensive list.

[685] During this research-based removal process, the Commission erred on the side of including those companies whose production of covered steel and aluminum products could not be ruled out with certainty.

# Questionnaire Development

The initial step of the questionnaire development involved extensive desk research. The Commission spoke to industry experts to understand the data requirements for estimating emissions intensities by product category. This outreach was extremely helpful to the Commission in identifying data that were already available and data that needed to be collected via the questionnaire.

As the U.S. Office of Management and Budget (OMB) guidelines require, the Commission held a 60-day public comment period during which the public could provide feedback on its questionnaires.[686] The Commission posted the questionnaires for this investigation for public comment on its website from November 7, 2023 to January 6, 2024.[687] Additionally, the Commission conducted field testing and cognitive interviews during the public comment period.[688] The participants in field testing and cognitive interviews included up to nine organizations each. The participating organizations were steel and aluminum producers of various sizes and using different production processes, and associations representing such steel and aluminum producers. This process allowed the Commission to receive feedback on the publicly posted draft questionnaires from all types of steel and aluminum producers.

After incorporating comments received during the public comment period and feedback from field testing and cognitive interviews, the Commission submitted its proposed data collection package—which included the questionnaires—to the OMB for approval in February 2024. The Commission then conducted extensive internal testing of the final questionnaires' online interface to ensure the smooth operation of online data collection and to ensure displayed questions were tailored to a specific respondent's operations. The Commission began data collection for this investigation in April 2024, shortly after receiving OMB approval.

# Data Collection

The 948 companies in the survey population received both an email and a letter containing instructions for completing the company-level questionnaire, which was due two weeks after the data collection period started in early April 2024. In the company-level questionnaire, companies received a prepopulated list of their facilities to confirm production of covered products in 2022 and were given the opportunity to add or remove any facilities from this list, depending on their production of covered products during that year.[689] Respondents were also asked to provide contact information for personnel with whom the Commission could correspond at each identified facility. After submission of the

---

[686] Sunstein, "Information Collection under the PRA," April 7, 2010.

[687] During the public comment period for this investigation, the Commission also held a public hearing on December 7, 2023, at which data collection was a primary topic.

[688] The Commission undertakes several widely accepted best practices for surveys associated with its factfinding investigations to ensure the quality of the data collected and the compliance of the collection process with OMB guidelines. Two of these practices are field testing and cognitive interviews. Field testing allows potential respondents to review the draft questionnaire and provide feedback on specific topics such as completeness and burdensomeness. Cognitive interviews are conducted with potential respondents with a focus on content validity and understanding of the questions. Sunstein, "Information Collection under the PRA," April 7, 2010.

[689] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Company-Level*, 2024.

company-level questionnaire to the Commission, the identified facility-level contacts were automatically emailed instructions for completing the facility-level questionnaire, which was due 60 days from the date the company-level questionnaire completion instructions were emailed.[690] Companies and facilities received extensions to questionnaire submission deadlines upon request—to the degree the investigation's schedule allowed—to accommodate internal delays.

To gather complete and accurate data inputs for estimating emissions intensity, the facility-level questionnaire collected a large amount of data. In some cases, respondents may have been unfamiliar with specific information (e.g., energy usage) requested in the questionnaire. The Commission hosted two webinars during the data collection period to explain the survey process, provide more detailed information on how to complete the questionnaire, and answer respondents' questions. One webinar specific to steel producers was held on April 23, 2024, and another specific to aluminum producers was held on April 26, 2024. Both webinars were well attended and included active question-and-answer sessions. The Commission updated the investigation's Frequently Asked Questions (FAQs) document to reflect these questions and answers so that the information disseminated during these events was accessible to all potential respondents.

# Response Rates

Of the 948 companies that received a company-level questionnaire, 329 were exempted from responding because none of their facilities produced covered products in 2022. During the course of data collection, an additional 33 companies were identified as owners of facilities that produced covered products in 2022. In those 33 cases, either the owner had purchased a facility that produced covered products from another company in the population; or, because of its corporate structure, the owner requested that a company listed in the population as one company be divided into two or more companies for questionnaire reporting purposes.

After all adjustments were made, 652 companies remained in the company-level survey population and 538 submitted completed questionnaires. Using the equation H.1 below, the Commission calculated 82.5 percent as the overall response rate for the company-level questionnaire.[691] The company-level response rate for steel companies was 89.6 percent; the response rate for aluminum companies was 80.0 percent (table H.1).

$$\text{Company response rate} = \frac{Total\ questionnaire\ responses\ received}{Total\ questionnaires\ sent - Companies\ exempted + Additional\ companies} \quad (H.1)$$

---

[690] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024.

[691] Of the 114 companies that did not respond to the company-level questionnaire, a portion of the nonrespondents may not be producers of covered steel and aluminum products. The response rate calculation for company-level questionnaire assumes that all nonrespondents were producers of covered steel and aluminum products in 2022. As a result, the response rate is likely understated, and the results may capture more than 82.5 percent of producers of covered steel and aluminum products.

**Table H.1** Company questionnaire response activity
In number of company-level questionnaires.

| Activity | Steel companies | Aluminum companies | Total companies |
|---|---|---|---|
| Total questionnaires sent | 349 | 627 | 948 |
| Companies exempted | 147 | 186 | 329 |
| Additional companies | 19 | 15 | 33 |
| Adjusted company population | 221 | 456 | 652 |
| Total questionnaire responses received | 198 | 365 | 538 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Company-Level*, 2024.
Notes: Adjusted survey population is calculated as total questionnaires sent minus exempted plus additional companies by column. Steel companies and aluminum companies do not sum to total companies because 28 companies owned facilities that produced both covered steel and aluminum products.

The facility-level questionnaire was sent only to facilities of the companies that responded to the company-level questionnaire and reported that the facility produced covered products in 2022. If a company did not respond to the company-level questionnaire, facilities of those companies did not receive facility-level questionnaires; therefore, those facilities were not considered in the response rate calculation. The company-level questionnaire respondents owned 1,030 facilities that produced covered products in 2022. All these facilities received the facility-level questionnaire, and 54 were subsequently granted exemptions, resulting in 976 eligible facilities.[692]

Of 976 facilities, 913 responded to the facility-level questionnaire, resulting in an overall response rate of 93.5 percent. The facility response rates were calculated by dividing the total responses received by the total questionnaires sent minus the facilities exempted (equation H.2). The response rates for facilities producing covered steel products and for those producing covered aluminum products were comparable at 93.1 percent and 93.9 percent, respectively (table H.2).[693]

$$Facility\ response\ rate = \frac{Total\ responses\ received}{Total\ questionnaires\ sent - Exempted\ facilites} \qquad (H.2)$$

Responses from 35 facilities were deemed unusable because the data provided were insufficient and could not be verified despite outreach attempts by the Commission (see Data Cleaning section below). The usable response rate is calculated after removing the total unusable facility responses from the numerator (equation H.3).

$$Facility\ usable\ response\ rate = \frac{Total\ responses\ received - Total\ unusable}{Total\ questionnaires\ sent - Exempted\ facilities} \qquad (H.3)$$

After removing unusable questionnaire responses, the overall facility usable response rate was 90.0 percent. The usable response rate for facilities producing covered steel products was 89.1 percent; the rate for facilities producing covered aluminum products was 90.5 percent.

---

[692] These facilities were granted exemptions if it was confirmed they did not produce covered steel and aluminum products in 2022 or in a few instances of duplicate listings.

[693] The Commission did not identify a single existing, completely comprehensive list of companies producing covered products or of all U.S. facilities producing a particular covered product category in 2022. Because the company-level questionnaire did not ask respondents for specifics on the covered products each facility produced, the Commission could not develop product category-specific response rates.

**Table H.2** Facility questionnaire response activity
In number of facility-level questionnaires.

| Activity | Steel facilities | Aluminum facilities | Total facilities |
|---|---|---|---|
| Total questionnaires sent | 502 | 541 | 1,030 |
| Exempted facilities | 53 | 1 | 54 |
| Adjusted facility population | 449 | 540 | 976 |
| Total unusable questionnaire responses | 18 | 18 | 35 |
| Total questionnaire responses received | 418 | 507 | 913 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024.
Notes: Adjusted survey population for facilities is calculated by removing the exempted facilities from the total number of questionnaires sent. Steel and aluminum facilities responses do not sum to the total facilities across because 12 facilities produced both steel and aluminum covered products in 2022.

# Analysis of Responses

## Data Cleaning

Given the complexity and volume of data requested in the questionnaires, the Commission reviewed each submitted questionnaire to ensure respondents had properly reported all required data for the calculations. In cases where data were missing, appeared inconsistent, or were found to be extreme values (see the Outlier Analysis section below), the Commission attempted to verify or revise the submitted data by contacting the respondent via phone, video conference, or email, depending on the level of complexity and detail needed. A substantial number of initial responses needed to be revised. Using experience reviewing questionnaires and industry knowledge, the Commission made simple corrections to data (e.g., obvious typographical mistakes, unit errors, common terminology misunderstandings, etc.). Because certain corrections to responses in the questionnaires were complex, many questionnaires were reopened to allow the facility to make appropriate corrections.

## Nonresponse Adjustment

The high response rates for the questionnaire meant that the nonresponse rates were low for this survey. When there is evidence of nonresponse bias and adequate auxiliary data are available for all nonrespondents, it is possible to improve some survey estimates through a process of nonresponse adjustment. That adjustment was not possible in the Commission's survey because auxiliary data were not available.[694]

---

[694] To perform an accurate nonresponse adjustment, certain data used in the adjustment would be needed for all facilities in the population. For example, the types of products produced, as well as the material inputs, and processes used to produce each product at the facility level would be necessary. Because different facilities could produce the same product using different production steps or material inputs (e.g., primary aluminum or scrap), the variation in overall emissions could be large. Thus, it is essential to know the materials and processes involved in producing a particular product for each facility. Additionally, the production quantity of each product produced at the facility, as well as the source facility or country for all material inputs purchased by the facility, would be needed. The amount and types of fuel used for on-site combustion or cogeneration and the amount of electricity produced on-site and purchased from third parties would also be needed. A complete accounting of these types of data is not available for the facilities that did not respond to the questionnaire. Thus, incorporating nonresponse adjustment would introduce an unknown amount of variance and error to the estimates.

The Commission reviewed the list of survey nonrespondents to confirm that all major presumed producers of covered steel and aluminum products had submitted a questionnaire. Upon further assessment, the Commission found that the risk of bias to emissions intensity estimates given the low nonresponse rates was minimal, for three main reasons. First, almost all nonrespondents were producers of downstream steel and aluminum products. Despite this nonresponse, the volume of responses received in these product categories was sufficient to produce reliable emissions intensity estimates for these downstream products. Second, nonrespondents were not expected to have significantly different emissions intensity profiles than respondents within the same product category (i.e., nonrespondents’ emissions intensity estimates were not expected to fall consistently on the highest or lowest end of the range).[695] Third, given the survey’s very high response rates, remaining nonrespondents did not comprise large enough shares of U.S. production within any product category to have an outsized impact on any national estimates.

# Response Coverage

Beyond the high response rate, the Commission is also confident that the production output of facility-level respondents to the questionnaire comprises the vast majority of U.S. production in covered steel and aluminum product categories in 2022. When comparing the 2022 total production collected in responses to the Commission’s questionnaire to that from external data sources, the survey captured nearly 100 percent of production for almost all product categories (tables H.3 and H.4).

The Commission sought to include all producers in the industry, which includes many smaller producers that are often excluded from national estimates produced by external data providers. For some categories, such as non-seamless tubular steel and secondary aluminum, the production totals captured through the survey were much higher than the production totals gathered from external data sources.

---

[695] The biggest contributions to the emissions associated with downstream products come from those embedded in their raw material inputs (given a calculation framework that includes scopes 1, 2, and 3). As such, the drivers of overall emissions intensity levels for these product categories will come from their input sourcing. The input sourcing choices for nonrespondents would not likely be any different from those of respondents. In terms of scope 1 and 2 emissions, the anticipated production processes or location (for the purposes of grid sourcing of electricity) of these nonrespondents is not expected to vary from those of respondents.

**Table H.3** Commission steel production totals compared to external data steel production totals
In 1,000 metric tons (mt).

| Product category | USITC production totals | External data production totals |
|---|---:|---:|
| Semifinished steel | 85,329 | 81,392 |
| Stainless steel semifinished steel | 2,625 | 2,017 |
| Carbon and alloy semifinished steel | 82,704 | 79,518 |
| Hot-rolled flat steel | 56,813 | 54,531 |
| Hot-worked long steel | 27,646 | 26,025 |
| Seamless tubular steel | 3,292 | 1,861 |
| Non-seamless tubular steel | 6,416 | 1,822 |
| Coated flat steel | 19,928 | 19,950 |
| Rebar | 9,662 | 8,657 |

Sources: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 2.1.1; AISI, "Pig Iron and Raw Steel Production," accessed January 31, 2023; worldsteel, *Steel Statistical Yearbook 2023*, accessed September 21, 2024.
Note: With the exception of semifinished steel, product categories shown above are combined totals for stainless and carbon and alloy steel types.

For secondary aluminum, the production totals estimated by external public data sources are smaller because those data sources typically do not include production for captive consumption(table H.4).[696] The production totals collected in the Commission's survey include captive consumption, which accounted for 56.8 percent of total production.[697] Other production totals provided by external data sources may be missing data on captive production or likely reflect small survey sample sizes.

**Table H.4** Commission aluminum production totals compared to external data aluminum production totals
In 1,000 metric tons (mt).

| Product category | USITC production totals | External data production totals |
|---|---:|---:|
| Primary unwrought | 877 | 861 |
| Secondary unwrought | 9,693 | 4,701 |
| Wrought | 8,598 | 9,311 |

Sources: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, section 2. Primary aluminum 2022 production total from USGS, *Mineral Commodity Summaries 2022: Aluminum*, January 2022. Secondary aluminum 2022 production from the Aluminum Association, email message to USITC staff, September 18, 2024. Wrought 2022 production total from LSEG Metals Research, "World Metals Statistics Yearbook 2022," 2023.
Note: The wrought external production total excludes castings, forgings, and wire production.

---

[696] Captive consumption is production that is made in a facility and then used or consumed to make other products in the same facility.

[697] USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 2.2.2 and 2.2.3. A 2017 USITC report on the aluminum industry included both captive and noncaptive production and estimated a production total much closer to this survey's production total (8,587,000 metric tons). USITC, *Aluminum: Competitive Conditions Affecting the U.S. Industry*, June 2017, 151. The external source's secondary aluminum production estimate of 4,701,000 metric tons is much closer to the Commission's collected data for noncaptive production, which is 4,192,435 metric tons.

# Computational Methods

## Calculation of the Average Emissions Intensity Estimates

As requested in the Trade Representative's letter, the Commission is providing the estimated production-weighted national average emissions intensity by product category in this report. The concept of a production-weighted average is most clearly explained when first described at the facility level. First, the Commission uses responses to the questionnaire and external data, e.g., from the GHGRP and eGRID, as inputs to the calculation equations—described in detail in the Commission's calculation methodology—to compute facility-level emissions by scope for each covered product produced at that facility.[698] Next, scope 1, 2, and 3 emissions are added to compute the total emissions for each product produced in that facility. Finally, total emissions are divided by the production volume in metric tons of that product at that facility to produce facility-specific product-level emissions intensity estimates (equation H.4).

Estimated facility-specific emissions intensity for product $y$:

$$\hat{x}_{iy} = \frac{\sum_{j=1}^{3} e_{ijy}}{p_{iy}} \qquad (H.4)$$

$e_{ijy}$ denotes estimated emissions in metric tons for product $y$ for facility $i$ and scope $j$; $p_{iy}$ denotes the total production in metric tons of product $y$ at facility $i$.

Emissions intensity estimates from each facility are then weighted by the production in metric tons of product $y$ and summed across facilities producing product $y$ to estimate the production-weighted national average emissions intensity for product $y$.

Estimated production-weighted national average emissions intensity:

$$\bar{x}_y = \frac{\sum_{i=1}^{n} \hat{x}_{iy} * p_{iy}}{\sum_{i=1}^{n} p_{iy}} \qquad (H.5)$$

Mathematically, equation H.5 simplifies to equation H.6 below when $\hat{x}_{iy}$ is replaced with equation H.4. This is the equation the Commission used in its estimation of average emissions intensities.

$$\bar{x}_y = \frac{\sum_{i=1}^{n} \sum_{j=1}^{3} e_{ijy}}{\sum_{i=1}^{n} p_{iy}} \qquad (H.6)$$

$e_{ijy}$ denotes emissions for each product category for facility $i$ and scope $j$; $p_{iy}$ denotes the total production of product $y$ for facility $i$; and $n$ denotes the total number of facilities producing product $y$.

## Calculation of the Highest Emissions Intensity Estimates

The Trade Representative's request letter asked that the Commission estimate the highest emissions intensities by product category. To estimate the highest emissions intensities without disclosing

---

[698] More information about the Commission's calculation methodology can be found in appendix E of this report.

confidential business information of facilities or companies, the report presents the production-weighted average of a set production share of the highest emissions-intensive facilities. This is computed for 10 percent (i.e., 90–100th percentile range) of the total production of a particular product category using the steps below.

Facility-specific emissions intensity estimates are calculated using equation H.4 for each steel and aluminum product category. Next, facilities are arranged in descending order of the emissions intensity estimates, and cumulative production shares are calculated for that product category. Facilities are included until 10 percent of production is captured from the top end of the emissions intensity estimate distribution.[699] Finally, production-weighted average emissions intensity estimates are calculated for the 90–100th percentile range using equation (H.6) over the facilities included.

Production-weighted averages have also been calculated for the 50–100th, 60–100th, 70–100th, and 80–100th percentile ranges (i.e., the most emissions-intensive facilities representing 50 percent, 40 percent, 30 percent, and 20 percent of all U.S. production in a product category, respectively) using these steps and presented in appendix I.

For product categories that do not qualify for publication in this report under the data disclosure rules (see Data Disclosure Review section below) at the 90–100th percentile range, the highest measure will be shown at the percentile range representing the narrowest percentile range of highest emissions intensities estimates as possible while protecting confidential business information. For example, if the highest emissions intensities estimate for a product category at the 90–100th percentile range does not meet the requirements of the Commission data disclosure rules but meets the requirements at 80–100th percentile range, the report will display the 80–100th percentile range.

## Precision of the Estimates

The standard error is a measure of the precision of the sample mean.[700] The Commission estimated the standard error using the Taylor series linearization method because the emissions intensities estimator is a non-linear estimator computed from the estimator of totals.[701] The standard errors calculated using the Taylor series method were all small compared to the mean estimate. As a result, the relative standard errors (standard error divided by the mean) were less than 5 percent for all emissions intensities estimates for steel and aluminum product categories. The low relative standard errors show that the estimates presented in the report have high levels of precision.

## Measures of Dispersion

When analyzing estimates of averages (i.e., means), it is important to consider how the underlying data are distributed. A measure of dispersion indicates how the data are distributed around a measure of

---

[699] For facilities that straddle the 10 percent threshold (i.e., where the previous facility’s inclusion resulted in a total of less than 10 percent and the current facility’s inclusion resulted in a total of more than 10 percent), only a portion of the emissions and production for the current facility is included.

[700] Altman and Bland, “Standard Deviations and Standard Errors,” October 15, 2005.

[701] SAS Institute Inc., “Taylor Series Variance Estimation,” accessed October 30, 2024.

central tendency. Production-weighted standard deviation was calculated on emissions intensities estimates to provide insight into the spread of the data (tables H.5–H.7).

The standard deviation, equation H.7, measures the amount of variation of the emissions intensity estimates around its mean for product $y$. Large standard deviations indicate the data are spread over a wider range than if the standard deviation were small, relative to the mean.[702] Because the national average emissions intensity estimate is production weighted, the standard deviation is also production weighted.

$$s_y = \sqrt{\frac{\sum_{i=1}^{n} p_{iy}\left(\hat{x}_{iy} - \bar{x}_y\right)}{\sum_{i=1}^{n} p_{iy}}} \qquad (H.7)$$

**Table H.5** Carbon and alloy steels: measures of dispersion by product category and subcategory
In number of facilities and metric tons of carbon dioxide equivalent per metric ton of steel produced (mt $CO_2$e/mt steel).

| **Product category and subcategory** | **Facilities (number)** | **Average emissions intensity (mt $CO_2$e/mt steel)** | **Standard deviation (mt $CO_2$e/mt steel)** |
|---|---:|---:|---:|
| Semifinished | 87 | 1.02 | 0.60 |
| Slab | 30 | 1.35 | 0.52 |
| Ingot | 12 | 0.61 | 0.59 |
| All other semifinished | 51 | 0.50 | 0.22 |
| Flat | 79 | 1.83 | 0.72 |
| Hot-rolled flat | 47 | 1.59 | 0.62 |
| Plate | 27 | 1.41 | 0.69 |
| All other hot-rolled flat | 36 | 1.61 | 0.60 |
| Cold-rolled flat | 41 | 1.91 | 0.70 |
| Coated flat | 45 | 2.17 | 0.80 |
| Long | 160 | 0.75 | 0.45 |
| Hot-worked long | 70 | 0.67 | 0.32 |
| Rebar | 32 | 0.54 | 0.13 |
| Wire rod | 14 | 0.94 | 0.52 |
| Heavy structural shapes | 15 | 0.67 | 0.22 |
| All other hot-worked long | 33 | 0.74 | 0.36 |
| Cold-formed long | 99 | 1.25 | 0.70 |
| Wire | 72 | 1.48 | 0.71 |
| All other cold-formed long | 34 | 0.89 | 0.50 |
| Tubular | 114 | 1.50 | 0.50 |
| Seamless tubular | 21 | 1.09 | 0.18 |
| Seamless oil country tubular goods | 14 | 1.08 | 0.16 |
| All other seamless tubular | 10 | 1.23 | 0.29 |
| Non-seamless tubular | 97 | 1.71 | 0.49 |
| Non-seamless oil country tubular goods | 13 | 1.52 | 0.51 |
| All other non-seamless tubular | 88 | 1.74 | 0.48 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 1.2.3. USITC estimates based on its calculation methodology, see appendix E.

---

[702] Upton and Cook, *Understanding Statistics*, 1996.

**Table H.6** Stainless steel: measures of dispersion by product category and subcategory

In number of facilities and metric tons of carbon dioxide equivalent per metric ton of steel produced (mt $CO_2e$/mt steel). d.s. = data are suppressed to protect confidentiality.

| Product category and subcategory | Facilities (number) | Average emissions intensity (mt $CO_2e$/mt steel) | Standard deviation (mt $CO_2e$/mt steel) |
|---|---|---|---|
| Stainless steel | 92 | 2.78 | 0.75 |
| Semifinished | 17 | 2.23 | 0.74 |
| Slab | 7 | 2.16 | 0.47 |
| Ingot | 11 | 2.85 | 1.65 |
| All other semifinished | d.s. | d.s. | d.s. |
| Hot-rolled flat | 14 | 2.31 | 0.50 |
| Cold-rolled flat | 15 | 3.08 | 0.32 |
| Hot-worked long | 14 | 2.93 | 1.29 |
| Cold-formed long | 22 | 3.55 | 1.03 |
| Wire | 16 | 4.55 | 1.31 |
| All other cold-formed long | 10 | 3.34 | 0.81 |
| Seamless tubular | 10 | 4.07 | 1.91 |
| Non-seamless tubular | 21 | 3.16 | 0.71 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 1.2.3. USITC estimates based on its calculation methodology, see appendixes E and H.

**Table H.7** Measures of dispersion by aluminum product category

In number of facilities and metric tons of carbon dioxide equivalent per metric ton of aluminum produced (mt $CO_2e$/mt aluminum).

| Product category | Facilities (number) | Average emissions intensity (mt $CO_2e$/mt aluminum) | Standard deviation (mt $CO_2e$/mt aluminum) |
|---|---|---|---|
| Unwrought | 108 | 3.46 | 4.75 |
| Primary unwrought aluminum | 6 | 14.52 | 7.37 |
| Secondary unwrought aluminum | 102 | 2.46 | 2.76 |
| Wrought | 417 | 6.23 | 4.78 |
| Bars, rods, and profiles | 126 | 8.35 | 5.93 |
| Wire | 22 | 8.35 | 4.51 |
| Plates, sheet, and strip | 36 | 4.97 | 3.70 |
| Foil | 8 | 8.66 | 2.02 |
| Tubes, pipes, and tube or pipe fittings | 42 | 8.21 | 4.11 |
| Castings | 200 | 6.00 | 6.39 |
| Forgings | 29 | 5.00 | 3.26 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, section 1.2.3. USITC estimates based on its calculation methodology, see appendixes E and H.

## Outlier Analysis

Estimates of averages and totals can be sensitive to the presence of unusual or extreme values (i.e., outliers) for a variable. The two primary categories of outliers included are reporting errors and unique units. The goal of outlier analysis is to identify extreme values and confirm them as unique units or correct them if they are reporting errors.[703]

Possible outliers in facility-specific product-level GHG emissions intensity estimates were identified and further assessed for validity and data quality. To identify these potential outliers, a modified Z-score was calculated at the product category level.[704] A modified Z-score (equation H.8) was used rather than a Z-score because the modified Z-score uses the median of the observations, which is more resistant to unusual observations than a mean that is used to calculate a Z-score. Additionally, emissions intensities estimate data did not follow a normal distribution for every product category, which made modified Z-scores more suitable for the outlier analysis for all product categories because they also do not assume a normal distribution. The modified Z-score is computed as follows for a product category:

$$M_{iy} = \frac{0.6745\left(\hat{x}_{iy} - x_y\right)}{MAD} \qquad (H.8)$$

$x_y$ is the median GHG emissions intensity estimate for all facilities that produce product category $y$, and $MAD = median_i\{|x_i - \tilde{x}|\}$ is the median of the absolute deviations about the median GHG emissions intensity.

Any values of $M_i > 3.5$ were identified as possible outliers and scrutinized closely to determine if they were reporting errors or correctly reported extreme values.[705] Respondents with reporting errors were contacted for corrections (see the Data Cleaning section above).

# Significance Testing and p-value

In instances where the intensities estimates were compared between product categories or between different methods in the sensitivity analyses, the Commission performed a statistical significance testing using a t-test.

A probability value, commonly known as p-value, is a statistical measurement used to validate a hypothesis against observed data. As p-values are generally used in this report to compare two groups (e.g., emissions intensity estimates between different types of products, or emissions intensity estimates for the same product using different calculation methodologies), the hypothesis is that there is no difference between the two groups or the two methods in case of sensitivity analyses. The smaller the p-value, the stronger the evidence that there is a difference between the means of two groups being

---

[703] Beaumonth and Rivest, *Handbook of Statistics. Vol. 29 A*, *Vol. 29A*, *digital printing*, 2010, 247.

[704] The standard Z-score indicates the number of standard deviations a data point is from the mean. Iglewicz and Hoaglin, *How to Detect and Handle Outliers*, *Vol. 16*, 2004, 10–13.

[705] Iglewicz and Hoaglin, *How to Detect and Handle Outliers*, *Vol. 16*, 2004, 12.

compared.[706] A p-value less than 0.05 is considered statistically significant. Use of the term “significantly” in the text also indicates statistical significance between the compared groups.

# Data Disclosure Review

The Trade Representative’s letter requested that the Commission not include any confidential business information in its report. The Commission has designated the information provided in response to its questionnaires as confidential business information unless such information is otherwise available to the public. Therefore, the Commission is obligated to withhold or suppress any data that would reveal a company’s or facility’s information. A comprehensive disclosure review was conducted for all survey results presented in this report. Data were suppressed to protect any data that were determined to be sensitive to a disclosure of information. Data such as production and emissions intensity estimates were determined to be sensitive and were subject to disclosure controls.

Estimates using survey data presented in the report were either calculated using only questionnaire responses (e.g., production totals) or questionnaire responses combined with external data in complex calculations (e.g., emissions intensity). Estimates based solely on questionnaire responses were determined to be sensitive to a disclosure of information if they failed either of two rules: the threshold rule or the dominance rule. Estimate disclosure failed the threshold rule if the estimate comprised data from fewer than a set minimum of companies and facilities. Estimate disclosure failed the dominance rule if the data from a small number of companies or facilities dominated the estimate, which could allow a data user to estimate any respondent’s data too closely. Estimates based on the Commission’s calculation methodology follow the threshold rule only; the data were transformed substantially so that no data user could infer an individual facility’s estimate.

---

[706] Beers, “P-Value,” 2024.

# Bibliography

Altman, Douglas, and J Martin Bland. "Standard Deviations and Standard Errors." *The British Medical Journal* 331, no. 903 (October 15, 2005). https://doi.org/10.1136/bmj.331.7521.903.

American Iron and Steel Institute (AISI). "AIS-7 Pig Iron and Raw Steel Production, December 2022." Accessed January 31, 2023. https://www.steel.org/.

Beaumonth, Jean-François, and Louis-Paul Rivest. *Handbook of Statistics*, *Vol. 29A*, *digital printing*. Edited by Danny Pfeffermann, and Calyampudi Radhakrishna Rao. Sample Surveys: Design, Methods and Applications. Amsterdam: Elsevier, 2010. https://www.sciencedirect.com/handbook/handbook-of-statistics/vol/29/part/PA.

Beers, Brian. "P-Value: What It Is, How to Calculate It, and Why It Matters." Investopedia, 2024. https://www.investopedia.com/terms/p/p-value.asp.

Iglewicz, Boris, and David C. Hoaglin. *How to Detect and Handle Outliers*, *Vol. 16*. The ASQC Basic References in Quality Control: Statistical Techniques. Milwaukee, Wisconsin: ASQC Quality Press, 2004. https://hwbdocs.env.nm.gov/Los%20Alamos%20National%20Labs/TA%2054/11587.pdf.

London Stock Exhange Group (LSEG). "WBMS, World Metal Statistics Yearbook 2022." LSEG Metals Research, 2023. https://www.lseg.com/en/data-analytics/financial-data/commodities-data/metals-data/world-bureau-of-metal-statistics-wbms.

SAS Institute Inc. "Taylor Series Variance Estimation." SAS Institute Inc. Accessed October 30, 2024. https://documentation.sas.com/doc/en/pgmsascdc/9.4_3.4/statug/statug_surveyfreq_details19.htm#:~:text=The%20Taylor%20series%20linearization%20method,formed%20from%20estimators%20of%20totals.

Sunstein, Cass R. "Information Collection Under the Paperwork Reduction Act." Executive Office of the President. Office of Management and Budget. Memorandum for the heads of executive departments and agencies, and independent regulatory agencies, April 7, 2010. https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/assets/inforeg/PRAPrimer_04072010.pdf.

Upton, Graham, and Ian Cook. *Understanding Statistics*. OUP Oxford, 1996. https://archive.org/details/understandingsta0000upto/page/n3/mode/2up.

U.S. Environmental Protection Agency (EPA). "National Emissions Inventory (NEI)." Other Policies and Guidance, June 2, 2015. https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei.

U.S. Environmental Protection Agency (EPA). "Find and Use GHGRP Data." Data and Tools, July 30, 2021. https://www.epa.gov/ghgreporting/find-and-use-ghgrp-data.

U.S. Geological Survey (USGS). *Mineral Commodity Summaries 2022: Aluminum*. USGS, January 2022. https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-aluminum.pdf .

U.S. International Trade Commission (USITC). *Aluminum: Competitive Conditions Affecting the U.S. Industry*. USITC Publication 4703, June 2017. https://www.usitc.gov/publications/332/pub4703.pdf.

U.S. International Trade Commission (USITC). *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Company-Level*. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_company-level_questionnaire.pdf.

U.S. International Trade Commission (USITC). *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*. 2024. https://www.usitc.gov/research_and_analysis/documents/sa_emissions/emissions_facility-level_questionnaire_aluminum_and_steel_combined.pdf.

World Steel Association (worldsteel). *Steel Statistical Yearbook 2023*. Accessed September 21, 2024. https://worldsteel.org/publications/bookshop/ssy_subscription-2023/.

# Appendix I
# Additional Emissions Intensity Tables

**Table I.1** Carbon and alloy steel products: additional percentile ranges for the highest measure emissions intensity, by product category and subcategory

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2$e/mt steel). d.s. = data are suppressed to protect confidentiality.

| Product category and subcategory | National average | 90–100% | 80–100% | 70–100% | 60–100% | 50–100% |
|---|---|---|---|---|---|---|
| Semifinished | 1.02 | 2.15 | 1.99 | 1.81 | 1.66 | 1.52 |
| Slab | 1.35 | 2.22 | 2.10 | 2.01 | 1.90 | 1.80 |
| Ingot | 0.61 | 1.44 | 1.05 | 0.91 | 0.84 | 0.79 |
| All other semifinished | 0.50 | 1.00 | 0.80 | 0.72 | 0.66 | 0.62 |
| Flat | 1.83 | 3.06 | 2.82 | 2.65 | 2.54 | 2.41 |
| Hot-rolled flat | 1.59 | 2.62 | 2.46 | 2.35 | 2.22 | 2.11 |
| Plate | 1.41 | 2.63 | 2.38 | 2.16 | 2.03 | 1.90 |
| All other hot-rolled flat | 1.61 | 2.61 | 2.47 | 2.36 | 2.25 | 2.13 |
| Cold-rolled flat | 1.91 | 3.08 | 2.94 | 2.79 | 2.63 | 2.50 |
| Coated flat | 2.17 | 3.82 | 3.43 | 3.14 | 2.97 | 2.80 |
| Long | 0.75 | 1.89 | 1.44 | 1.22 | 1.09 | 1.00 |
| Hot-worked long | 0.67 | 1.43 | 1.12 | 0.99 | 0.91 | 0.86 |
| Rebar | 0.54 | 0.80 | 0.74 | 0.69 | 0.66 | 0.63 |
| Wire rod | 0.94 | d.s. | 1.82 | 1.58 | 1.43 | 1.31 |
| Heavy structural shapes | 0.67 | 1.20 | 0.95 | 0.86 | 0.81 | 0.78 |
| All other hot-worked long | 0.74 | 1.52 | 1.20 | 1.07 | 0.99 | 0.94 |
| Cold-formed long | 1.25 | 2.62 | 2.38 | 2.16 | 1.97 | 1.82 |
| Wire | 1.48 | 2.76 | 2.55 | 2.38 | 2.26 | 2.08 |
| All other cold-formed long | 0.89 | 1.85 | 1.62 | 1.55 | 1.40 | 1.26 |
| Tubular | 1.50 | 2.50 | 2.30 | 2.15 | 2.02 | 1.90 |
| Seamless tubular | 1.09 | 1.43 | 1.37 | 1.29 | 1.24 | 1.21 |
| Seamless oil country tubular goods | 1.08 | d.s. | 1.32 | 1.25 | 1.22 | 1.19 |
| All other seamless tubular | 1.23 | 1.87 | 1.71 | 1.58 | 1.50 | 1.42 |
| Non-seamless tubular | 1.71 | 2.60 | 2.44 | 2.30 | 2.20 | 2.11 |
| Non-seamless oil country tubular goods | 1.52 | 2.37 | 2.22 | 2.12 | 2.06 | 1.97 |
| All other non-seamless tubular | 1.74 | 2.58 | 2.47 | 2.34 | 2.23 | 2.13 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: Percentile ranges show the production-weighted average of those facilities with the highest emissions intensities that represent that percentage range of production with each respective product category presented.

**Table I.2** Carbon and alloy steel products: measures of dispersion for highest measure, by product category and subcategory

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented. ^ indicates the measure of highest emissions intensity for hot-worked wire rod long products and seamless oil country tubular goods are shown at the 80–100th percentile range to protect confidentiality.

| Product category and subcategory | Highest emissions intensity | Standard deviation |
|---|---:|---:|
| Semifinished | 2.15 | 0.22 |
| Slab | 2.22 | 0.02 |
| Ingot | 1.44 | 1.62 |
| All other semifinished | 1.00 | 0.33 |
| Flat | 3.06 | 0.62 |
| Hot-rolled flat | 2.62 | 0.48 |
| Plate | 2.63 | 1.12 |
| All other hot-rolled flat | 2.61 | 0.03 |
| Cold-rolled flat | 3.08 | 0.28 |
| Coated flat | 3.82 | 0.41 |
| Long | 1.89 | 0.52 |
| Hot-worked long | 1.43 | 0.48 |
| Rebar | 0.80 | 0.07 |
| Wire rod | 1.82^ | 0.44 |
| Heavy structural shapes | 1.20 | 0.29 |
| All other hot-worked long | 1.52 | 0.63 |
| Cold-formed long | 2.62 | 0.23 |
| Wire | 2.76 | 0.18 |
| All other cold-formed long | 1.85 | 0.46 |
| Tubular | 2.50 | 0.34 |
| Seamless tubular | 1.43 | 0.30 |
| Seamless oil country tubular goods | 1.32^ | 0.18 |
| All other seamless tubular | 1.87 | 0.36 |
| Non-seamless tubular | 2.60 | 0.38 |
| Non-seamless oil country tubular goods | 2.37 | 0.42 |
| All other non-seamless tubular | 2.58 | 0.37 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table I.3** Stainless steel products: additional percentile ranges for the highest measure emissions intensity, by product category and subcategory

In tons of carbon dioxide equivalent per metric ton of steel (mt CO2e/mt steel). d.s. = data are suppressed to protect confidentiality.

| Product category and subcategory | National average | 90–100% | 80–100% | 70–100% | 60–100% | 50–100% |
|---|---|---|---|---|---|---|
| Stainless steel | 2.78 | 4.21 | 3.70 | 3.51 | 3.40 | 3.31 |
| Semifinished | 2.23 | 3.79 | 3.15 | 2.89 | 2.67 | 2.54 |
| Slab | 2.16 | 3.08 | 2.80 | 2.64 | 2.49 | 2.39 |
| Ingot | 2.85 | 6.93 | 5.31 | 4.73 | 4.44 | 4.04 |
| All other semifinished | d.s. | d.s. | d.s. | d.s. | d.s. | d.s. |
| Hot-rolled flat | 2.31 | 3.26 | 2.99 | 2.80 | 2.68 | 2.57 |
| Cold-rolled flat | 3.08 | 3.76 | 3.47 | 3.36 | 3.30 | 3.26 |
| Hot-worked long | 2.93 | 6.27 | 4.97 | 4.23 | 3.78 | 3.50 |
| Cold-formed long | 3.55 | 5.52 | 5.22 | 4.96 | 4.49 | 4.19 |
| Wire | 4.55 | 7.60 | 6.42 | 5.88 | 5.61 | 5.45 |
| All other cold-formed long | 3.34 | 5.00 | 4.92 | 4.28 | 3.96 | 3.76 |
| Seamless tubular | 4.07 | 7.85 | 6.58 | 5.87 | 5.52 | 5.31 |
| Non-seamless tubular | 3.16 | 4.49 | 4.26 | 4.11 | 3.88 | 3.68 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: Percentile ranges show production-weighted average of those facilities with the highest emissions intensities that represent that percentage range of production with each respective product category presented.

**Table I.4** Stainless steel products: measures of dispersion for highest measure, by product category and subcategory

In metric tons of carbon dioxide equivalent per metric ton of steel (mt CO2e/mt steel). d.s. = data are suppressed to protect confidentiality. The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented.

| Product category and subcategory | Highest emissions intensity | Standard deviation |
|---|---|---|
| Stainless steel | 4.21 | 1.15 |
| Semifinished | 3.79 | 1.45 |
| Slab | 3.08 | 0.79 |
| Ingot | 6.93 | 0.62 |
| All other semifinished | d.s. | d.s. |
| Hot-rolled flat | 3.26 | 0.82 |
| Cold-rolled flat | 3.76 | 0.34 |
| Hot-worked long | 6.27 | 1.61 |
| Cold-formed long | 5.52 | 1.07 |
| Wire | 7.60 | 0.39 |
| All other cold-formed long | 5.00 | 0.40 |
| Seamless tubular | 7.85 | 1.82 |
| Non-seamless tubular | 4.49 | 0.70 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table I.5** Unwrought aluminum products: additional percentile ranges for the highest measure emissions intensity, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2e$/mt aluminum). d.s. = data are suppressed to protect confidentiality.

| Product category | National average | 90–100% | 80–100% | 70–100% | 60–100% | 50–100% |
|---|---|---|---|---|---|---|
| Unwrought | 3.46 | 14.82 | 11.19 | 8.65 | 7.16 | 6.09 |
| Primary unwrought aluminum | 14.52 | d.s. | d.s. | 22.22 | 20.35 | 19.00 |
| Secondary unwrought aluminum | 2.46 | 9.62 | 6.98 | 5.66 | 4.79 | 4.14 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: Percentile ranges show production-weighted average of those facilities with the highest emissions intensities that represent that percentage range of production with each respective product category presented.

**Table I.6** Unwrought aluminum products: measures of dispersion for highest measure, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2e$/mt aluminum). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented. ^ indicates the measure of highest emissions intensity for primary unwrought aluminum is shown at the 70–100th percentile range to protect confidentiality.

| Product category | Highest emissions intensity | Standard deviation |
|---|---|---|
| Unwrought | 14.82 | 6.15 |
| Primary unwrought aluminum | 22.22^ | 8.64 |
| Secondary unwrought aluminum | 9.62 | 2.01 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table I.7** Wrought aluminum products: additional percentile ranges for the highest measure emissions intensity, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2e$/mt aluminum). d.s. = data are suppressed to protect confidentiality.

| Product category | National average | 90–100% | 80–100% | 70–100% | 60–100% | 50–100% |
|---|---|---|---|---|---|---|
| Wrought | 6.23 | 17.18 | 14.03 | 12.01 | 10.79 | 9.81 |
| Bars, rods, and profiles | 8.35 | 19.76 | 17.87 | 16.21 | 14.42 | 12.99 |
| Wire | 8.35 | d.s. | 16.11 | 14.47 | 12.68 | 11.45 |
| Plates, sheet, strip | 4.97 | 13.22 | 10.65 | 9.53 | 8.67 | 7.71 |
| Foil | 8.66 | d.s. | 11.80 | 11.40 | 10.53 | 10.00 |
| Tubes, pipes, and tube or pipe fittings | 8.21 | 15.08 | 14.19 | 13.23 | 12.42 | 11.89 |
| Castings | 6.00 | 20.24 | 17.33 | 14.33 | 12.08 | 10.42 |
| Forgings | 5.00 | 10.19 | 8.90 | 8.47 | 8.20 | 7.63 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: Percentile ranges show production-weighted average of those facilities with the highest emissions intensities that represent that percentage range of production with each respective product category presented.

**Table I.8** Wrought aluminum products: measures of dispersion for highest measure, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2$e/mt aluminum). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented. ^ indicates the measure of highest emissions intensity for wire products and foil products is shown at the 80–100th percentile range.

| Product category | Highest emissions intensity | Standard deviation |
|---|---|---|
| Wrought | 17.18 | 3.01 |
| Bars, rods, and profiles | 19.76 | 4.17 |
| Wire | 16.11^ | 3.19 |
| Plates, sheet, strip | 13.22 | 3.33 |
| Foil | 11.80^ | 0.81 |
| Tubes, pipes, and tube or pipe fittings | 15.08 | 1.56 |
| Castings | 20.24 | 3.93 |
| Forgings | 10.19 | 4.81 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

.

# Appendix J
# Data for Figures

**Table J.1** Average and highest emissions intensities, by aggregate steel product category

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented. This table corresponds to figure ES.2.

| Product category | Average emissions intensity | Highest emissions intensity |
|---|---|---|
| Carbon and alloy semifinished | 1.02 | 2.15 |
| Carbon and alloy flat | 1.83 | 3.06 |
| Carbon and alloy long | 0.75 | 1.89 |
| Carbon and alloy tubular | 1.50 | 2.50 |
| Stainless steel | 2.78 | 4.21 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table J.2** Average and highest emissions intensities, by steel product category

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented. This table corresponds to figure ES.3.

| Steel type | Product category | Average emissions intensity | Highest emissions intensity |
|---|---|---|---|
| Carbon and alloy | Semifinished | 1.02 | 2.15 |
| Carbon and alloy | Hot-rolled flat | 1.59 | 2.62 |
| Carbon and alloy | Cold-rolled flat | 1.91 | 3.08 |
| Carbon and alloy | Coated flat | 2.17 | 3.82 |
| Carbon and alloy | Hot-worked long | 0.67 | 1.43 |
| Carbon and alloy | Cold-formed long | 1.25 | 2.62 |
| Carbon and alloy | Seamless tubular | 1.09 | 1.43 |
| Carbon and alloy | Non-seamless tubular | 1.71 | 2.60 |
| Stainless | Semifinished | 2.23 | 3.79 |
| Stainless | Hot-rolled flat | 2.31 | 3.26 |
| Stainless | Cold-rolled flat | 3.08 | 3.76 |
| Stainless | Hot-worked long | 2.93 | 6.27 |
| Stainless | Cold-formed long | 3.55 | 5.52 |
| Stainless | Seamless tubular | 4.07 | 7.85 |
| Stainless | Non-seamless tubular | 3.16 | 4.49 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table J.3** Average and highest emissions intensities of unwrought aluminum, by product category.

In metric tons of carbon dioxide equivalent per metric tons of aluminum (mt $CO_2e$/mt aluminum). ^ indicates the highest estimate is an average of the top emissions-intensive facilities with 30 percent of production. The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented, except for primary aluminum, where the highest includes 30 percent of production because of confidentiality. This table corresponds to figure ES.4.

| Product category | Average emissions intensity | Highest emissions intensity |
|---|---|---|
| All unwrought | 3.46 | 14.82 |
| Primary unwrought | 14.52 | 22.22^ |
| Secondary unwrought | 2.46 | 9.62 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table J.4** Average and highest emissions intensity of wrought aluminum, by product category

In metric tons of carbon dioxide equivalent per metric tons of aluminum (mt $CO_2e$/mt aluminum). ^ indicates the highest estimate is an average of the top emissions-intensive facilities with 20 percent of production. The highest estimate is the production-weighted average of only those facilities with the highest emissions intensities that represent 10 percent of production with each respective product category presented, except for wire and foil products, where the highest includes 20 percent of production because of confidentiality. This table corresponds to figure ES.5.

| Product category | Average emissions intensity | Highest emissions intensity |
|---|---|---|
| Bars, rods, and profiles | 8.35 | 19.76 |
| Wire | 8.35 | 16.11^ |
| Plates, sheets, and strip | 4.97 | 13.22 |
| Foil | 8.66 | 11.80^ |
| Tubes, pipes, and tube or pipe fittings | 8.21 | 15.08 |
| Castings | 6.00 | 20.24 |
| Forgings | 5.00 | 10.19 |
| All wrought | 6.23 | 17.18 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table J.5** U.S. greenhouse gas emissions, by gas, measured in carbon dioxide equivalent ($CO_2e$), 2022

In percentages (%). $CH_4$ = methane; $N_2O$ = nitrous oxide; $CO_2$ = carbon dioxide; HFCs = hydrofluorocarbons; PFCs = perfluorocarbons; $SF_6$ and $NF_3$ = sulfur hexafluoride and nitrogen trifluoride (both fluorinated gases). This table corresponds to figure 1.1.

| Gas | Share of total (%) |
|---|---|
| $CO_2$ | 79.7 |
| $CH_4$ | 11.1 |
| $N_2O$ | 6.1 |
| HFCs, PFCs, $SF_6$ and $NF_3$ | 3.1 |
| Total emissions | 100.0 |

Source: EPA, OAR, “Greenhouse Gas Inventory Data Explorer,” accessed April 11, 2024.

**Table J.6** Share of U.S. greenhouse gas emissions measured in carbon dioxide equivalent ($CO_2e$), by UNFCCC/IPCC sector, 2022

In percentages. This table corresponds to figure 1.2.

| Sector | Share of total (%) |
|---|---|
| Energy | 82.0 |
| Industrial processes and product use | 6.0 |
| Agriculture | 9.4 |
| Waste | 2.6 |
| Total emissions | 100.0 |

Source: EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2022, 2024, ES-16.

Note: The land use, land-use change, and forestry (LULUCF) inventory category is not included in the figure because it was a net carbon sink in 2022 (negative 854.2 million mt $CO_2e$).

**Table J.7** U.S. direct emissions from industrial processes, measured in $CO_2e$, 2022

In million metric tons (mt) $CO_2e$ and percentages (%). n.a. = not applicable. This table corresponds to figure 1.3.

| Industrial process | Emissions (million mt $CO_2e$) | Share of total (%) | Share of metals industry (%) |
|---|---:|---:|---:|
| Iron, steel and metallurgical coke | 40.68 | 10.6 | 87.0 |
| Aluminum | 2.2 | 0.6 | 4.7 |
| Ferroalloy | 1.34 | 0.3 | 2.9 |
| Magnesium | 1.15 | 0.3 | 2.5 |
| All other metals | 1.38 | 0.4 | 3.0 |
| Metals industry | 46.75 | 12.2 | 100.0 |
| Production and use of fluorinated gases | 196.52 | 51.3 | n.a. |
| Mineral industry | 71.43 | 18.6 | n.a. |
| Chemical industry | 68.48 | 17.9 | n.a. |
| Total emissions | 383.18 | 100.0 | n.a. |

Source: EPA, OAR, “Greenhouse Gas Inventory Data Explorer,” accessed April 11, 2024.

Note: The category “production and use of fluorinated gases” encompasses emissions from industries involved in the production of hydrofluorocarbons (HFCs), the primary replacement for ozone depleting substances, among other manmade compounds.

**Table J.8** United States: semifinished steelmaking by process, 2013–22

In thousand metric tons (mt) and percentages (%). This table corresponds to figure 2.1.

| Year | Blast furnace and basic oxygen furnace (thousand mt) | Electric arc furnaces (thousand mt) | Total production (thousand mt) | Electric arc-furnace share of total production (%) |
|---|---:|---:|---:|---:|
| 2013 | 34,236.9 | 52,640.7 | 86,877.6 | 60.6 |
| 2014 | 33,000.2 | 55,173.6 | 88,173.7 | 62.6 |
| 2015 | 29,395.2 | 49,450.1 | 78,845.3 | 62.7 |
| 2016 | 25,887.7 | 52,587.3 | 78,475.0 | 67.0 |
| 2017 | 25,787.9 | 55,824.3 | 81,612.2 | 68.4 |
| 2018 | 27,704.0 | 58,903.4 | 86,607.4 | 68.0 |
| 2019 | 26,590.2 | 61,171.0 | 87,761.2 | 69.7 |
| 2020 | 21,350.0 | 51,380.0 | 72,730.0 | 70.6 |
| 2021 | 26,475.0 | 59,325.0 | 85,800.0 | 69.1 |
| 2022 | 24,985.0 | 55,555.0 | 80,540.0 | 69.0 |

Source: worldsteel, Steel Statistical Yearbook 2023, December 14, 2023; worldsteel, World Steel in Figures 2023, June 7, 2023.

**Table J.9** Greenhouse gas emissions in the global aluminum industry, by process, segment, and sector

In million metric tons (mmt) carbon dioxide equivalent ($CO_2e$). PFCs = perfluorocarbons; $CO_2$ = carbon dioxide. — (em dash) = not applicable. This table corresponds to figure 2.7.

| Process | Segment | Electricity (Scope 1 or 2) | PFCs (Scope 1) | Process ($CO_2$) (Scope 1) | Ancillary materials (Scope 3) | Thermal energy (Scope 1 or 2) | Transport (Scope 3) | All sectors |
|---|---|---|---|---|---|---|---|---|
| Mining | Primary unwrought | 0.3 | 0 | 0 | 0 | 2.6 | 0 | 2.9 |
| Refining | Primary unwrought | 22 | 0 | 0 | 30 | 114 | 16 | 183 |
| Anode production | Primary unwrought | 2 | 0 | 8 | 45 | 6 | 0 | 60 |
| Electrolysis | Primary unwrought | 616 | 52 | 103 | 5 | 0 | 13 | 789 |
| Casting | Primary unwrought | 2 | 0 | 0 | 0 | 4 | 0 | 7 |
| Recycling | Secondary unwrought | 4 | 0 | 0 | 0 | 19 | 0 | 23 |
| Semis production | Wrought | 14 | 0 | 0 | 0 | 22 | 0 | 36 |
| Internal scrap remelting | Scrap | 3 | 0 | 0 | 0 | 9 | 0 | 11 |
| Total | — | 663 | 52 | 111 | 80 | 177 | 29 | 1,112 |

Source: IAI, "Aluminium Sector Greenhouse Gas Emissions for 2022," April 11, 2024.

Note: Products included within "wrought production" may differ slightly from the products included within the "wrought production" category as defined in this report. Internal scrap remelting may occur in primary unwrought, secondary unwrought, or wrought production.

**Table J.10** Map of the Emissions and Generation Resource Integrated Database's (eGRID) 27 subregions and the emissions intensities of their electricity generation

In metric tons of carbon dioxide equivalent per megawatt-hour (mt $CO_2e$/MWh). This table corresponds to figure 3.2.

| eGRID subregion acronym | eGRID subregion name | Emissions factor |
|---|---|---:|
| AKGD | ASCC Alaska Grid | 0.480 |
| AKMS | ASCC Miscellaneous | 0.226 |
| AZNM | WECC Southwest | 0.354 |
| CAMX | WECC California | 0.226 |
| ERCT | ERCOT All | 0.351 |
| FRCC | FRCC All | 0.371 |
| HIMS | HICC Miscellaneous | 0.528 |
| HIOA | HICC Oahu | 0.720 |
| MROE | MRO East | 0.675 |
| MROW | MRO West | 0.428 |
| NEWE | NPCC New England | 0.245 |
| NWPP | WECC Northwest | 0.275 |
| NYCW | NPCC NYC-Westchester | 0.402 |
| NYLI | NPCC Long Island | 0.549 |
| NYUP | NPCC Upstate NY | 0.125 |
| PRMS | Puerto Rico Miscellaneous | 0.726 |
| RFCE | RFC East | 0.300 |
| RFCM | RFC Michigan | 0.555 |
| RFCW | RFC West | 0.456 |
| RMPA | WECC Rockies | 0.513 |
| SPNO | SPP North | 0.435 |
| SPSO | SPP South | 0.442 |
| SRMV | SERC Mississippi Valley | 0.365 |
| SRMW | SERC Midwest | 0.626 |
| SRSO | SERC South | 0.407 |
| SRTV | SERC Tennessee Valley | 0.426 |
| SRVC | SERC Virginia-Carolina | 0.284 |

Sources: EPA, eGRID Mapping Files, accessed August 23, 2024; EPA, “SRL22,” January 30, 2024.

**Table J.11** Total electricity purchases from facilities producing covered steel products, by Emissions and Generation Resource Integrated Database (eGRID) subregion

In gigawatt-hours (GWh). d.s. = data suppressed to protect confidentiality. This table corresponds to figure 4.1.

| eGRID subregion | eGRID Subregion NAME | Purchase quantity |
|---|---|---:|
| AKGD | ASCC Alaska Grid | d.s. |
| AKMS | ASCC Miscellaneous | d.s. |
| AZNM | WECC Southwest | 446.26 |
| CAMX | WECC California | 582.37 |
| ERCT | ERCOT All | 2,813.12 |
| FRCC | FRCC All | 589.46 |
| HIMS | HICC Miscellaneous | d.s. |
| HIOA | HICC Oahu | d.s. |
| MROE | MRO East | 36.76 |
| MROW | MRO West | 1,606.00 |
| NEWE | NPCC New England | 42.33 |
| NWPP | WECC Northwest | 1,460.52 |
| NYCW | NPCC NYC-Westchester | d.s. |
| NYLI | NPCC Long Island | d.s. |
| NYUP | NPCC Upstate NY | 305.90 |
| PRMS | Puerto Rico Miscellaneous | d.s. |
| RFCE | RFC East | 1,668.69 |
| RFCM | RFC Michigan | 989.22 |
| RFCW | RFC West | 22,471.75 |
| RMPA | WECC Rockies | d.s. |
| SPNO | SPP North | 36.93 |
| SPSO | SPP South | 955.12 |
| SRMV | SERC Mississippi Valley | 6,704.65 |
| SRMW | SERC Midwest | 840.82 |
| SRSO | SERC South | 4,795.97 |
| SRTV | SERC Tennessee Valley | 7,172.38 |
| SRVC | SERC Virginia-Carolina | 4,199.79 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 4.1 and 4.2a; EPA, eGRID Mapping Files, accessed August 23, 2024.

Note: Purchased electricity quantities for each subregion aggregate total facility-wide purchases of electricity and include electricity purchased to make noncovered products. The data do not include on-site electricity generation.

**Table J.12** Carbon and alloy steel: emissions intensities of semifinished steel, contributions from upstream materials and the steelmaking process

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). This table corresponds to figure 4.2.

| Upstream materials | Average emissions intensity |
|---|---|
| Pig iron and DRI | 0.555 |
| Ferroalloys | 0.025 |
| Flux materials | 0.065 |
| All other materials | 0.020 |
| Steelmaking | 0.360 |
| Total | 1.024 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Notes: "All other materials" includes metallurgical coke, carbon electrodes, and industrial gases used directly in steelmaking as well as a small quantity of semifinished steel that is remelted for use in producing a different form of carbon and alloy semifinished steel. The emissions values for materials shown in this figure include the total embedded emissions for these materials, including from off-site sourcing (scope 3 emissions) and from on-site production (which may include emissions under all scopes). Total embedded emissions of materials shown in this figure include any emissions from different upstream materials used in the production of the materials shown; for example, the value for "Pig iron and direct reduced iron" includes the emissions from metallurgical coke, flux materials, iron pellets, and iron sinter used in BFs and direct reduced iron facilities. The emissions value for "steelmaking" includes all scope 1 and 2 emissions in the unit process for the production of carbon and alloy semifinished steel.

**Table J.13** Carbon and alloy steel: scopes 1, 2, and 3 contribution to the average emission intensities of semifinished products

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$ /mt steel). BOF = basic oxygen furnace; EAF = electric arc furnace. This table corresponds to figure 4.3.

| Product category | Scope 1 | Scope 2 | Scope 3 |
|---|---|---|---|
| Semifinished | 0.414 | 0.178 | 0.432 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table J.14** Carbon and alloy steel flat, long, and tubular products: emissions intensity of semifinished steel available (sum of U.S. production and imports) for use in production of downstream products, by production pathway

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). This table corresponds to figure 4.4.

| Production pathway | Average emissions intensity |
|---|---|
| BF-BOF | 1.88 |
| EAF | 0.69 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table J.15** Carbon and alloy steel flat, long, and tubular products: scopes 1 and 2 average emissions intensities by subprocess

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). This table corresponds to figure 4.5.

| Subprocess | Average emissions intensity |
|---|---|
| Production of seamless tubular steel | 0.276 |
| Production of non-seamless tubular steel | 0.099 |
| Cold-forming long steel | 0.137 |
| Hot-working long steel | 0.132 |
| Coating flat steel | 0.147 |
| Cold-rolling flat steel | 0.108 |
| Hot-rolling flat steel | 0.156 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: The emissions intensities shown here do not include estimates for the embedded emissions associated with the upstream inputs, regardless of source.

**Table J.16** Carbon and alloy steel: share of imports of semifinished, hot-rolled flat, and hot-worked long steel by country of melt and pour

In percentages. This table corresponds to figure 4.6.

| Product | Country | Share of imports |
|---|---|---:|
| Semifinished | Brazil | 48.3 |
| Semifinished | Mexico | 29.8 |
| Semifinished | Canada | 8.5 |
| Semifinished | All other | 13.4 |
| Hot-rolled flat | Mexico | 11.9 |
| Hot-rolled flat | Canada | 45.3 |
| Hot-rolled flat | Netherlands | 12.1 |
| Hot-rolled flat | All other | 30.6 |
| Hot-worked long | Brazil | 9.7 |
| Hot-worked long | Canada | 14.8 |
| Hot-worked long | Algeria | 8.9 |
| Hot-worked long | All other | 66.6 |

Source: USITC, *Greenhouse Gas Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 5.1.17f, 5.1.18f, and 5.1.13g.

**Table J.17** Carbon and alloy steel flat, long, and tubular products: emissions intensities of U.S.-produced and imported steel products used as substrate, compared with the national average

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). This table corresponds to figure 4.7.

| Product category | Imported steel products used as substrate | U.S.-produced steel products used as substrate | National average of U.S.-produced steel products |
|---|---:|---:|---:|
| Semifinished steel | 1.499 | 1.023 | 1.024 |
| Hot-rolled flat steel | 2.380 | 1.697 | 1.589 |
| Hot-worked long steel | 1.978 | 0.939 | 0.674 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table J.18** Carbon and alloy steel flat, long, and tubular products: scopes 1, 2, and 3 contribution to the average emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$ /mt steel). This table corresponds to figure 4.8.

| Product category | Scope 1 | Scope 2 | Scope 3 |
|---|---:|---:|---:|
| Non-seamless tubular | 0.037 | 0.063 | 1.613 |
| Seamless tubular | 0.223 | 0.236 | 0.635 |
| Cold-formed long | 0.105 | 0.213 | 0.929 |
| Hot-worked long | 0.193 | 0.282 | 0.200 |
| Coated flat | 0.366 | 0.168 | 1.641 |
| Cold-rolled flat | 0.542 | 0.161 | 1.210 |
| Hot-rolled flat | 0.595 | 0.161 | 0.833 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

### **Table J.19** Stainless steel: emissions intensities of semifinished steel, contributions from upstream materials and the steelmaking process

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$ /mt steel). This table corresponds to figure 4.9.

| Upstream materials | Average emissions intensity |
|---|---:|
| Ferroalloys | 1.403 |
| Flux materials | 0.146 |
| All other materials | 0.116 |
| Steelmaking | 0.561 |
| Total | 2.226 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: “All other materials” includes pig iron, direct reduced iron, metallurgical coke, carbon electrodes, and industrial gases used directly in steelmaking as well as a small quantity of semifinished steel that is remelted for use in production of a different form of carbon and alloy semifinished steel. The emissions values for materials shown in this figure include the total embedded emissions for these materials, including from off-site sourcing (scope 3 emissions) and from on-site production (which may include emissions under all scopes). Total embedded emissions of materials shown in this figure include any emissions from different upstream materials used in the production of the materials shown; for example, the value for ferroalloys includes the emissions from upstream materials used in ferroalloy production. The emissions value for “steelmaking” includes all scope 1 and 2 emissions in the unit process for the production of stainless semifinished steel.

### **Table J.20** Stainless steel: scopes 1 and 2 average emissions intensities by subprocess

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). This table corresponds to figure 4.10.

| Subprocess | Average emissions intensity |
|---|---:|
| Production of seamless tubular steel | 1.290 |
| Production of non-seamless tubular steel | 0.330 |
| Cold-forming long steel | 0.262 |
| Hot-working long steel | 0.467 |
| Cold-rolling flat steel | 0.188 |
| Hot-rolling flat steel | 0.161 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

Note: The emissions intensities shown here do not include the embedded emissions associated with the upstream inputs, regardless of source.

### **Table J.21** Stainless steel: emissions intensities of U.S.-produced and imported steel products used as substrate for flat, long, and tubular products, compared with the national average

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). d.s. = data are suppressed to protect confidentiality. This table corresponds to figure 4.11.

| Product category | Imported steel products used as substrate | U.S.-produced steel products used as substrate | National average of U.S.-produced steel products |
|---|---:|---:|---:|
| Semifinished steel | 3.10 | 2.22 | 2.23 |
| Hot-rolled flat steel | d.s. | 2.27 | 2.31 |
| Hot-worked long steel | 3.89 | 2.78 | 2.93 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

### **Table J.22** Stainless steel: scopes 1, 2, and 3 contribution to the average emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of steel (mt $CO_2e$/mt steel). This table corresponds to figure 4.12.

| Product category | Scope 1 | Scope 2 | Scope 3 |
|---|---|---|---|
| Non-seamless tubular | 0.06 | 0.27 | 2.83 |
| Seamless tubular | 0.49 | 0.83 | 2.75 |
| Cold-formed long | 0.28 | 0.44 | 2.83 |
| Hot-worked long | 0.40 | 0.46 | 2.08 |
| Cold-rolled flat | 0.15 | 0.22 | 2.70 |
| Hot-rolled flat | 0.18 | 0.23 | 1.90 |
| Semifinished | 0.16 | 0.40 | 1.67 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

### **Table J.23** Electricity purchases from covered aluminum producing facilities in 2022, by eGRID subregion

In gigawatt-hours (GWh). d.s. = data suppressed to protect confidentiality. This table corresponds to figure 5.1.

| eGRID subregion | Subregion name | Purchase quantity |
|---|---|---|
| AKGD | ASCC Alaska Grid | d.s. |
| AKMS | ASCC Miscellaneous | d.s. |
| AZNM | WECC Southwest | 43.93 |
| CAMX | WECC California | 181.97 |
| ERCT | ERCOT All | 274.58 |
| FRCC | FRCC All | 69.00 |
| HIMS | HICC Miscellaneous | d.s. |
| HIOA | HICC Oahu | d.s. |
| MROE | MRO East | 360.51 |
| MROW | MRO West | 672.57 |
| NEWE | NPCC New England | 44.62 |
| NWPP | WECC Northwest | 427.85 |
| NYCW | NPCC NYC-Westchester | d.s. |
| NYLI | NPCC Long Island | d.s. |
| NYUP | NPCC Upstate NY | 2,527.76 |
| PRMS | Puerto Rico Miscellaneous | d.s. |
| RFCE | RFC East | 2,622.99 |
| RFCM | RFC Michigan | 199.95 |
| RFCW | RFC West | 2,052.53 |
| RMPA | WECC Rockies | 30.98 |
| SPNO | SPP North | 50.68 |
| SPSO | SPP South | 253.59 |
| SRMV | SERC Mississippi Valley | 114.09 |
| SRMW | SERC Mississippi Valley | 4,112.31 |
| SRSO | SERC South | 529.18 |
| SRTV | SERC Tennessee Valley | 7,578.11 |
| SRVC | SERC Virginia-Carolina | 2,634.35 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to questions 4.1 and 4.2a.

Note: Purchased electricity quantities for each subregion aggregate total facility-wide purchases of electricity and include electricity purchased to make noncovered products. The data do not include on-site electricity generation.

**Table J.24** Unwrought aluminum: scopes 1, 2, and 3 contributions to the average emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2$e/mt aluminum). This table corresponds to figure 5.2.

| Product category | Scope 1 | Scope 2 | Scope 3 |
|---|---|---|---|
| Primary Unwrought | 6.049 | 4.999 | 3.468 |
| Secondary Unwrought | 0.260 | 0.057 | 2.140 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table J.25** Scope 3 primary unwrought aluminum emissions, by contributor

In percentages. This table corresponds to figure 5.3.

| Inputs | Share (%) |
|---|---|
| Alumina | 68.4 |
| Calcined pet coke | 21.4 |
| Coal tar pitch | 7.4 |
| Alloy | 2.8 |
| Total inputs | 100.0 |

Source: USITC estimates based on its calculation methodology, see appendix E.

**Table J.26** Wrought aluminum: scopes 1, 2, and 3 contributions to the average emissions intensities, by product category

In metric tons of carbon dioxide equivalent per metric ton of aluminum (mt $CO_2$e/mt aluminum). This table corresponds to figure 5.4.

| Product category | Scope 1 | Scope 2 | Scope 3 |
|---|---|---|---|
| Bars, rods, and profiles | 0.207 | 0.236 | 7.906 |
| Wire | 0.101 | 0.232 | 8.014 |
| Plates, sheets, and strip | 0.157 | 0.215 | 4.598 |
| Foil | 0.354 | 0.359 | 7.945 |
| Tubes, pipes, and tube or pipe fittings | 0.242 | 0.312 | 7.658 |
| Castings | 0.879 | 1.047 | 4.073 |
| Forgings | 0.696 | 0.514 | 3.789 |
| Wrought | 0.226 | 0.281 | 5.719 |

Source: USITC estimates based on its calculation methodology, see appendixes E and H.

**Table J.27** Sources of metal in imported secondary unwrought aluminum

In percentages. This table corresponds to figure 5.5.

| Type of aluminum metal | Source of aluminum metal | Share of total imported secondary metal (%) |
|---|---|---|
| Scrap | All sources | 18.6 |
| Primary unwrought | Canada | 56.2 |
| Primary unwrought | United Arab Emirates | 10.7 |
| Primary unwrought | Bahrain | 3.4 |
| Primary unwrought | All other sources | 4.8 |
| Primary unwrought | All primary unwrought | 75.1 |
| All other or unknown type of metal | All other sources | 6.3 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 5.2.6.f.

Note: Source countries are country of smelt. Totals may not sum to 100 because of rounding.

**Table J.28** Sources of metal in imported wrought aluminum

In percentages. This table corresponds to figure 5.6.

| Type of aluminum metal | Source of aluminum metal | Share of total imported wrought metal (%) |
|---|---|---|
| Scrap | All sources | 4.1 |
| Primary unwrought | Canada | 35.6 |
| Primary unwrought | Oman | 18.1 |
| Primary unwrought | India | 16.6 |
| Primary unwrought | All other sources | 12.3 |
| Primary unwrought | All primary unwrought | 82.5 |
| All other or unknown type of metal | All other sources | 13.4 |

Source: USITC, *Greenhouse Gas (GHG) Emissions Intensities Questionnaire: Facility-Level*, 2024, responses to question 5.2.7.e.

Note: Source countries are country of smelt. Totals may not sum to 100 because of rounding.

**Table J.29** Averages of scope 1 and 2 emissions intensities, by process

In metric tons of carbon dioxide equivalent per metric ton aluminum (mt $CO_2$e/mt aluminum). This table corresponds to figure 5.7.

| Process | Average emissions intensity |
|---|---|
| Anode baking (primary) | 0.19 |
| Electrolysis (primary) | 10.76 |
| Casting (primary) | 0.10 |
| Secondary | 0.32 |
| Wrought | 0.51 |

Source: USITC estimates based on its calculation methodology, see (appendix E) and IAI, "Primary Aluminum Greenhouse Gas for 2022," April 12, 2024.

Note: Shares attributed to each primary subprocess estimated based on shares presented in IAI.