Direct Emissions from Iron & Steel Production
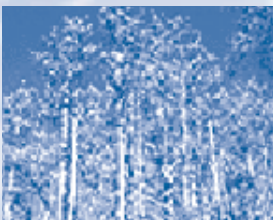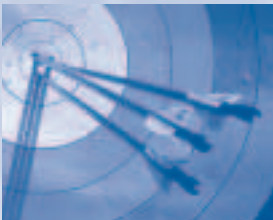
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This Guidance is based on the World Resources Institute and the World Business Council for Sustainable Development's GHG Protocol Initiative

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The Climate Leaders Greenhouse Gas Inventory Protocol is based on the Greenhouse Gas Protocol (GHG Protocol) developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The GHG Protocol consists of corporate accounting and reporting standards and separate calculation tools. The Climate Leaders Greenhouse Gas Inventory Protocol is an effort by EPA to enhance the GHG Protocol to fit more precisely what is needed for Climate Leaders. The Climate Leaders Greenhouse Gas Protocol consists of the following components:

- Design Principles Guidance

- Core Modules Guidance

- Optional Modules Guidance

- Reporting Requirements

All changes and additions to the GHG Protocol made by Climate Leaders are summarized in the Climate Leaders Greenhouse Gas Inventory Protocol Design Principles Guidance.

For more information regarding the Climate Leaders Program, e-mail climateleaders@epa.gov

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Introduction

This guidance outlines how a Climate Leaders Partner company in the iron and steel industry sector would account for greenhouse gas (GHG) emissions from iron and steel production. A Partner that is in the iron and steel industry sector would first define their inventory boundaries per guidance in the *Climate Leaders Design Principles.* A Partner might have a wide range of emission categories based on their inventory boundaries including: stationary combustion, purchased electricity, mobile sources, or HFC emissions from refrigeration/AC equipment use. These emission categories are not all unique to the iron and steel industry and an iron and steel Partner company would estimate emissions from them using the Climate Leaders Core Module Guidance for those specific categories of emissions. However, the iron and steel industry does have some specific issues and categories of emissions that are covered in this guidance.

Production of steel at an integrated iron and steel production plant is accomplished using several interrelated processes including coke production, sinter production, iron production, and steel production. Production of steel can also be accomplished through an electric ark furnace (EAF) using scrap steel as input. Both types of plants would also have operations involving semi-finished steel preparation, finished product preparation, heat and electricity supply, and handling and transport of intermediate and waste materials. Greenhouse gas emissions from most of these processes can be determined using the Climate Leaders guidance on stationary combustion, purchased electricity, mobile sources, etc. as mentioned previously.

Areas where there are specific considerations

for the iron and steel industry include:

- use of carbonate flux (calcination emissions)

- use of secondary fuels produced on site (coke, coke oven gas, blast furnace gas, etc)

- use of carbon electrodes in the EAF process, and

- sales of carbon bearing products off-site (outside the boundaries of an iron and steel company's inventory).

One of the first processes involved in primary iron and steel making is the sinter strand which coverts a raw material mix into a sinter product which is fed to the blast furnace. The feed to the sinter strand consists of raw materials, fluxes, solid fuel (usually coke breeze or coal), and recycled sinter fines from the sinter screening process. The sinter feed mix travels under an ignition hood where the hot combustion gases ignite the solid fuel in the sinter mix to start the sintering process. The fuels used in the ignition hood are usually gaseous fuels, such as natural gas or coke oven gas. Once the fuel in the sinter mix is ignited, the sintering process has begun. The reactions that take place on the sinter strand are not well defined but the process is a source of CO_2 emissions through the potential calcination of carbonate fluxes and combustion of fossil fuels.

Crude iron is produced by the reduction of iron oxide ores in a blast furnace. The combustion of coke, petroleum coke, or coal provides the carbon monoxide (CO) to reduce the iron oxides to iron and provides additional heat to melt the iron and impurities. Carbon dioxide (CO_2) emissions are produced as the coal/coke

is oxidized. Furthermore, during iron production, CO_2 emissions occur through the calcination of carbonate fluxes. Calcination occurs when the heat of the blast furnace causes fluxes containing limestone ($CaCO_3$) and magnesium carbonate ($MgCO_3$) to form lime (CaO), magnesium oxide (MgO), and CO_2. The CaO and MgO are needed to balance acid constituents from the coke and iron ore. Although some carbon is retained in the iron (typically 4 percent carbon by weight), most of the carbon is emitted as CO_2.

Emissions also occur, although to a much lesser extent, during the production of steel. CO_2 emissions occur as carbon present in the iron is oxidized to CO_2 or CO. The produced crude steel has a 0.5 to 2 percent carbon content by weight. Steel may be produced in a basic oxygen furnace (BOF) or an electric arc furnace (EAF). Low carbon steel is produced in a BOF, where a mixture of crude iron and scrap steel (typically 30% scrap and 70% molten iron) is converted in the presence of pure oxygen to molten steel. This process utilizes a jet of high purity oxygen at rates up to 30,000 cubic feet per minute, which oxidizes the carbon and the silicon in the molten iron, removes these products, and provides heat for melting the scrap. Carbon and alloy steels are produced in an EAF, which uses electric heating of scrap steel through graphite electrodes. Additional CO_2 emissions occur as these electrodes are consumed.

Furthermore, several carbon bearing by-products are produced during the iron and steel making process. During coking operations, where coal is converted to coke, the primary by-products are coke, coke oven gas (COG), tar, and residual fuel oil. Blast furnace gas (BFG) is a by-product produced during the production of crude iron. If recovered, the COG and BFG gaseous by-products are considered fuel gases because they contain methane and other hydrocarbon components. These gasses are typically used for oven under-firing and as a combustion gas for the furnaces and boilers used to provide electricity and steam to the plant[1]. All by-products can be used for internal use or sold off-site to other companies.

A simplified carbon balance around iron and steel production can be summarized by the carbon inputs and outputs shown in Table 1. The

Table 1: Carbon Balance around Iron & Steel Production

Carbon Inputs	Carbon Outputs
Coal for Coke	Carbon-Bearing By-Products Sold
Purchased Coke	Carbon in Finished Steel or Iron Sold
Fossil Fuels	CO_2 Emissions
Carbonate Flux	
Carbon in Steel Scrap	
Carbon in EAF Electrodes	

1 Basic oxygen furnace (BOF) gas is another potential by-product gas that can be recovered as a fuel gas. However, this is not done in the U.S. primarily because of economic factors. The low quality of the gas does not warrant the cost of installing the gas collection equipment.

Climate Leaders approach to calculating CO_2 emissions from iron and steel production is to assume all the carbon inputs are converted to CO_2 emissions and to subtract the amount of carbon that remains in products sold off-site.

Table 2 lists the different categories of emissions from iron and steel production and the corresponding guidance for accounting for these emissions under Climate Leaders.

Table 2: Categories of Emissions from Iron and Steel Production

Category of Emissions	Treatment in Climate Leaders
Emissions from use of purchased reducing agent (coal, coke) in blast furnace, sinter strand, EAF, etc.	**Stationary Combustion Guidance** Reported using *Core Module Guidance for Direct Emissions from Stationary Combustion Sources.* The stationary combustion guidance assumes a fraction of the carbon in the fuel combusted remains as ash or soot (default ~1%). When used to report emissions of reducing agent, the fraction oxidized factor should only account for carbon that remains as ash or soot, and not carbon that remains in products or by-products (e.g., BFG, iron).
Emissions from use of reducing agent (coke) produced in on site coke batteries	**Stationary Combustion Guidance** Accounted for by reporting coal used in coke batteries as stationary combustion. For example, if a facility has a coke oven, the coal used to produce coke should be accounted for in the stationary combustion module as if it is combusted directly. The coke itself is not reported if it is produced and used on-site. When using the stationary combustion module to report emissions of coal in coke production, the fraction oxidized factor should only account for carbon that remains as ash or soot, and not carbon that remains in coke by-products.
CO_2 emissions from calcination of carbonate fluxes in sinter strand, blast furnace, EAF, etc.	**Iron and Steel Guidance** Reported using this guidance.
CO_2 emissions from steel production (BOF)	Accounted for by assuming all of the carbon in the reducing agent is released as CO_2.
CO_2 emissions from steel production (EAF) electrode use	**Iron and Steel Guidance** Reported using this guidance.
Emissions from on-site combustion of carbon bearing by-products (COG, BFG, etc.)	Accounted for by assuming all of the carbon in the reducing agent is released as CO_2.
Emissions from combustion of other fossil fuels (e.g., used for on-site power production)	**Stationary Combustion Guidance** Reported using *Core Module Guidance for Direct Emissions from Stationary Combustion Sources.*
Emissions from purchased electricity/steam	**Purchased Electricity Guidance** Reported using *Core Module Guidance for Indirect Emissions from Purchases/Sales of Electricity and Steam.*
Emissions from mobile sources	**Mobile Source Guidance** Reported using *Core Module Guidance for Direct Emissions from Mobile Sources.*
Adjustment of emissions based carbon bearing by-products and steel products sold off-site	**Iron and Steel Guidance** Reported using this guidance.
HFC emissions from refrigeration/ AC equipment use	**Refrigeration/AC Guidance** Reported using *Core Module Guidance for Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Units.*

Methods for Estimating CO_2 Emissions

For purposes of this guidance document, the iron and steel sector is divided into two types of facilities: 1) primary iron and steel plants that produce iron and steel from coal and/or purchased coke and iron ore, and 2) EAF facilities that produce steel from scrap. The following sections present methods for calculating CO_2 emissions from the different facilities.

2.1. Primary Facilities

The method for calculating GHG emissions from primary iron and steel facilities includes calculating emissions from carbonate flux and adjusting stationary combustion emissions to account for carbon sold off-site in carbon bear-ing products and by-products. Emissions of CO_2 from use of the carbonate flux are calculated based on the amount of flux used and the stoichiometric ratio of CO_2 to $CaCO_3$ and $MgCO_3$. The CO_2 emissions from carbon inputs are adjusted to account for the amount of carbon that remains in products sold off-site.

Equation 1 represents the method used to calculate CO_2 emissions from iron and steel production at primary facilities. More explanation of emission factors and default values is provided in Section 3. Not all of the factors shown in the Equation 1 need to be included. For example, if the facility does not sell any by-products then those elements do not need to be considered.

Equation 1: Calculating CO_2 Emissions from Primary Iron and Steel Facilities

$$\text{Emissions} = [(\text{Flux} \times \text{CF}_{\text{Flux}}) - (\text{B-P} \times \text{CF}_{\text{B-P}}) - (\text{Iron} \times \text{CF}_{\text{I}}) - (\text{Steel} \times \text{CF}_{\text{S}})] \times \frac{CO_2 \text{ (m.w.)}}{C \text{ (m.w.)}}$$

where:

Flux	=	Mass of Flux used
CF_{Flux}	=	Flux Carbon Factor $\left(\dfrac{\text{mass C}}{\text{mass flux}}\right)$
B-P	=	Mass or Volume of By-Products Sold
$\text{CF}_{\text{B-P}}$	=	By-Product Carbon Factor $\left(\dfrac{\text{mass C}}{\text{mass or volume of by-products sold}}\right)$
Iron	=	Mass of Iron Sold
CF_{I}	=	Iron Carbon Factor $\left(\dfrac{\text{mass C}}{\text{mass iron sold}}\right)$
Steel	=	Mass of Steel Sold
CF_{S}	=	Steel Carbon Factor $\left(\dfrac{\text{mass C}}{\text{mass steel sold}}\right)$
CO_2 (m.w.)	=	Molecular weight of CO_2
C (m.w.)	=	Molecular Weight of Carbon

The steps involved with estimating iron and steel process related CO_2 emissions from primary facilities are shown below.

Step 1: Determine the amount of carbonate flux used. This should be in terms of pure $CaCO_3$ and $MgCO_3$. Therefore, the total amount of flux used needs to be adjusted for purity.

Step 2: Calculate the flux carbon factor. This is based on the stoichiometric ratio of C to $CaCO_3$ and $MgCO_3$. Default values are given in Section 3.2.

Step3: Determine the amount of by-products sold. The amounts of each separate type of by-product should be listed. These only include what is sold off-site.

Step 4: Calculate the carbon content of by-products sold. Carbon contents should be determined for each type of product sold. Default values are provided in Section 3.2.

Step 5: Determine the amount of iron and steel sold off-site. The amounts of iron and steel should be listed separately by carbon content. Only the amounts sold off-site should be included in this step.

Step 6: Calculate the iron and steel carbon factors. These should be determined for each of the different types of product sold. The carbon content of finished steel should be adjusted for scrap used as process input. The steel scrap input is assumed to have the same carbon content of finished steel.

Step 7: Calculate CO_2 emissions. Plug the values from the previous steps into Equation 1 to get CO_2 emissions.

2.2. EAF Facilities

The method for calculating GHG emissions from EAF steel facilities includes calculating emissions from carbonate flux and use of carbon electrodes. Emissions of CO_2 from use of carbonate flux are calculated based on the amount of flux used and the stoichiometric ratio of CO_2 to $CaCO_3$ and $MgCO_3$. The emissions from use of electrodes in EAF steel production are estimated based on the number of electrodes used and the carbon content of the electrodes. CO_2 emissions from any coke or coal used in the process is estimated using the Climate Leaders Stationary Combustion guidance.

Equation 2 (see next page) represents the method used to calculate CO_2 emissions from steel production at EAF facilities. More explanation of emission factors and default values is provided in Section 3.

The steps involved with estimating iron and steel process related CO_2 emissions from EAF facilities are shown below.

Step 1: Determine the amount of carbonate flux used. This should be in terms of pure $CaCO_3$ and $MgCO_3$. Therefore, the total amount of flux used needs to be adjusted for purity.

Step 2: Calculate the flux carbon factor. This is based on the stoichiometric ratio of C to $CaCO_3$ and $MgCO_3$. Default values are given in Section 3.2.

Step 3: Determine the amount of electrodes used. This could be based on the actual amounts used or could be estimated based on the amount of steel produced.

Step 4: Determine the electrode carbon factor. This is based on the carbon content of

the electrode. If values are not known, Section 3.2 provides a default factor that combines both Steps 3 & 4 based on the amount of EAF steel produced.

Note: EAF facility emissions are not adjusted for carbon in steel sold. It is assumed that the total carbon input in scrap steel is equal to the total carbon output in finished steel produced.

Step 5: Calculate CO_2 emissions. Multiply the values from Steps 1 – 4 with the factor to convert C to CO_2 emissions.

Equation 2: Calculating CO_2 Emissions from EAF Steel Facilities

$$\text{Emissions} = [(\text{Flux} \times CF_{Flux}) + (\text{Electrode} \times CF_E)] \times \frac{CO_2 \text{ (m.w.)}}{C \text{ (m.w.)}}$$

where:

Flux = Mass of Flux used

CF_{Flux} = Flux Carbon Factor $\left(\frac{\text{mass C}}{\text{mass flux}}\right)$

Electrode = Mass of Carbon Electrode used

CF_E = Electrode Carbon Factor $\left(\frac{\text{mass C}}{\text{mass of electrode}}\right)$

CO_2 (m.w.) = Molecular weight of CO_2

C (m.w.) = Molecular Weight of Carbon

Choice of Activity Data and Emissions Factors

This section identifies specific issues related to the choice of activity data (Section 3.1) and factors (Section 3.2) used in the preceding emissions calculations.

3.1. Activity Data

During iron and steel production, the largest CO_2 emissions source occurs as the reducing agent is consumed during iron production. As shown in Table 2, reducing agent emissions are reported as stationary combustion sources. The activity data for this source of emissions is fuel used (coal, coke produced on-site, or purchased coke). The Climate Leaders *Core Module Guidance for Direct Emissions from Stationary Combustion Sources* describes how activity data should be collected for purchased fuels used directly as reducing agents or used to produce reducing agents (i.e., coal used to produce coke).

This guidance deals with other sources of iron and steel production emissions and corrects for carbon from reducing agent fuels that is not released as CO_2. The activity data needed to do this includes the amounts of flux used, by-products sold, iron and steel sold, and electrodes used in the EAF process.

The amount of flux used can be based on purchase records adjusted for beginning and ending inventories or based on metering/monitoring records of actual flux input into the blast furnace over the reporting period. As with combustion emissions, it is important to know the amount of actual flux used in the process and not just what is purchased. Changes in inventory can cause purchases to be different than use over a fixed reporting period (Climate Leaders reporting period is annually). It is also important to know

the purity and make-up of the flux used. If carbon content is based on the stoichiometric ratio of carbon to $CaCO_3$ and $MgCO_3$ then the actual pure amounts of each type of carbonate flux should be determined. If carbon content is based on a Loss On Ignition (LOI) test, pure concentrations are not needed (see Section 3.2).

As shown in Table 1, the emissions for reducing agent use are determined with the stationary combustion module. These emissions are based on assuming all (~99%) of the carbon in the reducing agent is emitted as CO_2. However, this may not be the case if carbon bearing products or by-products of the process are sold off-site. Carbon bearing by-products could include coke, tars, light fuel oil, and COG from the coking process. Carbon from reducing agents could also be contained in the products shipped off-site including iron and finished steel. Therefore, iron and steel emissions are adjusted for carbon in the reducing agents that are not emitted as CO_2. Activity data needed to calculate this adjustment include the quantities of by-products and iron and steel products sold off-site. This data can come from sales records or metering/monitoring results of products shipped.

Activity data for by-products are physically measured in terms of volume (e.g., cubic feet for gas, tons for coke, and gallons for other coke oven by-products). Values can also be expressed in terms of energy units, which more accurately reflect the use of the by-products. Factors in Section 3.2 are given in terms of both volume and energy units. Partners should use the units that best fit their method of tracking activity data.

For the EAF process, CO_2 emissions result from the consumption of carbonate flux and carbon

electrodes in the steel making process. The activity data needed to estimate these emissions is the amount of flux and electrode used. Activity data surrounding use of flux was discussed previously. The estimate of electrode use can be based on measurements of actual quantity of electrode used or from purchase records adjusted for changes in inventory. If electrode use data is not known, a factor can be used based on the amount of EAF steel produced as given in Section 3.2.

3.2. Emission Factors

The factors used to calculate emissions from reducing agents are given in the Climate Leaders stationary combustion module. The calculation of stationary combustion emissions includes a

fraction oxidized factor. The fraction oxidized factor used for calculating reducing agent emissions should not include any adjustments for carbon in coke oven by-products or steel products. These adjustments are handled in this module.

The factors used to calculate emissions from the use of carbonate flux are based on the stoichiometric ratio of carbon to amount of flux. Factors for pure carbonate sources are shown in Table 3. If the amount of pure substance is not known, the amount of flux used can be assumed to be 100% $CaCO_3$ by default. Alternately, a LOI test can be performed on the flux. LOI data represents CO_2 release from the $CaCO_3$ and $MgCO_3$ in the raw flux under high temperature. A carbon factor can be based on the LOI result that takes into account amounts of $CaCO_3$, $MgCO_3$, and any impurities in the raw flux used.

For both reducing agent and flux use, it is assumed that all of the carbon in the fuel or flux is emitted as CO_2. Actually, this is not the case as some of the carbon is retained in by-products and the actual iron and steel products. Total iron and steel CO_2 emissions need to be adjusted for the carbon retained in by-products only if they are shipped off-site. If

Table 3: Carbon Factors for Pure Carbonate Fluxes

Carbonate Flux	Carbon Factor (metric ton C/metric ton flux)
$CaCO_3$	0.12

Table 4: Carbon Factors for Coke Oven By-Products

By-Product	Heat Content (HHV)	Carbon Factor	Carbon Factor
	(MMBTU/short ton)	(kg C/MMBTU)	(kg C/short ton)
Coke	24.8	27.85	690.68
	(MMBTU/barrel)		(kg C/barrel)
Tar	6.636	20.62	136.83
Residual Oil	6.287	21.49	135.11

Sources: Heat content from the Annual Energy Review 2000, DOE/EIA-0384(00), Energy Information Administration, U.S. Department of Energy, Washington, DC August 2001. Carbon content from Emissions of Greenhouse Gases in the United States 2000, DOE/EIA-0573(00), Energy Information Administration, U.S. Department of Energy, Washington, DC November 2001. Values for tar are based on asphalt/road oil, values for coke are based on petroleum coke.

they are combusted on-site then no adjustments need to be made. By-products include products from on-site coking operations and off-gases from the coking and iron production processes. Table 4 shows carbon factors for coking by-products and Table 5 shows the carbon factors for process related off-gases.

Total iron and steel CO_2 emissions also need to be adjusted for the carbon retained in iron and finished steel products that are shipped off-site. In most integrated facilities all the iron produced is used on-site in the production of steel. Adjustments only need to be made if the iron is shipped off-site. Table 6 shows carbon factors for iron and finished steel products.

The carbon emissions from electrode use in the EAF steel making process is based on the amount of electrode used and the carbon content of the electrode. The default method for calculating emissions is to determine the amount of electrode used from measurements or purchase records and multiply by a carbon content of electrode found through measure-

ment or analysis of the electrodes. If either of these vales is not known a default value can be used based on the amount of EAF steel produced. It is assumed that there is 0.0015 metric tons of carbon released from electrodes per metric ton of EAF steel produced[2].

Table 6: Carbon Factors for Iron and Steel Products

Product	Carbon Factor (metric ton C/metric ton product)
Iron	0.04
Finished Steel	0.0032

Sources: Iron carbon content from the Intergovernmental Panel on Climate Change (IPCC) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories,* Chapter 3, Section 3.1.3, page 3.26. Finished steel carbon content from the WRI & WBCSD GHG Inventory Protocol, Iron and Steel Sector Tool. Finished steel carbon content is adjusted for amount of carbon entering the process from scrap steel. It is assumed that steel is produced from 20% scrap. WRI/WBCSD factor of 0.4% carbon in steel is reduced by 20% to account for the carbon in the finished steel coming from scrap.

Table 5: Carbon Factors for Process Related Off-Gases

Type of Gas	Heat Content (HHV) (BTU/ft³)	Carbon Factor (kg C/MMBTU)	Carbon Factor (kg C/1000 ft³)
Coke Oven Gas	500	13.06	6.53
Blast Furnace Gas	95	67.98	6.46

Note: These gases are typically combusted on-site, adjustments only need to be made if they are shipped off-site.

Sources: Heat content of coke oven gas and blast furnace gas from the Annual Statistical Report, American Iron and Steel Institute, 2000. Carbon content from (WRI) & (WBCSD) GHG Inventory Protocol, Iron and Steel Sector Tool.

2 IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Chapter 3, Section 3.1.3

Completeness

An assessment of CO_2 emissions from iron and steel production must be complete from a corporate as well as a facility level basis. From a corporate perspective, the inventory should include emissions from all iron and steel facilities owned, partially owned, or leased by the company. This is addressed in Chapters 2 and 3 of the *Climate Leaders Design Principles* that discusses setting the boundaries of the corporate inventory.

Completeness of corporate wide emissions can be checked by comparing the list of facilities included in the GHG emissions inventory with those included in other emission's inventories/environmental reporting, financial reporting, etc.

The GHG inventory should also be complete at the facility level and include all sources of CO_2 emissions and adjustments for iron and steel production. This includes the use of reducing agent that is reported under the stationary combustion source module and the additional sources and adjustments accounted for under this module. Climate Leaders Partners are required to account for emissions from all iron and steel production sources. In some cases not all sources or adjustments will pertain to them. For example, if they do not export by-products or if they do not have EAF steel production.

Also, given the relative emission contributions of each source, Partners may wish to account for some emissions or adjustments by indicating that they are "not material"[3]. If this is the case, it is recommended that the Partner justify this decision. An example of accounting for coking by-products is shown on the following page.

The inventory should also accurately reflect the timeframe of the report. In the case of Climate Leaders, the emissions inventory is reported annually and represents a year of emissions data. Therefore, the inventory should include all emissions from iron and steel production during the reporting period in order to be complete.

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3   As outlined in Chapter 1 of the *Climate Leaders Design Principles,* there is no specific materiality threshold set for reporting under Climate Leaders. It is up to the individual reporting entity to justify the exclusion of emissions indicated to be not material.

Uncertainty Assessment

There is uncertainty associated with calculating CO_2 emissions from all sources. As outlined in Chapter 9 of the *Climate Leaders Design Principles,* Climate Leaders does not require Partners to quantify uncertainty as +/- % of emissions estimates or in terms of data quality indicators. It is recommended that Partners attempt to identify the areas of uncertainty in their emissions estimates and make an effort to use the most accurate data possible.

Uncertainties in estimating greenhouse gas emissions from iron and steel production result from several factors. The most important piece of information is the mass of reducing agent consumed. The reducing agent accounts for approximately 90 percent of total process emissions. Emissions from reducing agent use are reported under the stationary combustion module.

If adjustments for carbon storage are not included in the analysis, there will be an overestimation of emissions, since it assumes all carbon from the reducing agent is released. Typically, crude iron has a 4% carbon content, and crude steel a 0.5–2% carbon content by weight.

If no account is made for use of plant specific technologies, such as the EAF, which contribute approximately 1.5 kg carbon per ton of steel produced, there will be a slight underestimation of GHG emissions.

Example: Calculation of Coking By-Products

An example calculation assumes that for 1 million metric tons of coke produced per year approximately 50,000,000 ft^3/day of COG, 29,000 gallons/day of tar and 12,500 gallons/day of residual fuel oil are also typically produced[4]. The coke and COG are all assumed to be combusted on-site and the tar and residual fuel oil are sold off-site.

The amount of carbon in the coke is calculated based on factors in the stationary combustion source module and equals ~750,000 metric tons C per year. The amount of carbon in the COG is calculated based on factors in Table 4 and equals ~90,000 metric tons C per year (assuming 285 days/year).

The amounts of carbon in the tar and residual fuel oil are calculated based on factors in Table 3 and equal ~25,000 and ~10,000 metric tons C per year respectively.

Based on these results, and assuming there are no other carbon flows, the amount of carbon sent off-site represents about 4% of the total carbon input to the coking process. Therefore, if by-product sales were not adjusted for in emission calculations of reducing agent use, the emissions would be high by about 4%.

Partners may wish to consider adjustments based on by-product sales to be immaterial. Partners choosing to consider adjustments to be immaterial should document this decision and its supporting emissions estimates.

4 Platts, M., *The Coke Oven By-Product Plant,* American Iron and Steel Institute.

Reporting and Documentation

Partners are required to complete the Climate Leaders *Reporting Requirements* for iron and steel production and report past year emissions annually. Partners should report the data listed in Table 7 below. In order to ensure that estimates are transparent and verifiable, the documentation sources listed should be maintained. These documentation sources should be collected to ensure the accuracy and transparency of the data, but

Partners are not required to provide this data as part of their Climate Leaders data submission.

Adjustments to CO_2 emissions based on carbon-bearing product and by-product exports can only be made if there is verification that the products have been sold. This verification can take the form of sales receipts or contracts.

Table 7: Documentation for Iron and Steel Production Emission Sources

Data	Documentation Source
Reducing Agent/Carbonate Flux	Purchase receipts; delivery receipts; contract purchase or firm purchase records; stock inventory documentation
Crude Iron/Scrap Steel	Stock inventory documentation; delivery and purchase receipts; and operator daily/weekly/monthly production reports
Crude Steel/Crude Iron/ By-Product exports	Purchase receipts; delivery receipts; contracts
By-Product fuel use within facility	Metering documentation

Inventory Quality Assurance/Quality Control

Chapter 9 of the *Climate Leaders Design Principles* provides general guidelines for implementing a QA/QC process for all emission estimates. For iron and steel production sources, activity data and emission factors can be verified using a variety of approaches:

■ Checks should ensure that the best and most accurate emission factors are being used. If custom emission factors are available, are there any significant differences with the default numbers? What methodology was used to compute the company or plant specific emission factors?

■ Plant and company wide activity data should be checked to ensure that there is no double counting, specifically between this sector and the stationary combustion sector if coke and by-products are used for fuel within the facility or company. Only fuels that cross the boundaries of the facili-

ty should be considered. Intermediate products, such as coke, that are combusted should not be included in the stationary combustion source emissions.

■ If coking operations are part of the integrated facility, care must be taken to ensure that only the amount of coal used for coking is used to determine reducing agent consumption emissions. The quantity of coke produced from this process, for use in the blast furnace, should not be included in the calculation. However, if a quantity of coke has been purchased externally from the facility, then it should be included.

■ If coke is produced and transported from one Partner facility to another, checks should be made to ensure that there is no double counting between the two facilities. Namely, that the amount of coke transferred has not been included in the transferring facilities emission inventory.

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