Horizons

S&P Global
Energy

Emissions Guidebook

Center of Emissions Excellence

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Emissions Guidebook

Part 5: Commodity Carbon Intensities

Section 5: PLVHCC Carbon Intensity Quantification Methodology

Multi Region

Version 1.0

Center of Emissions Excellence

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About the Emissions Guidebook

Purpose

Greenhouse gas (GHG) emissions have emerged as a critical metric for governments and investors given an ever-growing focus on establishing transparent frameworks for measuring, reporting, quantifying and ultimately reducing GHG emissions globally. It is of utmost importance that methodologies used by different entities are transparent and clear so different studies and emission estimates can be compared on a like-for-like basis. Without this transparency, emissions estimates have limited utility in the marketplace. The Emissions Guidebook is an evergreen document that provides the market with unparalleled transparency into S&P Global Energy' approach, methodology and key assumptions behind our emissions work. We hope this document can contribute to advancing consistency in GHG emissions accounting.

Context

The Emissions Guidebook is a product of the S&P Global Energy Center of Emissions Excellence. The "Center" is a dedicated team of carbon accounting specialists focused on ensuring consistency, transparency and credibility of emissions data across any emissions offerings.

About S&P Global Energy

At S&P Global Energy, our complete view of global energy and commodity markets enables our customers to make decisions with conviction and create long-term, sustainable value.

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Approach

Overview

This document outlines the detailed methodology and formulae used to calculate a carbon intensity (CI) attribute for Premium Low-Volume Hard Coking Coal (PLVHCC) grade metallurgical (coking) coal. PLVHCC is the main prevailing coking coal benchmark, which represents coking coal with 70% coke strength after reaction (CSR). The PLVHCC assessment consists of coking coal sourced from several mines located in Queensland (QLD) and New South Wales (NSW), Australia. To estimate CI of coking coal contributing to the PLVHCC benchmark, supply chain emissions from each contributing mine to the loading port are accounted. Emission sources included are onsite mining operations, fugitive and vented methane, mine site haulage, processing, coal handling, on-land transport and port operations. It is important to note that the PLVHCC price benchmark is on a free-on-board (FOB) basis; therefore, maritime shipping emissions are not accounted for in the primary assessment but are calculated separately.

Table 1

Primary mines contributing to PLVHCC carbon intensity assessment

Mine/Brand Name	Type	Location	Operator
Goonyella North (Centurion)	Underground	QLD, Australia	Peabody Energy
Goonyella Riverside & Broadmeadow	Open pit & Underground	QLD, Australia	BMA
Hail Creek (GLV)	Open pit	QLD, Australia	Glencore
Illawarra (Appin & Dendrobium)	Underground	NSW, Australia	GM3
Moranbah North	Underground	QLD, Australia	Anglo American
Oaky North	Underground	QLD, Australia	Glencore
Peak Downs	Open pit	QLD, Australia	BMA
Saraji	Open pit	QLD, Australia	BMA
Caval Ridge	Open pit	QLD, Australia	BMA
Capcoal Complex	Open pit & Underground	QLD, Australia	Anglo American

The mines/brands contributing to the benchmark may change and will be duly accounted in the calculations.
Source: S&P Global Energy.
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Key purpose and expected application

S&P Global Energy seeks to provide an independent CI attribute to the PLVHCC coking coal benchmark, providing the industry with an emission benchmark alongside its widely referenced price assessment.

The CI calculated by S&P Global Energy is a weighted average of the individual supply chain carbon intensities of the coal produced from the mines located in QLD and NSW, Australia by its monthly traded volume. Each individual supply chain may differ materially from the weighted average for PLVHCC. Our objective is to serve as an independent resource for industry, investors and buyers to look to and compare their own operations, supply chains and investments against.
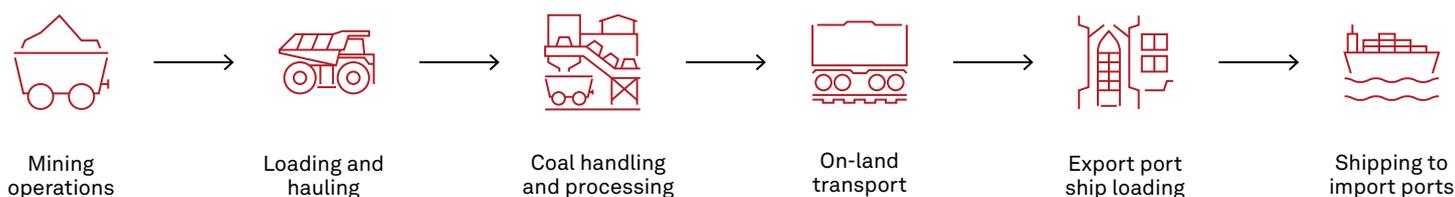
Supply chain emissions accounting

System boundary

Emissions are added over a supply chain of coking coal from the mine to loading terminal (port). The mines contributing to PLVHCC grade are both open pit and underground mines. The operations largely vary between an open pit and underground mining operation. Typically, for an open pit mine, the mined coal and waste rocks are loaded and handled using electric shovels, front-end loaders, excavators and trucks. The waste rocks and coal are hauled to designated locations for further storage and processing. Operations at underground mining sites further differ by method used, with Long Wall and Room and Pillar being the most popular underground mining methods. Post extraction, the mined coal undergoes stages of processing operations including washing, crushing, screening, separation, dewatering, etc., which varies from mine to mine. The processed coal is then transported to the loading port via heavy-duty trucks and/or rail, where the coal is subsequently unloaded at the loading port and loaded into bulk vessels (PLVHCC is an FOB price). Figure 1 shows the system boundary used for emissions accounting.

Figure 1

PLVHCC Supply chain system boundary

| Mining operations | Loading and hauling | Coal handling and processing | On-land transport | Export port ship loading | Shipping to import ports |

Source: S&P Global Energy.
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Units

Functional and reporting unit

A functional unit must be chosen before an assessment is undertaken, and it must be kept consistent throughout the evaluation of each segment of a supply chain. This functional unit is the denominator basis for a GHG intensity calculation. The units of kilograms of carbon dioxide equivalent per metric ton of coal ($kgCO_2e/mt$) are the units of choice for this assessment.

Treatment of coproducts

Mining operations can produce both metallurgical and thermal grade coal simultaneously as coproducts. Emissions are allocated to the coproducts based upon a mass ratio. The overall carbon intensity across the PLVHCC supply chain can be defined by:

$$CI = \frac{kgCO_2e}{mt_{Met\ coal}} = \left(\frac{kgCO_2e\ mining,\ processing\ \&\ transporting\ met\ coal}{mt_{Met+thermal\ coal}} \right)$$

Where, emissions allocated to metallurgical (met) coal based upon mass ratio:

$$kgCO_2e_{Mining, processing \& transporting met coal} = kgCO_2e_{Mining, processing \& transporting coal} \times \frac{mt_{Met coal}}{mt_{Met + thermal coal}}$$

It follows that,

$$CI = \frac{kgCO_2e}{mt_{Met coal}} = \left(\frac{kgCO_2e \ mining, \ processing \& transporting \ coal}{mt_{Met coal}} \right)$$

Following the above equations, it is apparent that both met coal & thermal coal will have the same resulting carbon intensity as per our methodology.

Global warming potential

GHGs emitted into the atmosphere trap heat from the sun and contribute to a rise in global temperatures. Once in the atmosphere, various GHGs can interact with the environment differently and contribute to varying degrees of global warming. This concept is known as global warming potential (GWP). GHG emissions are often expressed in units of mass of carbon dioxide equivalent (CO_2e), with GWPs being used to convert different gases into this comparative basis.

The United Nations Framework Convention on Climate Change (UNFCCC) International Panel on Climate Change (IPCC) publishes Assessment Reports (AR) of GWP. These are typically referenced as AR4, AR5 or AR6. For each GHG, the warming potential of each gas differs by the time horizon that is looked at because each gas has a different lifespan in the atmosphere and ability to absorb energy. The UNFCCC publishes two different time horizons to show short- and long-term effects of GHGs on global warming: 20-year and 100-year. For this work, AR4 100-year GWPs were used to convert emissions to a carbon dioxide equivalent basis, given in Table 2.

Table 2

100-year AR4 Global Warming Potentials of CH_4 and N_2O

Gas	GWP AR4 100-yr
CO_2	1
CH_4	25
N_2O	298

CH_4 = methane; CO_2 = carbon dioxide; N_2O = nitrous oxide.
Source: IPCC Fourth Assessment Report.
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Mine to export port emissions modeling

High-level methodology

To estimate the carbon intensity of coal produced from mines associated with the PLVHCC benchmark, the first step involves gathering mine-level operations information from annual reports, technical documents, S&P Global's proprietary platform (CapIQ ProTM) and reported emission data from regulatory authorities in Australia. The mines in Australia report their emissions under the Australian Clean Energy Regulator's (CER) safeguard mechanism. A major source of onsite emissions associated with coal mines is fugitive and vented methane. S&P Global Energy uses an independent satellite-enabled approach to estimate mine-level methane emissions, which assesses all mines on a level playing field. To estimate total emissions from mines, an in-house emissions estimation model was developed and calibrated against reported data.

The following sections highlight the approach used in our in-house model to calculate emissions from the various mining and processing activities.

Methane venting and fugitives

Methane emissions that result from mining operations can be responsible for more than 50% of the total emissions from extracting coal. Mine methane emissions are derived from daily methane concentration data collected by the Copernicus Sentinel – 5P satellite using the TROPOspheric Monitoring Instrument (TROPOMI) attached to the satellite. S&P Global Energy estimates the methane emission rate with a top-down atmospheric inversion framework using a GEOS-Chem simulation to conduct monthly perturbation analysis of historical emission inventory datasets for each area of interest.

Polygons have been created to encapsulate coal-producing sites that mainly contribute to the PLVHCC grade, while excluding non-coal mining sources such as feedlots or oil and gas fields. The allocation of methane is crucial to this process, as there may be other mines within a polygon that are near the mines of interest but do not contribute to the benchmark. A methodology for allocation has been established to allocate methane volumes among the mines within a polygon, based on their historical emission intensity and production levels.

$$kgCO_2e_{Venting\,\&\,fugitives} = Methane\ rate \left(\frac{ton}{h}\right) \times Hours\ in\ a\ month \times Methane\ allocation\ \% \times GWP_{Methane}$$

Emissions from onsite diesel consumption

Several operations at the mine site are performed with heavy-duty equipment that use diesel fuel. This section describes the methodology followed to estimate fuel consumption for each mining operation. In case reported data is available for diesel consumption in a mine, reported data is used over modeled numbers in emission estimation. The modeled diesel consumption uses specific diesel consumption factors sourced from Environmental Impact Studies (EIS) for underground and open pit operations typical to QLD and NSW. In all cases, an end-use diesel combustion emission factor is used to arrive at the final emissions estimate (denoted as $EF_{Diesel\ Combustion}$).

$$kgCO_2e_{Diesel\ emissions\ of\ mine} = \left\{ ROM\ coal \times Specific\ diesel\ consumption_{Mine\ type\ (underground,\ openpit)} \times EF_{Diesel\ combustion} \right\}$$

Emissions from electricity consumption

Several operations at the mine site are electricity powered. This section describes the methodology followed to estimate electricity consumption for each mining operation. If reported data is available for electricity consumption in a mine, reported data is used over modeled numbers in emissions estimation. The modeled electricity consumption uses specific electricity consumption factors sourced from EIS for underground and open-pit operations typical to QLD and NSW. In all cases, the local electricity grid intensity factor is used to arrive at final emissions estimates per operation (denoted as EF_{grid}).

Onsite operations

Equipment like electric rope shovels, long wall shearers, conveyer belts, processing and handling units use electricity to operate, which are primarily located at or near the mining location.

$$kgCO_2e_{Electricity\ emissions\ of\ mine} = \left\{ ROM\ coal \times Specific\ electricity\ consumption_{Mine\ type\ (underground,\ openpit)} \times EF_{Grid} \right\}$$

Port operations

The port operations comprise reclaimers, screeners, conveyers, etc., for loading and unloading coal from railway wagons/trucks into bulk vessel carriers. The electricity consumed during port operations is calculated using a specific electricity consumption factor and quantity of coal handled. The specific electricity consumption factor is sourced from data published by port operators in their annual technical reports.

$$kgCO_2e_{Loading\ port\ operations} = \left(\left[Specific\ energy_{Port\ operations} \right] \times [Quantity\ of\ coal\ handled] \right) \times EF_{Grid}$$

$$kgCO_2e_{Total\ port\ electricity\ emissions} = \left\{ \sum_{1}^{\#\ Loading\ ports} kgCO_2e_{Loading\ port\ operations} \right\}$$

Net emissions from electricity consumption

The net emissions from electricity consumption are given by:

$$kgCO_2e_{Total\ electricity\ emissions} = kgCO_2e_{Total\ minesite\ electricity\ emissions} + kgCO_2e_{Total\ port\ electricity\ emissions}$$

Transportation emissions modeling

Coal transportation in QLD is primarily performed using electric locomotives, while transportation of coal from some of the mines in NSW to the loading port is achieved using a combination of electric locomotives, diesel locomotives and heavy-duty trucks. This section describes the methodology followed to quantify emissions from each mode of transport used in the coal supply chain.

Railway transport

Emissions from railway transport are estimated by accounting for emissions from diesel or electricity consumption during round-trip journeys to transport coal products from the processing facilities to the maritime export terminals.

A diesel locomotive railway transport emission model considers factors such as: quantity of coal carried, distance, velocity, locomotive specifications, engine characteristics, traction motor characteristics, alternator characteristics and idling characteristics to arrive at the total diesel consumption.

Once the diesel consumption from railway transport operations is estimated, the combustion emission factor of diesel is used to arrive at net emissions from railway transport.

$$kgCO_2e_{Rail\ transport\ emissions\text{-}Diesel} = Diesel\ consumed\ in\ a\ roundtrip\ \times\ No.\ of\ roundtrips\ \times\ EF_{Diesel\ Combustion}$$

Similarly, in the case of an electric locomotive, the model uses factors such as quantity of coal carried, distance, electric locomotive specs, etc., to arrive at the round-trip specific electricity consumption factor.

Once the electricity consumption from railway transport operations is estimated, the grid emission factor of the Aurizon rail network is used to arrive at net emissions from railway transport.

$$kgCO_2e_{Rail\ transport\ emissions\text{-}\ Electric}$$
$$= Specific\ diesel\ consumption \left(\frac{kWh}{ton.km}\right) \times distance \times qty.\ of\ coal\ transported \times EF_{Aurizon\ grid}$$

Truck transport

Emissions from transportation of coal using HDD trucks (20-40 GCM+) is estimated by accounting for emissions from diesel consumption during round-trip journeys to transport iron coal products from the processing facilities to the maritime export terminals.

A specific diesel consumption factor, reported by the Australia Bureau of Statistics (2020), is used to arrive at the total diesel consumption.

Once the diesel consumption from truck-based transport operations is estimated, the combustion emission factor of diesel is used to arrive at net emissions from on-land transport using trucks.

$$kgCO_2e_{Diesel\ HDD\ truck\ emissions}$$
$$= Specific\ diesel\ consumption \left(\frac{L}{ton.km}\right) \times distance \times qty.\ of\ coal\ transported \times EF_{Diesel\ combustion}$$

Maritime transport

S&P Global Energy's proprietary service Commodities at Sea (CAS) is used to determine movement of coal from Australia to China. CAS provides the most comprehensive coverage of near real-time visibility into the waterborne trade volumes of globally traded coal and into freight analytics and fleet metrics. CAS tracks actual volumes of coal shipped along specific routes using different vessel types (Capesize, Newcastlemax, Panamax, etc.) on a twice-daily basis. The data is summarized monthly and used to arrive at the carbon intensity (CI) of shipping ores over a route in a certain month.

The shipping emissions model considers critical factors including route and distance, vessel characteristics (DWT, draught, fuel consumption, etc.), bunkering fuel, vessel speed, idling time, conditions at sea and volume of cargo to estimate the CI of shipping the bulk commodity from loading to the discharge port.

Three major discharge ports are considered based on the volume of iron coal handled historically and port turnover (listed in Table 3).

Table 3

Shipping routes

Route
Delivered Jingtang from Australia
Delivered Qingdao from Australia
Delivered Fangcheng from Australia

Source: S&P Global Energy.
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Final PLVHCC carbon intensity

PLVHCC CI FOB Australia and CFR China
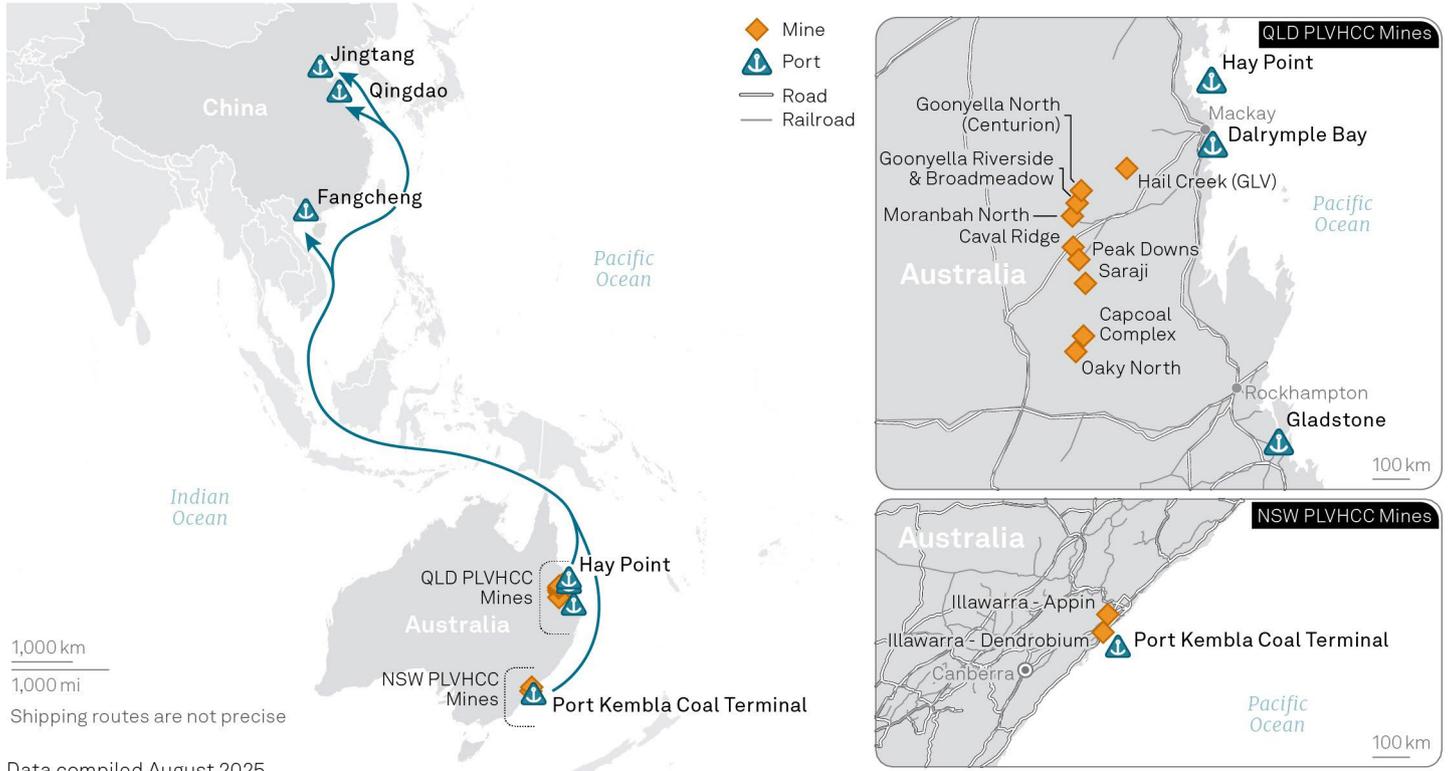
Data compiled August 2025.
Credit: Content Design.
Source: S&P Global Energy.

The computation of PLVHCC-grade metallurgical coal involves two major parts. The first part consists of calculating the supply chain (Mining to Load Port) carbon intensity of metallurgical coal produced in QLD and NSW. The other part involves determining a monthly weightage based on traded volume of shipped coal from ports located in QLD and NSW to across the globe. Since PLVHCC is assessed on an FOB basis, the final PLVHCC CI is a traded volume weighted average of the supply chain (Mining to Load Port) carbon intensity of metallurgical coal produced in QLD and NSW.

Part 1 - The equation represents the supply chain carbon intensity associated with each individual mine operation from mining until the product reaches the load port.

Supply chain CI – Calculated for individual supply chain associated with a mine:

$$CI_{Mine\ n}$$
$$= \frac{\left\{ kgCO_2e_{Venting\ \&\ fugitives} + kgCO_2e_{Onsite\ diesel\ emissions} + kgCO_2e_{Electricity\ emissions} + kgCO_2e_{Onland\ transportation\ emissions} \right\}}{Total\ Production\ (mt)}$$

Once individual supply chain carbon intensities are calculated for every mine. Production-weighted carbon intensity is calculated for of the mines based on their location i.e., QLD and NSW. The following equations represent the carbon intensity of PLVHCC grade coal in both provinces.

Part 2 – The equation represents the methodology used to calculate the weightages based on traded volume of coal produced from the mines of interest in QLD and NSW.

$$CI_{QLD\,PLVHCC\,coal} = \frac{\left\{ \sum_1^{\#\,Mines} CI_{Mine\,n} \times Production_{Mine\,n} \right\}}{\left\{ \sum_1^{\#\,Mines} Production_{Mine\,n} \right\}}$$

$$CI_{NSW\,PLVHCC\,coal} = \frac{\left\{ \sum_1^{\#\,Mines} CI_{Mine\,n} \times Production_{Mine\,n} \right\}}{\left\{ \sum_1^{\#\,Mines} Production_{Mine\,n} \right\}}$$

Weightage of QLD- and NSW-based coal products:

$$W1_{QLD\,PLVHCC\,coal} = \frac{\{\,ton\,of\,PLVHCC\,coal\,exported\,from\,ports\,in\,QLD\,\}}{\{\,ton\,of\,PLVHCC\,coal\,exported\,from\,ports\,in\,QLD\,and\,NSW\,\}}$$

$$W2_{NSW\,PLVHCC\,coal} = \frac{\{\,ton\,of\,PLVHCC\,coal\,exported\,from\,ports\,in\,NSW\,\}}{\{\,ton\,of\,PLVHCC\,coal\,exported\,from\,ports\,in\,QLD\,and\,NSW\,\}}$$

- The QLD ports exporting major volumes of PLVHCC-grade coal include Dalrymple Bay, Hay Point and Gladstone
- The NSW port exporting major volumes of PLVHCC-grade coal is Port Kembla Coal Terminal

PLVHCC FOB CI

The following equation represents the carbon intensity of PLVHCC-grade metallurgical coal that encapsulates emissions from mining, processing, loading and on land transportation to the export/loading port — ready to be shipped across the world.

$$PLVHCC\,CI = CI_{QLD\,PLVHCC\,coal} \times W1_{QLD\,PLVHCC\,coal} + CI_{NSW\,PLVHCC\,coal} \times W2_{NSW\,PLVHCC\,coal}$$

PLVHCC CFR China CI

Additionally, S&P Global Energy also calculates the delivered carbon intensity of PLVHCC grade metallurgical coal to three different ports in China. The maritime shipping carbon intensities are calculated for each shipping route, which is then added to the PLVHCC CI to get the delivered carbon intensity of metallurgical coal delivered to these ports from Australia.

$$PLVHCC\,CI_{delivered\,Qingdao} = PLVHCC\,CI + CI_{Shipping\text{-}Australia\,to\,Qingdao}$$

$$PLVHCC\,CI_{delivered\,Jingtang} = PLVHCC\,CI + CI_{Shipping\text{-}Australia\,to\,Jingtang}$$

$$PLVHCC\,CI_{delivered\,Fangcheng} = PLVHCC\,CI + CI_{Shipping\text{-}Australia\,to\,Fangcheng}$$

Where,

$CI_{Shipping\text{-}loading\ to\ discharge}$

represents the shipping carbon intensity between a given loading and discharge port.

Assessment frequency

The PLVHCC CI is assessed monthly. The carbon intensity of different supply chains is revised quarterly based on the latest available data of each mine of the supply chain. The weightages are calculated monthly based on the volumes of PLVHCC-grade coal shipped across the globe from the mines of interest. Since the shipped coal volumes from Australia vary by month, the weightages are calculated every month. Therefore, the overall intensity also varies monthly.

Appendix A: Overview of S&P Global Products

Commodities at Sea™

Commodities at Sea (CAS) is a service that offers near real-time visibility into the waterborne trade volumes of globally traded commodities such as coal, iron ore and soybeans (among many others) and into freight insights and fleet metrics that together can help clients to:

– Potentially better spot trading signals, competitive insight and strategic alternatives, and

– Better support negotiations, deal-making and operational planning in the physical commodity and freight markets.

Our clients — who are typically commodity or freight traders, analysts, marketers, buyers and procurement teams or chartering managers at miners, traders, utilities, refiners, mill operators, steel makers, investors and more — choose to buy CAS when they discover that our near real-time visibility helps them to better understand, confirm and potentially even anticipate market movements and early reporting signals on market-moving trade reports.

CAS is built with our authoritative, proprietary datasets of ships, berths, ports and AIS vessel positions (each dataset being the most complete of its kind in the world) and the combined research expertise of both our CAS-specific team of market analysts (drawn from industry) and our company's many research teams across disciplines.

Our models start with vessel activity tracking but also integrate third-party datasets from vessel lineups, fixtures, bills of lading and inspection records to help identify the cargoes and company names for voyages and use machine learning-based data science techniques in its predictions of vessel ETAs and destinations.

Appendix B: Reference definitions and data

Glossary of key terms

Table B-1

Glossary of key terms

Term	Definition
AR4	IPCC 4th Assessment Report – referred to for GWPs
AR5	IPCC 5th Assessment Report – referred to for GWPs
AR6	IPCC 6th Assessment Report – referred to for GWPs
Btu	British thermal unit
CER	Australian Clean Energy Regulator
CFR	Cost and freight
CH_4	Methane
CI	Carbon intensity
CMM	Coal mine methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CSR	Coke strength after reaction
DWT	Deadweight tons
EF	Emission factor
EIS	Environmental Impact Statement
FOB	Free on board
Fuel	Gas or diesel that is combusted at a site
GHG	Greenhouse gas
GREET	Greenhouse gases, regulated emissions and energy use in technologies
GWP	Global warming potential
Hp	Horsepower
mt	Metric ton
N_2O	Nitrous oxide
NSW	New South Wales
PLVHCC	Premium low-volume hard coking coal
QLD	Queensland
Qty	Quantity
TROPOMI	TROPOspheric Monitoring Instrument
Wt. Avg.	Weighted average

Source: S&P Global Energy.
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Conversion factors

Mass conversion

Source unit	Equals or denotes
1 kilogram (kg)	2.205 pounds (lb)
1 metric ton (t)	1,000 kg
1,000 grams (g)	1 kg
1 Mt	1 mega metric ton
1 kt	1 kilo metric ton

Volume conversion

Source Unit	Equals or denotes
1 m^3	35.31 ft^3
1 MMcf	1,000,000 ft^3
1 gallon (gal)	3.785 liters (L)

Energy conversion

Source unit	Equals or denotes
1 megajoule (MJ)	1,000,000 J
1 MMBtu	1,000,000 Btu
1 MJ	1,055 MMBtu
1 MWh	3,600 MJ
1 gigajoule (GJ)	1,000 MJ

Source: S&P Global Energy.
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Diesel characteristics

Higher and lower heating value definitions

Higher heating values or gross heating values are obtained by assuming that all water in the combustion products is in liquid form, therefore resulting in more energy availability in the fuel (as the energy to condense the water vapor is included as available energy). Most combustion processes do not condense the water vapor in the exhaust. The lower heating value or net heating value assumes that the water remains vapor in the exhaust. In the work that the Center of Emissions Excellence does for supply chain emission accounting, lower heating values are used to represent carbon intensities of energy commodities such as natural gas, crude oil and natural gas liquids.

Diesel characteristics

Source unit	Equals or denotes
Heating value (LHV)	129,306 Btu/gal
Density	0.85 kg/L

Source: S&P Global Energy.
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