S&P Global Energy

Emissions Guidebook

Part 5: Commodity Carbon Intensities

Section 2: LNG Carbon Intensity Quantification Methodology

Multi-Region

Version 1.0

Center of Emissions Excellence

[emission excellence@spglobal.com](mailto:emission_excellence@spglobal.com)

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.

We're a trusted connector that brings together thought leaders, market participants, governments and regulators, and we create solutions that lead to progress. Vital to navigating commodity markets, our coverage includes oil and gas, power, chemicals, metals, agriculture, shipping and energy transition. Platts® products and services, including the most significant benchmark price assessments in the physical commodity markets, are offered through S&P Global Energy. S&P Global Energy is a division of S&P Global (NYSE: SPGI).

S&P Global is the world's foremost provider of credit ratings, benchmarks, analytics and workflow solutions in the global capital, commodity and automotive markets. With every one of our offerings, we help many of the world's leading organizations navigate the economic landscape so they can plan for tomorrow, today.

For more information visit:
www.spglobal.com/energy

For more emissions information visit:
www.spglobal.com/commodityinsights/en/ci/products/emissions-capabilities.html

Table of contents

Approach

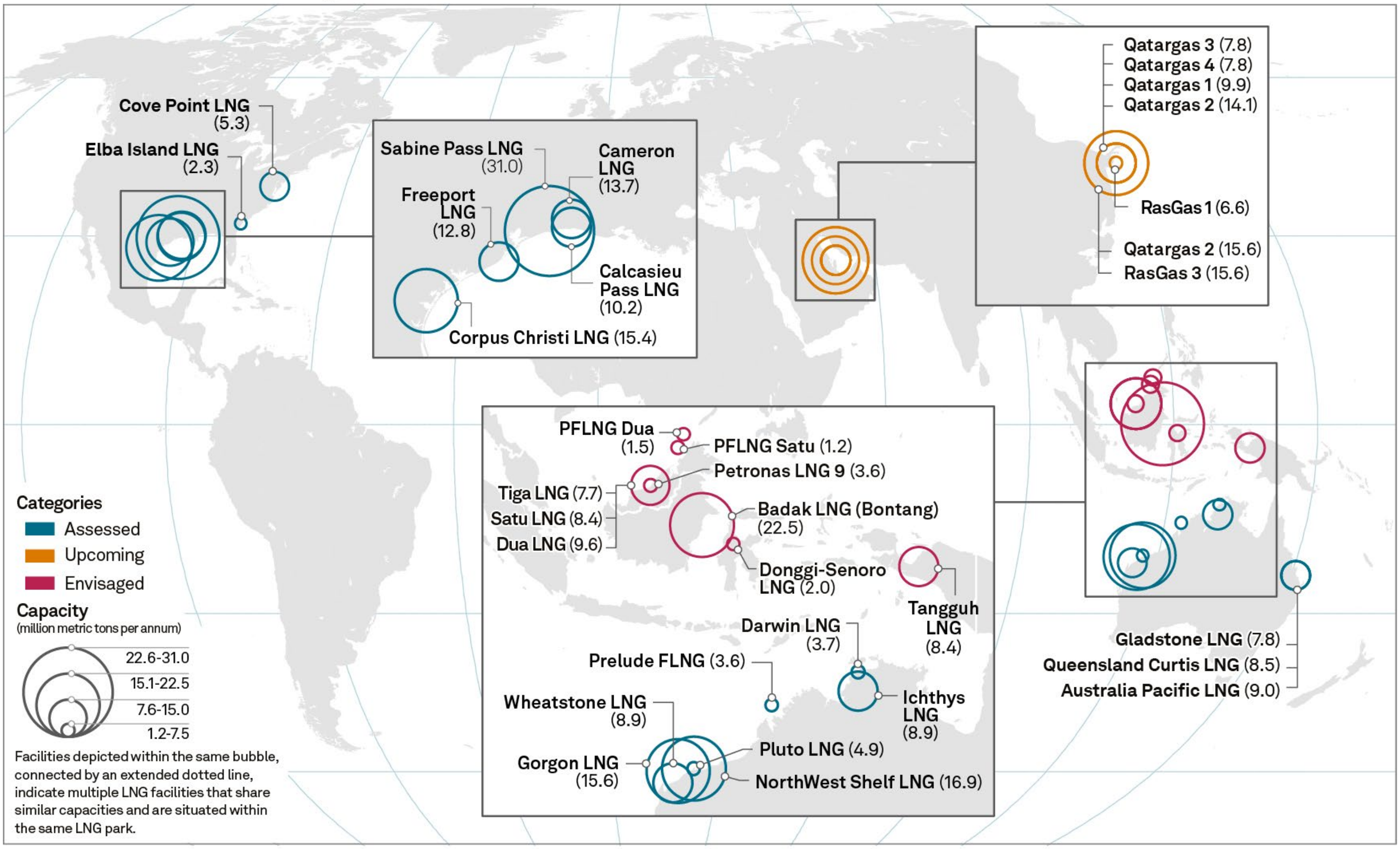
Overview

This document outlines the methodology for calculating absolute emissions and carbon intensities in the LNG value chain, covering production from facilities in the United States and Australia. Emissions from well drilling and completions, production, gathering and boosting, gas processing, transmission and storage and liquefaction are included as well as model extension to include loading, shipping, unloading, regasification and end-use combustion.

Currently, the United States hosts seven major LNG liquefaction facilities: Sabine Pass, Corpus Christi, Cameron, Freeport, and Calcasieu Pass along the Gulf Coast, as well as Cove Point and Elba Island on the East Coast. In Australia, nine key facilities include Gorgon, Wheatstone, Pluto, Northwest Shelf, Ichthys and Darwin in Western Australia, along with Australia Pacific, Queensland Curtis and Gladstone LNG in Eastern Australia. Figure 1 shows the locations of global LNG facilities of which US and Australian LNG facilities have currently been assessed with expansions planned to cover the remaining LNG supply chains in 2025.

Figure 1

Status of LNG facilities being considered for assessment



Data compiled Nov. 17, 2025.
Source: S&P Global Energy: IC-252127-02.

Key purpose and application

S&P Global Energy aims to offer an independent source of LNG carbon intensity for major LNG-exporting countries, serving as an emissions benchmark alongside its price assessment. The country-specific carbon intensities are calculated as the production-weighted average of carbon intensities from individual liquefaction facilities. Any individual liquefaction facility's intensity may vary from the average. Thus, it is essential to emphasize that this work does not aim to quantify emissions from any individual supply chain. Our goal is to act as an independent resource for industry, investors and buyers to reference and compare their operations, supply chains and investments against.

Supply chain emissions accounting

Categorization as integrated or nonintegrated facilities

LNG facilities can be categorized into two types: integrated facilities and nonintegrated facilities. Integrated facilities have their upstream (gas production) and midstream (gas gathering, gas processing and pipeline transportation) operations all integrated with the liquefaction facility under typically the same operatorship. These integrated operations typically have offshore wells integrated directly with either floating LNG facilities or onshore facilities in proximity. In contrast, nonintegrated facilities operate independently, with upstream and midstream components managed by different operators with the liquefaction facility functioning as a separate entity. Approximately 80% of LNG liquefaction facilities worldwide operate nonintegrated, while the remainder are integrated. Below is a table highlighting the key differences between integrated and nonintegrated liquefaction facilities:

Table 1

Differences between integrated and nonintegrated LNG facilities

Integrated	NonIntegrated
Facilities where the entire LNG value chain — from extraction, liquefaction, storage, to distribution — is managed within a single system or complex.	Facilities where different stages of the natural gas supply chain: extraction, gathering and boosting, gas processing, transmission and storage and liquefaction, are owned and operated by separate entities.
There is better control over the quality of feedstock received for processing at the facility.	There is greater flexibility to source LNG feed gas from multiple suppliers, also fostering competitive pricing.
Easier to manage and expand operations due to a single unified framework.	Each entity can focus on their area of expertise. Allows greater flexibility to implement technological upgrades.
Emissions are reported for the entire LNG value chain by the operator as a part of their regulatory or sustainability reporting.	Quantifying emissions is challenging, primarily because it involves examining the operations of separate entities and then aggregating the data.
Examples: Prelude Floating LNG (FLNG), Gorgon (Train 1), and Ras Laffan LNG complex.	Examples: Sabine Pass LNG, Corpus Christi LNG, Northwest Shelf project, Bintulu LNG, and Bonny Island LNG.

Source: S&P Global Energy.

LNG FOB supply chain system boundary

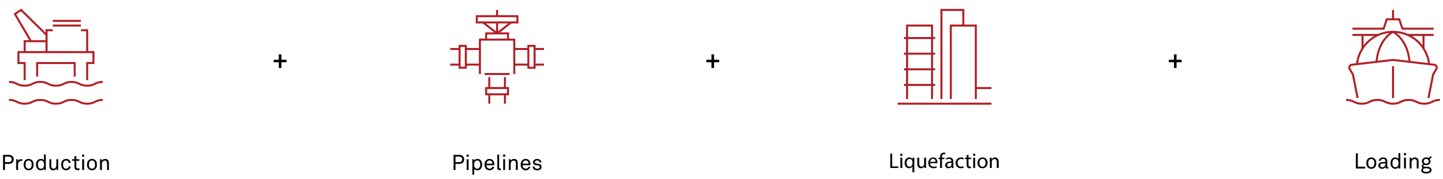
LNG free on board (FOB) carbon intensity includes all upstream supply chain emissions from preproduction (drilling and completions) through to ship loading at the LNG export terminals. Supply chain boundaries vary between integrated and nonintegrated operations.

Integrated LNG

For integrated LNG facilities, the production is typically extracted from offshore wells then piped to the liquefaction facilities. The liquefaction facilities for integrated operations will perform gas pre-processing including acid gas removal. After liquefaction, LNG is loaded as cargo into vessels for marine transport.

Figure 2

Integrated LNG FOB system boundary



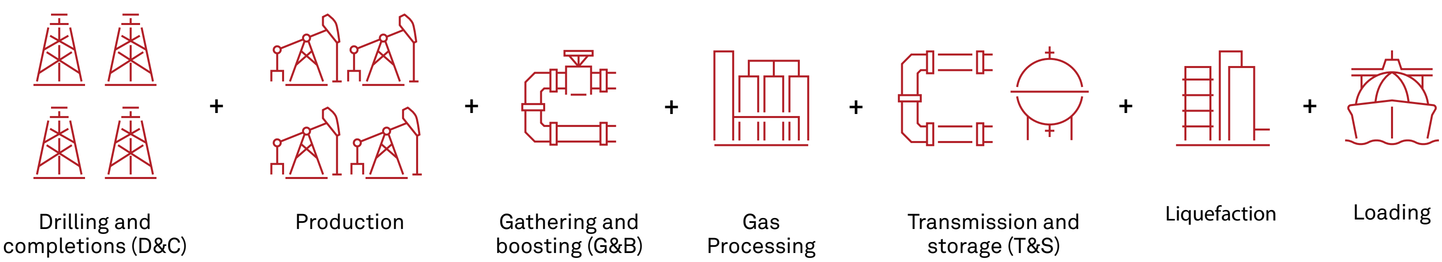
Source: S&P Global Energy.

Nonintegrated LNG

For nonintegrated LNG facilities, natural gas is sourced typically from multiple basins and travels through gas gathering networks through to gas processing plants and then further through transmission pipelines to liquefaction facilities. All segments of the supply chain are operated by numerous distinct operators.

Figure 3

Nonintegrated LNG FOB system boundary



Source: S&P Global Energy.

Units

Functional 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 grams of carbon dioxide equivalent per megajoule, gCO_2e/MJ, are the units of choice for this study. The basis for the energy must also be specified to be on a lower heating value (net calorific value) or higher heating value (gross calorific value) basis. This basis must be specified and kept consistent for each segment of a supply chain. For this study, a lower heating value (LHV) basis was used.

Reporting unit

While the functional unit chosen for this work is gCO_{2e}/MJ (LHV basis), following supply chain quantification, units may be converted to a unit that is commonly understood in the marketplace. For this work, final carbon intensities are reported as units of metric tons of carbon dioxide equivalent (CO_{2e}) per metric ton of LNG ($tCO_{2e}/tLNG$).

Global warming potential

Greenhouse gases (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 CO_{2e}, with GWPs being used to convert different gases into this comparative basis.

The United Nations Framework Convention on Climate Change (UNFCCC) Intergovernmental 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 below:

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; N_2O = nitrous oxide.
Source: IPCC Fourth Assessment Report (AR4).

Treatment of coproducts

Oil and gas are typically coproduced at the wellhead. Additionally, there is variability in the liquids content of all gas streams produced. Some have a large amount of natural gas liquids (ethane, propane, butane) and higher carbon content liquids often characterized as condensates. When we are accounting for a final dry marketable natural gas carbon intensity, we want to apportion to just the natural gas supply chain. This is done by applying an energy ratio to the emissions at each segment of the supply chain.

The energy ratio is defined as:

$$ER = \frac{MJ_{Natural\ Gas}}{MJ_{Natural\ Gas} + MJ_{Oil + NGLs + Condensates}}$$

Methane emissions estimation

Methane emissions are estimated for onshore basins in the United States and Australia with observed data from the European Space Agency's Copernicus Sentinel-5 Precursor satellite equipped with the TROPOMI (TROPOspheric Monitoring Instrument). Methane data is summarized monthly per basin and by province or state if applicable. Basin polygons have been set to encapsulate primarily oil- and gas-producing areas while excluding sources that are not oil and gas related such as feedlots or coal mines.

United States onshore

Satellite methane observation is currently being gathered and processed for 19 basin-state main oil- and gas-producing regions within the United States. In-house data experts ingest the raw data and apply algorithms to quantify mass emissions rates for all areas. Because this observed methane could be attributed to multiple segments along the natural gas supply chain, an attribution methodology was developed to assign a portion of the observed methane emissions within a basin to upstream oil and gas production, natural gas gathering, natural gas processing, natural gas transmission and storage, and distribution. For the US, this attribution was based upon the proportion of US Environmental Protection Agency (EPA) reported[1] methane emissions for each of the segments over the same polygon areas as observed methane is analyzed. The result is a unique set of attribution percentages for each basin. For areas where gridded EPA GHGI data was unavailable, attribution was assumed to follow an average of 58% production, 20% gathering, 8% processing, 10% transmission and storage and 4% other.

Australia onshore

In Australia, onshore natural gas production comes mainly from coal bed methane seams and upstream operations are fairly integrated with midstream operations. Therefore, total observed methane over the area of interest was determined to be more representative of the entire operations and not subsequently divided (or attributed) into upstream and midstream contributions.

Offshore

Offshore basins and shoreline LNG facilities pose challenges when estimating methane emissions due to humidity and cloud cover affecting satellite observations. For these areas, additional data is accessed through partner data suppliers such as GHGSat or InsightM. When no reliable data exists, reasonable assumptions are made for methane leak rates based upon studies or reporting data.

[1] Based upon gridded emissions reported in the 2018 GHGI using the GHGI Version 2 https://pubs.acs.org/doi/10.1021/acs.est.3c05138, "A Gridded Inventory of Annual 2012–2018 U.S. Anthropogenic Methane Emissions," Maasakkers, et al., Oct. 19, 2023.

LNG FOB carbon intensity

Upstream emissions for nonintegrated facilities

This section will cover emissions from all upstream operations related to the liquefaction facility, including gas production, gathering and pipeline transmission to nonintegrated LNG facilities.

Drilling and completions, and production

GHG emissions associated with the development of each well (occurring prior to production) including venting associated with mud degassing, flaring during well testing, and diesel, natural gas or electrical power consumption for drilling and completing each well is estimated.

Total pre-production and production emissions are estimated for each field or basin for each state at the play level and summed to production-weighted average intensities per field. Total volumes of oil and gas produced in the same field are summed, coupled with estimated energy content of each field, and included in the energy ratio (ER) correction factor.

$$gCO_2e_{\,Field,\,D\&C+Prod} = \left\{ \sum_{1}^{\#\,Plays} \left(gCO_{2e_{D\&C+Production}} \times ER_{Prod}\right) \right\}$$

Gathering and boosting

Gathering and boosting emissions are predominately taken from emissions data reported to federal regulatory bodies when available. This reported emissions data is augmented by additional emissions supported by reasonable assumptions regarding electricity imports, comprehensiveness of the dataset, and methane satellite emissions quantified for various basins. Total production volumes from each field coupled with the estimated energy content of each field are used in the ER correction factor.

$$gCO_2e_{\,Field,\,G\&B} = \left\{ \sum_{1}^{\#\,Plays} \left(gCO_{2e_{G\&B}} \times ER_{G\&B}\right) \right\}$$

Gas processing

Gas processing emissions are predominately taken from emissions data reported to federal regulatory bodies when available. This reported emissions data is augmented by additional emissions supported by reasonable assumptions regarding electricity imports, comprehensiveness of the dataset, and methane satellite emissions quantified for various basins. When reported data is unavailable, gas processing emissions are estimated with an internally developed detailed model. Total throughput volumes into each processing plant coupled with the estimated energy content of each throughput are used in the ER correction factor.

$$gCO_2e_{\,Field,\,Processing} = \left\{ \sum_{1}^{\#\,Plays} (gCO_{2e_{Processing}} \times ER_{Processing}) \right\}$$

Transmission and storage

Transmission and storage (T&S) emissions are estimated by using an emission factor derived primarily from reported emissions data for US pipelines and storage areas with methane emissions overlayed from the US average methane emission rate for the T&S segment according to the apportionment methodology described in the section on methane emissions. The applied emission rate is in gCO_{2e}/(MJ-km).

$$gCO_2e_{\,Field,\,T\&S} = \left\{ \sum_{1}^{\#\,Plays} (EF\ CO_{2e_{T\&S}} \times Transport\ Distance \times MJ_{Transported}) \right\}$$

Liquefaction facility emissions

Liquefaction facility emissions are modeled with S&P Global Energy's LNG facility model. The model includes optionality to include gas preprocessing, carbon capture and storage, acid gas removal, liquefaction, and onsite power generation. Equipment specifications are gathered for each LNG facility worldwide to accurately estimate emissions. Emissions associated with flaring, venting and fugitive methane leaks are also included. When available, satellite data for methane emissions and flaring volumes are analyzed and included within the model. When not available, standard assumptions are applied and reported data is collected to fill in the gaps. Scope 2 emissions associated with imported power are also included and allocated at the local grid power emission factor.

Acid gas removal unit (AGRU)

When feed gas arrives at the liquefaction facility from upstream production, it typically contains acid gases of CO_2 and H_2S. The AGRU is a specialized system within the liquefaction facility, and it is responsible for removing acid gases and preparing the gas for cooling by a series of compressors. The estimation of AGRU venting emissions is based on total production and carbon dioxide content in the feed gas.

Liquefaction

The principle of liquefaction employs complex vapor-compression cycles, utilizing various fluids as refrigerants at different stages. Each facility will employ multiple trains to simultaneously liquefy multiple streams of natural gas for export.

The liquefaction process is highly energy intensive, necessitating a reliable baseload power source to operate the compressors within the train. Given their coastal locations, often distant from populated areas, most facilities use on-site gas-based power generation systems.

Power generation

For gas-powered power generation, fuel consumption (MJ) is calculated based on the energy demands of the liquefaction process. Gas turbine models and their rated energy (MW) are obtained from regulatory reports, while the net heat rate (kilojoules per kilowatt-hour, or kJ/kWh) comes from the manufacturer's specifications. These turbines are assumed to operate year-round, but fuel consumption is adjusted proportionally for significant monthly production decreases. The combustion emission factor (EF) is estimated based on the fuel gas composition, with a 5%-10% derating applied to ensure operational reliability and availability.

Carbon capture and storage (CCS)

CCS is integrated into the model as a negative emissions or emission reduction system, primarily capturing reservoir CO_2 linked to produced gas from earth. For facilities with an operational CCS strategy, the most recent annual injection rate (in kilo metric tons per year) is sourced from regulatory or sustainability reports and incorporated into the model. This process reduces the total carbon intensity of the facility by subtracting the carbon intensity of CCS from the overall intensity.

Full FOB supply chain carbon intensity

To obtain the FOB carbon intensities at each export terminal, the emissions from well through to loaded cargo must be added. The denominator basis must be consistent as marketable gas/LNG. Integrated facilities will only have LNG facility and loading emissions components, while nonintegrated facilities will include the upstream and midstream components of supply chains.

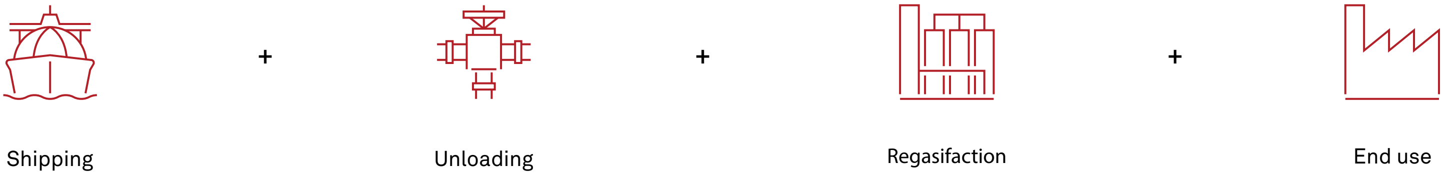
$$CI_{FOB} = \frac{gCO_{2e\,D\&C+Prod}}{MJ_{GAS}} + \frac{gCO_{2e\,G\&B}}{MJ_{GAS}} + \frac{gCO_{2e\,Processing}}{MJ_{GAS}} + \frac{gCO_{2e\,T\&S}}{MJ_{GAS}} + \frac{gCO_{2e\,LNG\,Facility}}{MJ_{GAS}} + \frac{gCO_{2e\,Loading}}{MJ_{GAS}}$$

LNG full life-cycle carbon intensity

LNG exported from various export terminals worldwide is shipped to multiple destinations or import ports. Emissions are further accrued due to shipping, unloading at the import port, regasification at the import location and end-use combustion of the natural gas. S&P Global Energy estimates emissions associated with shipping routes monthly into destination ports of interest, regasification and end-use combustion.

Figure 4

Additional supply chain segments after leaving export terminal (FOB)



Source: S&P Global Energy.

Shipping

Once natural gas is cooled to cryogenic temperatures through liquefaction, LNG is ready for export to global and local consumer markets. The methodology is designed to account for both legs of the shipping journey. The first is the loaded voyage, where the ship transports LNG from the export market to the destination regasification facility. On the return journey, the ship fills its ballast tanks with seawater for stability and returns to its point of origin. Fuel consumption by the vessel's main and auxiliary engines is considered when estimating emissions for both outbound and return journeys.

$$Emissions_{shipping} = (ktCO_2e) = Emissions_{laden}(ktCO_2e) + Emissions_{ballast}(ktCO_2e)$$

S&P Global Energy' shipping model accounts for emissions along specific routes taken, at varying vessel speeds, varying boil-off rates and boil-off management practices, engine configurations and engine fueling as well as fugitive methane emissions during the journey.

Regasification

Upon receiving LNG at import terminals, LNG is converted back to the gaseous form at regasification facilities. The energy consumption and associated emissions vary widely based on the technology employed. The employment of regasification technology often differs by region and facility design. Common regasification technologies include Open Rack Vaporizer (ORV), Submerged Combustion Vaporizer (SCV) and Intermediate Fluid Vaporizer (IFV). The methodology accounts for the variations by calculating regasification emissions based on each distinct regasification facility profile. The facility profiles are collected from energy organization sources and LNG analytics. For hybrid systems, the regasification emissions are estimated proportionally based on the usage and emission factors of each type of vaporizer used.

End use

For end-use applications, such as in power generation, imported natural gas is ultimately combusted. Bespoke end-use combustion emission factors are applied to LNG delivered into a variety of markets depending upon the LNG specifications of those importing regions. For example, the Japan/Korea Marker (JKM) specifications guide specifies a range of energy content, H_2S content and maximum ethane content of the LNG imported. This information is used to determine a combustion emission factor of JKM of 58gCO_{2e}/MJ (LHV basis) or 2.65 tCO_{2e}/tLNG. As additional importing regions are considered, regional differences in LNG import specifications may result in further specifications of bespoke end-use combustion emission factors.

Carbon intensity assessments

FOB

Free on board (FOB) carbon intensity is estimated for each export terminal of LNG according to the following formula:

$$CI_{FOB} = \frac{gCO_{2e\,D\&C+Prod}}{MJ_{GAS}} + \frac{gCO_{2e\,G\&B}}{MJ_{GAS}} + \frac{gCO_{2e\,Processing}}{MJ_{GAS}} + \frac{gCO_{2e\,T\&S}}{MJ_{GAS}} + \frac{gCO_{2e\,LNG\,Facility}}{MJ_{GAS}} + \frac{gCO_{2e\,Loading}}{MJ_{GAS}}$$

Regional weighted average carbon intensities are also produced in various regions. Regional FOB carbon intensity is a weighted average of the LNG produced from all LNG terminals in the region according to the following formula:

$$CI_{FOB\,regional} = \frac{\sum_i^{\#\,LNG\,Facilities}\left(CI_{FOB\,i} \times Prod_i\right)}{Prod_{Total}}$$

FOB + Shipping

Carbon intensities are reported from FOB along multiple shipping routes into import countries. Shipping emissions are weighted by the amount of LNG exported from one export port (e.g., the US Gulf Coast) to an import location (e.g., Japan) from each of the LNG terminals in the export region.

$$CI_{LNG\ Delivered} = CI_{FOB\ regional} + \frac{\sum_{i}^{\#\ Shipments}\left(CI_{Shipping\ route\ i} \times Shipment\ Volume_{i}\right)}{Shipment\ Volume_{Total}}$$

FOB + Shipping + Regasification

Carbon intensities are further built upon to add in the emissions associated with regasification of the LNG imported into specific regions or countries.

$$CI_{FOB\ +\ shipping\ +\ regasification} = CI_{LNG\ Delivered} + \frac{\sum_{i}^{\#\ regas\ Terminals} CI_{regasification} \times Vol_{regas}}{Total\ Vol_{regas}}$$

FOB + Shipping + Regasification + End use

Building on the previous equations and adding in the end-use combustion carbon intensity, the full carbon intensity of the supply chain of LNG is therefore given by the following formula:

$$CI_{supply\ chain} = CI_{FOB} + CI_{shipping} + CI_{regasification} + CI_{end\text{-}use}$$

Assessment frequency

LNG's carbon intensity is assessed monthly, taking into account changes in production data, maintenance schedules, global shipping trades, methane emissions, and flaring emissions.

Appendix A: Overview of S&P Global products and models

Energy Studio IMPACT™

Impact is a comprehensive data-enabled experience for advanced analytics focused on the North American upstream oil and gas supply chain. Energy Studio IMPACT integrates the North America Onshore Upstream model to present dashboard analytics for various parameters of interest including production, GHG emissions and GHG emissions intensity. Results can be presented by basin, operator and play.

It contains GHG emissions estimates for every month — from drilling and completions through operations for every well to the projected end of life and ultimately abandonment — for every well onshore since 1920. The emissions estimates are built on top of S&P Global Energy' extensive upstream data, which are principally sourced from publicly available government and regulatory data. It currently includes over 6 million wells with over 70 distinct variables running over 250 calculations per well to derive an independent estimate of monthly emissions and emissions intensity of drilling and completions and operational emissions by fuel and gas. This tool provides comprehensive estimates of all the activity within a play or basin to understand the full range, distribution, and medium and weighted average of activity.

The model uses detailed well data to estimate the GHG emissions. GHG emissions estimates are based on the estimated energy required during the drilling and completion of a well followed by the production of oil throughout the life of each well. Based on the energy requirements, GHG emissions factors for the appropriate fuels and energy sources are applied for each stage of the process.

EDIN™

EDIN is an interface into our E&P, Basin and global Midstream datasets. It is a web browser solution that provides customers with the most complete industry datasets available. EDIN supports core industry workflows such as country and basin screening, portfolio optimization, prospect evaluation, peer group analysis and country entry strategy. EDIN emission data is primarily sourced from publicly reported data from regulatory reporting in different jurisdictions.

S&P Vantage™

Vantage is an upstream analytical solution that provides economic valuation of both conventional and unconventional global assets (non-North American onshore) with forward-looking production, including detailed capital cost information for over 20,000 global upstream oil and gas assets. Vantage uses the offshore and onshore international models as input as well as data reported to various regulatory jurisdictions. Vantage includes detailed production, emissions and cost metrics.

International upstream oil and gas emissions are estimated at the project level and then rolled up to the asset level. An asset is defined as an entity with a defined ownership structure, associated commercial hydrocarbon resources, and planned or existing investment. An asset can include one or more oil and gas fields or can represent an acreage position with one or multiple planned or existing projects (or phases). Each project within an asset has an independent hydrocarbon production stream and corresponding investment schedule. In some cases, a single asset may include multiple projects, with each project representing a phase or area of development that can be considered as a separate entity or investment decision (such as a program of infield drilling late in the life of a field or an enhanced recovery project). Each project has an independent production and investment stream.

Emissions from these sources are calculated from the volumes or masses combusted (in the case of fuel consumption and flaring) or released to air (in the case of venting and fugitives) using S&P Global standard conversion factors, emissions factors and data on fluid/gas properties.

Vessel database (LNG Analytics)

S&P Global's LNG Analytics provides a vessel database containing technical details of LNG carriers used worldwide for transporting LNG. The database classifies vessels into 12 distinct propulsion types and 15 capabilities, including floating storage and regasification unit (FSRU), floating storage unit (FSU), bunker ships and conventional carriers, among others. The database also dives deep into ships currently under construction and ships due for retirement. This database served as the main source for vessel-specific technical parameters utilized in the shipping emissions calculator.

Trade balance (LNG Analytics)

S&P Global's LNG Analytics tracks LNG cargo trade between import and export markets, including the vessels transporting the cargo. Data is updated daily and pulled into the calculator yearly or monthly, based on user requirements. The vessel name, import and export markets, and LNG volume are sourced from the trade balance database to estimate historical emissions and carbon intensity.

MINT vessel tracker (Market Intelligence)

General data regarding a vessel's main and auxiliary engine size, fuel allocation matrix, available routes, and other operational procedures were drawn from Market Intelligence's vessel tracker. The MINT vessel tracker offers real-time technical and operational information on various commodity vessels at sea, along with historical data for up to one month to review past trades and routes.

LNG liquefaction and regasification infrastructure (LNG Analytics)

S&P Global's LNG Analytics tracks liquefaction and regasification infrastructure worldwide, including both operational and under-construction assets. High-level technical information such as production, capacity, ownership, storage capacity, and shipping berths is monitored for each facility and updated monthly. This data is interactively visualized on a map through the available dashboard.

LNG carbon intensity model

The LNG carbon intensity model offers a comprehensive analytical solution for the supply chain carbon intensity of LNG from equipment level across 14 countries. The model features an accuracy range of 10%-20%, validated against available regulatory datasets. While the model aligns closely with available regulatory data, it has a wider array of emission sources that surpasses standard regulatory reporting. It includes additional emission sources such as venting from acid gas removal units, Scope 2 emissions from imported electricity and methane fugitives. Data underpinning these estimates are predominantly sourced from internal data repositories, publicly available government and regulatory records, and company sustainability reports. The carbon intensity estimates can be delivered monthly. This ensures the estimates are up to date, reflecting the latest operational data for enhanced accuracy.

North America Grid Intensity Dashboard

The Power and Renewables team at S&P Global Energy conducts detailed power system modeling for over 45 electricity markets worldwide. They focus on forecasting key supply and demand metrics to develop a least-cost expansion plan.

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
AGRU	Acid gas removal unit
CH_4	Methane
CI	Carbon intensity
CCS	Carbon capture and storage
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
D&C	Drilling and completions
ER	Energy ratio
Fuel	Gas or diesel that is combusted at a site
Flare	Volumes of hydrocarbons that are flared at a site
FSRU	Floating storage and regasification unit
FSU	Floating storage unit
FLNG	Floating liquefied natural gas production unit
FOB	Free on board
Fugitives	Unintentional methane releases due to leaks
G&B	Gathering and boosting
GHG	Greenhouse gas
GWP	Global warming potential
GOR	Gas-to-oil ratio
LHV	Lower heating values
LNG	Liquefied natural gas
N_2O	Nitrous oxide
NGL	Natural gas liquids
NRU	Nitrogen rejection unit
T&S	Transmission and storage
Vent	Volumes of hydrocarbons that are intentionally vented via pneumatic devices, pneumatic pumps, tanks, compressor seals, dehydrators, blowdowns, etc.

Source: S&P Global Energy.

Conversion factors

Table B-2

Mass conversion

Source unit	Equals or denotes
1 kilogram (kg)	2.205 pounds
1 metric ton (t)	1,000 kg
1000 grams	1 kg
1 Mt	1 mega metric ton
1 kt	1 kilo metric ton

Table B-3

Volume conversion

Source Unit	Equals or denotes
1 m^3	35.31 ft^3
1 Mcf	1,000 ft^3
1 MMcf	1,000,000 ft^3
1 gallon (gal)	3.785 L
1 barrel (bbl)	42 gal
1m^3	6.2898 bbl

Table B-4

Energy conversion

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

Source: S&P Global Energy.

Heating values

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). In reality, 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.

Natural gas heating values

The default fuel gas composition has been assumed to contain 98% methane. The lower heating values and combustion ratios for fuel gas are estimated based on this default fuel gas composition.

Table B-5

Gas composition	Mol %
C_1	98%
C_2	1%
N_2	1%
Total	**100%**

Source: S&P Global Energy.

Table B-6

Fuel Gas LHV	
MJ/kg	**MJ/m3**
49.1	33.9

Source: S&P Global Energy.

CONTACTS

Americas: +1 800 597 1344
Asia-Pacific: +60 4 296 1125
Europe, Middle East, Africa: +44 (0) 203 367 0681

www.spglobal.com/energy
www.spglobal.com/en/enterprise/about/contact-us.html