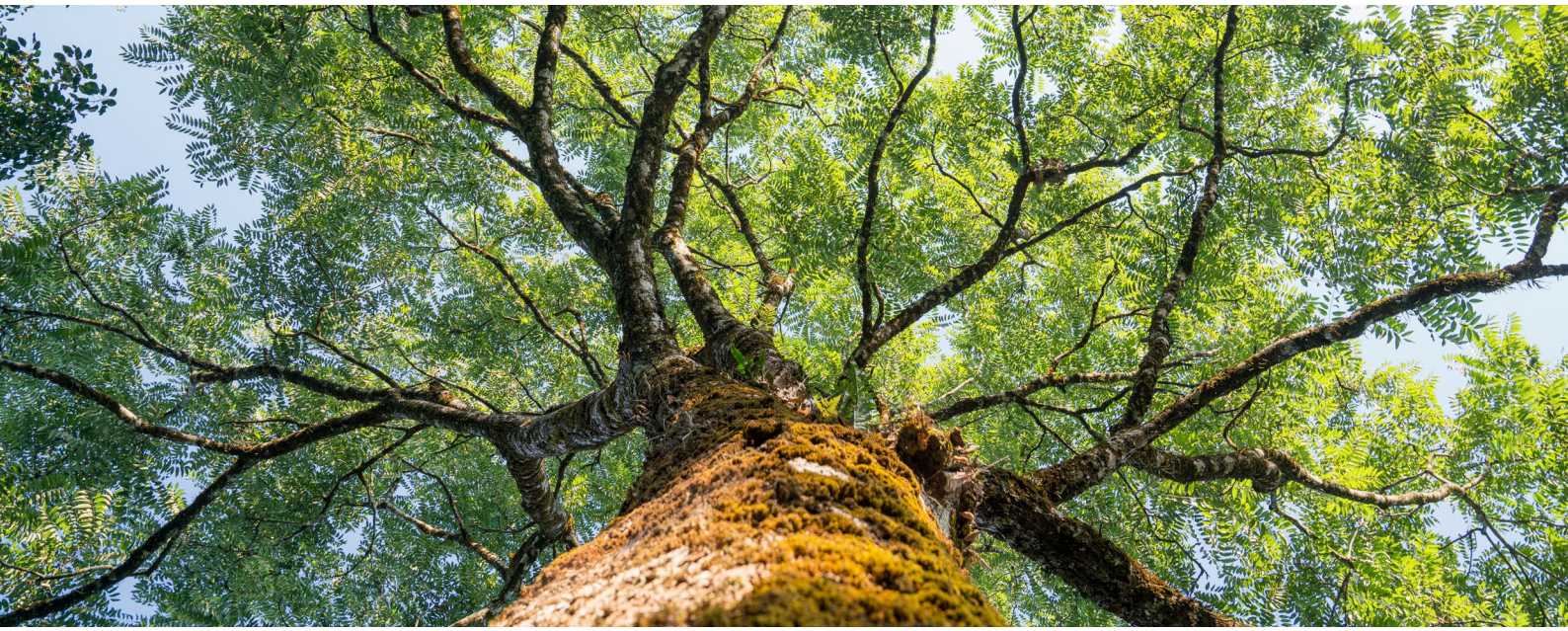
S&P Global
Energy



Emissions Guidebook

Part 4: Models and Products Overview

Version 2.0

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.

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.

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

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S&P Global Energy system boundaries

Asset-level system boundaries

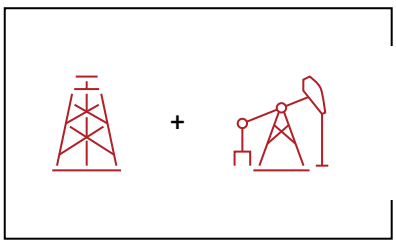
S&P Global Energy has several asset-level emissions datasets and models. The system boundaries for these products are shown in this chapter.

Upstream oil and gas extraction

Upstream oil and gas extraction and production models are available for onshore conventional and unconventional assets, and offshore oil and gas production. The system boundaries for these models and products are primarily the same, with drilling and completions and active production being included within scope. All models include both Scope 1 and Scope 2 emissions. Scope 3 emissions are not included.

Figure 1

Upstream oil and gas non-oil sands system boundary



Onshore conventional/unconventional: includes drilling and completions and active production, Scope 1 and Scope 2 emissions. If applicable, electricity exported is credited against the local annual average electricity grid intensity factor.

Offshore: includes sustained drilling and active production, Scope 1 emissions.

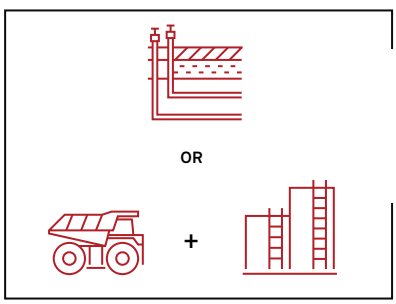
Source: S&P Global Energy.

Oil sands

Oil sands are modeled for three separate types of facilities: 1) thermals (SAGD, CSS), 2) mining and 3) mining plus upgrading. The system boundaries for each of these facility types includes all Scope 1 emissions associated with direct onsite emissions including trucks, mine face fugitives, mine tailings pond fugitives, stationary fuel combustion, flaring, venting, etc. For thermal facilities, sustained drilling operations are also included in Scope 1 emissions. Scope 2 emissions associated with net imported electricity valued at the current average regional grid consumption intensity and net exported electricity credited against the long-run marginal grid intensity, which we currently assume is that of a combined cycle natural gas power plant in Alberta. Downstream Scope 3 emissions are not included.

Figure 2

Oil sands system boundary



Oil Sands: Scope 1 and Scope 2 emissions include sustained drilling for thermal operations (e.g., SAGD), mining fleet and active production, and upgrading. If applicable, exported electricity is credited emissions against local annual average grid intensity of electricity. For integrated mine + upgrading facilities, emissions are included for both the upgrader and mine.

Source: S&P Global Energy.

Crude oil refining

Crude oil refineries are modeled at the asset level and include Scope 1 direct emissions, Scope 2 emissions associated with imported electricity and steam, and Scope 3 emissions associated with purchased hydrogen. Upstream Scope 3 emissions associated with crude oil feedstocks are not included. Likewise, downstream Scope 3 emissions associated with end use of refined products are not included.

Power generation

Individual power plants are modeled for selected regions power dispatch models are run to forecast the quantity of power production from each plant feeding the grid on an hourly basis. Average grid intensities are quantified regionally on an annual basis. Currently, only CO_2 emissions are considered.

Emissions models

S&P Global Energy Emissions Models

North America Onshore Model

S&P Global Energy has developed an in-house model to estimate GHG emissions of North American (Canada and the United States) conventional and unconventional oil and gas operations.[1] 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 in the 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 completions of a well followed by 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. Special considerations are being included in the model for conventional heavy oil, thermal oil extraction and other unique extractive processes.

Drilling and completions

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.

Drilling diesel consumption is estimated based on the number of drill days and daily diesel consumption for drilling estimates. Completions include fuel combustion for hydraulic fracturing, which includes diesel consumption by the frac fleet and by the frac pumps and delivery of sand to well sites. Well testing emissions are estimated using an assumed duration of three hours and the gas-to-oil ratio (GOR) for the well to estimate the volume of gas flared.

Results for drilling and completions can be presented with three options:

- Reported as they occur
- Amortized over 30 years using a straight-line amortization
- Amortized over 30 years using estimated ultimate recovery (EUR)

Production

Production-stage GHG emissions are estimated based on the monthly production profile of each well over its production life. For the Canadian oil sands, this occurs at the asset level. Production emissions include fuel use or electricity consumption for lifting, flaring, venting and well test (once per year). It was assumed that wells begin their life on natural lift for the first six months, then switch to gas lift for two months, and then rely on electric submersible pumps (ESPs) for the remainder of the well life.

[1] Does not include Alaska, US Gulf of Mexico or Canadian offshore production.

Energy for each lift mechanism is based on the production levels of oil, gas and water; water disposal; oil gathering; and gas gathering systems. The energy-use calculation is based on monthly production levels of oil, gas and water; power consumption for the various lift mechanisms; water disposal; oil gathering; and gas gathering levels on a well basis. Using the total estimated energy consumption, emissions are estimated based on the diesel combustion emissions factors and regional grid intensities.

Emissions from gas flared are estimated based on state or province averages (percent of produced gas volumes) generated by regulatory data. Satellite remote sensing data of 19 separate basin assessments are being incorporated to attempt to compensate for fugitive methane emission levels of key plays in North America.

Oil Sands Model

S&P Global has a well-established GHG emissions model for upstream oil sands extraction facilities. The tool consists of two separate models. One is for upstream oil sands in situ operations, which consists of steam-assisted gravity drainage projects (SAGD) and cyclic steam stimulation projects (CSS). Both types of facilities produce bitumen, but market or supply diluted bitumen or dilbit.

The other model covers upstream oil sands mining, which includes integrated mines and unintegrated mines. Integrated mining are facilities with have incorporated heavy oil processing units known as upgraders and market synthetic crude oil (SCO). An unintegrated mine produces bitumen, but markets or supplies dilbit.

S&P Global Energy maintains a detailed oil sands production and supply outlook back to 2005 and forward to 2050 by year. This is used to generate intensity estimates of each extraction method by facility. The model leverages data reported to the Alberta Energy Regulator through statistical reports 39 and 53 as well as data reported to Alberta Environment and Parks related to emissions and cogeneration.

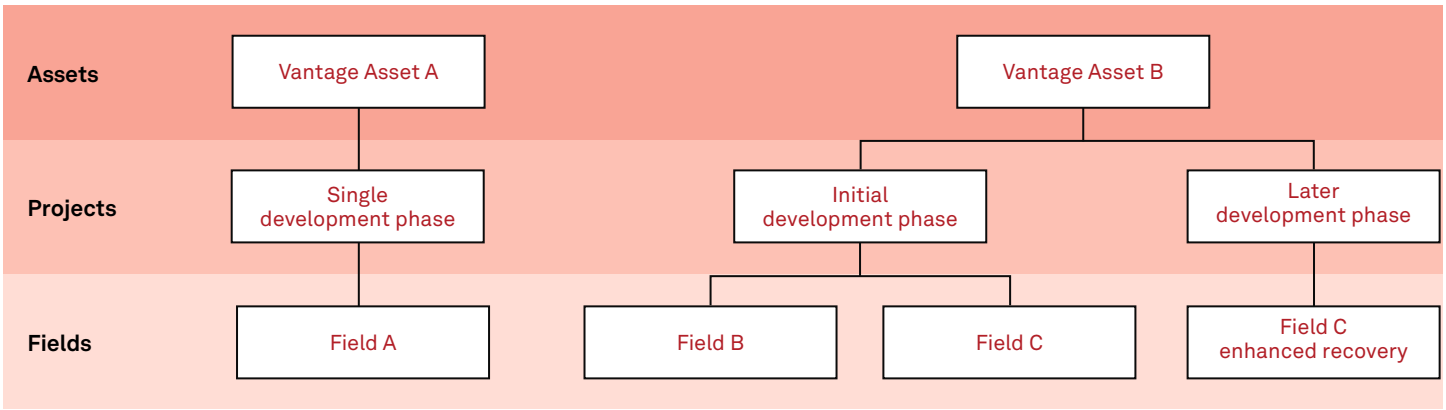
The oil sands model can generate GHG emissions (absolute and intensity) estimates under multiple system boundaries and can be used to develop detailed projections for all thermal and mined crude operations.

International Oil and Gas Model

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 defined ownership structure, associated commercial hydrocarbon resource, 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.

Figure 3

System boundary definitions: International Oil and Gas Model



Source: S&P Global Energy.

Emissions estimates are inclusive of direct emissions resulting from production, processing, maintenance, flaring, venting and fugitive releases. For offshore assets, emissions are estimated for fuel consumption, flaring, venting and fugitive emissions.

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.

Reported data derived from regulatory bodies or corporate public reports are used where available and are representative of the classes listed above. However, in the absence of representative reported data, an estimate is derived from one of the following sources:

- Metrics derived from S&P Global Energy Upstream database — for example, flaring to production ratio or venting to production ratio (with both typically being expressed in thousand standard cubic feet per barrel of oil equivalent)
- Analogue data
- Calibrated QUE$TOR™ fuel volumes
- Remote sensing data from Earth Observation Group's annual satellite flaring volumes
- Satellite methane data from Orbio Earth for methane vented volumes where data exists

Historical estimates use reported data where available. Data gaps are filled by metrics derived from data for the asset if available. If asset-specific data are not available, then the model will default to metrics from a suitable analogue.

Projected estimates for producing assets are an extrapolation of recent emissions as a proportion of production. In some cases, and where possible, S&P Global completes custom modeling/forecasting based on researched intelligence, for example, for electrification projects offshore Norway. In such cases, projected emissions have been adjusted to reflect the operator's plans to offset fuel combustion emissions by electrification.

Future emissions of relatively new or forthcoming assets (i.e., those that are newly discovered and/or appraised/under appraisal, but yet to start production) utilize fuel consumption estimates from the QUE$TOR software tool. Flaring, venting and fugitive emissions are estimated from analogue metrics.

Refining Emissions Model

S&P Global Energy has developed a detailed global refining emissions model. The model accounts for refining industrial process emissions as well as combustion, flaring and venting emissions of carbon dioxide, methane and nitrous oxide. The emissions calculation is a balance of bottom-up chemical engineering validated by top-down reported emissions data from various sources such as the EPA.

Scope 1 emissions are quantified for stationary fuel combustion, process generated emissions such as from the fluidized catalytic cracking (FCC) coke combustion, reformer or from catalytic cracking, hydrogen generation, and venting and fugitive emissions. Scope 2 emissions are included as imported emissions from the regional power grids. Scope 3 emissions from indirect hydrogen production for all imported hydrogen are also included in the model. The model predicts emissions at the facility level and also has the capability to report product-specific emissions intensity per refinery product produced.

Methane Inversion Model

S&P Global Energy' methane emissions data is derived from daily methane concentration data collected from the European Space Agency's Copernicus Sentinel-5P satellite using the TROPOspheric Monitoring Instrument (TROPOMI). S&P Global Energy estimates the methane emission rate with a top-down analytical inversion framework. Perturbation of prior inventory emissions is performed on each pixel in the automated optical inspection (AOI) to produce a Jacobian matrix describing the sensitivity of concentration to emission rate. Then simulated concentrations using 3D atmospheric chemical transport model GEOS-Chem (with real-time meteorological features and wind conditions also taken into consideration) are compared with TROPOMI observations, and inversion is performed to optimize for the posterior emission rate. Finally, pixel-wise emission rates are aggregated according to their area of intersection with oil and gas well dense polygons to arrive at basin-level monthly emission rates.

Open-source models

OPGEE

OPGEE (Oil Production Greenhouse Gas Emissions Estimator) is a well-known, open-source, Microsoft Excel–based tool developed at Stanford University to estimate GHG emissions associated with upstream drilling, development, production and transport of crude oil for processing. S&P Global Energy has used OPGEE in various studies (The Right Measure) and in current crude carbon intensity assessments for pricing. We also use some portions of OPGEE such as land-use change factors in various studies.

USEEIO

S&P Global Energy typically does not include fabrication and construction emissions in its estimates. However, when appropriate, it does so using the United States Environmentally Extended Input-Output (USEEIO) model. EEIO models use broad sector averages and correlations between economic activity and environmental impacts to assess potential environmental impacts associated with incremental economic activity. The method is simple to apply and provides comprehensive coverage, while requiring relatively little input data (e.g., economic value). The EEIO model makes use of capital expenditure to arrive at an estimate of fabrication and construction GHG emissions. Capital cost information is obtained from several sources.

PRELIM

Petroleum Refinery Life-cycle Inventory Model (PRELIM) from the University of Calgary is a Microsoft Excel–based tool that estimates the energy use and GHG emissions associated with processing crude oil in a range of refinery configurations. PRELIM requires users to enter numerous inputs to develop GHG estimates. S&P Global Energy has used PRELIM to estimate refining emissions in various studies in the past (The Right Measure), as well as in our current end-use fuel carbon intensities.

GREET

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model is a model that analyzes various fuel life-cycle pathways for the transportation sector and was developed by the US Argonne National Laboratory. It is the model that is used as a basis for assessing life-cycle carbon intensities that can be compared to the California Low Carbon Fuel Standard to assign credits or assess compliance. S&P Global uses emissions factors from this model for assessing emissions associated with transportation as well as in work to assess the carbon intensity of biofuels and biofuel feedstocks.

Overview of S&P Global offerings

Energy Studio IMPACT

IMPACT is a comprehensive data-enabled experience for advanced analytics focussed 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. This offering is part of our United States Upstream service packages.

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. This offering is part of our International Upstream service packages.

Refinery Cost & Margin Analytics

Refinery Cost & Margin Analytics (RCMA) provides S&P Global detailed refinery modeling for refinery benchmarking. RCMA provides clients with the complete S&P Global refining and marketing forecast scenario including crude and product supply balancing. RCMA includes cost forecasting as well as comprehensive GHG emissions data, which is also used to assess compliance costs associated with various carbon policies worldwide.

Refinery and Petrochemical Integrator and Decarbonizer

The Refinery and Petrochemical Integrator and Decarbonizer (RAPID) tool is a Microsoft Excel–based tool through which a user can assess emissions and costs associated with various refinery and petrochemical plant configurations and feedstocks. It provides a consistent dataset related to refinery and chemical process technologies, bio and energy feedstocks, product prices and CO_2e variable costs. It also allows users to interact with S&P Global process economics models and input their own assumptions to update the model in real time.

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. This offering is part of our International Upstream service package.

Corporate Emissions Solution

The S&P Global Corporate Emissions Solution (CES) provides standardized data and analytics on GHG emissions across the energy value chain and industrial sectors to assess climate risks, evaluate investment decisions and benchmark decarbonization performance.

The Corporate Emissions database leverages multiple public and proprietary data sets to create a single GHG emissions dataset beginning at the facility level. In countries and regions where historical regulatory data exists (United States, Canada, European Union, United Kingdom, Norway and Australia), we use the regulatory reported data for our historical source of truth and integrate proprietary estimates from S&P Global industry models. CES ingests model outputs from Energy Studio IMPACT, Vantage and EDIN™ to provide a total emissions profile on a company basis.

Where reported data are not available for facilities, S&P Global Energy estimates these emissions based on engineering principles, which are validated and calibrated against the reported data. Additional satellite data from the Earth Observation Group are used to derive facility-level flaring volumes. All these data are aligned with Energy' facility-level ownership information to derive portfolio-, sector-, and corporate-level emissions. This offering is part of the Carbon and Scenarios service package.

Carbon intensity and carbon accounted assessments

As organizations and countries across the globe continue toward their net-zero carbon goals and commitments, markets across the commodity landscape have seen an increasing need for reliable and market reflective carbon intensity and carbon accounted pricing and insights. S&P Global Energy is uniquely positioned to provide participants with the timely pricing information needed to confidently navigate these dynamic markets. We produce carbon intensity assessments for a variety of commodities, including:

- Crude Oil and Refined Products
- Liquefied Natural Gas (LNG)
- Methane
- Natural Gas
- Iron Ore
- Methanol

These assessments are available in the Carbon and Scenarios service package, as well as within each service package for each respective commodity.

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