Sustainable1

S&P Global Energy: Emission Factor Library

Methodology

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S&P Global
Energy

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Terms and Definitions

Term	Definition
Greenhouse gases (GHG)	Greenhouse gases are gases that trap heat in the Earth's atmosphere, contributing to the greenhouse effect and global warming. The main greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.
CO_2e	A standardized metric used to compare greenhouse gas emissions based on their global warming potential (GWP), expressed as the equivalent amount of carbon dioxide.
Global warming potential (GWP)	A factor representing the warming impact of a greenhouse gas relative to CO_2 over a specified time horizon.
Scope 1	Direct GHG emissions from sources owned or controlled by the reporting entity.
Scope 2	Indirect GHG emissions associated with the generation of purchased or acquired electricity, steam, heat or cooling consumed by the reporting entity.
Scope 3	All other indirect GHG emissions not included in Scope 2 that occur in the reporting entity's value chain, including upstream and downstream emissions.
Emissions	Release of greenhouse gases (GHGs) into the atmosphere. Limited to GHGs and excludes pollutants such as SOx and NOx.
Emission factor	A coefficient that converts activity data into an estimate of greenhouse gas emissions for a defined activity, commodity, sector, geography or time period.
Emissions intensity	Ratio of total GHG emissions to a unit of activity, output, energy, production or revenue, such as gCO_2/kWh, gCO_2e/MJ, tCO_2e per ton of product, or tCO_2e per million units of revenue.
Emissions source	Process that releases GHGs into the atmosphere.
Functional unit	The denominator basis for the emissions intensity calculation, such as revenue, electricity consumed, energy content, or physical production.
Megajoule (MJ)	A unit of energy used by selected commodity, fuel, and energy-based factors.
Barrel of oil equivalent (boe)	A unit used to express energy production or output on an oil-equivalent basis for selected production-based factors.
Kilowatt-hour (kWh)	A unit of electrical energy equal to one kilowatt of power used for one hour. Power Grid Emission Factors are typically expressed in gCO_2/kWh.
Higher heating value (HHV)	Higher heating value (gross heating value) assumes water in combustion products is in liquid form resulting in more available energy.
Lower heating value (LHV)	Lower heating value (net heating value) assumes water remains vapor in the exhaust.
System boundary	Defines which emissions sources and/or lifecycle stages are included in a factor (e.g., well to hub, end-use combustion, or asset-level emissions for a specific refinery or LNG plant).

Term	Definition
Location-based Scope 2 emissions	Scope 2 emissions calculated using average grid emission factors for the geography where electricity consumption occurs.
Market-based Scope 2 emissions	Scope 2 emissions calculated using contractual electricity instruments or supplier-specific electricity information, where applicable, rather than average location-based grid factors.
GICS	Global Industry Classification Standard.
NACE	Statistical Classification of Economic Activities (in the EU).

Introduction and Context

The S&P Global Emission Factor Library (EFL) provides a centralized set of emission factors designed to help users estimate greenhouse gas emissions (GHGs) from common business activity data, including revenue, electricity consumption, energy use, commodity exposure and physical production volumes.

The EFL brings together emission factors from S&P Global Sustainable1 and S&P Global Energy datasets under a consistent and transparent framework. The objective is to support consistency, traceability and ease of use across emissions estimation workflows.

This document provides an overview of the EFL methodology and explains the datasets included in the current release. It summarizes how each emission factor category is intended to be used and directs users to relevant source-specific methodology documents for detailed calculation methods, model inputs, system boundaries, assumptions and limitations.

Users should select the factor that best matches their available activity data, geography, time period and emissions boundary. While this document provides a consolidated overview, the source-specific methodology documents and factor-level metadata should be treated as the authoritative reference for each emission factor category.

Coverage and Scope

The current EFL release includes four primary emission factor categories. The EFL is designed to expand over time. Future releases may include additional emission factor categories using the same standardized approach: (i) define the factor's scope and boundary, (ii) document the methodology, (iii) publish factor-level metadata, and (iv) reference the relevant detailed methodology within this overview document.

Dataset	Purpose	Primary unit / functional unit	Typical factor grain
GICS/NACE sector-average factors	Revenue-based sector-average factors used when revenue or spend data is available and more granular operating data is not available	tCO_2e per USD million revenue for GICS; tCO_2e per EUR million revenue for NACE, where applicable	Sector, geography and year
Commodity & Fuel Emission Factors	Commodity, fuel and supply-chain pathway-specific factors, including supply-chain carbon intensity, methane intensity, end-use combustion, and lifecycle factors	Energy-based units, such as gCO_2e/MJ or gCH_4/MJ on a lower heating value (LHV) basis	Commodity or fuel and year
Production-based asset-derived factors	Production-based factors derived from asset-level emissions and production data associated with the Emissions Performance Analytics Factors dataset	Sector-specific units such as $kgCO_2e/boe$, gCO_2e/MJ, or tCO_2e per ton of product, depending on the sector	Subsector, primary product where applicable, geography and year
Power Grid Emission Factors	Average electricity generation emission intensity factors for defined geographies, intended primarily for location-based Scope 2 calculations	gCO_2/kWh	Geography and year

Data Sources and Collection

The EFL brings together outputs from several S&P Global datasets. The underlying data sources vary by emission factor category and may include disclosed company data, estimated company environmental data, regional power market models, commodity supply-chain models, regulatory-reported emissions, proprietary asset datasets, production data, satellite-informed observations and public reference factors.

This overview summarizes source categories at a high level. Detailed source lists, model names, data treatment, and calculation assumptions are provided in the source-specific methodology documents referenced later in this document:

Source category	Use in EFL
S&P Global Sustainable1 Trucost Environmental data	Used for GICS and NACE revenue-based sector-average factors
S&P Global Center of Emissions Excellence	Used for commodity and fuel factors, including specific natural gas, LNG, crude, methanol, methane, and combustion factor pathways
Emissions Performance Analytics	Used as the detailed methodology reference for production-based asset-derived factors
S&P Global Energy regional power analytics	Used for average power grid emissions intensity factors

Each emission factor category applies its own controls, modeling approach and review process. The EFL standardizes delivery fields and documentation references, but it does not replace the source-specific methodology for detailed assumptions, model design, data treatment or limitations. For production-based asset-derived factors, the EFL maintains alignment with the Emissions Performance Analytics methodology framework, including consistent sector definitions, system-boundary treatment, and factor metadata where applicable.

Geography standardization and integration

EFL uses a standardized geography nomenclature to support consistent identification across emission factor families. Geography display names and geography types may therefore differ from those used in an underlying source dataset where the EFL adopts the shared SPOT geography reference. Standardization changes the presentation and classification of the geography metadata; it does not, by itself, indicate a loss of factor coverage.

For integration, users should use the available ISO2 and ISO3 codes, where applicable, rather than relying solely on display names. Users should refer to the relevant source-specific methodology for the original geographic aggregation approach and source geography definitions.

Appendix A provides a crosswalk for revenue-based GICS/NACE geographies where the current S1 geography name or type differs from the EFL standardized geography metadata. Geographies without a name or type difference are not repeated in the appendix.

Methodology Overview

The EFL factors are calculated and sourced through different methodologies depending on the activity data they are intended to support. The key objective is to express emissions relative to a functional unit that aligns with the user's activity data. For example, revenue-based factors are applied to financial activity data, power grid factors are applied to electricity consumption, commodity and fuel factors are applied to fuel or commodity quantities, and production-based factors are applied to physical output or production data.

A) GICS/NACE sector-average factors

GICS and NACE factors provide revenue-based emission intensities for sector and geography combinations. They are designed for screening and estimation workflows where users have financial activity data but do not have more granular operational data.

These factors are modeled based on S&P Global Sustainable1 environmental data. The detailed GICS/NACE methodology describes the treatment of company emissions data, estimated data, sector classification, geography, outlier handling and revenue normalization. The methodology uses Extended Environmental Input-Output (EEIO) modeling and the Geo-Segmentation Revenue model to allocate emissions geographically.

Estimated emissions (tCO_2e) = Revenue (USD/EUR million) × Sector-average emissions intensity (tCO_2e per USD/EUR million)

For the complete methodology, please refer to the S&P Global Sustainable1 Industry GHG Averages Methodology: https://portal.s1.spglobal.com/survey/documents/GICS_GHG_Averages_Methodology.pdf

B) Commodity & Fuel Emission Factors

Commodity & Fuel Emission Factors help estimate greenhouse gas emissions associated with select commodities, fuels, regions and supply-chain pathways. These factors include supply-chain carbon intensity factors, methane intensity factors, end-use combustion factors and lifecycle factors.

These factors are developed using a combination of S&P Global proprietary models, satellite-informed emissions observations where available, public datasets, and stoichiometric assumptions for combustion. Factors are typically normalized based on fuel energy content, such as gCO_2e/MJ or gCH_4/MJ on a lower heating value (LHV) basis. If activity data is in a different unit, users should convert it to the factor's stated functional unit using the conversion factors provided in the S&P Global Commodity & Fuel Emission Factors Methodology.

System boundaries vary by factor type, for example well-to-hub for selected natural gas factors, well-to-terminal for crude oil factors, well-to-LNG export port for LNG factors and end-use only for combustion factors.

Estimated emissions = Activity data × Emission factor

For the complete methodology, please refer to the S&P Global Commodity & Fuel Emission Factors Methodology: https://portal.s1.spglobal.com/survey/documents/SPG_S1_EFL_CofEE_Emission_Factors.pdf

C) Production-based asset-derived factors

Production-based asset-derived factors are based on emissions and production data associated with assets. Within the EFL, these factors provide production-based emission intensities for selected sectors where emission and production data are available.

These factors are developed based on the S&P Global Emissions Performance Analytics Factors dataset, which is derived from standardized emitter-level emissions intensity calculations. Using a combination of regulatory-reported emissions, S&P Global proprietary data estimates, satellite-informed observations where available, and emitter-level activity data, the Emissions Performance Analytics methodology calculates emissions intensity at the emitter level across upstream, LNG, downstream and selected industrial sectors globally. For the EFL, the asset-level data from the dataset are aggregated to create representative production-based factors for the relevant subsector, primary product where applicable, geography and year.

Production-based factor (within each classification/geography/year)
= Total included emissions / Total included production

This is equivalent to a production-weighted average of asset-level intensities. Units vary by sector and may include $kgCO_2e$/boe, gCO_2e/MJ, or tCO_2e per ton of product, depending on the sector and production data.

The current release includes production-based factors for the following sectors:

- **Upstream:** Gas assets and liquid assets
- **LNG:** Integrated LNG, liquefaction plants, and regasification plants
- **Downstream:** Biodiesel plants, ethanol plants, and refineries
- **Industrial:** Ammonia plants and phosphate plants

Production-based emissions = Production × Production-based factor

Emissions Performance Analytics uses a subsector-level standard deviation approach to filter out extreme and non-representative observations while maintaining the overall integrity and coverage of the dataset. For complete details on the underlying asset-level calculations, please refer to the S&P Global Emissions Performance Analytics Methodology:

https://portal.s1.spglobal.com/survey/documents/SPG_S1_Emissions_Performance_Analytics_Methodology.pdf

Note on Forecasting and Modeling: The Emissions Performance Analytics methodology's use of recent emissions intensity as the default forecasting approach is intentional. It provides a consistent basis for projections while

avoiding subjective assumptions about future operational events. Analysis of the underlying datasets indicates that there is no single universal lookback window: forecast horizons and historical periods vary by asset type, operational stability, and the applicable source model methodology. Stable downstream sectors are predominantly informed by recent year performance, while more complex upstream sectors may incorporate varying historical periods and operational considerations to reflect asset-specific conditions. Where reported emissions are unavailable, forecasts may be developed through facility-level, scenario-based modeling that incorporates operational, market, and technical intelligence. The resulting asset-level estimates are then aggregated into the relevant EFL production-based outputs.

D) Power Grid Emission Factors

Power Grid Emission Factors estimate average direct CO_2 emissions from electricity generation within a defined geography and period. They are intended primarily for location-based Scope 2 calculations based on electricity consumption data.

The Power Grid records may use the inventory metric label 'Scope 1 Intensity' to describe the direct emissions intensity of electricity generation at the source or generation boundary. This label describes the emissions included in the factor itself; it does not determine the reporting scope for the factor user. When a reporting entity applies the factor to purchased electricity consumption, the resulting emissions are generally reported as location-based Scope 2 emissions.

The calculation approach is defined by the regional power methodology applicable to each geography. Depending on the market and available data, the underlying calculations use unit-level dispatch models such as PLEXOS or Aurora, regional outlooks, official generation data, fuel mix, fuel consumption, heat rates, emissions coefficients or aggregated power-sector approaches such as country-by-fuel calculations.

The detailed Power Grid Emission Factors methodology explains the calculation approach, denominator treatment, emissions boundary, methodology patterns and limitations.

Scope 2 emissions (tCO_2) = [Electricity consumed (kWh) × Grid factor (gCO_2/kWh)] / 1,000,000

For the complete methodology, please refer to the S&P Global Power Grid Emission Factors Methodology: https://portal.s1.spglobal.com/survey/documents/SPG_S1_EFL_Power_Grid_Emission_Factors.pdf

Assumptions and Limitations

1. The EFL is a factor library, not a complete GHG inventory system. The responsibility for selecting appropriate factors, mapping factors to their reporting boundary and applying activity data consistently remains with the user.

2. Scope classification depends on the user's position in the value chain. A factor labelled for an intended upstream or downstream use case may not correspond automatically to a reporting entity's final Scope 1, Scope 2, or Scope 3 category.

3. Factor boundaries are defined at the factor-category and factor-metadata level. Users should review metadata and source-specific methodology documents when combining factors across the four current EFL datasets: GICS/NACE revenue-based factors, Commodity & Fuel Emission Factors, Power Grid Emission Factors, and production-based asset-derived factors. This supports accurate factor selection and helps avoid potential boundary overlap or double counting.

4. Different emission factor categories use different functional units. Therefore, revenue-based factors, energy-based commodity/fuel factors, grid factors and production-based factors should be used with caution.

5. Some factor values represent weighted averages across companies, pathways, power markets, assets or commodity flows. These factors are intended to represent defined average conditions and may differ from any individual asset, supplier, company, or bespoke supply chain.

6. Underlying source models and datasets may follow different update schedules. The EFL provides published factor release and source-vintage metadata to support repeatable use.

7. Power Grid Emission Factors generally cover CO_2 from direct electricity generation and exclude CH_4, N_2O, transmission and distribution losses, upstream fuel supply-chain emissions, and lifecycle emissions unless factor metadata states otherwise. CH_4 and N_2O from electricity generation are generally expected to be small relative to CO_2, but future releases may consider expanded gas coverage where supported by regional power data.

8. The greenhouse gas coverage and GWP basis may vary by emission factor category. Users should review factor-level metadata and source-specific methodology documents for the applicable GHG coverage and GWP basis. For example, Commodity & Fuel Emission Factors use IPCC AR4 100-year GWP, while some other source methodologies may use a different GWP basis. Future releases may consider additional harmonization or selectable GWP variants, where supported by source data.

Application

Users should select emission factors based on the closest match between the factor's functional unit and their available activity data. A more specific physical factor should generally be preferred over a broader sector-average factor where the user has reliable activity data and the factor boundary matches the intended calculation.

Available activity data	Recommended EFL factor category
Financial spend or revenue only	Use GICS/NACE revenue-based sector-average factors where sector and geography are available.
Known fuel or commodity quantity or energy	Use Commodity & Fuel Factors where the fuel, commodity, pathway and boundary match the activity data, or where activity data can be converted to the factor's stated functional unit.
Known production or physical output	Use production-based asset-derived factors where subsector, product, geography, year and output unit align with the user's activity data.
Known electricity consumption	Use Power Grid Emission Factors for the relevant geography and period, primarily for location-based Scope 2 calculations.

Monitoring and Review

The EFL methodology documentation is reviewed as part of the library maintenance process and whenever methodology updates or changes are introduced. Source-specific methodology owners remain responsible for the detailed methodology supporting their respective emission factor categories.

Maintenance/Updates

The methodology and outcomes are reviewed on a yearly basis. Any significant changes or updates to the methodology are discussed internally through a standard review process.

Appendix

Appendix A: Revenue-based geography crosswalk

Purpose: This appendix supports the transition from the current S1 GICS/NACE geography presentation to the standardized EFL SPOT geography nomenclature. It lists the 31 revenue-based geography records for which the current S1 geography name and/or type differs from the EFL metadata. Both datasets contain 182 unique geography entities; unchanged records are omitted from this appendix.

Integration note: Use ISO2 and ISO3 codes where available. Regional and global aggregates do not always have ISO codes, so this crosswalk should be used for those records. The current S1 names and geography levels remain documented in the appendix of the S&P Global Sustainable1 Industry GHG Averages Methodology.

Current S1 type	Current S1 name	EFL type	EFL name	ISO2	ISO3	Change
Country	Macau	State/Province	Macao	MO	MAC	Type, Name
Subregion	Northern America	Region	North America			Type, Name
Subregion	Australia and New Zealand	Region	Australia and New Zealand			Type
Subregion	Caribbean	Region	Caribbean			Type
Subregion	Central Africa	Region	Central Africa			Type
Subregion	Central America	Region	Central America			Type
Subregion	Central Asia	Region	Central Asia			Type
Subregion	Eastern Africa	Region	Eastern Africa			Type
Subregion	Eastern Asia	Region	Eastern Asia			Type
Subregion	Eastern Europe	Region	Eastern Europe			Type
Global	Global	Region	Global			Type
Subregion	Melanesia	Region	Melanesia			Type
Subregion	Middle East	Region	Middle East			Type
Subregion	Northern Europe	Region	Northern Europe			Type
Subregion	Rest of Northern Africa	Region	Rest of Northern Africa			Type
Subregion	Rest of Southern Asia	Region	Rest of Southern Asia			Type
Subregion	Rest of Western Asia	Region	Rest of Western Asia			Type
Subregion	South America	Region	South America			Type
Subregion	Southeastern Asia	Region	Southeastern Asia			Type
Subregion	Southern Africa	Region	Southern Africa			Type
Subregion	Southern Europe	Region	Southern Europe			Type
Subregion	Western Africa	Region	Western Africa			Type
Subregion	Western Europe	Region	Western Europe			Type
Country	Bosnia & Herzegovina	Country	Bosnia and Herzegovina	BA	BIH	Name
Country	Brunei	Country	Brunei Darussalam	BN	BRN	Name
Country	Côte d'Ivoire	Country	Cote dIvoire	CI	CIV	Name
Country	Dem. Rep. Congo	Country	Democratic Republic of the Congo	CD	COD	Name
Country	Laos	Country	Lao Peoples Democratic Republic	LA	LAO	Name
Country	Rep. Of the Congo	Country	Republic of the Congo	CG	COG	Name
Country	Türkiye	Country	Turkey	TR	TUR	Name
Country	USA	Country	United States	US	USA	Name

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