Net Zero Metrics Methodology

December 2024

Contents

Net Zero Metrics Methodologies

Scope of Analysis

As of FY2023 reporting, financed emissions calculations encompass the loan portfolio for the Aluminum, Auto Manufacturing, Aviation, Cement, Commercial Real Estate (CRE) (for North America), Energy and Energy-related project financing, Power and Power-related project financing and tax equity financing, Shipping, Steel and Thermal Coal Mining sectors.

Facilitated emissions calculations encompass reporting year transaction volumes for Auto Manufacturing, Energy and Power clients in equity capital markets (ECM), debt capital markets (DCM) and syndicated loans. These were sourced from Dealogic and align with the Partnership for Carbon Accounting Financials (PCAF) Standard for the scope of covered activities. For the purposes of target setting, facilitated emissions metrics include ECM and DCM activities only. For syndicated loans, Citi also plays a direct financing role and those transactions are represented in our financed emissions.

Structured products (e.g., derivatives, hedging or trading) are excluded from this scope of analysis.

The reporting year has been determined as January 1 to December 31 in alignment with the financial reporting year. Financial values related to client loan exposure and company financials have been aligned to this year-end date where possible, or we have taken information as of the company's closest financial reporting year-end date. Greenhouse gas (GHG) emissions reporting is the latest available year and for most sectors, this is at a one-year lag of the financial reporting year (i.e., 2023 financials are matched with 2022 emissions reporting, the latest available at that time). Where available for an entire sector population, GHG emissions reporting in line with the most recent financial reporting year are used.

Throughout our reporting, we offer our financed emissions calculations based on two summations of client exposure:

Drawn amount: value of the loan that the borrower has drawn down as of the year-end date (also referred to as outstanding in the PCAF Standard).

Committed amount: drawn amount plus undrawn committed credit which the borrower has available, less any amounts related to fronting facilities.

We disclose absolute metrics based on drawn exposure, aligned to the PCAF Standard. For the purposes of target setting, we use metrics based on committed exposure.

Sector portfolios are identified using an internal industry classification system. See more details on each sector scoping below.

Absolute Financed Emissions: Client Scopes 1 & 2 Emissions

Across all our sector absolute emissions, Scopes 1 and 2 emissions have been included for all clients. These emissions data sources include:

- Reported actual company emissions as sourced through S&P Global Sustainable1;

- Reported actual company or site emissions from publicly available databases (such as the Environmental Protection Agency (EPA) Greenhouse Gas Reporting Program (GHGRP) or CDP) and/or company disclosures;

- S&P Global Sustainable1 estimations based on reported company data or their proprietary estimation model; and

- Estimated emissions based on industry average emission factors by sector from the PCAF emissions factor database.

Due to an inherent lag in public greenhouse gas accounting and reporting by clients, the majority of reported actuals and estimates will be based on an earlier year's (one year prior to the financial reporting year) operating emissions information. This follows the PCAF principle of using the best available data and is a known issue for this calculation and reporting.

Our approach to calculating Scopes 1 and 2 emissions for each commercial loan is aligned with the PCAF calculation approach for Business Loans:

Private Companies

$$\text{Financed Emissions} = \sum_{c} \frac{\text{Outstanding Amount}_{C}}{\text{Total Equity + Debt}_{C}} \times \text{Company Emissions}_{C}$$

Listed Companies

$$\text{Financed Emissions} = \sum_{c} \frac{\text{Outstanding Amount}_{C}}{\text{Enterprise Value Including Cash}_{C}} \times \text{Company Emissions}_{C}$$

(with C= borrower or investee company)

Financial information such as company equity, debt and Enterprise Value Including Cash (EVIC) is sourced from S&P Global Market Intelligence. Where obligor-level emissions information is not available, we have attributed emissions based on the parent company's reported financials and emissions.

Where financial information is available, but the client does not disclose emissions, we use a revenue emissions factor to estimate client emissions and attribute emissions as stated below.

$$\text{Financed Emissions} = \sum_{c} \frac{\text{Outstanding Amount}_{C}}{\substack{\text{EVIC (public company) or} \\ \text{Debt and Equity (private company)}}} \times \text{Revenue}_{C} \times \frac{\text{GHG Emissions}_{s}}{\text{Revenue}_{s}}$$

(with C= borrower or investee company, s= sector)

Where financial information is not available for clients, we have applied an industry average emissions intensity factor (as available through the PCAF emissions factor database) based on the company's primary industry to the client's exposure.

$$\text{Financed Emissions} = \sum_c \text{Outstanding Amount}_C \times \frac{\text{GHG Emissions}_s}{\text{Assets}_s}$$

(with C= borrower or investee company, s= sector)

For the purposes of target setting, we also calculate absolute financed emissions using committed exposure. The formulas for these calculations are the same as above, but instead of outstanding (drawn) exposure, we use committed exposure.

Absolute Financed Emissions: Client Scope 3 Emissions

Among the 15 Scope 3 categories, as defined by the GHG Protocol Corporate Standard, several sectors have material Scope 3 categories that are identified and included in the financed emissions calculation. Please see sector-specific methodologies below for more detail.

Capital Markets Facilitated Emissions Calculation Methodology

Citi has utilized the PCAF Standard for facilitated emissions disclosure and target setting:

$$\text{Facilitated Emissions} = \sum_c \frac{\text{Citi League Table Share}_C}{\text{EVIC or Total Debt + Equity}_C} \times 33\% \times \text{GHG Emissions}_C$$

(with c=company)

Citi's League Table Share is based on value of the transaction volume for the reporting year as attributed to Citi's bookrunning role and is sourced from Dealogic. The 33% weighting factor is aligned to the PCAF Standard, intended to represent the different role of facilitating versus lending, as the facilitator does not provide direct funding to the company (see more details in the PCAF Standard Part B).

Physical Intensity Calculation Methodology

Sectoral physical emissions intensity metrics are calculated for portfolios in all covered sectors.

For all sectors, portfolio-weighted physical intensity was calculated as the sum of parent company emissions intensities, weighted by the parent-level committed exposure as a percentage of total portfolio-level committed exposure.

Across the sectors with portfolio physical intensity metrics, the formula is:

$$\text{Portfolio Intensity} = \sum \frac{\text{Client Exposure}}{\text{Citi's Total Sector Exposure}} \times \frac{\text{Client Emissions}}{\text{Client Production}}$$

For climate alignment score methodology, please see the sector details below.

The physical emissions intensity metric by sector and with related data sources is as follows:

Sector	Physical Intensity Metric	Production Data Source
Aluminum	Kilograms of CO_2e emitted for each ton of aluminum produced (kg CO_2e/ton), weighted by primary or recycling production (Climate Alignment Score) (Scopes 1-3)	CRU
Auto Manufacturing	Grams CO_2e emitted for each lifetime vehicle kilometer (g CO_2e/km) (Scopes 1-3)	LMC Automotive, a GlobalData Company data
Aviation	Grams CO_2e emitted for each revenue tonne kilometer (RTK) (g CO_2e/RTK) (Scopes 1 and 3, Well-to-Wake)	PACE
Cement	Metric tons CO_2e per ton of cementitious product produced (t CO_2e/t cementitious product) (Scopes 1-2)	Public company disclosures
Commercial Real Estate	Kilograms CO_2e for each square meter (kg CO_2e/m^2) (Scopes 1-2)	Measurabl
Energy	Kilograms CO_2e emitted for each MJ produced (kg CO_2e/MJ) (Scopes 1-3)	Wood Mackenzie; Environmental Protection Agency (EPA) Greenhouse Gas Reporting Program (GHGRP)
Power	Kilograms of CO_2e emitted for each MWh produced (kg CO_2e/MWh) (Scope 1)	CDP, S&P Global Sustainable1, project operating information from annual credit reports and public company disclosure
Shipping	Grams of CO_2e emitted for each ship to move one deadweight ton one nautical mile (gCO_2e/deadweight ton-nautical mile) (Climate Alignment Score) (Scopes 1-2)	Company disclosures
Steel	Kilograms of CO_2e emitted for each ton of steel produced (kg CO_2e/ton) for each company, weighted by primary or secondary production (Climate Alignment Score) (Scopes 1-3)	CRU
Thermal Coal Mining	Kilograms of CO_2e emitted for each short ton produced (kg CO_2e/short ton) (Scopes 1-3)	Public company disclosures

Sector-Specific Considerations

Aluminum

Scope of Analysis

The industry boundary for the Aluminum sector focuses on entities that are involved in the primary production, recycled production and semi-fabrication value chain segments. This aligns with guidance under the Sustainable Aluminum Finance Framework (SAFF) and covers the most material sources of emissions for the sector.

As the absolute emissions rely on corporate emissions footprints for companies that meet Aluminum production criteria, but may be diversified, our Aluminum absolute emissions footprint is reflective of the full corporate operations of these diversified companies and therefore more than Aluminum-related emissions. The alignment score is reflective of Aluminum-related emissions intensity for these companies.

Scope 3

The SAFF fixed system boundary includes upstream Scope 3 emissions, Category 1 – purchased goods and services and upstream Scope 3 emissions, Category 3 – fuel and energy-related activities. For the purposes of absolute financed emissions calculations, Scope 3, Category 1 and Category 3 emissions were obtained through CDP disclosures, where available.

Intensity

We receive crude aluminum primary production and emissions data from a third-party data provider, CRU, to calculate the Climate Alignment Score. This alignment score represents kilograms of CO_2e emitted for each ton of aluminum produced (kg CO_2e/ton) for each company, benchmarked against the Mission Possible Partnership Aluminum Sector Transition Strategy (MPP STS) and the International Aluminum Institute (IAI) 1.5^{O}C roadmaps. This is calculated per the Sectoral Decarbonization Convergence Approach (SDA) stated in SAFF guidance to account for variability in emissions intensity of aluminum production processes (primary production, recycling and semi-fabrication).

For further details on the Sustainable Aluminum Finance Framework and its methodology, please see here.

Auto Manufacturing

Scope of Analysis

The industry boundary for the Auto Manufacturing sector focuses on Original Equipment Manufacturers (OEM) of light-duty vehicles.

Scope 3

For Auto Manufacturing sector loans, Scope 3 tailpipe emissions are the most carbon intensive segment of the vehicle value chain. Therefore, for the automotive sector, Scope 3 Category 11 - use of sold products is used in the Scope 3 financed emissions calculations. Auto manufacturers report their Scope 3 tailpipe emissions in two ways, using a Well-to-Wheel (WTW) methodology or using a Tank-to-Wheel (TTW) methodology. Well-to-Wheel calculations capture combustion of fuel over the lifetime of a vehicle as well as upstream emissions associated with fuel extraction and transport. Tank-to-Wheel calculations only capture the end use combustion of the fuel in the vehicle's tank over its lifetime.

We calculate Scope 3 tailpipe emissions using a hybrid approach, deferring to the public disclosures made by parent companies, despite inconsistent approaches (e.g., TTW or WTW), using publicly reported data provided by S&P Global Sustainable1 and CDP and a bottom-up, production-based approach (TTW) when neither S&P Global Sustainable1, CDP nor publicly disclosed data is available. The bottom-up calculation, shown below, uses make, model and body data from LMC Automotive, regional lifetime kilometer assumptions, EPA emissions factors and fuel efficiency data from Fueleconomy.gov:

$$\text{Tailpipe CO}_2\text{e Emissions} = \sum_v \text{Vehicle Units}_v \times \text{Fuel Efficiency}_v \times \text{Avg Lifetime km}_v \times \text{Emissions Factor}_l$$

(with l=location, v=vehicle)

The equation captures parent company fleet emissions over the lifetime of the fleet. The vehicle units and their corresponding fuel efficiency provide a metric measuring kilometers traveled per gallon of fuel consumed. Total gallons consumed over the life of the vehicle were determined using the average lifetime kilometer metric. Finally, a fuel combustion emissions factor was applied to total lifetime gallons consumed.

For clients that produce only electric vehicles, we do not include tailpipe emissions associated with EV battery charging, as emissions from battery charging are covered by the electric power generators in the Power sector.

Aviation

Scope of Analysis

The industry boundary for aviation includes passenger air service, aircraft lessors and air freight for absolute emissions calculations. The financed emissions calculations cover aircraft operations, as well as emissions measured across the full life cycle of aircraft fuel from extraction through combustion. The Aviation portfolio intensity metric includes only passenger air service and air freight.

Scope 3

For Aviation, Scope 3 financed emissions are calculated for Category 3 - fuel and energy-related activities and Category 13 - downstream leased assets. This aligns with the material Scope 3 emissions identified under the Pegasus Guidelines and aligns with a Well-to-Wake (WTW) calculation approach.

Cement

Scope of Analysis

The industry boundary for the Cement sector includes clinker production and cement production, as those are the highest emitting activities in the cement manufacturing value chain.

Commercial Real Estate

Scope of Analysis

For the Commercial Real Estate sector, we focus on GHG emissions associated with the direct financing of existing buildings in North America. We exclude properties under construction during the reporting period, land and lot development, agricultural properties, indirect financing (e.g., Real Estate Investment Trusts (REITs) and Real Estate Operating Companies (REOCs), or securitized assets) and properties located outside of North America. This exclusion is in part due to data limitations and lack of operational emissions from said property types in our loan book.

Calculation Methodology

Financed emissions for this sector focus on a building's operational activity to capture Scope 1 and Scope 2 emissions. Where possible, and given variable constraints on emissions data, calculations capture a building's energy consumption, but exclude all remaining value chain segments from scope (e.g., embodied emissions from construction, etc.).

Citi utilizes a third-party data provider, Measurabl, for building operational emissions estimates. Measurabl's Whole Building Estimates service utilizes a machine learning model trained on hundreds of thousands of monthly datapoints across 100 different property types to estimate a building's energy use based on its attributes (e.g., location, size, property type, year built). Then, the model determines an energy mix based on property type and location for the reporting period and generates an emissions estimate for each building in Citi's portfolio.

FY21 and FY22 metrics used a calculated estimation approach. For more details, see pages 76 - 77 of the 2022 TCFD Report.

The financed emissions formula for CRE is as follows:

$$\text{Financed Emissions} = \sum_c \frac{\text{Committed Amount}_c}{\sum \text{Value at Origination}_a} \times \sum_a \text{Building Emissions}$$

(with c=counterparty, a=asset)

<u>Intensity</u>

The CRE portfolio emission intensity is calculated as the sum of the resulting asset emissions intensities, weighted by the committed exposure as a percentage of total portfolio-level committed exposure. The formula for CRE portfolio intensity is as follows:

$$\text{Portfolio Intensity} = \sum \frac{\text{Company Committed Exposure}}{\text{Portfolio Committed Exposure}} \times \frac{\text{Total Building Operational Emissions}}{\text{Total Gross Floor Area}}$$

Energy

<u>Scope of Analysis</u>

The industry boundary for absolute financed emissions includes all segments of the Energy value chain: upstream, midstream and downstream. Scopes 1 and 2 emissions are included for all entities. For entities in crude oil extraction, natural gas extraction and refining, we include Scope 3 Category 11 - use of sold products emissions as these reflect the most material sources of emissions for companies in these sectors.

<u>Scope 3</u>

For Energy sector loans, Scope 3 emissions have been included for clients in the extractive (crude oil and natural gas) sectors, refining sector and other sectors with production information available.

Downstream Scope 3 emissions were either obtained through S&P Global Sustainable1, or calculated using emissions factors for Category 11 - use of sold products.

Net entitlement production data for clients in these sectors is from Wood Mackenzie data and the EPA Greenhouse Gas Reporting Program* (GHGRP). EPA emissions intensity factors for combustion of stationary fuels are utilized for liquid crude products and natural gas products. For refined fuels, liquid products are separated into the following components per barrel of oil equivalent (BOE)**: gasoline (45%), heating oil (25%), jet fuel/kerosene (9%) and residual fuel (2%). Remaining volumes towards petrochemical products, hydrocarbon gas liquids and other uses are not included. EPA emissions intensity factors for combustion of transport fuels are utilized to estimate emissions.

For companies in the extractives and refining sub-sectors where no production data is available, we applied an internal extrapolation factor based on the average Scope 3 emissions and financial attribution factor for each of these three sub-sectors within our portfolio.

It is possible that crude and natural gas product Scope 3 Category 11 - use of sold products, which are accounted for at the extractive stage, may be double counted at the refining stage. The double counting is minimized for integrated companies where we accounted for their products based on their primary activity in the value chain. Given the complex commodities trading environment that exists, it is currently not possible to discount the allocation of Scope 3 Category 11 - use of sold products

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  * Greenhouse Gas Reporting Program (GHGRP), EPA: https://www.epa.gov/ghgreporting.
** Matt Muenster, What's in a Crude Oil Barrel? A Breakdown of Crude Oil Refined Products, Breakthroughfuel (Jan. 10, 2020).

emissions across the production and refining value chain in order to eliminate double counting.

In addition, Scope 3 emissions related to Category 11 - use of sold products for the distribution of natural gas were not calculated for entities within our Power loan book, as we consider that the Scope 3 emissions related to the combustion of these hydrocarbons have been sufficiently captured under our Energy loan book for clients operating within the natural gas extraction sector.

Power

Scope of Analysis

For the Power sector, GHG emissions mostly come from fuel combustion to generate electricity (i.e., Scope 1 emissions), and therefore, the industry boundary for the Power sector is the counterparties' Scopes 1 & 2 emissions. For absolute emissions, we include entities within the Power value chain, including generation and transmission and distribution. For the intensity metric, we only include entities that generate power.

Shipping

Scope of Analysis

We have followed the Poseidon Principles guidance to determine in-scope counterparties, focusing on ship operators and shipping services, while excluding those involved in fuel production, ship construction, land transport and end-of-life use/disposal of ships and cargo. The absolute financed emissions include relationships that are included in the Poseidon Principles and names that were identified as ship operators and shipping services by Citi's Shipping banking team.

The FY23 Poseidon Principles Climate Alignment Score calculation included cargo ship operators, passenger shipping and shipping services companies that met the financed emissions scope of analysis.

Intensity

The internal industry team receives vessel-specific information and emissions data to calculate the Climate Alignment Score. This score represents grams of CO_2e emitted to move one deadweight ton one nautical mile (g CO_2e/deadweight ton-nautical mile) by vessel (Scopes 1-2).

For further details on the Poseidon Principles and its methodology, please see here.

Steel

Scope of Analysis

We have followed the Sustainable STEEL Principles (SSP) guidance to determine in-scope counterparties, focusing on crude steel producers, while excluding stainless steel producers and fabricators from the scope of our financed emissions reporting.

<u>Scope 3</u>

For Steel sector loans, there is a high degree of variability in Scope 3 emissions given the complexity of final steel product manufacturing processes and the variation among different steel plants (e.g., integrated vs. non-integrated steel plants). The SSP fixed system boundary includes upstream Scope 3 emissions, Category 1 – purchased goods and services, and downstream Scope 3 emissions, Category 10 – processing of sold products. Scope 3, Category 1 and Category 10 emissions were obtained through CDP disclosures, when available. Where that data was unavailable, upstream and downstream Scope 3 emissions were obtained through S&P Global Sustainable1. When using S&P Global Sustainable1 data, Scope 3 emissions are broken down into "upstream" and "downstream," not by category. As such, applying S&P Global Sustainable1 Scope 3 upstream and downstream emissions data for financed emissions calculations where categorical information is not available leads to an overestimation of financed Scope 3 emissions compared to the SSP boundary.

<u>Intensity</u>

Through the SSP for the Steel sector we receive crude steel production and emissions data from a third-party data provider, CRU, to calculate the Climate Alignment Score. This alignment score represents kilograms of CO_2e emitted for each ton of steel produced (kg CO_2e/ton) for each company, weighted by primary or secondary production (Scopes 1-3).

For further details on the Sustainable Steel Principles and its methodology, please see here.

Thermal Coal Mining

<u>Scope of Analysis</u>

The industry boundary for the Thermal Coal Mining sector includes in-scope counterparties with ≥5% revenue generated from thermal coal mining activities. Mining companies that only produce metallurgical coal are excluded. For companies that produce both thermal coal and metallurgical coal, financed emissions calculations are inclusive of Scopes 1 and 2 emissions resulting from both thermal and metallurgical coal activities, but Scope 3 estimates are based only on thermal coal production.

<u>Scope 3</u>

Thermal coal product combustion Scope 3 emissions are the most carbon-intensive segment of the thermal coal mining value chain. These emissions belong to Scope 3, Category 11 - use of sold products and are considered "downstream" in the value chain. To calculate these emissions, we use S&P Global Sustainable1 Category 11 - use of sold products or Scope 3 downstream emissions data, where available. For companies that do not have S&P Global Sustainable1 data available or the emissions values are estimated by S&P Sustainable1, a bottom-up approach is applied by using thermal coal sales figures sourced through company sustainability reports or annual reports and EPA emissions factors.

For the bottom-up approach, thermal coal combustion emissions were calculated as follows:

$$\text{Combustion Emissions CO}_2\text{e} = \sum_c \text{Tons of Thermal Coal Sold}_c \text{ X Emissions Factor}$$

(with c=company)

Additional data sources for Scope 3 calculations:

Tons of Thermal Coal Sold: Thermal coal sales values are sourced through companies' sustainability reports or annual reports. For companies that do not report coal sales by type, a thermal coal sales ratio is used to calculate thermal coal sales.

Emissions factors: The EPA "Mixed (electric power sector)" emissions factors (under Coal and Coke category for stationary combustion) are used in this calculation. The emissions factors are sourced through the U.S. EPA's Center for Corporate Climate Leadership GHG Emission Factors Hub.*

Global Warming Potential (GWP): GWP is applied to CH_4 and N_2O emissions to calculate the total CO_2e emissions. The GWP values used in the calculation are from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4).** We use AR4 instead of the latest AR5, per the recommendation of the US EPA.

Project Finance - Energy and Power

Scope of Analysis

For project finance loans, we include actively operating electricity generation-related assets in the reporting year for the Power sector and actively operating projects in the Energy sector, which include midstream assets.

Our approach to calculating financed emissions for each project finance loan is aligned with the PCAF calculation approach for project finance:

$$\text{Financed Emissions CO}_2\text{e} = \sum_p \frac{\text{Outstanding Amount}_p}{\text{Total Equity + Debt}_p} \text{ X Project Emissions}_p$$

(with p=project)

For the purposes of target setting, we also calculate absolute financed emissions using committed exposure. The formulas for these calculations are the same as above, but instead of outstanding (drawn) exposure, we use committed exposure.

Power

For Power project finance deals, Scope 1 emissions are calculated for the reporting year, as these represent the most material source of emissions for electricity generation assets. Full-year generation

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 * 2022 GHG Emissions Factors Hub, EPA: https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf.
** Fourth Assessment Report, IPCC: https://www.ipcc.ch/assessment-report/ar4/.

data is sourced through project annual operating reports as provided to Citi relationship teams to monitor the status of invested projects.

Emissions are estimated based on the MWh of electricity produced by the project — for renewables generation, avoided emissions are not deducted from the calculated emissions.

For natural gas and coal-fired generation, Scope 1 emissions are estimated based on International Energy Agency (IEA)[1] emissions intensity factors for combustion of stationary fossil fuels.

For renewable energy generation, we considered the life cycle emissions of solar and wind projects per megawatt hour (MWh) generated, as estimated by the National Renewable Energy Laboratory (NREL). A share of these lifecycle emissions include operational emissions, accounting for approximately 26% of solar and 9% of wind estimations, in addition to the generation-related emissions. For hydropower plants, the full estimated lifecycle emissions per MWh generated, as estimated by the Intergovernmental Panel on Climate Change (IPCC),[2] have been applied.

Our approach to calculating Scope 1 emissions for each project finance power generation loan is aligned with the PCAF calculation approach for project finance.

Energy

Given that the majority of financed Energy projects are midstream (i.e., part of the transportation of fuel process), we only calculate operational emissions (Scopes 1 and 2) as they represent the most material source of emissions for midstream projects. Energy projects include natural gas pipelines, liquid pipelines, liquified natural gas (LNG) plants and Floating Production Storage & Offloading (FPSO), and emissions are estimated based on the following by project type:

Natural Gas Transmission Pipelines

For natural gas transmission pipelines, methane emissions account for more than 99% of GHG emissions.[3] A common metric used for transmission pipeline companies to track their GHG emissions is methane emissions intensity, which is a measure of methane emissions relative to natural gas throughput. A 2020 methane emissions intensity of 0.142% was reported by [ONE Future Coalition](#) for the transmission and storage sector. This average methane emissions intensity was calculated based on U.S. companies representing 56% of U.S. pipeline mileage. With the limitation of regional data access, this U.S.-based average methane emissions intensity is used to estimate GHG emissions for all natural gas pipelines projects. The equation used to calculate GHG emissions is presented below:

CO_2e Emissions (metric tons) from Natural Gas Pipeline Operations $=$ *Natural Gas Throughput (scf)* $\times$ *Methane Content of Natural Gas (%)* $\times$ *Methane Density* $\times$ *Methane Emissions intensity (%)* $\times$ *Methane GWP*

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1 IEA, Emissions Factors 2023, IEA, Paris https://www.iea.org/data-and-statistics/data-product/emissions-factors-2023.
2 Fourth Assessment Report, IPCC: https://www.ipcc.ch/assessment-report/ar4/.
3 Greenhouse Gas Reporting Program (GHGRP), EPA: [2020 dataset, Transmission Pipelines](#).

Liquid Pipelines

To calculate GHG emissions from liquid pipelines, an emissions intensity of tCO_2e/t-km was calculated based on a research paper "Carbon footprint of oil products pipeline transportation."* In this paper, a detailed Life Cycle Assessment (LCA) model is established to analyze carbon emissions of an oil products pipeline system from construction to disposal. Data from six Chinese oil pipelines were adopted as the benchmark case study to reflect emissions produced in different stages.

The average calculated life cycle emissions intensity based on the case studies is 1.45×10^{-5} t CO_2e /t-km. As approximately 30% of emissions come from pipeline operation phase, an emissions intensity of 4.36×10^{-6} tCO_2e /t-km was applied to estimate emissions from liquid pipeline projects using the annual throughput and pipeline distance data. The equation used to calculate GHG emissions is listed below:

CO_2e Emissions (metric tons) from Oil Pipeline Operations $=$ *Annual Oil Throughput (bbl)* $\times$ *Conversion Factor (tons/bbl)*

$\times$ *Pipeline Distance (km)* $\times$ *4.36* $\times$ *10^{-6} tCO_2e/t-km*

(with t-km = a unit of measure representing the transport of one ton of goods over the distance of one kilometer)

Note: The pipeline distances provided reflect a network of pipelines with many entry and delivery points instead of point-to-point pipelines, and as a result, there is a possibility of overestimating emissions as the products do not travel through the whole network.

Floating Production Storage and Offloading (FPSO)

Published CO_2 intensity is applied to calculate GHG emissions for oil and gas production.

Liquified Natural Gas (LNG) Processing Plants

GHG emissions calculated for the LNG plant projects are based on project specific emissions factors sourced through company reports.

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* Huang L, Liao Q, Yan J, Liang Y, Zhang H. Carbon footprint of oil products pipeline transportation. Science of the Total Environment. (April 5, 2021).