Verified Carbon Standard

VCS Module

VMD0057

CO_2 TRANSPORT FOR CCS PROJECTS

Version 1.0

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Sectoral Scope 16: Carbon Capture and Storage

This module was developed by the CCS+ Initiative and Verra. The CCS+ Initiative is a collaboration of 48 member companies. Perspectives Climate Group GmbH and South Pole Carbon Asset Management Ltd. served as the secretariat and consultants to the initiative throughout this methodology.

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1 SUMMARY DESCRIPTION

This module provides procedures and requirements to calculate project and leakage emissions for project activities that transport carbon dioxide (CO_2) via pipelines, ships/barges, rail, and trucks for eligible carbon capture and storage (CCS) activities under *VCS Methodology VM0049 Carbon Capture and Storage*.

Project emissions from transportation *($PE_{Tra,y}$)* are calculated in Equation (1).

Leakage emissions from transportation ($LE_{Tra,y}$) are calculated in Equation (7).

2 SOURCES

This module is used in combination with the most recent versions of *VM0049* and the following VCS Program modules and tools:[1]

Capture Modules

- *VMD0056 CO_2 Capture from Air (Direct Air Capture)*
- *VMD00XX CO_2 Capture from Bioenergy Combustion*
- *VMD00XX CO_2 Capture from Bioproduction Processes*
- *VMD00XX CO_2 Capture from Post-combustion Flue Gases in Fossil Fuel Power and Heat Generation*
- *VMD00XX CO_2 Capture from Industrial Processes*
- *VMD00XX CO_2 Capture from Oil and Gas Production and Processing*
- *VMD00XX CO_2 Capture from Precombustion Processes in Fossil Fuel Power and Heat Generation*
- *VMD00XX CO_2 Capture from Oxyfuel Combustion in Fossil Fuel Power and Heat Generation*

Storage Module

- *VMD0058 CO_2 Storage in Saline Aquifers and Depleted Hydrocarbon Reservoirs*
- *VMD00XX Project Emissions from CO_2 Storage via Geological Mineralization*

Other Modules, Tools, and Requirements

[1] Modules labeled"*VMD00XX*" and tools labelled"*VT00XX*" are under development.

- *VT0010 Emissions from Electricity Consumption* (t CO2e)
- *VT00XX Differentiating Reductions and Removals in CCS Projects*
- *VT00XX Accounting non-VCS CO_2 in CCS Projects*
- *Geologic Carbon Storage (GCS) Non-Permanence Risk Tool*
- *GCS Requirements*

3 DEFINITIONS

The definitions set out in the *VCS Program Definitions* and *VM0049* apply to this module.

4 APPLICABILITY CONDITIONS

This module applies to the transport of CO_2 in CCS project activities using the most recent version of *VM0049*.

This module is applicable under the following conditions:

1) The project activity transports a concentrated CO_2 stream from a capture site to a discrete storage site using at least one transport leg.
2) The project CO_2 stream is transported through one or a combination of the following transport modes:
    a) Pipelines
    b) Ships
    c) Barges
    d) Rail
    e) Trucks

This module is not applicable under the following conditions:

3) The project activity involves transportation or intermediate storage of CO_2 that is dissolved in solvents, diluted in diluents (beyond remnants of the capture process or feedstock contaminants), mineralized in materials, or infused in products.[2]
4) Intermediate storage is in a geological reservoir.
5) Transportation of flue gas to a capture facility.

[2] Additional modules allowing alternative forms of transport (e.g., in dissolved water) are under development.

5 PROCEDURES

5.1 Module Boundary

The module boundary for this module encompasses CO_2 transport and all the associated processes from capture to storage. Commonly used equipment or processes may include:

- CO_2 conditioning[3] (e.g., dehydration, cooling);
- Compression of CO_2;
- Loading and unloading of CO_2 to/from ships, trains, and trucks;
- Propulsion of ships, trains, and trucks for transport of CO_2;
- Holding CO_2 conditions (e.g., temperature) in pressure vessels; and
- Reconditioning of CO_2 to alter the mode of transport or change the delivery condition (e.g., regasification).

Where projects have diverse ownership, the point of custody transfer is appropriate to define module and transport leg boundaries.

Within the transport module boundary, project activities are further sub-divided into intermediate storage sites or transport legs, where:

1) Intermediate storage sites include the processes and equipment on a site that enables temporary storage of CO_2 in transit during the transfer of CO_2 from one transport leg to another.
2) Transport legs include equipment and processes for moving a CO_2 stream through a portion of the transportation system that uses a common quantification approach, as described in Section 5.2. Transport legs must meet the following criteria:
    a) Transport legs do not include intermediate storage facilities or equipment outside the module boundary (as defined above).
    b) All equipment and processes within a transport leg maintain a clear and distinct boundary. Where equipment, such as a liquefaction unit, serves multiple transport means, it must be delineated and accounted for in the boundaries of each leg.
    c) Each transport leg moves CO_2 through one mode of transport (i.e., each different mode of transport in a project must be a separate transport leg).
    d) Pipelines, electric rail networks, and electric trucks that cross international boundaries must use separate transport legs for each country to properly determine project emissions from grid electricity consumption in each jurisdiction.

[3] Depending on the specific project context, CO_2 conditioning processes may also be accounted for within capture modules where fully integrated with capture activities and sharing common fuel, electricity, and material inputs.

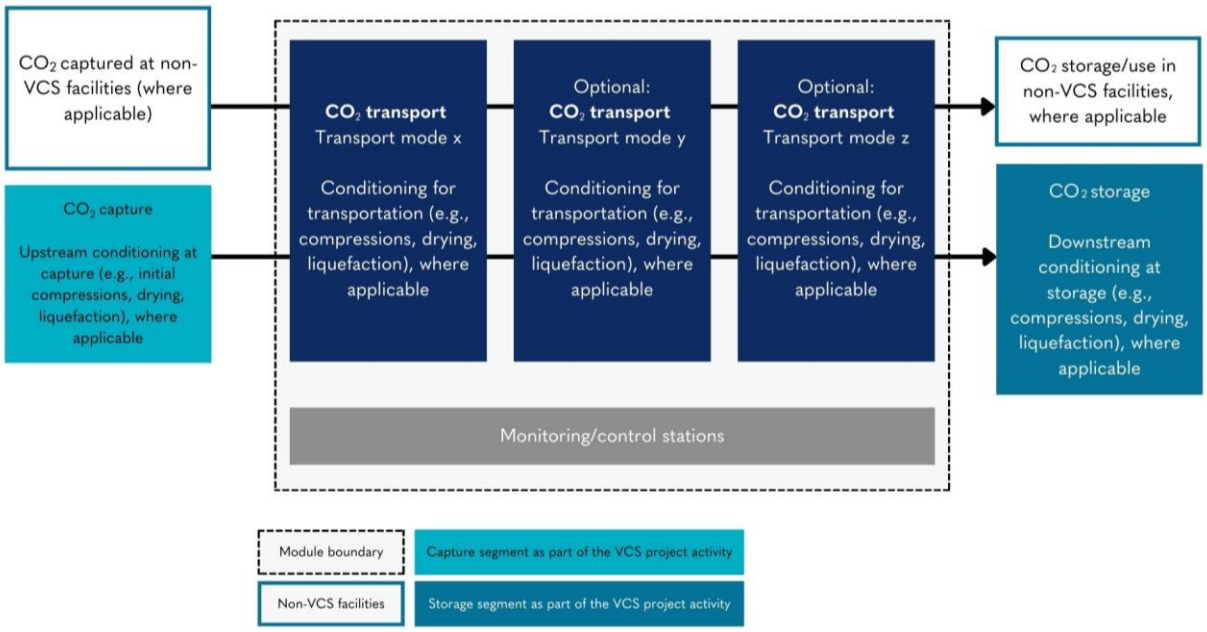
Truck, ship, and diesel rail networks that cross international boundaries do not need a separate transport leg for portions of the transport in each country.

Section 5 of the most recent version of *VM0049* provides further details on determining the module boundary. The transport legs and intermediate storage facilities and relevant project emissions included in the module boundary and quantified using this module must be clearly identified and documented. The project proponent must ensure that equipment is not omitted or double counted.

This module calculates the total emissions from the sources listed in Table 1. In cases where non-VCS[4] CO_2 flows through the project boundary, the most recent version of *VT00XX Accounting non-VCS CO_2 in CCS Projects* must be used to calculate the proportion of emissions from project sources associated with that non-VCS CO_2.

The boundary for this module is presented in Figure 1.

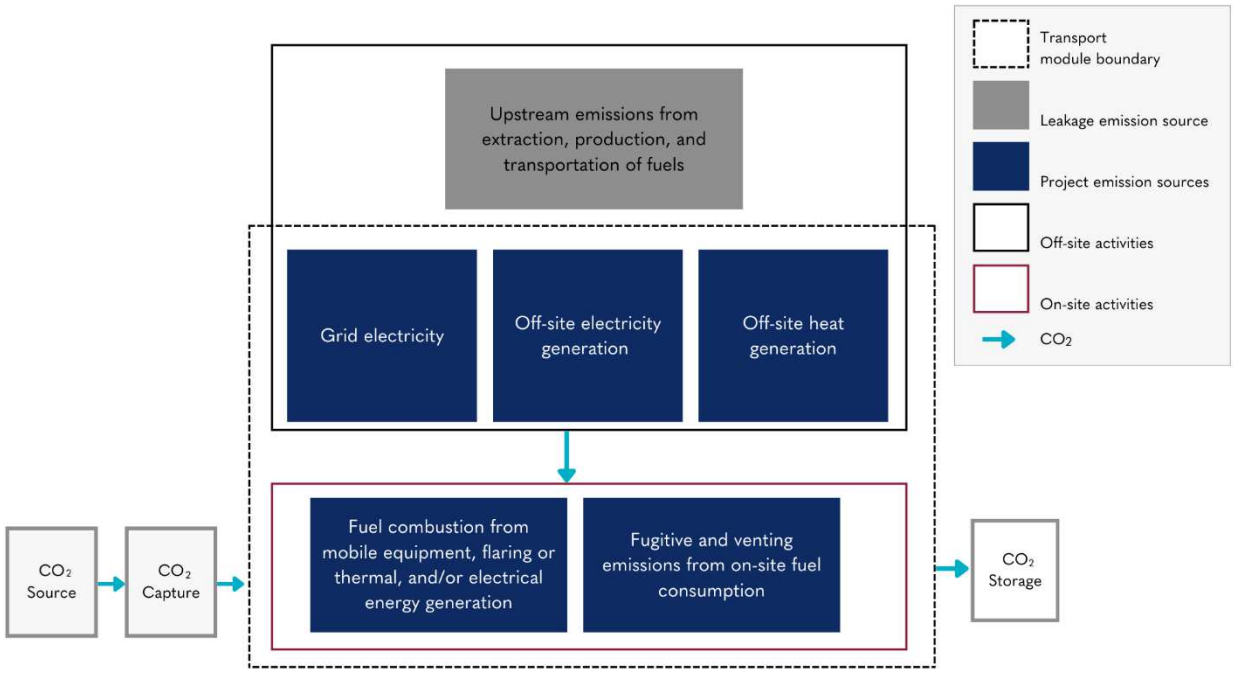
Figure 1 - Module boundary for CO2 transport



Emission sources, including both primary and secondary effects, that are considered in this module are illustrated relative to the module boundary in Figure 2.

[4] Non-VCS CO_2 is defined as "CO_2 that flows through a CCS project boundary that is not eligible for crediting in the VCS" in *VT00XX Accounting non-VCS CO_2 in CCS Projects.*

Figure 2 - Included greenhouse gas sources



The greenhouse gases (GHGs) included in or excluded from the module boundary are presented in Table 1. This module assumes that no transportation or intermediate storage of CO_2 relevant to the project activities took place in the baseline scenario. As such, no emissions sources associated with the baseline scenario are included in Table 1.

Table 1: GHG sources included in or excluded from the module boundary

Source		Gas	Included?	Justification/Explanation
Project	Electricity consumption	CO_2	Yes	Major emission source
		CH_4	Yes	Included for completeness
		N_2O	Yes	Included for completeness
		Other	No	Excluded for simplicity; emissions are considered negligible.
	Fuel consumption	CO_2	Yes	Major emission source
		CH_4	Yes	Included for completeness
		N_2O	Yes	Included for completeness
		Other	No	Excluded for simplicity; emissions are considered negligible.

Source		Gas	Included?	Justification/Explanation
	CO_2 fugitive and venting emissions	CO_2	Yes	Included. Any loss of CO_2 due to fugitive emissions or venting during transport and intermediate storage is inherently deducted from the overall calculation of GHG emission removals since only injected CO_2 volumes are quantified as the baseline emissions.
	Fugitive and venting emissions from on-site fuel use	CO_2	No	Excluded for simplicity; emissions are considered negligible.
		CH_4	Yes	Significant emission source
		N_2O	No	Excluded for simplicity; emissions are considered negligible.
		Other	No	Excluded for simplicity; emissions are considered negligible.

5.2 Quantification of Project Emissions

Total project emissions of the transported CO_2 are calculated as per Equation (1).

$$PE_{Tra,y} = \sum_{r} PE_{Tra,r,y} + \sum_{f} PE_{Tra,f,y} - PE_{nonVCS\ CO2,y} \quad (1)$$

Where:

$PE_{Tra,y}$ = Total project emissions from CO_2 transportation in year *y* (t CO_2e)

$PE_{Tra,r,y}$ = Total project emissions for transport leg *r* in year *y* (t CO_2e)

$PE_{Tra,f,y}$ = Total project emissions from the operation of intermediate storage site *f* in year *y* (t CO_2e)

$PE_{nonVCS\ CO2,y}$ = Project emissions from processes and equipment related to non-VCS sources in year *y* determined using the most recent version of *VT00XX Accounting Non-VCS CO_2 in CCS Projects*; equal to zero for projects with no non-VCS CO_2 (t CO_2e)

Project emissions from intermediate storage sites and transport legs include those from grid electricity consumption, fossil fuel combustion, and heat consumption.

This module provides two methods for calculating project emissions. Option A provides procedures for direct monitoring and is applicable to both transport legs ($PE_{Tra,r,y}$) and intermediate storage sites ($PE_{Tra,f,y}$). Option B applies to transport legs only (except for pipelines) and uses default values.

Where Option A is used to calculate project emissions, leakage emissions must be quantified using Section 0. For Option B, quantifying leakage emissions is not required because the default factors used for transportation legs are conservative and incorporate leakage.

5.2.1 Option A: Direct Monitoring

Project emissions associated with a transport leg or an intermediate storage site are calculated as per Equation (2).

$$PE_{Tra,r,y} \text{ or } PE_{Tra,f,y} = PE_{Comb_{Fuel},y} + PE_{Fuel_{FV},y} + PE_{Elec,y} \quad (2)$$

Where:

$PE_{CombFuel,y}$ = Project emissions from combustion of fuel *d* to operate equipment for transport or intermediate storage processes in year *y* (t CO_2e)

$PE_{Fuel\_FV,y}$ = Fugitive and venting from on-site fuel use (e.g., natural gas) in the transport leg or intermediate storage site in year *y* (t CO_2e)

$PE_{Elec,y}$ = Project emissions from electricity consumption to operate transport or intermediate storage processes in year *y* calculated using *VT0010 Emissions from Electricity Consumption* (t CO2e)

Project emissions from fossil fuel consumption for CO_2 transport via trucks, rail, and ships must consider both outbound and empty return trips.

5.2.1.1 Fuel Combustion

Project emissions from fossil fuel combustion for mobile equipment, flaring and power and heat generation for each transport leg and each intermediate storage site are calculated separately as follows:

$$PE_{Comb_{Fuel},y} = \sum_{d}(Q_{Fuel,d,y} \times EF_{Fuel,CO2,d}) + \sum_{d}(Q_{Fuel,d,y} \times EF_{Fuel,CH4,d}) \times GWP_{CH4} + \sum_{d}(Q_{Fuel,d,y} \times EF_{Fuel,N2O,d}) \times GWP_{N2O} \quad (3)$$

Where:

$Q_{Fuel,d,y}$ = Quantity of fuel type *d* used to operate on-site and/or third-party (for off-site heat/steam supply) equipment for an individual transport leg or intermediate storage site in year *y* (m^3 or kg or GJ)

$EF_{Fuel,CO2,d}$ = CO_2 emission factor for combustion of fuel *d* (t CO_2/m^3 or t CO_2/kg or t CO_2/GJ); equal to zero for fuels derived from biomass[5]

[5] Sustainable biomass is defined in the most recent version of *VT00XX Differentiating Reductions and Removals in CCS Projects.*

$EF_{Fuel,CH4,d}$ = CH_4 emission factor for combustion of fuel *d* (t CH_4/m^3 or t CH_4/kg or t CH_4/GJ)

$EF_{Fuel,N2O,d}$ = N_2O emission factor for combustion of fuel *d* (t N_2O/m^3 or t N_2O/kg or t N_2O/GJ)

GWP_{CH4} = Global warming potential for CH_4 (t CO_2e/t CH_4)

GWP_{N2O} = Global warming potential for N_2O (t CO_2e/t N_2O)

In the absence of an emissions factor that only considers combustion emissions for a given fuel, a combined emissions factor for both combustion and upstream emissions may be used as $EF_{Fuel,d}$ in Equation (3).

Off-site Fuel Consumption

The quantity of power or heat supplied from a directly connected off-site facility, $Q_{Fuel,d,y}$, is determined using Equation (4).

$$Q_{Fuel,d,y} = Q_{Cogen,d,y} \times \frac{\left(Heat_{Tra,y}/\eta_{Heat,y} + Electricity_{Tra,y}/\eta_{Elec,y}\right)}{\left(Heat_{Cogen,y}/\eta_{Heat,y} + Electricity_{Cogen,y}/\eta_{Elec,y}\right)} \quad (4)$$

Where:

$Q_{Cogen,d,y}$ = Quantity of fuel type *d* used by the cogeneration unit to generate electricity and/or heat in year *y* (m^3 or kg or GJ)

$Heat_{Tra,y}$ = Quantity of useful thermal energy supplied to the transport facility by the cogeneration unit in year *y* (MWh)

$Electricity_{Tra,y}$ = Quantity of electricity supplied to the transport facility by the cogeneration unit in year *y*; equal to zero where only heat is supplied to the transport facility (MWh)

$Heat_{Cogen,y}$ = Total quantity of useful thermal energy produced by the cogeneration unit in year *y* (MWh)

$Electricity_{Cogen,y}$ = Total quantity of electricity produced by the cogeneration unit in year *y* (MWh)

$\eta_{Heat,y}$ = Efficiency of heat production determined in year *y* using CDM TOOL09[6]

$\eta_{Elec,y}$ = Efficiency of electricity production determined in year *y* using CDM TOOL09

Waste Heat

Project emissions from the consumption of waste heat may be assumed to be zero for heat sources that meet the definition of waste heat in *VM0049*. The emissions associated with the generation of heat that does not meet the definition of waste heat must be accounted for in Equation (3) or (4) as appropriate.

5.2.1.2 Fugitive and Venting Emissions from On-site Fuel Use

Transportation activities using natural gas must quantify fugitive and venting emissions during facility operations. Quantification is based on component counts and respective emission

[6] Available at: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-09-v3.0.pdf

factors, fugitive emissions are quantified following the approach in the US Environmental Protection Agency's *Electronic Code of Federal Regulations*, Title 40, Part 98, Subpart W, § 98.233(r) [7].

Examples of emission sources for fugitive emissions include components such as valves, pipe fittings/connectors, open-ended pipes, pressure relief valves, flanges, meters, and instruments.

$$PE_{Fuel_{FV},y} = \left(\sum_n Count_{n,y} \times EF_n \times T_{n,y} \times 0.001 + \sum_m V_m\right) \times GWP_{CH_4} \quad (5)$$

Where:

$Count_{n,y}$	=	Total number of components *n* in natural gas service in the transport leg or intermediate storage site during year *y* (unitless)
EF_n	=	Emission factor for fugitive emissions for component *n* (kg CH_4/hr)
$T_{n,y}$	=	Pressurized time of component *n* in year *y* (hours)
V_m	=	Vented CH_4 emissions for venting event *m* (t CH_4)
0.001	=	Conversion from kg to t

5.2.2 Option B: Default Values

Project emissions associated with a transport leg may be calculated as per Equation (6), except when a pipeline is used as the transport mode.

$$PE_{Tra,r,y} = \sum_r (D_{r,y} \times MCO2_{Tra,r,y} \times DEF_r \times 10^{-6}) \quad (6)$$

Where:

$PE_{Tra,r,y}$	=	Total project emissions to operate transport legs in year *y* (t CO_2)
$D_{r,y}$	=	Trip distance traveled in transport leg *r* in year *y* (km)
$MCO2_{Tra,r,y}$	=	Mass of CO_2 transported by transport leg *r* in year *y* (tonnes)
DEF_r	=	Default emission factor to transport 1 t CO_2 for 1 km by ship, truck, or rail in transport leg *r* (g CO_2/t-km)
10^{-6}	=	Conversion from g to t

Project emissions from fossil fuel consumption for CO_2 transport via trucks, rail, and ships must consider both outbound and empty return trips.

[7] Available at: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-98/subpart-W/section-98.233

5.3 Quantification of Leakage

Equation (7) calculates the total leakage emissions of the transported CO_2 and is only required for legs using Option A to calculate project emissions from transportation. For transport legs using Option B, $LE_{Tra,y} = 0$.

$$LE_{Tra,y} = \sum_r LE_{Tra,r,y} + \sum_f LE_{Tra,f,y} - LE_{nonVCS\ CO2,y} \quad (7)$$

Where:

$LE_{Tra,y}$	=	Leakage emissions from CO_2 transportation in year *y* (t CO_2e)
$LE_{Tra,r,y}$	=	Leakage emissions for transport leg *r* in year *y* (t CO_2e)
$LE_{Tra,f,y}$	=	Leakage emissions from the operation of intermediate storage site *f* in year *y* (t CO_2e)
$LE_{nonVCS\ CO2,y}$	=	Leakage emissions from processes and equipment related to non-VCS sources in year *y* determined using the most recent version of *VT00XX Accounting Non-VCS CO_2 in CCS Projects*; equal to zero for projects with no non-VCS CO_2 (t CO_2e)

Leakage emissions from intermediate storage sites and transport legs include those from grid electricity consumption, fossil fuel combustion, and heat consumption.

5.3.1 Leakage of Fuel and Electricity Consumption

Leakage emissions associated with a transport leg are calculated as per Equation (8).

$$LE_{Tra,r,y} = LE_{Fuel,r,y} + LE_{Elec,r,y} \quad (8)$$

Where:

$LE_{Fuel,r,y}$	=	Leakage GHG emissions from upstream fuel consumption for transport leg *r* in year *y* (t CO_2e)
$LE_{Elec,r,y}$	=	Leakage GHG emissions from upstream electricity consumption to operate transport leg *r* in year *y* calculated using *VT0010 Emissions from Electricity Consumption* (t CO_2e)

Leakage emissions from upstream fossil fuel consumption for CO_2 transport via trucks, rail, and ships must consider both outbound and empty return trips.

Leakage emissions associated with intermediate storage are calculated as per Equation (9).

$$LE_{Tra,f,y} = LE_{Fuel,f,y} + LE_{Elec,f,y} \quad (9)$$

Where:

$LE_{Fuel,f,y}$ = Leakage GHG emissions from upstream fuel consumption for intermediate storage site *f* in year *y* (t CO_2e)

$LE_{Elec,f,y}$ = Leakage GHG emissions from upstream electricity consumption to operate intermediate storage site *f* in year *y* calculated using *VT0010 Emissions from Electricity Consumption* (t CO_2e)

5.3.1.1 Leakage Emissions from Fuel Consumption

Upstream emissions from the production and transportation of fuel consumed in the module boundary are calculated using Equation (10).

$$LE_{Fuel,y} = \sum_{d} (Q_{Fuel,d,y} \times EF_{Upstream\_Fuel,d,y}) \quad (10)$$

Where:

$EF_{Upstream\_Fuel,d,y}$ = Emission factor for upstream sources related to fuel type *d* consumed for transport or intermediate storage processes in year *y* (t CO_2e/m^3 or t CO_2e/kg or t CO_2e/GJ)

Where power and heat are supplied from an off-site facility, $Q_{Fuel,d,y}$ must be determined as a proportion of the total fuel used to generate the total electricity and heat generated by the directly connected facility, using Equation (4).

Equation (10) is not required if an emissions factor covering both fuel combustion ($EF_{Fuel,d}$) and upstream emissions ($EF_{Upstream\_Fuel,d,y}$) was used in Equation (3).

5.4 Uncertainty

The main source of uncertainty identified for the project activities covered in this module is measurement error.

However, this uncertainty is considered *de minimis* where:

- The default emission factors for transport are used, or
- The metering equipment used for determining fuel volumes $Q_{fuel,d,y}$ is a custody transfer meter or fiscal metering for a transaction.

Proponents whose projects do not meet the above conditions for a source of uncertainty must include that source of uncertainty in their uncertainty assessment.

6 DATA AND PARAMETERS

Additional data and parameters are defined in *VM0049* and related tools (VCS and CDM) as applicable.

6.1 Data and Parameters Available at Validation

Data/Parameter	GWP_{CH4}
Data unit	t CO_2e/t CH_4
Description	Global warming potential for CH_4
Equations	(3), (5)
Source of data	Most recent version of the *VCS Standard*
Value applied	See the most recent version of the *VCS Standard*.
Justification of choice of data or description of measurement methods and procedures applied	Required by the *VCS Standard*
Purpose of data	Calculation of project emissions
Comments	N/A

Data/Parameter	GWP_{N2O}
Data unit	t CO_2e/t N_2O
Description	Global warming potential for N_2O
Equations	(3)
Source of data	Most recent version of the *VCS Standard*
Value applied	See the most recent version of the *VCS Standard*.
Justification of choice of data or description of	Required by the *VCS Standard*

measurement methods and procedures applied	
Purpose of data	Calculation of project emissions
Comments	N/A

Data/Parameter	DEF_r
Data unit	g CO_2/t-km
Description	Default emission factor to transport 1 t CO_2 for 1 km by ship, truck, or rail in transport leg *r*
Equations	(6)
Source of data	Figure 8.6 in Chapter 8, *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (referred to as Figure 8.6)
Value applied	See table below
Justification of choice of data or description of measurement methods and procedures applied	The IPCC provides a range of emission intensities for different transportation modes in Figure 8.6. The value at the high-end of the ranges is used. Where the high-end of the range landed between two emission factors, the higher of the emission factors is used. For example, the high-end of the range for t*rucks (HDV large)* in Figure 8.6, falls between 150 gCO2/km and 200 gCO2/km. So, a value of 200 gCO2/km is used. To account for the upstream emissions associated with the fuel use, the combustion emission factor value is multiplied by a conversion factor of 1.2.

Transport Modality	DEF_r (g CO_2/t-km)
Truck (HDV large)	240
Rail	120
Ships	60
Barges	120

The values presented in the table above may be subject to change if the emission factors presented in Figure 8.6 are superseded.

In such a case, project proponents must recalculate the default emission factors using the process outlined in the procedures section below.

	For example, the value for t*rucks (HDV large)* of 200 gCO2/km multiplied by 1.2 yields a default factor of 240 gCO2/km. The conversion factor of 1.2 was determined by comparing the emission factors presented in Figure 8.6 of the IPCC for the typical transportation fuels (e.g. - gasoline/diesel and natural gas) to upstream emission factors from Table 3 in CDM Tool15 Upstream Leakage emissions associated with fossil fuel use. Upstream emission factors were divided by combustion emission factors to determine a ratio. The ratios across the fuel types were averaged and rounded up to yield 1.2.
Purpose of data	Calculation of project emissions
Comments	

6.2 Data and Parameters Monitored

Data/Parameter	$Q_{Fuel,d,y}$
Data unit	m^3 or kg or GJ
Description	Quantity of fuel type *d* used to operate on-site and/or third-party (for off-site heat/steam supply) equipment for an individual transport leg or intermediate storage site in year *y*
Equations	(3), (4), (10)
Source of data	Onsite measurements or fuel receipts/invoices
Description of measurement methods and procedures to be applied	Measured from flow meters or calculated from fuel receipts/invoices.
Frequency of monitoring/recording	Aggregated annually
QA/QC procedures to be applied	Flow meters, including those used in custody transfers or for the purposes of fiscal metering must be operated within the manufacturer's specified operating conditions at all times. Flow meters must be routinely calibrated, inspected, and maintained according to the manufacturer's specifications.

	Fuel consumption quantities should be cross-checked against an annual energy balance based on purchased quantities, stock changes and purchase invoices as appropriate[8].
Purpose of data	Calculation of project and leakage emissions
Calculation method	Measured not calculated
Comments	Volumetric gas flow meter readings must be corrected for temperature and pressure. Fuel consumption must be adjusted as follows: For transport via trucks, rail, barges or ships, the distance must consider both outbound and empty return trips. Where other freight is transported on the return trip, the distance associated with the return trip need not be accounted for. The company supplying or transporting the CO_2 should provide data to the project proponent about the mode(s) of transportation used, the total number of tonnes delivered, and the total distance traveled. Where the transportation process incurs stops that are not part of the direct trip, their added distances must be included (e.g., a ship transporting CO_2 that detours to collect another cargo from another site before arriving at the storage site).

Data/Parameter	$EF_{Fuel,CO2,d}$
Data unit	t CO_2/m^3 or t CO_2/kg or t CO_2/GJ
Description	CO_2 emission factor for combustion of fuel *d*
Equations	(3)
Source of data	The following data sources may be used: *1)* Emission factor from IPCC (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* 2) Emission factor from US EPA https://www.epa.gov/climateleadership/ghg-emission-factors-hub or similar source 3) Data provided by the fuel supplier or manufacturer where the data used is consistent with that reported to a regulatory body.

[8] Adapted from CDMTool03: Tool to calculate project or leakage CO2 emissions from fossil fuel combustion

Description of measurement methods and procedures to be applied	Use the most recent data published by the above sources at the time of reporting project emissions.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	N/A

Data/Parameter	$EF_{Fuel,CH4,d}$
Data unit	t CH_4/m^3 or t CH_4/kg or t CH_4/GJ
Description	CH_4 emission factor for combustion of fuel *d*
Equations	(3)
Source of data	The following data sources may be used: *1)* Emission factor from IPCC (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* 2) Emission factor from US EPA https://www.epa.gov/climateleadership/ghg-emission-factors-hub or similar source 3) Data provided by the fuel supplier or manufacturer where the data used is consistent with that reported to a regulatory body.
Description of measurement methods and procedures to be applied	Use the most recent data published by the above sources at the time of reporting project emissions.
Frequency of monitoring/recording	Annual

QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	N/A

Data/Parameter	$EF_{Fuel,N2O,d}$
Data unit	t N_2O/m^3 or t N_2O/kg or t N_2O/GJ
Description	N_2O emission factor for combustion of fuel *d*
Equations	(3)
Source of data	The following data sources may be used: *1)* Emission factor from IPCC (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* 2) Emission factor from US EPA https://www.epa.gov/climateleadership/ghg-emission-factors-hub or similar source 3) Data provided by the fuel supplier or manufacturer where the data used is consistent with that reported to a regulatory body.
Description of measurement methods and procedures to be applied	Use the most recent data published by the above sources at the time of reporting project emissions.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	N/A

Data/Parameter	$Q_{Cogen,d,y}$
Data unit	m^3 or kg or GJ
Description	Quantity of fuel type *d* used by the cogeneration unit to generate electricity and/or heat in year *y*
Equations	(4)
Source of data	Fuel receipts/invoices or flow meter readings, as applicable
Description of measurement methods and procedures to be applied	Measured from flow meters or calculated from fuel receipts/invoices.
Frequency of monitoring/recording	Continuous or for every invoice, aggregated annually
QA/QC procedures to be applied	Measuring equipment (e.g., flow meters, weighing scale) must operate within the manufacturer's specified operating conditions and must be routinely calibrated, inspected, and maintained according to manufacturer specifications.
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	Invoices and/or contracts with the third party must be in place to allow proper data collection.

Data/Parameter	$Heat_{Tra,y}$
Data unit	MWh
Description	Quantity of useful thermal energy supplied to the transport facility by the cogeneration unit in year *y*
Equations	(4)
Source of data	Utility receipts/invoices or metered data for heat usage
Description of measurement methods and procedures to be applied	Measured from calorimeters or calculated from receipts/invoices.

Frequency of monitoring/recording	Aggregated annually
QA/QC procedures to be applied	Calorimeter must be routinely calibrated, inspected, and maintained according to manufacturer specifications.
Purpose of data	Calculation of project emissions
Calculation method	See above
Comments	Invoices and/or contracts with the third party must be in place to allow proper data collection.

Data/Parameter	$Electricity_{Tra,y}$
Data unit	MWh
Description	Quantity of electricity supplied to the transport facility by the cogeneration unit in year *y*
Equations	(4)
Source of data	Utility receipts/invoices or metered data for electricity use
Description of measurement methods and procedures to be applied	Measured from electricity meters or calculated from receipts/invoices.
Frequency of monitoring/recording	Aggregated annually
QA/QC procedures to be applied	Electricity meters must be routinely calibrated, inspected, and maintained according to manufacturer specifications.
Purpose of data	Calculation of project emissions
Calculation method	Measured not calculated.
Comments	Invoices and/or contracts with the third party must be in place to allow proper data collection. Equal to zero where only heat is supplied to the transport facility.

Data/Parameter	$Heat_{Cogen,y}$

Data unit	MWh
Description	Total quantity of useful thermal energy produced by the cogeneration unit in year *y*
Equations	(4)
Source of data	Utility receipts/invoices or metered data for heat produced
Description of measurement methods and procedures to be applied	Direct measurement of steam flows (or other heat transfer fluid) and characteristics at the cogeneration facility, taking into consideration energy content in steam and condensate return
Frequency of monitoring/recording	Aggregated annually
QA/QC procedures to be applied	Calorimeters must be routinely calibrated, inspected, and maintained according to manufacturer specifications.
Purpose of data	Calculation of project emissions
Calculation method	Measured not calculated.
Comments	Invoices and/or contracts with the third party must be in place to allow proper data collection.

Data/Parameter	$Electricity_{Cogen,y}$
Data unit	MWh
Description	Total quantity of electricity produced by the cogeneration unit in year *y*
Equations	(4)
Source of data	Utility receipts/invoices or metered data
Description of measurement methods and procedures to be applied	Measured from electricity meters or calculated from receipts/invoices.
Frequency of monitoring/recording	Aggregated annually

QA/QC procedures to be applied	Invoices and/or contracts with the third party
Purpose of data	Calculation of project emissions
Calculation method	Measured not calculated.
Comments	Invoices and/or contracts with the third party must be in place to allow proper data collection.

Data/Parameter	$Count_{n,y}$
Data unit	Unitless
Description	Total number of components *n* in natural gas service in the transport leg or at intermediate storage site during year *y*
Equations	(5)
Source of data	Records of transportation legs or intermediate storage facility (e.g., pipe and instrument drawing, parts lists)
Description of measurement methods and procedures to be applied	Counting based on facility records as per US EPA *Electronic Code of Federal Regulations Title 40,* Chapter I, Subchapter C, Part 98, Subpart W § 98.233. Available at: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-98/subpart-W/section-98.233#p-98.233(a)(1)
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Use the most recent data available from the transportation or intermediate storage facility.
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	N/A

Data/Parameter	$T_{n,y}$
Data unit	hours
Description	Pressurized time of component *n* in year *y*
Equations	(5)
Source of data	Records of transportation or intermediate storage facility (e.g., control systems, recorded operational data)

Description of measurement methods and procedures to be applied	Data from transportation or intermediate storage facility records
Frequency of monitoring/recording	Continuous, aggregated monthly
QA/QC procedures to be applied	Use the most recent data available from the transportation or intermediate storage facility.
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	

Data/Parameter	V_m
Data unit	t CH_4/event
Description	Vented CH_4 emissions for venting event *m*
Equations	(5)
Source of data	Data from the transportation or intermediate storage facility
Description of measurement methods and procedures to be applied	**Option 1:** Direct measurement of venting **Option 2:** Estimated based on isolated volumes of pipes and equipment **Option 3:** Estimated based on non-isolated volumes of pipes and equipment. The project proponent must determine the quantity of vented CH_4 by transient flow rate calculations for compressible fluids appropriate for the expected evolving conditions in the pipeline or component based on the approximate geometry of the escaping flow and pipelines/components connected to the venting.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Cross-checked based on energy balance related to metered fuel use.
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	N/A

Data/Parameter	EF_n
Data unit	kg CH_4/hr

Description	Emission factor of fugitive emissions for component *n*
Equations	(5)
Source of data	Emission factor derived from US EPA *Electronic Code of Federal Regulations, Title 40*, Part 98, Subpart W, § 98.233(a)(1)[9] or equivalent regulations appropriate to the jurisdiction in which the project is located.
Description of measurement methods and procedures to be applied	Use the most recent data published by the above sources at the time of reporting project emissions.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	N/A

Data/Parameter	$D_{r,y}$
Data unit	km
Description	Trip distance traveled in transport leg *r* in year *y*
Equations	(6)
Source of data	Determined for each CO_2 transportation leg for a reference trip using the vehicle odometer or equivalent measurement device (e.g., using handheld/mounted global positioning systems (GPS), online sources (maps)).
Description of measurement methods and procedures to be applied	For transport via trucks, rail, barges or ships, the distance must consider both outbound and empty return trips. Where other freight is transported on the return trip, the distance associated with the return trip need not be accounted for. The company supplying or transporting the CO_2 must provide data to the project proponent about the mode(s) of transportation used, the total number of tonnes delivered, and the total distance traveled.

[9] For more information see US EPA: Available at: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-98/subpart-W/section-98.233

	Where the transportation process incurs stops that are not part of the direct trip, their added distances must be included (e.g., a ship transporting CO_2 that detours to collect another cargo from another site before arriving at the storage site).
Frequency of monitoring/recording	Continuous Where the mode of transport, origin, and destination are the same, the distance between the origin and the destination may be multiplied by the total number of trips taken during the monitoring period.
QA/QC procedures to be applied	To be updated when the distance changes. Devices used (such as odometers and GPS) must be calibrated as per the manufacturer's specifications. Where using online sources (e.g., maps), the distance between the start and end destination must not be less than the actual distance traveled between those two points.
Purpose of data	Calculation of project emissions
Calculation method	Where distances are measured through devices such as odometers, the distance is the difference between the reading at the start of the transport leg and the reading at the end of the transport leg.
Comments	Applicable only to Option B and where project emissions from transport modes (trucks, ships, and rail) are separate from emissions to operate intermediate storage and other equipment.

Data/Parameter	$MCO2_{Tra,r,y}$
Data unit	tonnes
Description	Mass of CO_2 transported by transport leg *r* in year *y*
Equations	(6)
Source of data	Measurement
Description of measurement methods and procedures to be applied	As per the criteria and procedures established in *VM0049*. Where CO_2 is transported in containers/tanks that are not part of the mode of transport used (e.g., a train transporting CO_2 in a container attached to the train), the weight of the container/tank must be included in the total mass transported.
Frequency of monitoring/recording	Continuous

QA/QC procedures to be applied	As per the criteria and procedures established in *VM0049*. Calculated per the manufacturer's specifications.
Purpose of data	Calculation of project emissions
Calculation method	As per the criteria and procedures established in *VM0049*
Comments	Applicable only to Option B and where trucks, ships, and rail are used. This is not applicable to transport via pipeline.

Data/Parameter	$EF_{Upstream\_Fuel,d,y}$
Data unit	t CO_2e/m^3 or t CO_2e/kg or t CO_2e/GJ
Description	Emission factor for upstream sources related to fuel type *d* used in equipment in the transport module boundary in year *y*
Equations	(10)
Source of data	The value of this parameter may be obtained from the following sources: 1) A life cycle assessment (LCA) conducted by a qualified third party in accordance with the most recent versions of ISO 14040 and 14044, that uses either primary or published and peer-reviewed data;[10] 2) A compliance market-approved tool (e.g., such as CA-GREET[11], GHGenius[12]); 3) Emission factors published in peer-reviewed literature[13] that are representative of the fuels used in transport legs or at intermediate storage sites both temporally and geographically: or 4) Data provided by the fuel supplier or manufacturer where the data used is consistent with that reported to a regulatory body.
Description of measurement methods	Use the most recent data published by the sources at the time of reporting project emissions.

[10] State or national government data on a fuel's carbon intensity are also acceptable sources of data for determining emission factors for fuels used by the transport facility.

[11] The Greenhouse Gases, Regulated Emissions and Energy use in Technologies (GREET) model. Available at: https://greet.es.anl.gov/

[12] Model for Life Cycle Assessment of Transportation Fuels. Available at: https://www.ghgenius.ca/

[13] Peer-reviewed literature must be indexed in the Web of Science: Science Citation Index (SCI; available at https://mjl.clarivate.com), as specified in Section 2.5.2 of the *VCS Methodology Requirements, v4.4*.

and procedures to be applied	
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	Use the most recent data published by the above sources at the time of reporting project emissions. Where peer-reviewed literature is used, it must have been published within a year of reporting project emissions. It must be temporally and geographically representative of the transport facility.
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	N/A

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DOCUMENT HISTORY

Version	Date	Comment
v1.0	October 24, 2024	Initial version