METHODOLOGY

BIOMASS FERMENTATION WITH CARBON CAPTURE AND GEOLOGIC STORAGE

SDG 13

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SUMMARY

This methodology is applicable to the project activities where captured carbon dioxide (CO_2) from biomass fermentation is captured and permanently stored in geological storage. Biomass captures significant quantities of CO_2 during photosynthesis and much of that carbon is released back into the atmosphere during the fermentation process. This methodology can be used to quantify the emission reductions associated with the capture and storage of the CO_2, leading to a permanent removal of CO_2 from the atmosphere.

ACKNOWLEDGEMENT

The development of the methodology is inspired by relevant publicly available documents, including compliance and voluntary greenhouse gas (GHG) emissions reduction quantification methodologies. The following sources have informed the development of the methodology, in order of relative contribution:

- International Organization of Standardization (ISO) 14064-2:2019 Greenhouse gases - Part 2 (2019),
- Carbon Capture and Sequestration Protocol under the Low Carbon Fuel Standard California Air Resources Board, (2018),
- Clean Fuel Regulations, SOR/2022-140, and
- Carbon Capture and Storage Projects Methodology, V2.0 Draft American Carbon Registry, (2022).

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1| INTRODUCTION

1.1.1 | The following table describes the key requirements for the methodology:

Table 1 Key Information

Typical project type	Activities that involve capturing CO_2 from the fermentation of renewable biomass and permanently storing it in geologic storage complex.
Activity Type	Engineered GHGs removal
Applicable GS4GG products	☒ GSVERs ☒ Certified impact statement
Geographical applicability	Global
Applicable project scale	☒ Micro scale ☒ Small scale ☒ Large scale
Mitigation type	☐ Emission reduction ☒ Emission removal
Project start date	— The earliest date on which the project developer has committed to expenditures related to the implementation of the project. — Relevant expenditures exclude those associated with the acquisition of title or access rights to the surface and/or subsurface estates on which the project is intended to take place.
Crediting period start date	The earliest date on which CO_2 is injected into a geologic storage complex or a maximum of two years prior to the date of project design certification, whichever occurs later. For the purposes of determining the crediting period start date, injection activity – required by regulators for the receipt or maintenance of a permit, license, or other such authorizations to operate any portion of the project infrastructure, or for scientific or research and development purposes – shall not be considered.
Crediting period	Forty Five years (maximum); Project follows five year renewal cycle per latest version of GS4GG requirements for renewal of crediting period.

2| DEFINITION

2.1.1 | The terms and definitions contained in the Glossary of GS4GG, along with the those provided in this methodology, apply to this methodology.

Table 2 Terms and Definitions

TERM	DEFINITION
Biomass Fermentation Facility	A facility which converts biomass feedstock into various products (e.g., ethanol, animal feed, and CO_2) through fermentation.
Capture Site	A site where various equipment captures, dehydrates, compresses, and meters CO_2 that is transported and injected for storage in geologic storage complex. Begins directly after the outlet of the CO_2 source and ends at the origin of the transport site(s) which transmit the site's captured fluids, as shown in Figure 1.
Captive Power Source	A facility or source of power from which the project or project developer directly, by means of direct ownership, contractual agreement, or other such arrangement, secures quantities of electricity and/or heat. Captive power sources may be connected to a regional energy system or grid (grid-connected) or may be standalone (grid-disconnected). Example: on-site co-generation or electricity generation facilities, or a facility or power source with which the project or project developer has physical or virtual power purchasing agreements.
Carbon Capture and Geologic Storage (CCGS)	The separation and capture of CO_2 from the atmosphere or from atmospheric emissions of industrial processes, and the transport and safe, permanent geologic storage of the CO_2.
Decommission	To take an engineered system or component out of service, render it inoperative, and dismantle and decontaminate it.
Fermentation	A biochemical conversion process in which biomass is decomposed using microorganisms, such as bacteria, yeasts, or enzymes. Example: the biochemical conversion of biomass into CO_2, ethanol, and animal feed products, or the anaerobic digestion of biomass into biogas and digestate.
Injection Site	The area on the ground surface, defined by the operator and/or regulator, where CO_2 injection facilities are developed and operational activities take place. Begins directly after the ultimate termini of the transport sites and ends directly before the geologic storage complex (e.g., at the perforations in the injection well), as shown in Figure 1.
Kick	Any unexpected entry of water, gas, oil, or other formation fluid into a wellbore that is under control and can be circulated out.
Non-Project Stream and Non-Project Fluid	A non-project stream is any quantity of CO_2 and/or fluids which are:

	a. Emitted from sources other than the fermentation of renewable biomass and subsequently captured[1] i. Where emissions from the fermentation of both renewable and non-renewable biomass at a facility commingle prior to the point of capture, the project developer shall consider the captured stream as two separate streams, one project and the other non-project, respectively; or, b. Captured at project sites and are considered in the selected baseline[2] (see 5.4.1 |a); or, c. Emitted during the fermentation of renewable biomass and subsequently captured and are also counted towards the host country's domestic climate mitigation policy; or d. Emitted during the fermentation of renewable biomass and subsequently captured and are also accounted for in other voluntary or compliance standards or programs.[3]
Geological Storage Complex	The subsurface geological system extending vertically to comprise geologic reservoirs and identified seal(s) and extending laterally to the defined limits of the CO_2 storage project.
Site Characterization	The detailed evaluation of one or more candidate sites for CO_2 storage identified in the screening and selection stage of a CO_2 storage project to confirm and refine geological storage complex

[1] For example, where CO_2 is captured exclusively from combustion emissions, the entire captured quantity is non-project stream; where CO_2 is captured from both combustion and renewable biomass fermentation sources, the quantity captured from combustion sources is a non-project stream; where CO_2 is captured from the co-fermentation of both renewable and non-renewable biomass, the quantity captured from non-renewable biomass fermentation sources is a non-project stream. Further guidance on quantification and monitoring of project and non-project streams are provided in 5.5.5 | and

Table 4.

[2] For example: fermentation products (e.g. renewable fuels) produced at the biomass fermentation facility may be subject to regulatory performance standard requirements (such as maximum lifecycle emissions per MJ of renewable fuel), representing a credible and plausible alternative scenario to the project activity. In some cases, this scenario corresponds with the lowest baseline emissions of the remaining credible and plausible alternative scenarios and, per 5.4.1 |, it shall be selected as the baseline scenario. In such cases, where the project enables the fermentation facility to exceed the regulatory performance standard requirement, only reductions in excess of the requirement are eligible. For conservativeness, project developers shall consider all emissions reductions required to conform with the performance standard requirements as non-project CO_2 captured at the project site ($Q_{Non-project,i,k}$);

[3] Further guidance on quantification and monitoring of non-project streams which participate in other voluntary or compliance programs are provided in the applicable monitoring parameter tables in 5.11 |

	integrity, storage capacity, and injectivity estimates and to provide basic data for initial predictive modelling of fluid flow, geochemical reactions, geomechanical effects, risk assessment, and monitoring and validation program design.
Storage Project	The physical and temporal extent of activities associated with a project for the geological storage of CO_2 which includes site selection and characterisation, data collection, permitting, design and construction of site facilities (site pipelines, compressors, etc.), well drilling, receipt of CO_2 at the storage site, CO_2 injection during the active injection phase, and site closure (including well and facilities abandonment).
Storage Site	The physical and spatial extent, at the surface and in the underlying strata, encompassing the injection and storage of CO_2, and locations where the geological storage complex is monitored. Includes the injection site, geological storage complex, and associated infrastructure required to operate and monitor the injection and storage activity (such as, for example, observation wells), as shown in Figure 1.
Storage Site Operator	A person, corporation, or entity authorized to drill injection and monitoring wells and operate a storage site, possesses surface and subsurface access rights sufficient to allow appropriate monitoring during the injection period, closure period and post-closure period.
Transport Site	A site consisting of equipment which continuously transmits project CO_2 along a fixed path, either via pipeline, rail or truck.

3| SCOPE, APPLICABILITY, AND ENTRY INTO FORCE

3.1 | Scope

3.1.1 | This methodology is appliable to the project involving capturing CO_2 emitted from the fermentation of renewable biomass, transporting the CO_2 via pipeline, rail, or truck and injecting the CO_2 into a geologic storage complex.

3.2 | Applicability

3.2.1 | The methodology is applicable under following conditions.

a. Source(s) of Biomass

3.2.2 | Source of CO_2 shall be demonstrable renewable biomass.

b. Capturing of CO_2

3.2.3 | The project shall capture CO_2 emitted during the fermentation of renewable biomass at new or existing biomass fermentation facilities, where a facility is defined as:

a. An existing facility if fermentation of biomass at facility starts before the project start date.

b. A new facility if fermentation of biomass at facility starts after the project start date.

c. Transportation of CO_2

3.2.4 | The project shall transport captured CO_2 to the injection site(s) through one or a combination of connected transport sites, each consisting of infrastructure which continuously transport captured CO_2 along a fixed path.

a. A transport site shall have only one mode: either pipeline, rail or truck

i. Where captured CO_2 is conveyed via pipeline, the fixed path comprises the surveyed route of the pipeline network which allows for the continuous transmission of captured CO_2 between, and is bounded by, the maximal independent set of origins and termini and is bounded by those points.

ii. Where captured CO_2 is conveyed via railway, the fixed path comprises the specific combination of railways that are transited to convey captured CO_2 between, and is bounded by, a single origin and a single terminus and is bounded by those points.

iii. Where captured CO_2 is conveyed via truck, the fixed path comprises the specific combination of roads that are transited to convey captured CO_2 between, and is bounded by, a single origin and a single terminus and is bounded by those points.

3.2.5 | A transport site origin refers to the following locations, in order of applicability:

a. An international boundary;

b. A documented custody transfer point, per 3.2.8 | and 3.2.9 |,

c. A pipeline injection station or similar;[4]

d. A railway car loading station, or

e. A truck loading station.

3.2.6 | A transport site terminus refers to the following locations, in order of applicability:

a. A project injection site;

b. An international boundary;

c. A documented custody transfer point, per 3.2.8 | and 3.2.9 |,

d. A pipeline delivery station or similar;[5]

e. A railway car unloading station, or

[4] For example, A tie-in or junction of a CO_2 gathering system and CO_2 transmission pipeline, using as an analogue the characterization of petroleum and natural gas systems by the U.S. Environmental Protection Agency provided at: https://www.epa.gov/ghgreporting/ghgrp-petroleum-and-natural-gas-systems

[5] Ibid

f. A truck unloading station.

d. Storage of CO_2

3.2.7 | The project injects the captured CO_2 into one or more secure geologic storage complex. Refer to GS4GG Tool 03 - Project emissions calculation and monitoring requirements for geological storage complex for requirements applicable to the storage complex.

e. Project Configurations

3.2.8 | Projects may include multiple capture sites, transport sites, injection sites, and/or storage sites such as those participating in a carbon capture and sequestration hub.

a. A project may have multiple transport sites only where the transport site's equipment and processes are connected such that there is no spatial and temporal overlap with other transport sites.

b. The project developer shall provide documentation of the custody of streams captured from each CO_2 source and, if applicable, any transfers of custody which occur downstream of the point of capture.

3.2.9 | Project infrastructure may be used to capture, transport, and store non-project streams (as shown in Figure 1) only where each of the following requirements are met:

a. Non-project streams supplied to project capture, transport, and storage infrastructure shall be monitored using methods prescribed or permitted in this methodology, and

b. The project developer shall provide documentation of the custody of non-project streams captured from each CO_2 source, and if applicable, any transfers of custody which occur downstream of the point of capture.

3.2.10 |Project infrastructure may be used to capture, transport, and export captured fluids outside of the project boundary only where each of the following requirements are met:

a. The fluid is exported outside of the project boundary at the location of a transport site terminus, and

b. Fluids exported outside of the project boundary are monitored using methods prescribed or permitted in this methodology, and

c. The project developer shall provide documentation of the custody of exported fluids captured from each CO_2 source, including transfers of custody which occur downstream of the point of capture.

3.2.11 |The Project may expand over time by addition of capture, transport, injection, and/or storage sites. Project developer shall follow latest version of Design Change requirements for approval of proposed and/or implemented design changes.

f. Permanence

3.2.12 | Project developers shall assess the potential Reversal Risk associated with the project and implement the measure to address the potential reversals as per the GS4GG Tool 04 - Reversal risk assessment for geological storage.

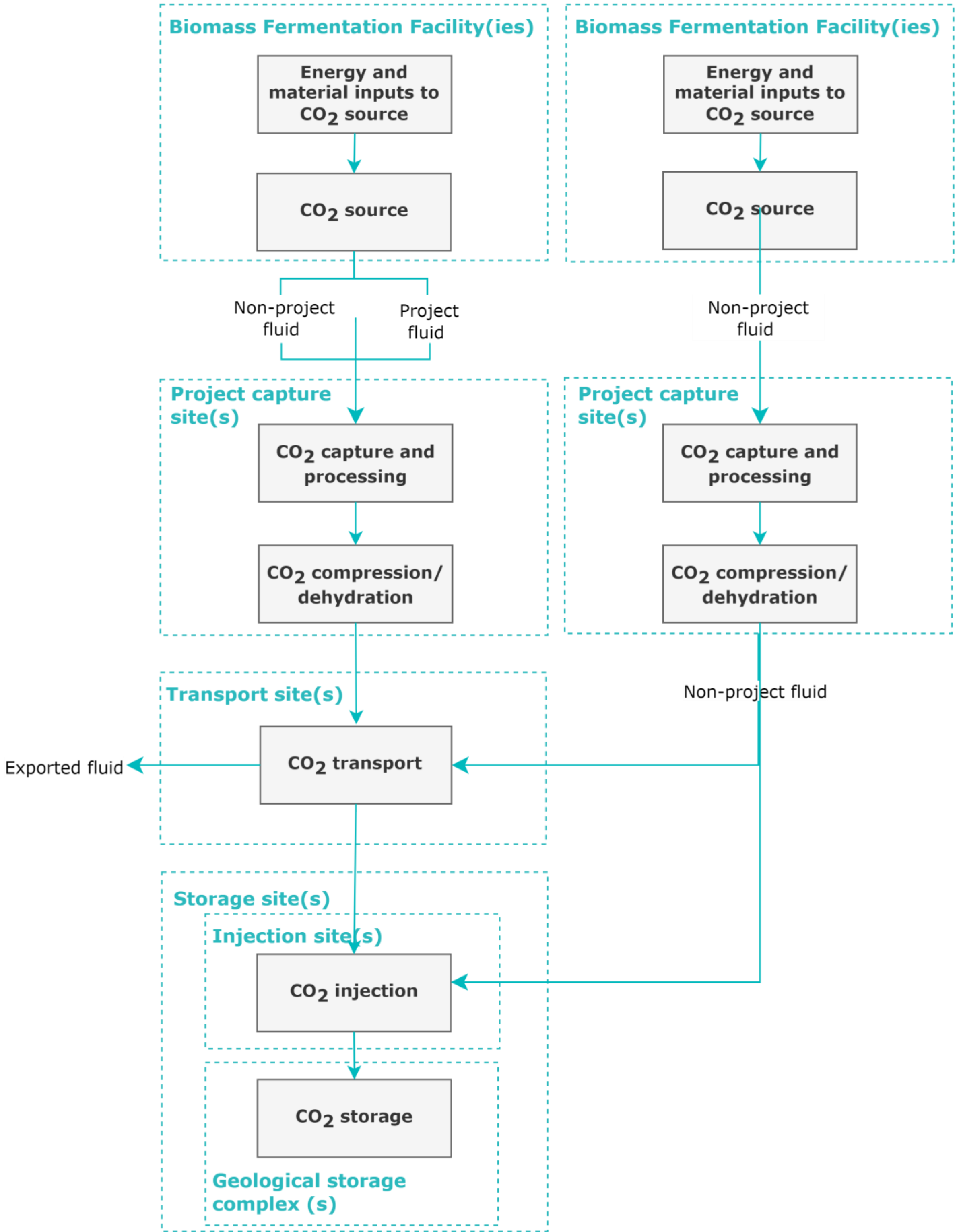

Figure 1: Process Elements at Capture, Transport, Injection, and Storage Site(s) and Potential Configurations with Non-Project Streams

3.3 | Safeguards

3.3.1 | **Legal compliance:** The project shall not undermine or conflict with any national, sub-national or local regulations or guidance relevant to project activity.

3.3.2 | **Contractual Obligation:** It is the sole responsibility of the project developer to ensure that all data and monitoring requirements are met. The project developer shall, by means of direct ownership, contractual agreement, or other such arrangement between the project developer and the relevant project and non-project participants, establish access to the required monitoring data and supporting documentation set forth in this methodology, Gold Standard Principles & Requirements, GHG Emissions Reduction & Sequestration Product Requirements, and applicable Activity Requirements.

3.3.3 | **Double counting:** If the source(s) of CO_2 are regulated under a host country's domestic climate mitigation policy or participate in other voluntary or compliance standards or programs, the project shall demonstrate in line with GHG Emissions Reduction & Sequestration Product Requirements that no double-counting takes place.

3.3.4 | **Double issuance and/or Claims:** To mitigate the risk of double issuance and claims, developer shall conform with the requirements and apply the procedures set forth in GHG Emissions Reduction & Sequestration Product Requirements.

3.4 | Entry into Force

3.4.1 | The date of entry into force of this methodology version is 30 days from publication date.

4| NORMATIVE REFERENCES

4.1.1 | This methodology refers to the latest approved versions of the following methodologies and tool(s):

a. CDM Tool 03 - Tool to calculate project or leakage CO2 emissions from fossil fuel combustion (to be replaced with GS4GG Tool 01 - Project or Leakage Emissions From Fossil Fuel Combustion)
b. CDM Tool 05 – Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation,
c. CDM Tool 07 - Tool to calculate the emission factor for an electricity system
d. CDM Tool 12 – Project and leakage emissions from transportation of freight, (to be replaced with GS4GG Tool 02 - Project and Leakage Emissions From Transportation),
e. CDM Tool 16 – Project and leakage emissions from biomass,
f. ISO 14044:2006 - Life Cycle Assessment, Requirements and Guidelines.

5| BASELINE METHODOLOGY

5.1 | Project Boundary

5.1.1 | The spatial extent of the project boundary

a. encompasses the physical, geographical site(s) where CO_2 generated by biomass fermentation is captured by the project, the site(s) where the captured CO_2 is processed, the site(s) where the processed CO_2, is compressed and dehydrated, the site(s) of the CO_2 transport system, the site(s) where CO_2 is injected for storage, and the geological storage complex where the injected CO_2 is stored, and

b. includes the site(s) where biomass fermented by the CO_2 source facility(ies) is cultivated in dedicated plantations, and the site(s) where biomass and/or biomass residues are transported and/or processed.

5.1.2 | The location of each project site shall be uniquely identified using global positioning system (GPS) coordinates (five decimals), or in the case of a pipeline, using a map that allows for the determination of the GPS coordinates to five decimal places for any location along the pipeline.

5.1.3 | Project developer shall provide supporting documentation demonstrating the project location(s) which includes one of the following: shape files, aerial photographs, maps, or satellite imagery. The supporting documentation shall clearly indicate the project boundary.

5.2 | Emissions Sources Included in the Project Boundary

5.2.1 | This methodology applies to the capture, compression, transport, and injection of CO_2 into geological storage complex for permanent storage. Project developers shall consider the emissions sources and guidance provided below when assessing baseline, project, and leakage emissions.

5.2.2 | Baseline emissions sources which are considered relevant for assessment are:

a. Injection of captured CO_2 that would have been emitted to the atmosphere in the absence of the project.

i. The developer shall consider quantities of CO_2 and fluids which are captured at project sites and considered in the selected baseline as non-project quantities.

ii. Where source(s) of CO_2 are regulated under a host country's domestic climate mitigation policy or participate in other voluntary or compliance standards or programs, project developers shall ensure (using the procedures described for non-project stream, and the guidance provided in 7.2 | for relevant parameters 14, 15, 16, and 17) that no-double counting takes place.

5.2.3 | Project emissions sources which are considered relevant for assessment:

a. Emissions from biomass due to cultivation of biomass in dedicated plantations, and processing and transportation of biomass and biomass residues.

i. Only biomass which is fermented at the following facility types are included:

a. A facility which is new and ferments renewable biomass which is either cultivated in dedicated plantations or is derived from biomass residues; project developers may choose allocate emissions from biomass to the project using a suitable method as per ISO 14044 or similar product lifecycle assessment (LCA) standards; otherwise, the biomass emissions are conservatively attributed solely to the CO_2 captured by the project at the facility; or,

b. A facility that does not receive revenue for products (excluding CO_2) manufactured at the facility via fermentation of the same renewable biomass which emits CO_2 that is captured by the project.

b. Direct land use change emissions resulting from the installation of project infrastructure.

i. Infrastructure, or portions thereof, utilised by the project for which land use changes occurred prior to the project start date are considered part of the baseline scenario, and are excluded for consistency.

ii. Temporary changes in land use during the construction of the project infrastructure are excluded for simplicity.

iii. Land use changes from installation of infrastructure used to capture or transport exclusively non-project fluids are considered outside of the project boundary and excluded.

iv. Emissions from land use changes are amortised over the project's remaining crediting period. For example, emissions from land use changes occurring after the project start date and prior to the crediting period start date are amortised over a period of 40 years, whereas emissions from land use change occurring after the project crediting period start date are amortised over the period spanning the end of the most recent monitoring period through to the end of the project crediting period (i.e., less than 40 years).

c. Emissions from the construction of project infrastructure, including well drilling and servicing.

i. For simplicity, only emissions from the potential kick or blowout event that could release hydrocarbons or CO_2 during the drilling or servicing of injection and monitoring wells are included.

ii. Emissions from the construction of project infrastructure which occur before the crediting period start date are amortised over the project crediting period (i.e., 40 years), whereas emissions from the construction of project infrastructure which occur during the project crediting period are not amortised (i.e., the total emission is accounted for in the monitoring period in which it occurs).

d. Emissions from the production, transportation, and delivery of material inputs consumed by project infrastructure, such as amine-based sorbents, glycols, or lubricants.

e. Direct and upstream emissions from fuels consumed by project equipment.

    i. Fuels consumed by vehicles and other mobile equipment in the project for purposes other than the transportation of captured CO_2 are a minor source and are excluded for simplicity.

f. Emissions from the generation of electricity on- and off-site which is consumed by the project.

    i. Where projects consume electricity from captive power sources, developers shall demonstrate (using the procedures described in 5.6.8 |a & b) that no-double counting takes place.

g. Emissions from fugitive GHG, and routine and non-routine venting throughout the carbon capture and storage (CCS) value-chain.

    i. Venting and fugitive emissions of CO_2 which occur upstream of injection metering are accounted for in the baseline scenario, thus no monitoring or quantification of this source is required.

    ii. Non-CO_2 GHGs are conservatively excluded from the baseline as storage site permitting and permanence are undertaken and assessed in the context of permanent geological sequestration of CO_2. Any venting or fugitive emissions of non-CO_2 GHGs are necessarily a portion of those ultimately injected by the project, but not accounted for within the project boundary. For consistency and relevance, venting and fugitives of non-CO_2 GHGs along CCS value-chain (prior to injection metering) are excluded.

    iii. Only venting and fugitive emissions from injection surface facility instrumentation and piping located downstream of the injection metering point are included.

h. Emissions from the subsurface to the atmosphere resulting from loss of containment of injected CO_2.

5.2.4 | Leakage emissions which are considered relevant for assessment are:

a. Leakage emissions from biomass due to shift of pre-project activities, diversion of biomass from other applications, processing and transportation of biomass and biomass residues outside of the project. Project developers shall apply the various approaches described in 5.7.3 | in assessing and estimating leakage from biomass.

Figure 2: Project Process Flow Diagram and Baseline, Project, Leakage Emissions Sources and Sinks

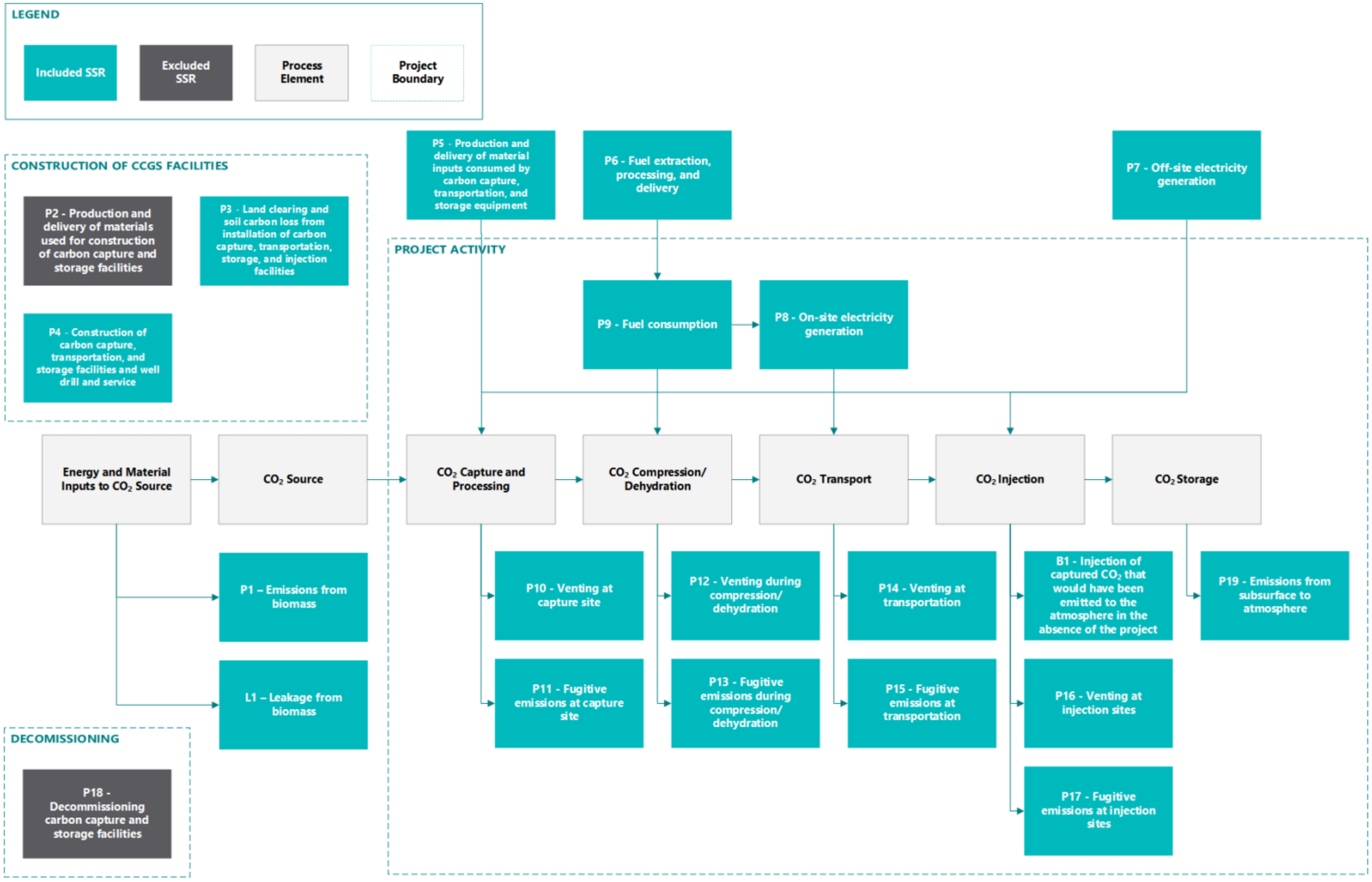

Table 3: Emissions Sources and Sinks Included in or Excluded from the Project Boundary

PROJECT OR BASELINE	SOURCE / SINK	GAS	INCLUDED OR EXCLUDED	JUSTIFICATION / DESCRIPTION
Baseline	B1 - Injection of captured CO_2 that would have been emitted to the atmosphere in the absence of the project	CO_2	Included	Baseline CO_2 emissions are dynamic and determined based on data from the direct measurement of the injected fluid streams which are measured upstream of the injection wellhead in the project. Major emissions source
		N_2O	Excluded	It is conservative to exclude non-CO_2 emissions in the baseline as storage site permitting and permanence are undertaken and assessed in the context of permanent geological sequestration of CO_2.
		CH_4	Excluded	As above
Project	P1 – Emissions from biomass	CO_2	Included	The project may capture CO_2 from the fermentation of renewable biomass from new or existing biomass fermentation facilities. Emissions from biomass may occur due to cultivation in dedicated plantations, and processing and transportation of biomass and biomass residues. Significant upstream emissions source
		N_2O	Included	As above
		CH_4	Included	As above
	P2 - Production and delivery of materials used for construction of carbon capture and storage facilities	CO_2	Excluded	Materials used in the construction of CO_2 capture, CO_2 transportation, and CO_2 storage facilities such as steel and concrete shall need to be manufactured and delivered to the site. Emissions are attributed to fossil fuel and electricity consumption for material manufacture and fossil fuel consumption for material delivery. Minor emissions source; excluded for simplicity
		N_2O	Excluded	As above

PROJECT OR BASELINE	SOURCE / SINK	GAS	INCLUDED OR EXCLUDED	JUSTIFICATION / DESCRIPTION
		CH_4	Excluded	As above
	P3 - Land clearing and soil carbon loss from installation of carbon capture, transportation, storage, and injection facilities	CO_2	Included	Installation of project facilities can cause changes in above and belowground carbon stocks depending on the type of land and use prior to the installation of project facilities. Minor emissions source
		N_2O	Included	As above
		CH_4	Included	As above
	P4 - Construction of carbon capture, transportation, and storage facilities and well drill and service	CO_2	Included	Site construction shall require a variety of heavy equipment, smaller power tools, cranes, generators and well drilling operations. The operation of this equipment shall have associated GHG emissions from the use of fossil fuels and electricity and from the potential kick or blowout event which could release hydrocarbons during the drilling or servicing of injection and monitoring wells. Minor emissions source
		N_2O	Excluded	Not applicable
		CH_4	Included	Site construction shall require a variety of heavy equipment, smaller power tools, cranes, generators and well drilling operations. The operation of this equipment shall have associated GHG emissions from the use of fossil fuels and electricity and from the potential kick or blowout event that could release hydrocarbons during the drilling or servicing of injection and monitoring wells. Minor emissions source
	P5 - Production and delivery of material inputs	CO_2	Included	Material inputs, including specialised chemicals or additives such as amine-based sorbents, glycols, or lubricants are required for CO_2 capture, CO_2 transportation, and CO_2 storage. Emissions are attributed to the fossil fuel consumption for transport and

PROJECT OR BASELINE	SOURCE / SINK	GAS	INCLUDED OR EXCLUDED	JUSTIFICATION / DESCRIPTION
	consumed by carbon capture, transportation, and storage equipment			delivery of these materials, and the electricity and fossil fuel inputs for their production. Minor emissions source
		N_2O	Included	As above
		CH_4	Included	As above
	P6 - Fuel extraction, processing, and delivery	CO_2	Included	Upstream well-to-tank (liquid fuels) or well-to-meter (gaseous fuels) emissions from fuels consumed by project equipment. Each of the fuels used throughout the project shall need to be extracted, processed and transported to the site. Delivery may include shipments by pipeline, rail or truck. CO_2, CH_4 and N_2O emissions are associated with these activities. Major emissions source
		N_2O	Included	As above
		CH_4	Included	As above
	P7 - Off-site electricity generation	CO_2	Included	Major emissions source
		N_2O	Included	As above
		CH_4	Included	As above
	P8 - On-site electricity generation	CO_2	Included	Electricity inputs may be required for CO_2 capture, CO_2 compression, CO_2 transportation, and CO_2 injection. Electricity may be generated independently or from cogeneration within the project boundary. The quantity and type of fuels consumed to generate electricity and the quantity of electricity consumed by the project from each generating source would be tracked. Major emissions source

PROJECT OR BASELINE	SOURCE / SINK	GAS	INCLUDED OR EXCLUDED	JUSTIFICATION / DESCRIPTION
		N_2O	Included	As above
		CH_4	Included	As above
	P9 - Fuel consumption	CO_2	Included	Fuel use may be required for CO_2 capture, CO_2 processing, CO_2 compression, CO_2 dehydration, CO_2 transportation, and CO_2 injection or for heat or electricity generation. The quantity and type of fuels consumed from each source would be tracked. Major emissions source
		N_2O	Included	As above
		CH_4	Included	As above
	P10 - Venting at capture site	CO_2	Included	Some CO_2 is vented during the project. CO_2 venting may also be necessary for equipment maintenance or emergency shutdowns. CO_2 vented upstream of injection metering is accounted for in the baseline scenario, thus no monitoring or quantification of this source is required. Identified and included within the project boundary for completeness.
		N_2O	Excluded	Non-CO_2 GHGs are conservatively excluded from the baseline as storage site permitting and permanence are undertaken and assessed in the context of permanent geological sequestration of CO_2. Any venting emissions of non-CO_2 GHG are necessarily a portion of those ultimately injected by the project, but not accounted for within the project boundary. Non-CO_2 GHG vented upstream of injection metering is excluded for consistency and relevance.
		CH_4	Excluded	As above

PROJECT OR BASELINE	SOURCE / SINK	GAS	INCLUDED OR EXCLUDED	JUSTIFICATION / DESCRIPTION
	P11 - Fugitive emissions at capture site	CO_2	Included	Unintended leaks of gas from the CO_2 capture and processing unit may occur through faulty seals, loose fittings, or equipment. Fugitive emissions of CO_2 upstream of injection metering are accounted for in the baseline scenario, thus no monitoring or quantification of this source is required. Identified and included within the project boundary for completeness.
		N_2O	Excluded	Non-CO_2 GHGs are conservatively excluded from the baseline as storage site permitting and permanence are undertaken and assessed in the context of permanent geological sequestration of CO_2. Any fugitive emissions of non-CO_2 GHG are necessarily a portion of those ultimately injected by the project, but not accounted for within the project boundary. Fugitive emissions of non-CO_2 GHG upstream of injection metering are excluded for consistency and relevance.
		CH_4	Excluded	As above
	P12 - Venting during compression/ dehydration	CO_2	Included	Some CO_2 is vented during the project. CO_2 venting may also be necessary for equipment maintenance or emergency shutdowns. CO_2 vented upstream of injection metering is accounted for in the baseline scenario, thus no monitoring or quantification of this source is required. Identified and included within the project boundary for completeness.
		N_2O	Excluded	Non-CO_2 GHGs are conservatively excluded from the baseline as storage site permitting and permanence are undertaken and assessed in the context of permanent geological sequestration of CO_2. Any venting emissions of non-CO_2 GHG are necessarily a portion of those ultimately injected by the project, but not accounted for within the project boundary. Non-CO_2 GHG vented upstream of injection metering is excluded for consistency and relevance.

PROJECT OR BASELINE	SOURCE / SINK	GAS	INCLUDED OR EXCLUDED	JUSTIFICATION / DESCRIPTION
		CH_4	Excluded	As above
	P13 – Fugitive emissions during compression/ dehydration	CO_2	Included	Unintended leaks of gas from the compressor and/or dehydrator may occur through seals, loose fittings, equipment, or compressor packing. These gases shall be composed primarily of CO_2 with trace amounts of other gases. Fugitive emissions of CO_2 upstream of injection metering are accounted for in the baseline scenario, thus no monitoring or quantification of this source is required. Identified and included within the project boundary for completeness.
		N_2O	Excluded	Non-CO_2 GHG are conservatively excluded from the baseline as storage site permitting and permanence are undertaken and assessed in the context of permanent geological sequestration of CO_2. Any fugitive emissions of non-CO_2 GHG are necessarily a portion of those ultimately injected by the project, but not accounted for within the project boundary. Fugitive emissions of non-CO_2 GHG upstream of injection metering are excluded for consistency and relevance.
		CH_4	Excluded	As above
	P14 – Venting at transportation	CO_2	Included	Some CO_2 is vented during the project. CO_2 venting may also be necessary for equipment maintenance or emergency shutdowns. CO_2 vented upstream of injection metering is accounted for in the baseline scenario, thus no monitoring or quantification of this source is required. Identified and included within the project boundary for completeness.
		N_2O	Excluded	Non-CO_2 GHG are conservatively excluded from the baseline as storage site permitting and permanence are undertaken and assessed in the context of permanent geological sequestration of CO_2. Any venting emissions of non-CO_2 GHG are necessarily a portion of those ultimately injected by the project, but not accounted for within the project boundary.

PROJECT OR BASELINE	SOURCE / SINK	GAS	INCLUDED OR EXCLUDED	JUSTIFICATION / DESCRIPTION
				Non-CO_2 GHG vented upstream of injection metering is excluded for consistency and relevance.
		CH_4	Excluded	As above
	P15 – Fugitive emissions at transportation	CO_2	Included	Unintended leaks of gas from CO_2 pipelines, stations loading and unloading CO_2 transported by truck or rail, CO_2 transportation equipment, and additional compressors may occur through seals, loose fittings, equipment, or compressor packing. These gases will be composed primarily of CO_2 with trace amounts of other gases. Fugitive emissions of CO_2 upstream of injection metering are accounted for in the baseline scenario, thus no monitoring or quantification of this source is required. Identified and included within the project boundary for completeness.
		N_2O	Excluded	Non-CO_2 GHG are conservatively excluded from the baseline as storage site permitting and permanence are undertaken and assessed in the context of permanent geological sequestration of CO_2. Any fugitive emissions of non-CO_2 GHG are necessarily a portion of those ultimately injected by the project, but not accounted for within the project boundary. Fugitive emissions of non-CO_2 GHG upstream of injection metering are excluded for consistency and relevance.
		CH_4	Excluded	As above
	P16 – Venting at injection sites	CO_2	Included	Planned and emergency venting may be necessary for injection well work overs, mechanical integrity checks, and maintenance. Instances of venting shall be logged, including the duration of the venting event and the estimated quantities and makeup of gasses vented. GHG vented upstream of injection metering are accounted for in the baseline scenario, thus no monitoring or quantification of these emissions are required. Only vented GHG

PROJECT OR BASELINE	SOURCE / SINK	GAS	INCLUDED OR EXCLUDED	JUSTIFICATION / DESCRIPTION
				which are emitted from injection surface facility instrumentation and piping located downstream of the injection metering point are included.
		N_2O	Included	As above
		CH_4	Included	As above
	P17 – Fugitive emissions at injection sites	CO_2	Included	Unintended or unplanned leaks of gas at the CO_2 injection sites may occur through valves, flanges, pipe connections, mechanical seals, or related equipment. Fugitive emissions of GHG upstream of injection metering are accounted for in the baseline scenario, thus no monitoring or quantification of these emissions are required. Only fugitive emissions of GHG which are emitted from injection surface facility instrumentation and piping located downstream of the injection metering point are included.
		N_2O	Included	As above
		CH_4	Included	As above
	P18 – Decommissioning carbon capture and storage facilities	CO_2	Excluded	Infrastructure is decommissioned at the end of project operations. This involves the disassembly of the equipment, demolition of on-site structures, landfill disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Emissions result from fossil fuels combustion and electricity use. Excluded for simplification.
		N_2O	Excluded	As above
		CH_4	Excluded	As above

PROJECT OR BASELINE	SOURCE / SINK	GAS	INCLUDED OR EXCLUDED	JUSTIFICATION / DESCRIPTION
	P19 – Emissions from subsurface to atmosphere	CO_2	Included	Major source of emissions Accidental emissions to the atmosphere may occur from gas migration through undetected faults, fractures and/or subsurface equipment resulting from compromised casing/cement/wellhead or packer/tubing. CO_2 that migrates from the intended geological storage complex but remain subsurface are considered the same as if they had leaked to the atmosphere and shall be quantified accordingly.
		N_2O	Excluded	Non-CO_2 GHGs are conservatively excluded from the baseline as storage site permitting and permanence are undertaken and assessed in the context of permanent geological sequestration of CO_2. As the methodology prohibits usage of hydrocarbon reservoirs for CO_2 storage purposes, non-CO_2 GHG emissions from subsurface releases to atmosphere are necessarily a portion of those ultimately injected by the project, but not accounted for within the project boundary. Project emissions of non-CO_2 GHG from subsurface to atmosphere are excluded for consistency and relevance.
		CH_4	Excluded	As above
Leakage	L1 - Leakage from biomass	CO_2	Included	Potential leakage source
		N_2O	Included	Potential leakage source
		CH_4	Included	Potential leakage source

5.3 | Demonstration of additionality

5.3.1 | The project developer shall demonstrate that the project is additional, meaning that it reduces anthropogenic emissions of GHGs below those that would have occurred in the absence of the proposed project.

5.3.2 | The project developer shall demonstrate additionality, in accordance with the Principles & Requirements, by using the latest version of one of the following UNFCCC-approved or Gold Standard-approved additionality tools:

a. CDM TOOL 01 – Tool for the demonstration and assessment of additionality; or

b. CDM TOOL 02 – Combined tool to identify the baseline and demonstrate additionality; or

c. An approved Gold Standard additionality tool

5.3.3 | In addition to the requirements set forth in 5.3.2 | the project developer shall consider, in the assessment of additionality:

a. Revenue which is enabled by project within the project boundary (as defined in 5.1 |), of which the project developer and/or project participants are beneficiaries, such as from:

i. Services rendered to project and non-project participants for the capture and/or transport and/or storage of CO_2 in geological storage complex; and,

ii. Services rendered for the export of CO_2 outside of the project boundary; and,

iii. Provisions in jurisdiction or host country regulations which incentivise the construction and/or operation of infrastructure for the capture and/or transportation and/or permanent storage of CO_2 (e.g., the 45Q Tax Credit for CO_2 sequestration); and,

iv. Cost-sharing agreements with CO_2 source facilities; and,

v. Revenue sharing agreements with CO_2 source facilities, such as those applicable to provisions in jurisdiction or host country regulations which incentivise the production of renewable fuels (e.g., 45Z tax credit for clean fuels production), and excluding those which are applicable to the sale of environmental attributes resulting from the project.

b. Costs incurred for the benefit of the project and within the project boundary (as defined in 5.1 |), of which are borne by project developer and/or project participants, such as from:

i. Revenue sharing agreements with CO_2 source facilities, excluding those which are applicable to the sale of GSVERs from the project; and,

ii. Payments for title to, or rights for the exclusive use of, CO_2 supplied by sources facilities; and,

iii. Funds or collateral that are held in trust or escrow, or otherwise secured and dedicated to post-injection site care.

5.4 | Baseline Scenario

5.4.1 | Project developers shall apply the latest approved version of CDM Tool 02 – Combined tool to identify the baseline and demonstrate additionality[6] and additional requirements defined by GS4GG to identify the most plausible baseline scenario among all realistic and credible alternatives.

a. If more than one credible and plausible alternative scenario remains, project developers shall select the scenario corresponding with the lowest baseline emissions as the baseline scenario.

5.4.2 | The CO_2 emissions in the baseline scenario are dynamic and determined based on data from the direct measurement of the injected fluid streams which are measured upstream of the injection wellhead in the project.

5.5 | Baseline Emissions

5.5.1 | The baseline emissions ($\mathrm{BE_y}$) from the project in year y are determined as follows:

$$\mathrm{BE_y} = \sum_{\mathrm{s}} \mathrm{BE_{B1_{s,y}}} \qquad \text{Equation 1}$$

Where:

$\mathrm{BE_y}$	=	Baseline emissions in year y (t CO_2e)
$\mathrm{BE_{B1_{s,y}}}$	=	Baseline emissions from the injection of captured CO_2 at injection site s that would have been emitted to the atmosphere in the absence of the project in year y (t CO_2e)

5.5.2 | Baseline emissions from the injection of captured CO_2 at injection site s in year y ($\mathrm{BE_{B1_{s,y}}}$) shall be determined as follows:

$$\mathrm{BE_{B1_{s,y}}} = \mathrm{Q_{inj_{\mathit{s,y}}}} \times \mathrm{w_{CO_2\,inj_{\mathit{s,y}}}} \times \mathrm{Allocation_{Project_{\mathit{s,y}}}} \qquad \text{Equation 2}$$

Where:

$\mathrm{Q_{inj_{\mathit{s,y}}}}$	=	Mass of fluid injected at injection site s in year y (tonnes)
$\mathrm{w_{CO_2\,inj_{\mathit{s,y}}}}$	=	Mass fraction of CO_2 in fluid injected at injection site s in year y (% CO_2 by mass)
$\mathrm{Allocation_{Project_{\mathit{s,y}}}}$	=	Portion of CO_2 supplied to injection site s which is attributable to CO_2 captured by the project in year y (unitless)

[6] Ibid.

5.5.3 | The project shall monitor the mass or volume and density of project and non-project streams of captured, or transported, or injected fluids through direct measurement. Equations 3 and 4 below shall be applied to determine the quantity of stream injected or project or non -project, where the stream is an injected stream $Q_{Fluid} = Q_{inj,i,y}$, where the stream is a project capture stream $Q_{Fluid} = Q_{Project,i,y}$, $Q_{Non-project,i,y}$.

a. Where volume and density of the fluid are monitored, the mass of the fluid, Q_{fluid} shall be determined as follows:

$$Q_{Fluid} = V_{Fluid} \times \rho_{Fluid}$$ Equation 3

Where:

V_{Fluid}	=	Volume of fluid (m^3) at project developer's chosen references conditions, T_{ref} and P_{ref}
ρ_{Fluid}	=	Density of fluid (kg/m^3) at project developer's chosen references conditions, T_{ref} and P_{ref}

5.5.4 | The project shall monitor the mass fraction or mole fraction of CO_2 in captured and injected quantities of fluid through direct measurement.

a. Where mole fraction of a fluid is monitored, the mass fraction of component z of the fluid, w_z, shall be determined as follows:

$$w_z = \frac{MM_z \times X_z}{\sum_{y=1}^{N} MM_y \times X_y}$$ Equation 4

Where:

MM_z	=	Molar Mass of component z (kg/kmol or other)
X_z	=	Mole fraction of component z (% CO_2 by mol)
MM_y	=	Molar Mass of component y (kg/kmol or other)
X_y	=	Mole fraction of component y (% component y by mol)

5.5.5 | The project infrastructure may be used to transport and store non-project CO_2 and/or fluid from project and non-project capture sites. When non-project CO_2 streams commingle with streams of CO_2 captured by the project, developers shall determine the portion of injected CO_2 which is attributable to the project.

a. Where emissions from the fermentation of both renewable and non-renewable biomass at a facility commingle prior to the point of capture, project developers shall apportion the quantities measured downstream of the point of capture to the project and non-project streams based on the quantities of renewable and other biomass fermented at that facility during the monitoring period, respectively.

i. If a developer is unable to substantiate the quantities of renewable biomass fermented at that facility, the developers shall conservatively assume that the total quantity captured at that facility is a non-project stream.

ii. The quantities measured at or downstream of the point of capture shall be apportioned to the project stream based on the ratio of the dry mass of renewable biomass to the total dry mass (renewable and non-renewable) of biomass. The balance of the captured quantities less the project quantities shall be considered the non-project stream.

b. The portion of CO_2 supplied to injection site s which is attributable to CO_2 captured by the project in year y, $\mathrm{Allocation}_{\mathrm{Project}_{s,y}}$, is determined as follows:

$$\mathrm{Allocation}_{\mathrm{Project}_{s,y}} = \underbrace{\left(\frac{\sum_{i\in C_{s,y}}\left(Q_{\mathrm{Project}_{i,y}} \times w_{CO_2\,\mathrm{Project}_{i,y}}\right)}{\sum_{i\in C_{s,y}}\left(\left(Q_{\mathrm{Project}_{i,y}} \times w_{CO_2\,\mathrm{Project}_{i,y}}\right) + \left(Q_{\mathrm{Non-project}_{i,y}} \times w_{CO_2\,\mathrm{Non-project}_{i,y}}\right)\right)}\right)}_{\text{Project Fraction}}$$
$$\times \underbrace{\left(1 - \frac{\sum_{k\in E_{s,y}}\left(\mathrm{Export}_{k,y} \times w_{CO_2\,\mathrm{Export}_{k,y}}\right)}{\sum_{s\in I_{s,y}}\left(Q_{\mathrm{inj}_{s,y}} \times w_{CO_2\,\mathrm{inj}_{s,y}}\right) + \sum_{k\in E_{s,y}}\left(\mathrm{Export}_{k,y} \times w_{CO_2\,\mathrm{Export}_{k,y}}\right)}\right)}_{\text{Export Fraction}}$$
$$\times \underbrace{\left(\frac{\sum_{s\in I_{s,y}}\left(Q_{\mathrm{inj}_{s,y}} \times w_{CO_2\,\mathrm{inj}_{s,y}}\right) + \sum_{k\in E_{s,y}}\left(\mathrm{Export}_{k,y} \times w_{CO_2\,\mathrm{Export}_{k,y}}\right)}{\sum_{i\in C_{s,y}}\left(\left(Q_{\mathrm{Project}_{i,y}} \times w_{CO_2\,\mathrm{Project}_{i,y}}\right) + \left(Q_{\mathrm{Non-project}_{i,y}} \times w_{CO_2\,\mathrm{Non-project}_{i,y}}\right)\right)}\right)}_{\text{Shrinkage Factor}} \quad \text{Equation 5}$$

Where:

$Q_{\mathrm{Project}_{i,y}}$	=	Mass of fluid captured at project capture site i in year y (kg, tonnes, or other)
$w_{CO_2\,\mathrm{Project}_{i,y}}$	=	Mass fraction of CO_2 in fluid captured at project capture site i in year y (% CO_2 by mass)
$Q_{\mathrm{Non-project}_{i,y}}$	=	Mass of non-project fluid captured at site i in year y (kg, tonnes, or other)
$w_{CO_2\,\mathrm{Non-project}_{i,y}}$	=	Mass fraction of CO_2 in non-project fluid captured at site i in year y (% CO_2 by mass)
$\mathrm{Export}_{k,y}$	=	Total mass of CO_2 (or fluid, see note below) exported at export site k in year y
$C_{s,y}$	=	The set of capture sites upstream of injection site s in year y
$E_{s,y}$	=	The set of export sites downstream of capture sites in set $C_{s,y}$
$I_{s,y}$	=	The set of injection sites downstream of capture sites in set $C_{s,y}$

5.6 | Project Emissions

5.6.1 | Total emissions from the project in year y ($\mathrm{PE_y}$) are determined as follows:

$$\mathrm{PE_y} = \mathrm{PE_{P1_y}} + \mathrm{PE_{P3_y}} + \mathrm{PE_{P4_y}} + \mathrm{PE_{P5_y}} + \mathrm{PE_{P6_y}} + \mathrm{PE_{P7_y}} + \mathrm{PE_{P8_y}} + \mathrm{PE_{P9_y}} + \mathrm{PE_{P16_y}} + \mathrm{PE_{P17_y}} + \mathrm{PE_{P19_y}} \quad \text{Equation 6}$$

Where:

$\mathrm{PE_y}$	=	Project emissions in year y (t CO_2e)
$\mathrm{PE_{P1_y}}$	=	Project emissions from biomass in year y (t CO_2e)
$\mathrm{PE_{P3_y}}$	=	Project emissions from land clearing and soil carbon loss from installation of carbon capture, transportation, storage, and injection facilities in year y (t CO_2e)
$\mathrm{PE_{P4_y}}$	=	Project emissions from construction of carbon capture, transportation, and storage facilities and well drill and service in year y (t CO_2e)
$\mathrm{PE_{P5_y}}$	=	Project emissions from production and delivery of material inputs used carbon capture, transportation, and storage equipment in year y (t CO_2e)
$\mathrm{PE_{P6_y}}$	=	Project emissions from fuel extraction, processing, and delivery in year y (t CO_2e)
$\mathrm{PE_{P7_y}}$	=	Project emissions consumption of electricity from grid-connected captive and non-captive power sources in year y (t CO_2e)
$\mathrm{PE_{P8_y}}$	=	Project emissions from grid-disconnected captive power sources in year y (t CO_2e)
$\mathrm{PE_{P9_y}}$	=	Project emissions from fuel consumption in year y (t CO_2e)
$\mathrm{PE_{P16_y}}$	=	Project emissions from venting at injection sites in year y (t CO_2e)
$\mathrm{PE_{P17_y}}$	=	Project emissions from fugitive emissions at injection sites in year y (t CO_2e)
$\mathrm{PE_{P19_y}}$	=	Project emissions from the subsurface to atmosphere in year y (t CO_2e)

5.6.2 | The project infrastructure may be used to transport and store non-project CO_2 and/or fluid from project and non-project capture sites or to export captured CO_2 outside of the project boundary. The quantification of project emissions shall consider only those emissions from sources associated with the capture, transport, and storage of project fluid streams.

a. Project developers shall apply the apportionment factor $\mathrm{AF_{Project_{i,y}}}$ for the quantification of project emissions from $\mathrm{PE_{P5_y}}$, $\mathrm{PE_{P6_y}}$, $\mathrm{PE_{P7_y}}$, $\mathrm{PE_{P8_y}}$, $\mathrm{PE_{P9_y}}$, $\mathrm{PE_{P16_y}}$, and $\mathrm{PE_{P17_y}}$ as follows:

i. Where an emission is caused, either directly or indirectly, by activity at a capture site supplying both project and non-project fluids to project transport and storage infrastructure or where a capture site supplies captured fluids to project transport infrastructure from which fluid is exported, the apportionment factor applied in the quantification of project emissions from that source shall be $AF_{Project_{Capture_{c,y}}}$ (i.e., $AF_{Project_{i,y}} = AF_{Project_{Capture_{c,y}}}$).

a. The portion of emissions attributable to the project at capture site i in year y, $AF_{Project_{Capture_{c,y}}}$, is determined as follows:[7]

$$AF_{Project_{Capture_{c,y}}} = \underbrace{\left(\frac{\sum_{i=c} Q_{Project_{i,y}}}{\sum_{i=c}\left(Q_{Project_{i,y}} + Q_{Non-project_{i,y}}\right)}\right)}_{\text{Project Fraction}} \times \underbrace{\left(1 - \frac{\sum_{k\in E_{c,y}} Export_{k,y}}{\left(\sum_{s\in I_{c,y}} Q_{inj_{s,y}}\right) + \left(\sum_{k\in E_{c,y}} Export_{k,y}\right)}\right)}_{\text{Export Fraction}} \times \underbrace{\left(\frac{\left(\sum_{s\in I_{c,y}} Q_{inj_{s,y}}\right) + \left(\sum_{k\in E_{i,y}} Export_{k,y}\right)}{\sum_{i\in C_{i,y}}\left(Q_{Project_{i,y}} + Q_{Non-project_{i,y}}\right)}\right)}_{\text{Shrinkage Factor}} \quad \text{Equation 7}$$

Where:

$E_{c,y}$	=	The set of export sites downstream of capture site c in year y
$I_{c,y}$	=	The set of injection sites downstream of capture site c in year y
$C_{i,y}$	=	The set of capture sites upstream of injection sites in set $I_{c,y}$
$E_{i,y}$	=	The set of export sites downstream of capture sites in set $C_{i,y}$

ii. Where an emission is caused, either directly or indirectly, by activity at a transport site conveying both project and non-project

[7] These apportionments are applied to project emissions associated with electricity, fuel, and materials consumed at capture sites, and other energy consumed to do work on and/or heat/cool captured project fluids, which on aggregate may comprise significant quantities of non-CO_2 components. If a project stream has a lower fraction of CO_2 than a non-project stream with which it is commingled and if the apportionment factor was determined on a CO_2 mass basis, project emissions would be underestimated. Thus it is necessary to determine the apportionment factor on a total mass basis and not the mass basis of a particular component.

fluids or where a transport site supplies captured fluids to or exports captured fluids from project transport infrastructure, the apportionment factor applied in the quantification of project emissions from that source shall be $AF_{Project_{Transport_{j,y}}}$ (i.e., $AF_{Project_{i,y}} = AF_{Project_{Transport_{j,y}}}$).

a. The portion of emissions attributable to the project at transport site j in year y, $AF_{Project_{Transport_{j,y}}}$, is determined as follows:

$$AF_{Project_{Transport_{j,y}}} = \underbrace{\left(\frac{\sum_{i \in C_{j,y}} Q_{Project_{Transport_{i,j,y}}}}{\sum_{i \in C_{j,y}} \left(Q_{Project_{Transport_{i,j,y}}} + Q_{Non-project_{Transport_{i,j,y}}}\right)}\right)}_{\text{Project Fraction}} \times \underbrace{\left(1 - \frac{\sum_{k \in E_{j,y}} Export_{k,y}}{\left(\sum_{s \in I_{j,y}} Q_{inj_{s,y}}\right) + \left(\sum_{k \in E_{j,y}} Export_{k,y}\right)}\right)}_{\text{Export Fraction}} \times \underbrace{\left(\frac{\left(\sum_{s \in I_{i,y}} Q_{inj_{s,y}}\right) + \left(\sum_{k \in E_{i,y}} Export_{k,y}\right)}{\sum_{i \in C_{i,y}} \left(Q_{Project_{i,y}} + Q_{Non-project_{i,y}}\right)}\right)}_{\text{Shrinkage Factor}} \qquad \text{Equation 8}$$

Where:

$Q_{Project_{Transport_{i,j,y}}}$	=	Mass of project fluid transported from capture site i through transport site j in year y
$Q_{Non-project_{Transport_{i,j,y}}}$	=	Mass of non-project fluid transported from capture site i through transport site j in year y
$C_{j,y}$	=	The set of capture sites upstream of transport site j in year y
$I_{j,y}$	=	The set of injection sites downstream of transport site j in year y
$E_{j,y}$	=	The set of export sites downstream of transport site j in year y
$C_{i,y}$	=	The set of capture sites upstream of injection sites in set $I_{j,y}$
$E_{i,y}$	=	The set of export sites downstream of capture sites in set $C_{i,y}$
$I_{i,y}$	=	The set of injection sites downstream of capture sites in set $C_{i,y}$

iii. Where an emission is caused, either directly or indirectly, by activity at an injection site which is supplied with both project and non-project streams, the apportionment factor applied in the quantification of project emissions from that source shall be $AF_{Project_{Injection_{s,y}}}$ (i.e., $AF_{Project_{i,y}} = AF_{Project_{Injection_{s,y}}}$).

a. The portion of emissions attributable to the project activity at injection site s in year y, $AF_{Project_{Injection_{s,y}}}$, is determined as follows:

$$AF_{Project_{Injection_{s,y}}} = \underbrace{\left(\frac{\sum_{i \in C_{s,y}} Q_{Project_{i,y}}}{\sum_{i \in C_{s,y}} \left(Q_{Project_{i,y}} + Q_{Non-project_{i,y}}\right)}\right)}_{\text{Project Fraction}} \times \underbrace{\left(1 - \frac{\sum_{k \in E_{s,y}} Export_{k,y}}{\left(\sum_{s \in I_{s,y}} Q_{inj_{s,y}}\right) + \left(\sum_{k \in E_{s,y}} Export_{k,y}\right)}\right)}_{\text{Export Fraction}} \times \underbrace{\left(\frac{\left(\sum_{s \in I_{s,y}} Q_{inj_{s,y}}\right) + \left(\sum_{k \in E_{s,y}} Export_{k,y}\right)}{\sum_{i \in C_{s,y}} \left(Q_{Project_{i,y}} + Q_{Non-project_{i,y}}\right)}\right)}_{\text{Shrinkage Factor}} \quad \text{Equation 9}$$

Where:

$C_{s,y}$	=	The set of capture sites upstream of injection site s in year y
$E_{s,y}$	=	The set of export sites downstream of capture sites in set $C_{s,y}$
$I_{s,y}$	=	The set of injection sites downstream of capture sites in set $C_{s,y}$

iv. In all other cases, the apportionment factor applied in the quantification of project emissions shall be 1 (i.e., $AF_{Project_{i,y}} = 1$)

5.6.3 | Project emissions from biomass in year y, PE_{P1_y}, are determined as follows:

$$PE_{P1_y} = \sum_i PE_{P1_{i,y}} \quad \text{Equation 10}$$

Project developers shall determine project emissions from biomass at biomass fermentation facility i in year y, $PE_{P1_{i,y}}$, according to CDM Tool 16 for any biomass fermentation facility to which either of the following apply:

a. The facility is new and ferments renewable biomass which is either cultivated in dedicated plantations or derived from biomass residues. Project developers may allocate emissions from biomass to the project using a suitable method per ISO 14044 or similar product LCA standards; otherwise, the biomass emissions are conservatively attributed solely to the CO_2 captured by the project at the facility, or

b. The facility does not receive revenue for products (excluding CO_2) manufactured at the facility via fermentation of the same renewable biomass which emits CO_2 is captured by the project.

c. In all other cases, project emissions from biomass at biomass fermentation facility i in year y, $PE_{P1_{i,y}}$, are assumed to be zero.

5.6.4 | Project emissions from land clearing and soil carbon loss from installation of carbon capture, transportation, storage, and injection facilities in year y, PE_{P3_y}, are determined as follows:

$$PE_{P3_y} = \sum_{i} \sum_{GHG} \left(M_{dLUC_{i,GHG}} \times GWP_{GHG} \right) \quad \text{Equation 11}$$

And:

$$M_{dLUC_{i,GHG}} = Area_{dLUC_i} \times EF_{dLUC_{i,GHG}} \quad \text{Equation 12}$$

Where:

$M_{dLUC_{i,GHG}}$	=	GHG emissions from land clearing and soil carbon loss from installation of carbon capture, transportation, storage, and injection facilities in at site i in year y (t GHG)
GWP_{GHG}	=	Global warming potential of GHG (t CO_2e per t GHG)
$Area_{dLUC_i}$	=	Area affected by direct land use changes from construction of project infrastructure at site i in year y (m^2, ha, acre, or other)
$EF_{dLUC_{i,GHG}}$	=	Soil and aboveground land use change GHG emissions factor for site i (t GHG per m^2, ha, acre, or other)

a. Project emissions from land clearing and soil carbon loss shall be amortised over the project's remaining crediting period.[8]

5.6.5 | Project emissions from construction of carbon capture, transportation, and storage facilities and well drill and service in year y, PE_{P4_y}, are determined as follows:

$$PE_{P4_y} = \sum_{i} \sum_{GHG} \left(Q_{DS_{i,y}} \times w_{GHG} \times GWP_{GHG} \right) \quad \text{Equation 13}$$

Where:

[8] Emissions occurring after the project start date and prior to the crediting period start date are amortized over a period of 40 years, whereas emissions occurring after the project crediting period start date are amortised over the period spanning the end of the most recent monitoring period through to the end of the project crediting period.

$Q_{DS_{i,y}}$ = Mass of vent gas emitted during well drill and service at site i in year y (kg, tonnes, or other)

w_{GHG} = Mass fraction of GHG in vent gas (% GHG by Mass)

a. Project emissions from construction of carbon capture, transportation, and storage facilities and well drill and service which occur before the crediting period start date shall be amortised over the project crediting period.

5.6.6 | Project emissions from production and delivery of material inputs (such as amine-based sorbents, glycols, or lubricants) consumed in year y, PE_{P5_y}, are determined as follows:

$$PE_{P5_y} = \sum_i (PE_{P5_{i,y}} \times AF_{Project_{i,y}}) \quad \text{Equation 14}$$

And:

$$PE_{P5_{i,y}} = \sum_j \sum_{GHG} \left(MI_{i,j} \times EF_{MI_{j,GHG}} \times GWP_{GHG} \right) \quad \text{Equation 15}$$

Where:

$MI_{i,j}$ = Quantity of material inputs of type j consumed at site i in year y (kg, tonnes, L, m^3 or other)

$EF_{MI_{j,GHG}}$ = GHG emission factor for material input of type j (t GHG per kg, tonnes, L, m^3 or other)

5.6.7 | Project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}, are determined as follows:

$$PE_{P6_y} = \sum_i (PE_{P6_{i,y}} \times AF_{Project_{i,y}}) \quad \text{Equation 16}$$

And:

$$PE_{P6_{i,y}} = \sum_j \sum_{GHG} \left(\left(Fuel_{j,i,y} \times EF_{EPD_{Fuel_j,GHG}} \times GWP_{GHG} \right) + \left(Fuel_{j_{Generation},i,y} \times Generation_{CCGS_{i,j,y}} \times EF_{EPD_{Fuel_j,GHG}} \times GWP_{GHG} \right) \right) \quad \text{Equation 17}$$

And:

$$Generation_{CCGS_{i,j,y}} = \frac{\left(\frac{Electricity_{CCGS_{i,j,y}}}{\eta_{Electricity_j}} \right) + \left(\frac{Heat_{CCGS_{i,j,y}}}{\eta_{Heat_j}} \right)}{\left(\frac{Electricity_{Total_{j,y}}}{\eta_{Electricity_j}} \right) + \left(\frac{Heat_{Total_{j,y}}}{\eta_{Heat_j}} \right)} \quad \text{Equation 18}$$

Where:

$Fuel_{j,i,y}$ = Quantity of fuel of type j consumed at site i by the project for purposes other than generation of electricity and/or co-generation of heat in year y (L, m^3, kg, or other)

$\text{Fuel}_{j_{\text{Generation}},i,y}$	=	Quantity of fuel of type j consumed at site i by grid-disconnected captive source to generate electricity and/or co-generate heat in year y (L, m^3, kg, or other)
$EF_{EPD_{Fuel_j,GHG}}$	=	Emission factor associated with the extraction, processing, and delivery of fuel j (t GHG per L, m^3, kg or other)
$\text{Generation}_{CCGS_{i,j,y}}$	=	Portion of the generation of energy (electrical and thermal) supplied to the project at site i by grid-disconnected captive power source j in year y (unitless)
$\text{Electricity}_{CCGS_{i,j,y}}$	=	Quantity of electricity supplied to the project at site i by grid-disconnected captive power source j in year y (MWh_E, GJ, or other)
$\text{Heat}_{CCGS_{i,j,y}}$	=	Quantity of heat supplied to the project at site i and co-generated by captive power source j in year y (MWh_T, GJ, or other)
$\eta_{\text{Electricity}_j}$	=	Efficiency of electricity production of captive power source j in year y (unitless)
η_{Heat_j}	=	Efficiency of heat production of captive power source j in year y (unitless)
$\text{Electricity}_{\text{Total}_{j,y}}$	=	Total quantity of electricity generated by grid-disconnected captive power source j in year y (MWh, GJ, or other)
$\text{Heat}_{\text{Total}_{j,y}}$	=	Total quantity of heat co-generated by captive power source j in year y (MWh_T, GJ, or other)

5.6.8 | Project emissions from consumption of electricity from grid-connected captive and non-captive power sources in year y, PE_{P7_y}, are determined as follows:

$$PE_{P7_y} = \sum_i (PE_{P7_{i,y}} \times AF_{Project_{i,y}}) \qquad \text{Equation 19}$$

And:

$$PE_{P7_{i,y}} = \sum_j \left(\text{Electricity}_{i,j,y} \times \left(1 + TDL_{i,y}\right) \times EF_{GCPP_{j,y}} \right) \qquad \text{Equation 20}$$

Where:

$\text{Electricity}_{i,j,y}$	=	Quantity of electricity consumed at site i from the grid-connected power source j in year y (MWh_E)
$EF_{GCPP_{j,y}}$	=	Emissions factor associated generation of electricity at the grid-connected power source j in year y (t CO_2e per MWh_E)
$TDL_{i,y}$	=	Average transmission and distribution losses for provided electricity to site i in year y (unitless)

a. Where project consumption of electricity from grid-connected captive and non-captive power sources is measured using a single meter, the project developer shall assign to the grid-connected non-captive sources any metered electricity consumption exceeding the quantities (accounting for transmission and distribution losses) which are demonstrated to have been provided by grid-connected captive power sources in the monitoring period.

b. Where project developers are unable to demonstrate full and uncontested ownership of the associated carbon attributes for a quantity of electricity supplied by captive sources, project developer shall consider this quantity as having been supplied to the project by a regional or national grid and quantify project emissions from consumption of electricity conservatively, using the greatest grid emissions intensity applicable to the project area.

5.6.9 | Project emissions from grid-disconnected captive power sources in year y, PE_{P8_y}, are determined as follows:

$$PE_{P8_y} = \sum_i (PE_{P8_{i,y}} \times AF_{Project_{i,y}}) \qquad \text{Equation 21}$$

a. Grid-disconnected captive power sources which do not consume fuel (fossil or otherwise) are deemed to have no emissions. In all other cases, project developers shall apply CDM TOOL 05 to determine project emissions from grid-disconnected captive power sources at site i in year y, $PE_{P8_{i,y}}$.

i. In applying CDM TOOL 05, the project developer shall also include biomass consumed by the grid-disconnected captive power sources applying the guidance provided for $Fuel_{j_{Generation},i,y}$ and $EF_{Fuel_j,GHG}$ in monitoring section.

ii. If grid-disconnected captive power sources combust fuel to generate electricity and/or heat and do not export or supply electricity and/or heat to consumption sources outside of the project boundary, there is no other reason to separately report on PE_{P8_y}, as fuel consumption is accounted for in PE_{P9_y}.

5.6.10 | Project emissions from fuel consumption at site i in year y, PE_{P9_y}, are determined as follows:

$$PE_{P9_y} = \sum_i (PE_{P9_{i,y}} \times AF_{Project_{i,y}}) \qquad \text{Equation 22}$$

And:

$$PE_{P9_{i,y}} = \sum_j \sum_{GHG} \Big(\big(Fuel_{j,i,y} \times EF_{Fuel_j,GHG} \times GWP_{GHG} \big) + \big(Fuel_{j_{Generation},i,y} \times Generation_{CCGS_{i,j,y}} \times EF_{Fuel_j,GHG} \times GWP_{GHG} \big) \Big) \qquad \text{Equation 23}$$

Where:

$EF_{Fuel_j,GHG}$	=	Emissions factor for combustion of fuel of type j (t GHG per L, m^3, kg or other)

a. For transport sites, project developers shall apply CDM TOOL 12 to determine project emissions from fuel consumption at transport site i in year y, $PE_{P9_{i,y}}$.

b. For avoidance of doubt and consistency with 5.6.9 |, the project developer shall not consider in the determination of PE_{P9_y} quantities of $Fuel_{j_{Generation},i,y}$ that are considered in the determination of PE_{P8_y}.

5.6.11 | Project emissions from emissions from venting at injection sites, PE_{P16_y}, are determined as follows:

$$PE_{P16_y} = \sum_s (PE_{P16_{s,y}} \times AF_{Project_{Injection_{s,y}}}) \quad \text{Equation 24}$$

And:

$$PE_{P16_{s,y}} = \left(V_{gas\ vented_{s,y}} \times w_{CO_2\,inj_{s,y}} \times \rho_{CO_2}\right) \times 0.001 \quad \text{Equation 25}$$

Where:

$V_{gas\ vented_{s,y}}$	=	Volume of gas vented to atmosphere downstream of the injection meter at injection site s in year y (m^3)
0.001	=	Conversion of kg to tonnes

5.6.12 | Project emissions from fugitive emissions at injection sites, PE_{P17_y}, are determined as follows:

$$PE_{P17_y} = \sum\nolimits_s (PE_{P17_{s,y}} \times AF_{Project_{Injection_{s,y}}}) \quad \text{Equation 26}$$

And:

$$PE_{P17_{s,y}} = \sum_k \left(Source_{k,s,y} \times EF_{Source_k} \times Time_{s,y} \times w_{CO_2\,inj_{s,y}} \times \rho_{CO_2} \times 0.001\right) \quad \text{Equation 27}$$

Where:

$Source_{k,s,y}$	=	Number of fugitive gas sources of type k downstream of the injection meter at injection site s in year y
EF_{Source_k}	=	Emission rate of fugitive gas source type k (m^3 per hour)
$Time_{s,y}$	=	Operating hours at injection site s in year y (hours)
0.001	=	Conversion of kg to tonnes

5.6.13 | Project emissions from emissions from the subsurface to atmosphere, PE_{P19_y}, are determined as follows:

$$PE_{P19_y} = M_{CO_2\,leaked_y} \times \text{Cumulative Allocation}_{Project_y} \qquad \text{Equation 28}$$

Where:

$M_{CO_2\,leaked_y}$	=	Mass of CO_2 leaked from the subsurface to atmosphere in year y (t CO_2e)
$\text{Cumulative Allocation}_{Project_y}$	=	Portion of CO_2 supplied to project injection sites since the project start (y_0) which is attributable to CO_2 captured by the project through to the end of year y (unitless)

And:

$$\text{Cumulative Allocation}_{Project_y} = \frac{\sum_{y=y_0}^{y} BE_{B1_y}}{\sum_{y=y_0}^{y} \sum_s (Q_{inj_{s,y}} \times w_{CO_2\,inj_{s,y}})} \qquad \text{Equation 29}$$

5.7 | Leakage Emissions

5.7.1 | Total leakage emissions in year y, LE_y, are determined as follows:

$$LE_y = LE_{Biomass_y} \qquad \text{Equation 30}$$

Where:

LE_y	=	Leakage emissions in year y (t CO_2e)
$LE_{Biomass_y}$	=	Leakage emissions from biomass in year y (t CO_2e)

5.7.2 | Leakage may occur outside of the project boundary and may involve emissions due to shift of pre-project activities, diversion of biomass residues from other applications, and processing and transportation of biomass residues outside of the project boundary.

5.7.3 | Leakage from biomass in year y, $LE_{Biomass_y}$ are determined as follows:

$$LE_{Biomass_y} = \sum_i \left(LE_{L1_{i,y}} + LE_{L2_{i,y}}\right) \qquad \text{Equation 31}$$

Where:

$LE_{L1_{i,y}}$	=	Leakage from biomass at biomass fermentation facility i in year y (t CO_2e)
$LE_{L2_{i,y}}$	=	Leakage from biomass due to beneficial combustion at project site i in year y (t CO_2e)

a. The project may capture CO_2 from the fermentation of renewable biomass from new or existing biomass fermentation facilities. As such, various approaches are required to determine leakage from biomass at biomass fermentation facility i in year y, $LE_{L1_{i,y}}$:

i. Where an existing facility has materially increased its consumption of biomass to the benefit of the project (i.e., condition 5.7.4 |a is met and condition 5.7.4 |b is met for at least one renewable energy product p participating in an eligible program – see APPENDIX 1|) and the biomass has been demonstrated to conform with the conditions of Option 2 of monitoring parameter $\text{Renewability of biomass}_{i,n,k}$, project developers shall estimate leakage emissions from biomass at biomass fermentation facility i in year y, $LE_{L1_{i,y}}$, using CDM TOOL 16 and based solely on the materially increased quantities and types of biomass consumed at the facility, $\text{Biomass}_{\text{increase}_{i,b,y}}$, calculated using Equation 32 for each renewable energy product p that breached the materiality threshold.

$$\text{Biomass}_{\text{increase}_{i,b,y}} = \text{Biomass}_{\text{total}_{i,b,y}} \times \max_{p}\left(\frac{\text{Output}_{\text{current}_{i,p}} - \text{Output}_{\text{initial}_{i,p}}}{\text{Output}_{\text{initial}_{i,p}}}\right) \quad \text{Equation 32}$$

Where:

$\text{Biomass}_{\text{total}_{i,b,y}}$	=	The total quantity of the relevant renewable biomass of type b consumed by biomass fermentation facility i in year y (tonnes or other, dry basis).
$\text{Output}_{\text{current}_{i,p}}$	=	The trailing three-year average quantity of renewable energy product p produced by the biomass fermentation facility i ending in the current period (kg, m^3, GJ, or other).
$\text{Output}_{\text{initial}_{i,p}}$	=	The trailing three-year average quantity of renewable energy product p produced by the biomass fermentation facility i in the initial period (kg, m^3, GJ, or other).

This calculation conservatively attributes leakage potential based on the highest observed disproportionate growth rate among all eligible products, applying it to the total biomass consumed. Project developers may allocate leakage emissions from biomass to the project using a suitable method per ISO 14044 or similar product LCA standards; otherwise, the biomass emissions are conservatively attributed solely to the CO_2 captured by the project at the facility.

ii. Where the biomass is consumed at an existing facility which has not materially increased its consumption of biomass to the benefit of the project, and where the biomass consumed by that facility has been demonstrated to conform with the conditions of Option 2 of monitoring parameter $\text{Renewability of biomass}_{i,n,k}$, the project does not contribute to positive leakage from biomass outside the project boundary and thus leakage from biomass at biomass fermentation facility i in year y, $\mathrm{LE}_{\mathrm{L1}_{i,y}}$ is assumed to be zero.[9]

iii. Where the biomass consumed at the facility has been demonstrated to conform with the conditions described for Option 2 of monitoring parameter $\mathrm{Renewability\ of\ biomass}_{i,n,k}$, project developers shall estimate leakage emissions from biomass at biomass fermentation facility i in year y, $\mathrm{LE}_{\mathrm{L1}_{i,y}}$ in accordance with CDM TOOL 16. Project developers may allocate leakage emissions from biomass to the project using a suitable method per ISO 14044 or similar product LCA standards; otherwise, the biomass emissions are conservatively attributed solely to the CO_2 captured by the project at the facility.

b. Biomass may be combusted to the benefit of the project, such as to generate electricity or heat consumed by the project. Project developers shall estimate the leakage from biomass due to beneficial combustion at project site i in year y, $\mathrm{LE}_{\mathrm{L2}_{i,y}}$ in accordance with CDM TOOL 16, this estimation shall consider all quantities of biomass combusted to the benefit of the project, irrespective of the renewability of that biomass.

5.7.4 | A biomass fermentation facility has materially increased its consumption of biomass to the benefit of the project if and only if both of the following conditions are met:

a. The facility has undertaken capital expenditures intended to increase its production output capacity for a renewable energy product p participating in an eligible program (see APPENDIX 1|). This event must have occurred after the Project Start Date (or the date the facility was added to the project, whichever is later). Evidence of this expenditure and its intended purpose (e.g., engineering designs showing modifications, permits for expansion, purchase orders for larger/additional key equipment) must be provided.

b. For at least one renewable energy product (p) manufactured at the facility and participating in an eligible program (see APPENDIX 1|), the relative growth in the facility’s Actual Production Output (Output) for that product (Output_p) significantly outpaces the relative growth in Market Demand (Demand) for that specific product (Demand_p) within the relevant eligible program's market. Specifically, that the materiality ratio,

[9] In this scenario, leakage emissions from biomass consumption are zero because the biomass consumption is entirely attributable to the existing manufacturing activity of renewable energy activity at the biomass fermentation facility are subject to pressures (incentives, quota, renewable fuel content requirements, or other) from the jurisdictional or host country standards, regulations, or programs that promote the use of renewable energy.

$\mathrm{Ratio}_{\mathrm{Materiality}_{\mathrm{p}}}$, calculated using Equation 33 below for any renewable energy product p is 1.05 or greater.

$$\mathrm{Ratio}_{\mathrm{Materiality}_{\mathrm{p}}} = \frac{\left(\frac{\mathrm{Output}_{\mathrm{current}_{\mathrm{i,p}}} - \mathrm{Output}_{\mathrm{initial}_{\mathrm{i,p}}}}{\mathrm{Output}_{\mathrm{initial}_{\mathrm{i,p}}}}\right)}{\left(\frac{\mathrm{Demand}_{\mathrm{current}_{\mathrm{i,p}}} - \mathrm{Demand}_{\mathrm{initial}_{\mathrm{i,p}}}}{\mathrm{Demand}_{\mathrm{initial}_{\mathrm{i,p}}}}\right)} \qquad \text{Equation 33}$$

Where:

$\mathrm{Demand}_{\mathrm{current}_{\mathrm{i,p}}}$	=	The trailing three-year average market demand for renewable energy product p produced by the biomass fermentation facility i in the current period (kg, m^3, GJ, or other).
$\mathrm{Demand}_{\mathrm{initial}_{\mathrm{i,p}}}$	=	The trailing three-year average market demand for renewable energy product p produced by the biomass fermentation facility i in the initial period (kg, m^3, GJ, or other).

i. Where $\mathrm{Ratio}_{\mathrm{Materiality}_{\mathrm{p}}} \geq 1.05$ for any renewable energy product p participating in an eligible program (see APPENDIX 1|), the increase in actual output for that product is considered to materially outpace its market demand growth, and condition 5.7.4 |b is met for the facility overall, triggering the leakage calculation, as described in 5.7.3 |a.i. Where $\mathrm{Output}_{\mathrm{initial}_{\mathrm{p}}}$ or $\mathrm{Demand}_{\mathrm{initial}_{\mathrm{p}}}$ are zero (indicating new production or new markets, respectively, at the facility for renewable energy product p) or the denominator $\frac{\mathrm{Demand}_{\mathrm{current}_{\mathrm{p}}} - \mathrm{Demand}_{\mathrm{initial}_{\mathrm{p}}}}{\mathrm{Demand}_{\mathrm{initial}_{\mathrm{p}}}}$ is zero or negative (indicating flat or declining market demand for renewable energy product p) any increase in production output for renewable energy product p ($\mathrm{Output}_{\mathrm{p}}$) automatically satisfies condition 5.7.4 |a for that product.

5.8 | Emission Removals

5.8.1 | Total emissions removals from the project activity in year y, ER_{y} are determined as follow:

$$\mathrm{ER}_{\mathrm{y}} = \mathrm{BE}_{\mathrm{y}} - \mathrm{PE}_{\mathrm{y}} - \mathrm{LE}_{\mathrm{y}} \qquad \text{Equation 34}$$

Where:

ER_{y}	=	Emission removals in year y (t CO_2e)
BE_{y}	=	Baseline emissions in year y (t CO_2e)
PE_{y}	=	Project emissions in year y (t CO_2e)
LE_{y}	=	Leakage emissions in year y (t CO_2e)

5.9 | Reversal Mitigation

5.9.1 | The project developer shall determine the potential risk of reversal at each verification following the GS4GG TOOL 04 - Reversal risk assessment for geological storage.

5.9.2 | The project developer shall contribute GSVERs to the buffer pool corresponding to the risk of reversal determined as per GS4GG TOOL 04 or 2.5 percent of estimated net emission removal, whichever is higher.

5.9.3 | When a reversal is detected and quantified during the crediting period, the project developer shall address the reversal event(s) following options in order of preference:

a. Compensate by using an equivalent number of GSVERs that were not affected from the reversal event and are available in project's registry account,
b. Compensate by using an equivalent number of GSVERs purchased from other Gold Standard project of same type with same eligibility compliance,
c. Compensate by using an equivalent number of GSVERs contributed to buffer pool. With this option, the project can only use GSVERs contributed to buffer pool above 2.5 percent threshold. The project shall ensure contribution of 2.5 percent GSVERs to buffer pool from net issued GSVERs to project at any given time.

5.9.4 | When a reversal is detected and quantified after the crediting period, the project developer shall address the reversal event(s) following the procedures set forth in the applicable activity requirements.

5.9.5 | In all scenarios, the project developer is responsible for addressing the volume of GSVERs affected by the reversal event, and for addressing – either directly or by enforcing the responsibilities contractually assigned to other parties for – any other climate, remedial, and/or tort liabilities associated with the reversal event.

5.10 | Changes Required for Methodology Implementation at the Time of Renewal of Crediting Period

5.10.1 | At the time of renewal of crediting period, the project shall

a. Reassess the continued validity of the baseline in line with any changes in the relevant national and/or sectoral regulations and incorporate the impact of new regulations on baseline.
b. Update the baseline emissions using the new data available, where needed.
c. Update the ex-ante parameters value (not updated during the crediting period).
d. Incorporate any relevant updates to the GS4GG requirements as applicable to the project activity.

5.10.2 | For renewal of crediting period, the project shall apply the latest available version of the methodology.

5.11 | Data and Parameters Not Monitored

5.11.1 | In addition to the data and parameters listed below, the guidance on all tools to which this methodology refers shall apply. Thus, it is also recommended to refer to specific guidelines and tools applied in methodology, as not all parameters may be listed in this section.

Parameter ID	**1**
Data/Parameter:	T_{ref}
Data unit:	Kelvin
Description:	Project developer's chosen references temperature
Source of data:	Relevant academic, governmental, or industry sources
Measurement procedures (if any):	-
Any comment:	Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration.

Parameter ID	**2**
Data/Parameter:	P_{ref}
Data unit:	Pa
Description:	Project developer's chosen references pressure
Source of data:	Relevant academic, governmental, or industry sources
Measurement procedures (if any):	-
Any comment:	Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration.

Parameter ID	**3**
Data/Parameter:	MM_z
Data unit:	kg/kmol or other
Description:	Molar mass of component z
Source of data:	Relevant academic, governmental, or industry sources

Measurement procedures (if any):	-
Any comment:	None

Parameter ID	**4**
Data/Parameter:	ρ_{GHG}
Data unit:	kg/m^3
Description:	Density of GHG at the project developer's chosen references conditions, T_{ref} and P_{ref}
Source of data:	Relevant academic, governmental, or industry sources
Measurement procedures (if any):	-
Any comment:	Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration.

Parameter ID	**5**
Data/Parameter:	GWP_{GHG}
Data unit:	t CO_2e per t GHG
Description:	100-year global warming potential of GHG
Source of data:	Developers shall apply values as per latest version of Principles & Requirements.
Measurement procedures (if any):	-
Any comment:	None

Parameter ID	**6**
Data/Parameter:	$EF_{dLUC_{i,GHG}}$
Data unit:	tGHG per m^2, ha, acre, or other
Description:	Soil and aboveground land use change GHG emissions factor for site i
Source of data:	The following sources are permitted, in order of preference:

	1. U.S. Department of Energy Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model (GREET), Argonne National Labs, U.S. Department of Energy (2022), model. 2. Most recent version of the UNFCCC IPCC Guidelines for National Greenhouse Gas Inventories for the country and region in which the project is located. 3. National source
Measurement procedures (if any):	-
Any comment:	Used to determine project emissions from land clearing and soil carbon loss from installation of carbon capture, transportation, storage, and injection facilities in year y, PE_{P3_y}.

Parameter ID	**7**
Data/Parameter:	$EF_{MI_{j,GHG}}$
Data unit:	t GHG per kg, tonnes, L, m^3 or other
Description:	GHG emission factor for material input of type j
Source of data:	The following sources are permitted, in order of preference: 1. Life-cycle methods in accordance with host country or jurisdictional standards or, if unavailable, international standards (e.g. ISO, IEC). 2. Most recent version of the UNFCCC IPCC National Greenhouse Gas Inventory for the country and region in which the project is located.
Measurement procedures (if any):	**-**
Any comment:	Used to determine project emissions from production and delivery of material inputs consumed by carbon capture, transportation, and storage equipment in year y, PE_{P5_y}.

Parameter ID	**8**
Data/Parameter:	$EF_{EPD_{Fuel_{j,GHG}}}$
Data unit:	t GHG per L, m^3, kg or other
Description:	Emission factor associated with the extraction, processing, and delivery of fuel j
Source of data:	The following sources are permitted, in order of preference:

	1. GREET, 2022. 2. Most recent version of the UNFCCC IPCC National Greenhouse Gas Inventory for the country and region in which the project is located. 3. An equivalent lifecycle method.
Measurement procedures (if any):	-
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}

Parameter ID	**9**
Data/Parameter:	$EF_{Fuel_j,GHG}$
Data unit:	t GHG per L, m^3, kg or other
Description:	Emissions factor for combustion of fuel of type j
Source of data:	Biomass which is demonstrated to be renewable is deemed to have no combustion emissions. In all other cases, the following sources are permitted, in order of preference: 1. As determined through the application of CDM TOOL 03 (n.b., this tool is not applicable to biomass). 2. Values published by jurisdictional and national host country authorities. 3. GREET, 2022. 4. An equivalent life-cycle method. 5. Most recent version of the UNFCCC IPCC National Greenhouse Gas Inventory for the country and region in which the project is located.
Measurement procedures (if any):	-
Any comment:	Used to determine project emissions from fuel consumption in year y, PE_{P9_y}

Parameter ID	**10**
Data/Parameter:	EF_{Source_s}
Data unit:	m^3 per hour
Description:	Emission rate of fugitive gas source type i
Source of data:	The following sources are permitted, in order of preference:

	1. Manufacturers specifications for the equipment type. 2. Subpart W of the US EPA GHG Reporting Program, or equivalent national regulations and/or programs. 3. An equivalent life-cycle method.
Measurement procedures (if any):	-
Any comment:	Used to determine project emissions from fugitive emissions at injection sites, PE_{P16_y}.

6| UNCERTAINITY QUANTIFICATION

6.1.1 | Potential sources of uncertainty, along with the associated Quality Assurance/Quality Control (QA/QC) requirements to minimize them, are summarized in monitoring parameter tables below. The overall uncertainty can be determined by considering the uncertainties of each element in a calculation. Refer to

6.1.2 | Table 4 and

6.1.3 |

6.1.4 | Table 5 below for further details.

7| MONITORING METHODOLOGY

7.1 | Baseline Monitoring Requirements

7.1.1 | Unless specified otherwise, the additional guidance on the measurement and monitoring requirements for project and non-project streams of captured, or transported, or injected fluids provided in

7.1.2 | Table 4 below shall apply.

Table 4: Measurement and Monitoring Guidance for Captured and Injected and Exported Fluids

VARIABLE	UNITS	MEASUREMENT FREQUENCY	UNCERTAINTY LEVEL OF DATA	GUIDANCE
Flow rate of fluid stream	L, m^3, kg, tonne, or other	Continuous measurement of the mass flow or volumetric flow of the fluid stream, where continuous measurement is defined as a minimum of one measurement every 15 minutes.	Low	• Meter readings may need to be temperature and pressure compensated such that the meter output is set to the project developer's reference temperatures and pressures. • Flow meters shall be placed based on manufacturer recommendations and with all the following guidance applied: – Flow meters shall be located as close as possible to and measure the same fluid stream as the corresponding density and/or composition meters. – Each capture site shall meter the fluid flow of all capture streams supplied to the project, either exclusively as a project or non-project stream or as a commingled stream(s), using one or more meters located downstream of the site's capture and processing equipment. – Except both for the non-project streams comprising commingled emissions from the fermentation of renewable and non-renewable biomass, and for the non-project streams which have been counted towards the

				host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs, the fluid flow of non-project streams shall be metered upstream of the location where that non-project stream commingles with a project stream[10] and downstream of the equipment used to capture that non-project stream.[11] – Where a capture stream commingles with a capture stream from one or more separate capture sites, the fluid flow of each capture stream shall be metered upstream of the location where the capture streams commingle. – Flow meters which measure fluids injected for storage shall be located downstream of all tie-ins supplying captured streams to the injection site and be placed as close as possible to the injection wellheads to ensure measurement accuracy. • Flow meters shall be calibrated according to manufacturer specifications. Meters shall be checked/calibrated at regular intervals according to these specifications and industry standards.
Density of fluid stream	kg/m^3 or other	Continuous measurement of the density where	Low	• Meter readings may need to be temperature and pressure compensated such that the meter output is set to the project developer's reference temperatures and pressures.

[10] For example, CO_2 emitted and subsequently captured from the combustion of biomass at a biomass fermentation facility which ferments renewable biomass that emits CO_2 which is subsequently captured by the project.

[11] It is not permissible for such non-project fluids to commingle with project fluids prior to capture. Only direct metering of non-project fluid flow is allowed, except for those non-project fluids described above. Further guidance is provided in the relevant monitoring parameter tables.

		continuous measurement is defined as a minimum of one measurement every 15 minutes.		• Where necessary to determine the mass flow of a fluid stream in combination with volumetric flow measurement, density meters shall be placed based on manufacturer recommendations and shall be located as close as possible to and measure the same fluid stream as the corresponding composition and fluid low meters. • Density meters shall be calibrated according to manufacturer specifications. Meters shall be checked/calibrated at regular intervals according to these specifications and industry standards.
Composition of fluid stream	mass % or mol %	Continuous measurement of the fluid composition where continuous measurement is defined as a minimum of one measurement every 15 minutes.	Low	• Meter readings may need to be temperature and pressure compensated such that the meter output is set to the project developer's reference temperatures and pressures. • Composition meters shall be placed based on manufacturer recommendations and shall be located as close as possible to and measure the same fluid stream as the corresponding density and/or fluid flow meters. • Composition meters shall be calibrated according to manufacturer specifications. Meters shall be checked/calibrated at regular intervals according to these specifications and industry standards.

7.2 | Project Monitoring Requirements

7.2.1 | Unless specified otherwise, the additional guidance on the measurement and monitoring requirements for exported fluids and for project and non-project energy inputs provided in

7.2.2 | Table 5 below apply.

Table 5: Measurement and Monitoring Guidance for Energy Inputs

VARIABLE	UNITS	MEASUREMENT FREQUENCY	UNCERTAINTY LEVEL OF DATA	GUIDANCE
Electricity Consumption	MWh_E	Continuous measurement of electricity consumption or reconciliation of maximum power rating for each type of equipment and operating hours	Low	• Electricity consumption shall be from continuously metered data whenever possible; however, in certain cases other loads may be tied into the same electricity meter. When this occurs, estimates with justification are required. In these cases, the maximum power rating of each piece of equipment is used in conjunction with operating hours to estimate the electricity consumption, and • Electricity meters shall be calibrated by an accredited third party in accordance with manufacturer specifications.
Volume of fuels combusted (gaseous)	ft^3, m^3, or other	Continuous measurement of the gas flow rate where continuous measurement is defined as one measurement every 15 minutes	Low	• The flow meter readings shall be corrected for temperature and pressure, • Flow meters shall be placed based on manufacturer recommendations and shall operate within manufacturers specified operating conditions at all times; and • Flow meters shall be calibrated according to manufacturer specifications and shall be checked and calibrated at regular intervals according to these specifications.
Volume of or mass of fuels combusted (liquid or solid)	L, m^3, kg, or other	Quarterly reconciliation of purchasing records on a and inventory adjustments as needed	Low	• Volume or mass measurements are made at time of purchase or delivery of the fuel. Reconciliation of purchase receipts or weigh scale tickets is an acceptable means to determine the volumes of fuels consumed to operate the carbon capture and storage project.
Flow rate of	L, m^3, kg,	Continuous	Low	• Meter readings may need to be temperature and pressure

fluid stream	tonne, or other	measurement of the mass flow or volumetric flow of the fluid stream, where continuous measurement is defined as a minimum of one measurement every 15 minutes.		compensated such that the meter output is set to the project developer's reference temperatures and pressures. • Flow meters shall be placed based on manufacturer recommendations, and with the following guidance: – Flow meters shall be located as close as possible to and measure the same fluid stream as the corresponding density and/or composition meters. – Flow meters which measure fluids exported outside of the project boundary shall be placed as close as possible to shared project transportation infrastructure and shall not be placed downstream of any meter which measures fluids injected for storage at injection sites nor be placed upstream of any meter which measures a captured fluid stream. • Flow meters shall be calibrated according to manufacturer specifications. Meters shall be checked and calibrated at regular intervals according to these specifications and industry standards.
Density of fluid stream	kg/m^3 or other	Continuous measurement of the density where continuous measurement is defined as a minimum of one measurement every 15 minutes.	Low	• Meter readings may need to be temperature and pressure compensated such that the meter output is set to the project developer's reference temperatures and pressures. • Where necessary to determine the mass flow of a fluid stream in combination with volumetric flow measurement, density meters shall be placed based on manufacturer recommendations and shall be located as close as possible to, and measure the same fluid stream as the corresponding composition and fluid flow meters. • Density meters shall be calibrated according to manufacturer specifications. Meters shall be checked/calibrated at regular intervals according to these specifications and industry

				standards.
Composition of fluid stream	mass % or mol %	Continuous measurement of the fluid composition where continuous measurement is defined as a minimum of one measurement every 15 minutes.	Low	• Meter readings may need to be temperature and pressure compensated such that the meter output is set to the project developer’s reference temperatures and pressures. • Composition meters shall be placed based on manufacturer recommendations and shall be located as close as possible to, and measure the same fluid stream as the corresponding density and/or fluid flow meters. • Composition meters shall be calibrated according to manufacturer specifications. Meters shall be checked/calibrated at regular intervals according to these specifications and industry standards.

7.3 | Data and Parameters Monitored

7.3.1 | In addition to the data and parameters listed below, the guidance on all tools to which this methodology refers shall apply. Thus, it is also recommended to refer to specific guidelines and tools applied in methodology, as not all parameters may be listed in this section.

Parameter ID	**11**
Data/Parameter:	$Q_{inj_{s,y}}$
Data unit:	tonnes
Description:	Mass of fluid injected at injection site s in year y
Source of data:	Measurement
Measurement procedures (if any):	Direct measurement of the mass flow of injection fluid. Calculation, per Equation 3, using direct metering of volumetric flow and density of injected fluid
Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration. Flow meters shall be placed based on manufacturer recommendations, located downstream of tie-ins supplying commingled streams to the injection site, and placed as close as possible to the injection wellheads to ensure measurement accuracy. Meters shall be checked and calibrated at regular intervals according to manufacturer's specifications.
Any comment:	Used to determine baseline emissions from the injection of captured CO_2 at injection site s that would have been emitted to the atmosphere in the absence of the Project in year y, $BE_{B1_{s,y}}$. Used to determine the portion of injected CO_2 which is attributable to CO_2 captured by the project in year y, $Allocation_{Project_{s,y}}$. Used to determine the portion of CO_2 supplied to project injection sites since the project start (y_0) which is attributable to CO_2

	captured by the project through to the end of year y, $\text{Cumulative Allocation}_{\text{Project}_y}$. Used to determine the apportionment factor to quantify project emissions caused by activities related to project and non-project streams, $AF_{\text{Project}_{i,y}}$.

Parameter ID	**12**
Data/Parameter:	X_z
Data unit:	% CO_2 by mol
Description:	Mole fraction of component z
Source of data:	Measurement
Measurement procedures (if any):	Direct measurement, using gas chromatographs, of the mole fraction of component z in the captured or injected fluid.
Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes. Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	Meters shall be placed based on manufacturer recommendations and guidance provided in Table 4. Meters shall be maintained according to manufacturer's specifications.
Any comment:	Used to determine the mass fraction of component z of the fluid, w_z

Parameter ID	**13**
Data/Parameter:	$w_{CO_2\,\text{inj}_{s,y}}$
Data unit:	% CO_2 by mass
Description:	Mass fraction of CO_2 in fluid injected at injection site s in year y
Source of data:	Measurement
Measurement procedures (if any):	Direct measurement, using gas chromatographs, of the mass fraction of CO_2 in the injected fluid Calculation, per Equation 4, using direct metering of the mole fraction, using gas chromatographs, of CO_2 in the injected fluid.

Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	Meters shall be placed based on manufacturer recommendations and shall be located downstream of tie-ins supplying commingled streams to the injection site and shall be placed as close as possible to the injection wellheads to ensure measurement accuracy. Meters shall be maintained according to manufacturer's specification.
Any comment:	Used to determine baseline emissions from the injection of captured CO_2 at injection site s that would have been emitted to the atmosphere in the absence of the Project in year y, $BE_{B1_{s,y}}$. Used to determine the portion of injected CO_2 which is attributable to CO_2 captured by the project in year y, $Allocation_{Project_{s,y}}$. Used to determine the portion of CO_2 supplied to project injection sites since the project start (y_0) which is attributable to CO_2 captured by the project through to the end of year y, $\text{Cumulative Allocation}_{Project_y}$. Used to determine project emissions from emissions from venting at injection sites, PE_{P16_y}. Used to determine project emissions from fugitive emissions at injection sites, PE_{P17_y}..

Parameter ID	**14**
Data/Parameter:	$Q_{Project_{i,y}}$
Data unit:	kg, tonnes, or other
Description:	Mass of project fluid captured at site i in year y
Source of data:	Measurement or estimation
Measurement procedures (if any):	Direct measurement of the mass of project streams that commingle with non-project streams which have been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs at site i in year y is not required only if:

	a. all capture streams connected to shared project transportation infrastructure are metered for both flow and composition; and b. documentation (see Parameter 16 QA/QC procedures) is provided at verification to confirm the combined quantity of CO_2 captured at the site which has been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs in year y. Instead, where the above conditions are met, the mass of project fluids captured at site i in year y may be estimated via application of mass balance, based on the documented (as described above) combined quantity of CO_2 captured at the site which has been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs. Where emissions from the fermentation of both renewable and non-renewable biomass at a facility commingle prior to the point of capture applies, project developers shall apportion the quantities measured downstream of the point of capture to the project and non-project streams based the quantities of renewable and other biomass fermented at that facility during the monitoring period, respectively. If a developer is unable to substantiate the quantities of renewable biomass fermented at that facility, it is conservatively assumed that the total quantity captured at that stream is a non-project stream. Otherwise, the quantities measured at or downstream of the point of capture shall be apportioned to the project stream based on the ratio of the dry mass of renewable biomass to the total dry mass (renewable and non-renewable) of biomass. In all other cases, only direct measurement of the mass of fluid captured at project capture site i in year y is permitted. Calculation, per Equation 3, using direct metering of volumetric flow and density of fluid captured at project capture site i in year y.
Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes. Absolute frequency of metering should be highest level possible.
QA/QC procedures:	Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration.

	To ensure that no emissions are omitted or double-counted, documentation of the combined quantity of CO_2 captured at the site which has been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs shall demonstrate that such quantities are suitable for application of mass-balance together with other monitored project and non-project capture data. To do so, the documentation shall a) clearly establish that such quantities correspond with quantities of CO_2 captured at the site, prior to tying into shared transportation infrastructure and are exclusive of deductions from any activity related emissions, via b) a detailed accounting of the applied quantification methods, which c) shall be either LCA methods or project, regional, subnational, or national GHG accounting methods, and d) include the relevant activity rates and data where LCA methods are applied. Flow meters shall be placed based on manufacturer recommendations and with the guidance provided in Table **4** applied. Meters shall be checked/calibrated at regular intervals according to manufacturer's specifications. Where the source of the data is estimation, data from pressure and temperature compensated instruments used in the mass balance approach shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration.
Any comment:	Used to determine the portion of injected CO_2 which is attributable to CO_2 captured by the project in year y, $\mathrm{Allocation}_{\mathrm{Project}_{s,y}}$. Used to determine the apportionment factor to quantify project emissions caused by activities related to project and non-project streams, $\mathrm{AF}_{\mathrm{Project}_{i,y}}$.

Parameter ID	**15**
Data/Parameter:	$w_{CO_2\,\mathrm{Project}_{i,y}}$
Data unit:	% CO_2 by mass
Description:	Mass fraction of CO_2 in project fluid captured at site i in year y
Source of data:	Measurement or estimation

Measurement procedures (if any):	Direct measurement of the mass fraction of CO_2 in those project fluids emitted during the fermentation of renewable biomass and are counted towards the host country's domestic climate mitigation policy and/or participate in other voluntary or compliance standards programs at site i in year y is not required only if: a. all capture streams connected to shared project transportation infrastructure are metered for both flow and composition, and b. documentation (see Parameter 16 QA/QC procedures) is provided at verification to confirm the combined quantity of CO_2 captured at the site which has been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs in year y. Instead, where the above conditions are met, the mass fraction of CO_2 in those project fluids emitted during the fermentation of renewable biomass and are counted towards the host country's domestic climate mitigation policy and/or participate in other voluntary or compliance standards programs may be estimated via application of mass balance, based on the documented (as described above) combined quantity of CO_2 captured at the site which has been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs. In all other cases, only direct measurement, using gas chromatographs, of the mass fraction of CO_2 in project fluid captured at site i in year y is permitted. Calculation, per Equation 4, using direct metering of the mole fraction, using gas chromatographs, of CO_2 in project fluid captured at site i in year y.
Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes. Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	Fluid composition and density meters shall be placed based on manufacturer recommendations and with the guidance provided in Table 4 applied. Meters shall be maintained according to manufacturer's specifications.

	Where the source of the data is estimation, data from pressure and temperature compensated instruments used in the mass balance approach shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration.
Any comment:	Used to determine the portion of injected CO_2 which is attributable to CO_2 captured by the project in year y, $\mathrm{Allocation}_{\mathrm{Project}_{s,y}}$. Used to determine the apportionment factor to quantify project emissions caused by activities related to project and non-project streams, $\mathrm{AF}_{\mathrm{Project}_{i,y}}$.

Parameter ID	**16**
Data/Parameter:	$\mathrm{Q}_{\mathrm{Non-project}_{i,y}}$
Data unit:	kg, tonnes, or other
Description:	Mass of non-project fluid captured at site i in year y
Source of data:	Measurement or estimation
Measurement procedures (if any):	Direct measurement of the mass of those non-project fluids emitted during the fermentation of renewable biomass and are counted towards the host country's domestic climate mitigation policy and/or participate in other voluntary or compliance standards programs and captured at site i in year y is not required only if: a) all capture streams connected to shared project transportation infrastructure are metered for both flow and composition and b) documentation (see QA/QC procedures below) is provided at verification to confirm the combined quantity of CO_2 captured at the site which has been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs in year y. Instead, where the above conditions are met, the mass of those non-project fluids emitted during the fermentation of renewable biomass and are counted towards the host country's domestic climate mitigation policy and/or participate in other voluntary or compliance standards programs and captured at site i in year y may be estimated based on the documented (as described above) combined quantity of CO_2 captured at the site which has been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs. Where emissions from the fermentation of both renewable and non-renewable biomass at a facility commingle prior to the point of capture applies, project developers shall apportion the quantities

	measured downstream of the point of capture to the project and non-project streams based the quantities of renewable and other biomass fermented at that facility during the monitoring period, respectively. If a developer is unable to substantiate the quantities of renewable biomass fermented at that facility, it is conservatively assumed that the total quantity captured at that stream is a non-project stream. Otherwise, the quantities measured at or downstream of the point of capture shall be apportioned to the project stream based on the ratio of the quantity of renewable biomass to the total quantity (renewable and non-renewable) of biomass; the balance of the captured quantities less the project quantities shall be considered the non-project stream. In all other cases, only direct measurement of the mass of non-project fluid captured at site i in year y is permitted. Calculation per Equation 3, using direct metering of volumetric flow and density of non-project fluid captured at site i in year y.
Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes. Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration. To ensure that no emissions are omitted or double-counted, documentation of the combined quantity of CO_2 captured at the site which has been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs should demonstrate that such quantities are suitable for application of mass-balance together with other monitored project and non-project capture data. To do so, the documentation shall a) clearly establish that such quantities correspond with quantities of CO_2 captured at the site, prior to tying into shared transportation infrastructure and are exclusive of deductions from any activity related emissions, via b) a detailed accounting of the applied quantification methods, which c) shall be either LCA methods or project, regional, subnational, or national GHG accounting methods, and d) include the relevant activity rates and data where LCA methods are applied. Flow meters shall be placed based on manufacturer recommendations, and with the guidance provided in

	Table 4 applied. Meters shall be checked/calibrated at regular intervals according to manufacturer's specifications. Where the source of the data is estimation, data from pressure and temperature compensated instruments used in the mass balance approach shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration. A non-project stream is any quantity of CO_2 and/or fluids which are: a) emitted from sources other than the fermentation of renewable biomass and subsequently captured; or, b) captured at project sites and are considered in the selected baseline, or, c) emitted during the fermentation of renewable biomass and subsequently captured and are also counted towards the host country's domestic climate mitigation policy, or, d) emitted during the fermentation of renewable biomass and subsequently captured and are also accounted in other voluntary or compliance standards or programs.
Any comment:	Used to determine the portion of injected CO_2 which is attributable to CO_2 captured by the project in year y, $\mathrm{Allocation}_{\mathrm{Project}_{s,y}}$. Used to determine the apportionment factor to quantify project emissions caused by activities related to project and non-project streams, $\mathrm{AF}_{\mathrm{Project}_{i,y}}$.

Parameter ID	**17**
Data/Parameter:	$\mathrm{w}_{\mathrm{CO_2}\,\mathrm{Non-project}_{i,y}}$
Data unit:	% CO_2 by mass
Description:	Mass fraction of CO_2 in non-project fluid captured at site i in year y
Source of data:	Measurement
Measurement procedures (if any):	Direct measurement of the mass fraction of CO_2 in those non-project fluids emitted during the fermentation of renewable biomass and are counted towards the host country's domestic climate mitigation policy and/or participate in other voluntary or compliance standards programs and captured at site i in year y is not required only if: a) all capture streams connected to shared project transportation infrastructure are metered for both flow and composition, and b) documentation (see QA/QC procedures, below) is provided at verification to confirm the combined quantity of CO_2 captured at the site which has been counted towards the

	host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs in year y. Instead, where the above conditions are met, the mass fraction of CO_2 in those fluids described in emitted during the fermentation of renewable biomass and are counted towards the host country's domestic climate mitigation policy and/or participate in other voluntary or compliance standards programs and captured at site i in year y may be assumed to be equal to 100% CO_2, based on the documented (as described above) combined quantity of CO_2 captured at the site which has been counted towards the host country's domestic climate mitigation policy and/or participated in other voluntary or compliance standards programs. In all other cases, only direct measurement, using gas chromatographs, of the mass fraction of CO_2 in non-project fluid captured at site i in year y is permitted. Calculation, per Equation 4, using direct metering of the mole fraction, using gas chromatographs, of CO2 in non-project fluid captured at site i in year y.
Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes. Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	Fluid composition and density meters shall be placed based on manufacturer recommendations, and with the guidance provided in Table 4 applied. Meters shall be maintained according to manufacturer's specifications. Where the source of the data is estimation, data from pressure and temperature compensated instruments used in the mass balance approach shall be converted to the project reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration.
Any comment:	Used to determine the portion of injected CO_2 which is attributable to CO_2 captured by the project in year y, $\mathrm{Allocation}_{\mathrm{Project}_{s,y}}$. Used to determine the apportionment factor to quantify project emissions caused by activities related to project and non-project streams, $\mathrm{AF}_{\mathrm{Project}_{i,y}}$.

Parameter ID	**18**

Data/Parameter:	$\mathrm{Export}_{k,y}$
Data unit:	kg, tonnes, or other
Description:	Mass of fluid exported outside of the project boundary from export site k in year y (kg, tonnes, or other)
Source of data:	Measurement
Measurement procedures (if any):	Direct measurement of the mass of fluid exported outside of the project boundary from export site k in year y; alternatively, calculation per Equation 3, using direct metering of volumetric flow and density of fluid exported outside of the project boundary from export site k in year y
Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes. Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration. Flow meters shall be placed based on manufacturer recommendations, and with the guidance provided in Table 4 applied. Meters shall be checked and calibrated at regular intervals according to manufacturer's specifications.
Any comment:	Used to determine the portion of injected CO_2 which is attributable to CO_2 captured by the project in year y, $\mathrm{Allocation}_{\mathrm{Project}_{s,y}}$. Used to determine the apportionment factor to quantify project emissions caused by activities related to project and non-project streams, $\mathrm{AF}_{\mathrm{Project}_{i,y}}$.

Parameter ID	**19**
Data/Parameter:	$\mathrm{Q}_{\mathrm{Project}_{Transport}{}_{i,j,y}}$
Data unit:	kg, tonnes, or other
Description:	Mass of project fluid transported from capture site i through transport site j in year y
Source of data:	Measurement and/or estimation
Measurement procedures (if any):	Direct measurement of the mass of project fluid transported from capture site i through transport site j in year y; alternatively, calculation per Equation 3, using direct metering of volumetric flow

	and density of project fluid transported from capture site i through transport site j in year y Estimation, via application of mass balance on all sites and/or intermediate nodes, beginning at capture site i, and ending at transport site j. An intermediate node is any location where two or more flowpaths commingle or diverge.
Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes. Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration. Flow meters shall be placed based on manufacturer recommendations, and with the guidance provided in Table 4 applied. Meters shall be checked and calibrated at regular intervals according to manufacturer's specifications.
Any comment:	Used to determine the apportionment factor to quantify project emissions caused by activities related to project and non-project streams, $AF_{Project_{i,y}}$.

Parameter ID	**20**
Data/Parameter:	$Q_{Non-project_{Transport}\,i,j,y}$
Data unit:	kg, tonnes, or other
Description:	Mass of non-project fluid transported from capture site i through transport site j in year y
Source of data:	Measurement and/or estimation
Measurement procedures (if any):	Direct measurement of the mass of non-project fluid transported from capture site i through transport site j in year y; alternatively, calculation per Equation 3, using direct metering of volumetric flow and density of non-project fluid transported from capture site i through transport site j in year y Estimation, via application of mass balance on all sites and/or intermediate nodes, beginning at capture site i, and ending at transport site j. An intermediate node is any location where two or more flowpaths commingle or diverge.

Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes. Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration. Flow meters shall be placed based on manufacturer recommendations, and with the guidance provided in Table 4 applied. Meters shall be checked and calibrated at regular intervals according to manufacturer's specifications.
Any comment:	Used to determine the apportionment factor to quantify project emissions caused by activities related to project and non-project streams, $AF_{Project_{i,y}}$.

Parameter ID	**21**
Data/Parameter:	$Area_{dLUC_i}$
Data unit:	m^2, ha, acre, or other
Description:	Area affected by direct land use changes from construction of project infrastructure at site i in year y
Source of data:	Estimated
Measurement procedures (if any):	Engineering estimates based on facility drawings and other project documentation
Monitoring frequency:	Once at project validation, and/or at verification immediately following installation of additional project infrastructure
QA/QC procedures:	Per 5.2.3 b) temporary changes in land use during the construction of the project infrastructure are excluded for simplicity. Land use changes from installation of facilities used to capture or transport exclusively non-project fluids are considered outside of the project boundary and excluded.
Any comment:	Used to determine project emissions from land clearing and soil carbon loss from installation of carbon capture, transportation, storage, and injection facilities in year y, PE_{P3_y}.

Parameter ID	**22**
Data/Parameter:	$Q_{DS_{i,y}}$

Data unit:	kg, tonnes, or other
Description:	Mass of vent gas emitted during well drill and service at site i in year y
Source of data:	Estimation
Measurement procedures (if any):	If the drilling or well service activity results in release from subsurface to atmosphere, the quantity of gas released shall be estimated according to the relevant rules in the injection site jurisdiction. In the absence of relevant rules in the injection site jurisdictions, engineering estimates based on site-specific parameters are required.
Monitoring frequency:	Once per event
QA/QC procedures:	Where possible, these estimates shall be obtained from drilling or well servicing reports to the relevant regulators. Where needed, project developers shall apply the methods described in 5.5.3 |a to determine the relevant mass.
Any comment:	Used to determine project emissions from construction of carbon capture, transportation, and storage facilities and well drill and service in year y, PE_{P4_y}.

Parameter ID	**23**
Data/Parameter:	w_{GHG}
Data unit:	% GHG by mass
Description:	Mass fraction of GHG in vent gas
Source of data:	Measurement or estimation
Measurement procedures (if any):	Two options are permitted: 1. A measured gas analysis. 2. Conservatively estimation of the entire release to be methane (i.e., $w_{CH_4} = 100\%$).
Monitoring frequency:	Once per event
QA/QC procedures:	Where needed, project developers shall apply the methods described in 5.5.5 |a to determine the relevant mass fractions.

Any comment:	Used to determine project emissions from construction of carbon capture, transportation, and storage facilities and well drill and service in year y, PE_{P4_y}.

Parameter ID	**24**
Data/Parameter:	$MI_{i,j}$
Data unit:	kg, tonnes, L, m^3 or other
Description:	Quantity of material inputs of type j consumed at site i in year y
Source of data:	Measurement
Measurement procedures (if any):	Measurement of the quantity of material inputs consumed by carbon capture, transportation, and storage equipment based on operating records.
Monitoring frequency:	Continuous, with monthly aggregation
QA/QC procedures:	None
Any comment:	Used to determine project emissions from production and delivery of material inputs consumed by carbon capture, transportation, and storage equipment in year y, PE_{P5_y}.

Parameter ID	**25**
Data/Parameter:	$Fuel_{j,i,y}$
Data unit:	L, m^3, kg, or other
Description:	Quantity of fuel of type j consumed at site i by the project for purposes other than generation of electricity and/or co-generation of heat in year y
Source of data:	Measurement
Measurement procedures (if any):	For gaseous fuels: direct measurement of the quantity of fuel of type j consumed at site i by the project for purposes other than generation of electricity and/or co-generation of heat in year y. For liquid or solid fuels: monthly reconciliation or allocation of the quantity of fuel of type j consumed at site i by the project for purposes other than generation of electricity and/or co-generation of heat in monitoring period.
Monitoring frequency:	For gaseous fuels: continuous metering with monthly aggregation, with at least one measurement every 15 minutes; absolute frequency of metering shall be highest level possible.

	For liquid or solid fuels: reconciliation of purchasing records monthly with inventory adjustments as needed.
QA/QC procedures:	For gaseous fuels only: Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration. Flow meters shall be placed based on manufacturer recommendations and checked and calibrated at regular intervals according to manufacturer's specifications. For liquid or solid fuels: reconciliation of purchasing records with inventory adjustments as needed.
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}. Used to determine project emissions from fuel consumption in year y, PE_{P9_y}.

Parameter ID	**26**
Data/Parameter:	$Fuel_{j_{Generation},i,y}$
Data unit:	L, m^3, kg, or other
Description:	Quantity of fuel of type j consumed at site i by grid-disconnected captive sources to generate electricity and/or co-generate heat in year y.
Source of data:	Measurement
Measurement procedures (if any):	For gaseous fuels: direct measurement of the quantity of fuel of type j consumed at site i by grid-disconnected captive sources to generate electricity and/or co-generate heat in year y For liquid or solid fuels: monthly reconciliation or allocation of the quantity of fuel of type j consumed at site i by grid-disconnected captive sources to generate electricity and/or co-generate heat in year y
Monitoring frequency:	For gaseous fuels: continuous metering with monthly aggregation, with at least one measurement every 15 minutes; absolute frequency of metering shall be highest level possible For liquid or solid fuels: reconciliation of purchasing records monthly with inventory adjustments as needed

QA/QC procedures:	For gaseous fuels only: Data from pressure and temperature compensated instruments shall be converted to the project's reference conditions. Conversion shall be done using the same pressure and/or temperature used for the specific meter calibration. Flow meters shall be placed based on manufacturer recommendations and checked and calibrated at regular intervals according to manufacturer's specifications. For liquid or solid fuels: reconciliation of purchasing records with inventory adjustments as needed.
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}. Used to determine project emissions from fuel consumption in year y, PE_{P9_y}.

Parameter ID	**27**
Data/Parameter:	$Generation_{CCGS_{i,j,y}}$
Data unit:	Unitless
Description:	Portion of the generation of energy (electrical and thermal) supplied to the project at site i by grid-disconnected captive power source j in year y
Source of data:	Calculation
Measurement procedures (if any):	Calculated according to Equation 18
Monitoring frequency:	Continuously, with monthly aggregation
QA/QC procedures:	None
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y} Used to determine project emissions from fuel consumption in year y, PE_{P9_y}

Parameter ID	**28**

Data/Parameter:	$Electricity_{CCGS_{i,j,y}}$
Data unit:	MWh_E, GJ, or other
Description:	Quantity of electricity supplied to the project at site i by grid-disconnected captive power source j in year y.
Source of data:	Measurement or estimation
Measurement procedures (if any):	Direct measurement of electricity that is generated on-site and consumed in project equipment at each facility involved in the capture, processing, compression, transport, injection, and storage of CO_2 In certain cases, non-project loads may be tied into the same electricity meter. Where this occurs, estimates with justification are required to deduct consumption from non-project loads from the continuously metered data. In these cases, the maximum power rating of each piece of equipment is used in conjunction with operating hours of the equipment to estimate the electricity consumption. Operating hours may be derived from recorded operating hours of the equipment or conservatively estimated to be equal to the recorded operating hours of the plant. Projects require an individual meter for exported electricity.
Monitoring frequency:	Continuous metering, with monthly aggregation, of electricity which is generated at grid-disconnected captive power sources and consumed in project equipment, or reconciliation of maximum power rating for each type of equipment and operating hours, or a combination of the two. Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	In cases where electricity meters are regulated (e.g. the electricity is supplied to the electric grid), the electricity meter shall be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier and/or per the requirements set by the grid operators or national requirements. The calibration of meters, including the frequency of calibration, shall be done in accordance with national standards or requirements set by the meter supplier or requirements set by the grid operators. The accuracy class of the meters should be in accordance with the stipulation of the meter supplier and/or as the requirements set by the grid operators or national requirements. In cases where electricity meters are not regulated (e.g. the electricity is supplied to captive users), the electricity meter shall be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier or national requirements. The calibration of meters, including the frequency of calibration, shall

	be done in accordance with national standards or requirements set by the meter supplier. The accuracy class of the meters shall be in accordance with the stipulation of the meter supplier or national requirements. If these standards are not available, calibrate the meters every three years and use the meters with at least 0.5 accuracy class (e.g. meter with 0.2 accuracy class is more accurate and thus it is accepted). The electricity generation (gross or net) shall be cross-checked with records of electricity sale (e.g. sales receipt).
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}. Used to determine project emissions from fuel consumption in year y, PE_{P9_y}.

Parameter ID	**29**
Data/Parameter:	$Heat_{CCGS_{i,j,y}}$
Data unit:	MWh_T, GJ, or other
Description:	Quantity of heat supplied to the project at site i and co-generated by captive power source j in year y
Source of data:	Measurement or estimation
Measurement procedures (if any):	Heat generation is determined as the difference of the enthalpy of the steam or hot water generated minus the enthalpy of the feedwater and any condensate return. The respective enthalpies shall be determined based on the mass (or volume) flows, the temperatures and, in case of superheated steam, the pressure. Steam tables or appropriate thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure. In certain cases, non-project equipment may be tied into the heat supply. Where this occurs, estimates with justification are required to deduct consumption from non-project equipment from the continuously metered data. In these cases, the maximum heat duty of each piece of equipment is used in conjunction with operating hours of the equipment to estimate heat consumption. Operating hours may be derived from recorded operating hours of the equipment or conservatively estimated to be equal to the recorded operating hours of the plant.
Monitoring frequency:	Continuous measurement, with monthly aggregation, of the heat that is co-generated by captive power sources and consumed in project equipment, or reconciliation of maximum heat duty for

	each type of equipment and operating hours, or a combination of the two
QA/QC procedures:	Cross check measurement results with records for sold heat and the other energy measurements where relevant.
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}. Used to determine project emissions from fuel consumption in year y, PE_{P9_y}.

Parameter ID	**30**
Data/Parameter:	$\eta_{Electricity_j}$
Data unit:	Unitless
Description:	Efficiency of electricity production of captive power source j in year y
Source of data:	The following sources are permitted, in order of preference: 1. Manufacturer specifications 2. Measurement of the efficiency of electricity production of the captive power source Assume a default value of 35%.
Measurement procedures (if any):	1. Manufacturer specification would provide the appropriate value for efficiency of electricity production. 2. Use national or international standards applicable to the captive power source to determine the efficiency of electricity production.
Monitoring frequency:	1. Once, at project validation 2. Once, at project validation
QA/QC procedures:	In cases where electricity meters are regulated (e.g. the electricity is supplied to the electric grid), the electricity meter shall be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier and/or as per the requirements set by the grid operators or national requirements. The calibration of meters, including the frequency of calibration, shall be done in accordance with national standards or requirements set by the meter supplier or requirements set by the grid operators. The accuracy class of the meters shall be in accordance with the

	stipulation of the meter supplier and/or per the requirements set by the grid operators or national requirements. In cases where electricity meters are not regulated (e.g. the electricity is supplied to captive users), the electricity meter shall be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier or national requirements. The calibration of meters, including the frequency of calibration, shall be done in accordance with national standards or requirements set by the meter supplier. The accuracy class of the meters shall be in accordance with the stipulation of the meter supplier or national requirements. If these standards are not available, calibrate the meters every three years and use the meters with at least 0.5 accuracy class (e.g. meter with 0.2 accuracy class is more accurate and thus it is accepted). The electricity generation (gross or net) shall be cross-checked with records of electricity sale (e.g. sales receipt).
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}. Used in the determination of project emissions from fuel consumption in year y, PE_{P9_y}.

Parameter ID	**31**
Data/Parameter:	η_{Heat_j}
Data unit:	Unitless
Description:	Efficiency of heat production of captive power source j in year y
Source of data:	The following sources are permitted, in order of preference: 1. Manufacturer specifications 2. Measurement of the efficiency of heat production of the captive power source Assume a default value of 80%
Measurement procedures (if any):	1. Manufacturer's specification would provide the appropriate value for efficiency of heat production 2. Use national or international standards applicable to the captive power source to determine the efficiency of heat production
Monitoring frequency:	1. Once, at project validation 2. Once, at project validation

QA/QC procedures:	Heat consumption shall be from continuously metered data wherever possible; however, in certain cases other non-project equipment may be tied into the heat supply. Where this occurs, estimates with justification are required. In these cases, the maximum heat duty of each piece of equipment is used in conjunction with operating hours of the equipment to estimate heat consumption. Operating hours may be derived from recorded operating hours of the equipment, or conservatively estimated to be equal to the recorded operating hours of the plant.
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}. Used to determine project emissions from fuel consumption in year y, PE_{P9_y}.

Parameter ID	**32**
Data/Parameter:	$Electricity_{Total_{j,y}}$
Data unit:	MWh_E, GJ, or other
Description:	Total quantity of electricity generated by grid-disconnected captive power source j in year y
Source of data:	Measurement
Measurement procedures (if any):	Direct measurement of electricity that is generated by grid-disconnected captive power sources Projects require a separate meter for exported electricity
Monitoring frequency:	Continuous metering, with monthly aggregation, of electricity that is generated at grid-disconnected captive power sources. Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	In cases where electricity meters are regulated (e.g. the electricity is supplied to the electric grid), the electricity meter shall be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier and/or as per the requirements set by the grid operators or national requirements. The calibration of meters, including the frequency of calibration, shall be done in accordance with national standards or requirements set by the meter supplier or requirements set by the grid operators. The accuracy class of the meters shall be in accordance with the stipulation of the meter supplier and/or as per the requirements set by the grid operators or national requirements. In cases where electricity meters are not regulated (e.g. the electricity is supplied to captive users), the electricity meter shall

	be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier or national requirements. The calibration of meters, including the frequency of calibration, should be done in accordance with national standards or requirements set by the meter supplier. The accuracy class of the meters shall be in accordance with the stipulation of the meter supplier or national requirements. If these standards are not available, calibrate the meters every three years and use the meters with at least 0.5 accuracy class (e.g. meter with 0.2 accuracy class is more accurate and thus it is accepted). The electricity generation (gross or net) shall be cross-checked with records of electricity sale (e.g. sales receipt).
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}. Used to determine project emissions from fuel consumption in year y, PE_{P9_y}.

Parameter ID	**33**
Data/Parameter:	$Heat_{Total_{j,y}}$
Data unit:	MWh_T, GJ, or other
Description:	Total quantity of heat co-generated by captive power source j in year y
Source of data:	Measurement or estimation
Measurement procedures (if any):	Heat generation is determined as the difference of the enthalpy of the steam or hot water generated minus the enthalpy of the feedwater and any condensate return. The respective enthalpies shall be determined based on the mass (or volume) flows, the temperatures and, in case of superheated steam, the pressure. Steam tables or appropriate thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure.
Monitoring frequency:	Continuous measurement, with monthly aggregation, of the heat that is co-generated by captive power sources.
QA/QC procedures:	Cross check measurement results with records for sold heat and the other energy measurements where relevant.
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}. Used to determine project emissions from fuel consumption in year y, PE_{P9_y}.

Parameter ID	**34**
Data/Parameter:	$\text{Electricity}_{i,j,y}$
Data unit:	MWh_E
Description:	Quantity of electricity consumed at site i from the grid-connected power source j in year y
Source of data:	Measurement or estimation
Measurement procedures (if any):	Direct measurement of electricity consumed at site i from the grid-connected power source j in year y In certain cases, non-project loads may be tied into the same electricity meter. Where this occurs, estimates with justification are required to deduct consumption from non-project loads from the continuously metered data. In these cases, the maximum power rating of each piece of equipment is used in conjunction with operating hours of the equipment to estimate the electricity consumption. Operating hours may be derived from recorded operating hours of the equipment, or conservatively estimated to be equal to the recorded operating hours of the plant. Projects require a separate meter for exported electricity.
Monitoring frequency:	Continuous metering with monthly aggregation, with a minimum of one measurement every 15 minutes Continuous metering with monthly aggregation, or reconciliation of maximum power rating for each type of equipment and operating hours, or a combination of the two Absolute frequency of metering shall be highest level possible.
QA/QC procedures:	The project shall provide documentation at verification (such as invoices or contracts for quantities of electricity purchased under a physical or virtual power purchasing agreement during the monitoring period) to demonstrate the quantities supplied to the project by grid-connected captive power sources. Where project developers are unable to demonstrate full and uncontested ownership of the associated carbon attributes for a quantity of electricity supplied by captive sources, project developers shall consider this quantity as having been supplied to the project by the regional or national grid with the greatest emissions intensity and quantify project emissions from consumption of electricity accordingly. Where project consumption of electricity from grid-connected captive and non-captive power sources is measured using a single

	meter, the project developer shall assign to the grid-connected non-captive sources any metered electricity exceeding the quantities (accounting for transmission and distribution losses) that are demonstrated to have been provided by captive power sources in the monitoring period. In cases where electricity meters are regulated (e.g. the electricity is supplied to the electric grid), the electricity meter shall be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier and/or as per the requirements set by the grid operators or national requirements. The calibration of meters, including the frequency of calibration, shall be done in accordance with national standards or requirements set by the meter supplier or requirements set by the grid operators. The accuracy class of the meters shall be in accordance with the stipulation of the meter supplier and/or as per the requirements set by the grid operators or national requirements. In cases where electricity meters are not regulated (e.g. the electricity is supplied to captive users), the electricity meter shall be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier or national requirements. The calibration of meters, including the frequency of calibration, shall be done in accordance with national standards or requirements set by the meter supplier. The accuracy class of the meters shall be in accordance with the stipulation of the meter supplier or national requirements. If these standards are not available, calibrate the meters every three years and use the meters with at least 0.5 accuracy class (e.g. meter with 0.2 accuracy class is more accurate and thus it is accepted). The electricity generation (gross or net) shall be cross-checked with records of electricity sale (e.g. sales receipt).
Any comment:	Used to determine project emissions from fuel extraction, processing, and delivery in year y, PE_{P6_y}. Used to determine project emissions from fuel consumption in year y, PE_{P9_y}.

Parameter ID	**35**
Data/Parameter:	$EF_{GCPP_{j,y}}$
Data unit:	t CO_2e per MWh
Description:	Emissions intensity factor associated generation of electricity at the grid-connected power source j in year y

Source of data:	Grid-connected power generation facilities which do not consume fuel(s) (fossil or otherwise), are deemed to have no emissions. Biomass which is demonstrated to be renewable is deemed to have no emissions when consumed in grid-connected power generation facilities. For captive power sources, the following sources are permitted, in order of preference: 3. As determined through the application of the methods described in Scenario B of CDM TOOL 05. 4. GREET, 2022. 5. An equivalent life-cycle method. For non-captive power sources, the following sources are permitted, in order of preference: 1. As determined through the application of CDM TOOL07. 2. Values published by jurisdictional and national host country authorities. 3. GREET, 2022. 4. Most recent version of the UNFCCC IPCC National Greenhouse Gas Inventory for the country and region in which the project is located. 5. An equivalent life-cycle method.
Measurement procedures (if any):	None
Monitoring frequency:	Once per monitoring period
QA/QC procedures:	None
Any comment:	Used to determine project emissions from consumption of electricity from grid-connected captive and non-captive power sources in year y, PE_{P7_y}.

Parameter ID	**36**
Data/Parameter:	$TDL_{i,y}$
Data unit:	%
Description:	Average technical transmission and distribution losses for provided electricity to site i in year y
Source of data:	The following sources are permitted, in order of preference:

	1. Applicable default values in CDM TOOL 05. 2. Values published by jurisdictional and national host country authorities. 3. GREET, 2022 4. Most recent version of the UNFCCC IPCC National Greenhouse Gas Inventory for the country and region in which the project is located. 5. An equivalent life-cycle method.
Measurement procedures (if any):	None
Monitoring frequency:	Once per monitoring period
QA/QC procedures:	None
Any comment:	Used to determine of project emissions from consumption of electricity from grid-connected captive and non-captive power sources in year y, PE_{P7_y}.

Parameter ID	**37**
Data/Parameter:	$V_{gas\ vented_{s,y}}$
Data unit:	m^3
Description:	Volume of gas vented to atmosphere downstream of the injection meter at injection site s in year y
Source of data:	Estimation
Measurement procedures (if any):	Estimate volume based on the pressure, length and diameter of the pipe being serviced
Monitoring frequency:	Once per venting event, aggregated by monitoring period.
QA/QC procedures:	None
Any comment:	Used to determine project emissions from emissions from venting at injection sites, PE_{P16_y}.

Parameter ID	**38**
Data/Parameter:	$Source_{k,s,y}$
Data unit:	Unitless

Description:	Number of fugitive gas sources of type k downstream of the injection meter at injection site s in year y
Source of data:	Measured
Measurement procedures (if any):	Based on the number of sources of each type at the injection site, after the injection meter and above the surface, per facility engineering drawings and/or operating records
Monitoring frequency:	Continuously, with monthly aggregation
QA/QC procedures:	None
Any comment:	Used to determine project emissions from fugitive emissions at injection sites, PE_{P17_y}.

Parameter ID	**39**
Data/Parameter:	$Time_{s,y}$
Data unit:	Hours
Description:	Operating hours at injection site s in year y
Source of data:	Measured
Measurement procedures (if any):	Based on operating hours of injection site, per site operating records
Monitoring frequency:	Continuously, with monthly aggregation
QA/QC procedures:	Where operating hours are unknown, apply prorated hours for year y at an assumed rate of 8760 hours per calendar year.
Any comment:	Used to determine project emissions from fugitive emissions at injection sites, PE_{P17_y}.

Parameter ID	**40**
Data/Parameter:	$M_{CO_2 leaked_y}$
Data unit:	t CO_2e
Description:	Mass of CO_2 estimated to have leaked from the subsurface to atmosphere in loss event j in year y
Source of data:	Estimation
Measurement procedures (if any):	Estimated via calibrated reservoir modelling

Monitoring frequency:	Once per loss event
QA/QC procedures:	GS4GG Tool 03 - Project emissions calculation and monitoring requirements for geological storage complex for requirements
Any comment:	Used to determine project emissions from the subsurface to atmosphere, $\mathrm{PE}_{\mathrm{P19}_y}$

Parameter ID	**41**
Data/Parameter:	$\text{Cumulative Allocation}_{\text{Project}_y}$
Data unit:	Unitless
Description:	Portion of CO_2 supplied to project infrastructure since the crediting period start date which is attributable to CO_2 captured by the project through to the end of year y
Source of data:	Calculation
Measurement procedures (if any):	Calculated using Equation 29
Monitoring frequency:	Continuously, with monthly aggregation
QA/QC procedures:	None
Any comment:	Used to determine leakage emissions from emissions from the subsurface to atmosphere, $\mathrm{PE}_{\mathrm{P19}_y}$.

Parameter ID	**42**
Data/Parameter:	$\text{Renewability of biomass}_{\mathrm{i,n,k}}$
Data unit:	None
Description:	Renewability of biomass of type n fermented at biomass fermentation facility i in year y.
Source of data:	Biomass fermentation facility records
Measurement procedures (if any):	Operating records from the biomass fermentation facility (e.g., purchasing invoices, sourcing agreements with growers, registration records or supply agreements with the fermentation facility or fermentation products) which indicate the type and source of biomass used at the facility during the monitoring period. For any new biomass fermentation facility, the renewability of biomass feedstock consumed at the facility shall be ascertained as follows:

	— **Option 1:** During validation and at each verification, provision of suitable evidence to VVBs that biomass used at the biomass fermentation facility(ies) during the monitoring period complies with both the criteria for the definition of renewable biomass provided in CDM EB 23 Report Annex 18 and any applicable laws and regulations; or, For any existing biomass fermentation facility, the renewability of biomass feedstock consumed at the facility shall be ascertained using one of the following options: — **Option 1:** (as above); or, — **Option 2:** At validation and each verification, provision of suitable evidence confirming the registration or certification of the biomass fermentation facility(ies) or fermentation product(s) under any eligible jurisdictional or host country standard, regulation, or program identified in APPENDIX 1|
Monitoring frequency:	At each verification, following reconciliation of types and sources of biomass used during the monitoring period.
QA/QC procedures:	None
Any comment:	Monitoring applicability of biomass fermented at biomass fermentation facilities.

Parameter ID	**43**
Data/Parameter:	$\mathrm{Biomass}_{\mathrm{total}_{i,b,y}}$
Data unit:	tonnes, or other (dry basis)
Description:	The total quantity of the relevant renewable biomass of type b consumed by biomass fermentation facility i in year y.
Source of data:	Biomass fermentation facility operating records
Measurement procedures (if any):	Operating records from the biomass fermentation facility (e.g., Facility operating records, weighbridge data, purchase invoices, inventory management system) which indicate the type and quantity of biomass consumed at the facility during the monitoring period.
Monitoring frequency:	Continuous monitoring with annual aggregation, if applicable (i.e., if a capital expenditures satisfies condition 5.7.4 |a).
QA/QC procedures:	Cross-check with purchase records, inventory adjustments. Ensure moisture content adjustments are documented and applied correctly. Monitor per relevant biomass type. This is a facility-total, not per product.
Any comment:	Used to determine leakage emissions at biomass fermentation facility i in year y, $\mathrm{LE}_{\mathrm{L1}_{i,y}}$.

Parameter ID	**44**
Data/Parameter:	$\text{Output}_{\text{current}_{i,p}}$
Data unit:	kg, m^3, GJ, or other
Description:	The trailing three-year average quantity of renewable energy product p produced by the biomass fermentation facility i ending in the current period.
Source of data:	Biomass fermentation facility operating records
Measurement procedures (if any):	Operating records from the biomass fermentation facility (e.g., sales invoices, inventory management system) which indicate the type and quantity of renewable energy product manufactured and sold or verifiably utilized at the facility during the monitoring period based on the most recent three year Estimate the average quantity of renewable energy product p participating in an eligible program (see APPENDIX 1|) produced by the biomass fermentation facility i using the most recent three years data. If the facility has been operating for less than three years, use the average over the operational portion of the three-year period.
Monitoring frequency:	Continuous monitoring with annual aggregation, if applicable (i.e., if a capital expenditures satisfies condition 5.7.4 |a).
QA/QC procedures:	Cross-check with sales records, inventory adjustments. Monitor per renewable energy product type.
Any comment:	Used to determine leakage emissions at biomass fermentation facility i in year y, $LE_{L1_{i,y}}$.

Parameter ID	**45**
Data/Parameter:	$\text{Output}_{\text{initial}_{i,p}}$
Data unit:	kg, m^3, GJ, or other
Description:	The trailing three-year average quantity of renewable energy product p produced by the biomass fermentation facility i ending in the initial period.
Source of data:	Biomass fermentation facility operating records
Measurement procedures (if any):	Operating records from the biomass fermentation facility (e.g., audited production logs, sales receipts/invoices, inventory reconciliation reports.) which indicate the type and quantity of renewable energy product manufactured and sold or verifiably utilized at the facility during the monitoring period.

	Estimate the average quantity of renewable energy product p participating in an eligible program (see APPENDIX 1|) produced by the biomass fermentation facility i using data from the period spanning three-years prior to date on which the biomass fermentation facility began supplying CO_2 to project transportation and/or storage infrastructure. If the facility was in operation for less than three years by that date, use the average over the operational portion during the three-year period.
Monitoring frequency:	Once at validation or first verification, if applicable (i.e., if a capital expenditures satisfies condition 5.7.4 |a).
QA/QC procedures:	Cross-check with sales records, inventory adjustments. Monitor per renewable energy product type
Any comment:	Used to determine leakage emissions at biomass fermentation facility i in year y, $\mathrm{LE}_{\mathrm{L1}_{i,y}}$.

Parameter ID	**46**
Data/Parameter:	$\mathrm{Demand}_{\mathrm{current}_{i,p}}$
Data unit:	kg, m^3, GJ, or other
Description:	The trailing three-year average market demand for renewable energy product p produced by the biomass fermentation facility i ending in the current period.
Source of data:	The following sources are permitted, in order of preference: — Reports from authorities overseeing respective eligible programs (see APPENDIX 1|) — Official statistics published by jurisdictional and/or national host country authorities — Independent renewable energy product market analysis/research reports.
Measurement procedures (if any):	Estimate the average demand for renewable energy product p within the market(s) associated with the eligible program(s) (see APPENDIX 1|) using the most recent three years data. If the facility has been operating for less than three years, use the average over the operational portion of the three-year period.
Monitoring frequency:	Once per monitoring period aggregated annually, if applicable (i.e., if a capital expenditures satisfies condition 5.7.4 |a).
QA/QC procedures:	Cross-check relevance of the assessed market demand to renewable energy product p and/or the associated eligible program.

Any comment:	Used to determine leakage emissions at biomass fermentation facility i in year y, $\mathrm{LE}_{\mathrm{L1}_{i,y}}$.

Parameter ID	**47**
Data/Parameter:	$\mathrm{Demand}_{\mathrm{initial}_{i,p}}$
Data unit:	kg, m^3, GJ, or other
Description:	The trailing three-year average market demand for renewable energy product p produced by the biomass fermentation facility i ending in the initial period.
Source of data:	The following sources are permitted, in order of preference: — Reports from authorities overseeing respective eligible programs (see APPENDIX 1|) — Official statistics published by jurisdictional and/or national host country authorities — Independent renewable energy product market analysis/research reports.
Measurement procedures (if any):	Estimate the average demand for renewable energy product p within the market(s) associated with the eligible program(s) (see APPENDIX 1|) using data from the more recent of either: — The period beginning on the facility's initial commissioning date and ending three years hence, or on the project start date (whichever is earlier); or, — The period beginning on the latest recommissioning date associated with capital expenditures occuring prior to the project start date, and ending three years hence or on the project start date (whichever is earlier); or, — The period beginning on the earliest date on which the facility participated in an eligible renewable energy program (see APPENDIX 1|), and ending three years hence or on the project start date (whichiver is earlier);
Monitoring frequency:	Once at validation or first verification, if applicable (i.e., if a capital expenditures satisfies condition 5.7.4 |a).
QA/QC procedures:	Cross-check relevance of the assessed market demand to renewable energy product p and/or the associated eligible program.
Any comment:	Used to determine leakage emissions at biomass fermentation facility i in year y, $\mathrm{LE}_{\mathrm{L1}_{i,y}}$.

Parameter ID	**48**

Data/Parameter:	$\text{Renewability of combusted biomass}_{i,n,k}$
Data unit:	None
Description:	Renewability of biomass beneficially combusted at project site i in year y
Source of data:	Operating records
Measurement procedures (if any):	Operating records from the combustion equipment operator (e.g., purchasing invoices, sourcing agreements with growers, registration records or supply agreements with the combustion equipment operator) which indicate the type and source of biomass consumed by the combustion equipment at the facility during the monitoring period, to demonstrate the renewability of the biomass.
Monitoring frequency:	At verification, following reconciliation of types and sources of biomass used during the monitoring period
QA/QC procedures:	None
Any comment:	Monitoring applicability of biomass fermented at biomass fermentation facilities.

8| APPLICATION TO PROGRAMME OF ACTIVITIES

8.1.1 | The methodology may be applied for standalone projects or a programme of activities (PoAs). In the latter case, the technology provider(s) may act as Coordinating and Managing Entity (CME). For inclusion of a Voluntary Project Activity (VPA) to the PoA, the inclusion criteria shall be designed following the methodology requirements and other applicable Gold Standard requirements.

APPENDIX 1|POSITIVE LIST OF ELIGIBLE JURISDICTIONAL STANDARDS, REGULATIONS, AND PROGRAMS FOR BIOMASS RENEWABILITY DEMONSTRATION

A1.1 |Background

A1.1.1 | This appendix provides a positive list of eligible jurisdictional standards, regulations, and programs that are deemed acceptable for demonstrating biomass renewability under Option 2 for existing biomass fermentation facilities. The standards listed herein have been evaluated through rigorous evidence-based analysis and determined to provide sufficient safeguards against land use change and ensure that biomass feedstocks meet renewable biomass criteria comparable to those outlined in CDM EB 23 Report Annex 18.

A1.2 |Eligible Programs

A1.2.1 | The following jurisdictional standards, regulations, and programs are currently recognized as eligible for demonstrating biomass renewability under Option 2:

a. United States Environmental Protection Agency Renewable Fuel Standard (U.S. EPA RFS2), if each of the following conditions are met:
    i. The biomass fermentation facility must demonstrate current registration and compliance with the U.S. EPA RFS2 program; and,
    ii. The facility must comply with all applicable RFS2 recordkeeping, reporting, and verification requirements.

a. European Union Renewable Energy Directive II (EU RED II), if each of the following conditions are met:
    i. The biomass fermentation facility must demonstrate current certification under an EU RED II approved voluntary scheme; and,
    ii. The facility must comply with all applicable EU RED II recordkeeping, reporting, and verification requirements.

A1.3 |Criteria for Assessment of Additional Programs

A1.3.1 | Project developers may submit a request to Gold Standard to include programs not currently identified on this positive list.

A1.3.2 | To be eligible for inclusion on the positive list, a jurisdictional standard, regulation, or program must:

a. Include specific provisions to prevent direct land use change, particularly the conversion of forested land, wetlands, peatlands, or areas of high biodiversity value to cropland for biomass production. A clear cutoff date for land conversion must be specified; and,

b. Contain a clear and enforceable definition of "renewable biomass" that is comparable to the definition provided in CDM EB 23 Report Annex 18, addressing:

i. Land use criteria ensuring agricultural land remains as cropland or is reverted to forest; and,
ii. Sustainable management practices that maintain or enhance carbon stocks; and,
iii. Compliance with national and regional conservation regulations; and,

c. Include robust verification requirements with:
i. A clear procedure for documenting and tracking biomass origin; and,
ii. Regular compliance verification by independent third parties or regulatory authorities; and,
iii. Transparency in reporting; and,

d. Be enacted through legislation, regulation, or a formally recognized certification scheme with compliance consequences and enforcement mechanisms; and,

e. Have been in effect for a minimum of two years with evidence of implementation and enforcement.

A1.3.3 | The following aspects will also be considered in evaluating candidate programs:

a. Degree of alignment with internationally recognized standards for sustainable biomass (e.g., ISCC, RSB, or similar).
b. The geographic scope and applicability of the program.
c. Whether the program includes greenhouse gas accounting requirements.
d. Provisions addressing or mitigating indirect land use change impacts.

A1.4 | Process for Requesting Program Inclusion

A1.4.1 | Project developers wishing to request the inclusion of additional programs on the positive list shall contact Gold Standard (standards@goldstandard.org) and:

a. Submit a formal request to Gold Standard with comprehensive documentation of the program, including:
i. Official regulatory or programmatic documents; and,
ii. Evidence of the program's alignment with each of the Core Requirements in A1.3.2 | ; and,
iii. Information addressing the Supplementary Considerations in A1.3.3 | ; and,
iv. Documentation of the program's implementation history and enforcement record.

b. Provide a comparative analysis demonstrating how the program's requirements align with both CDM EB 23 Report Annex 18 and existing programs on the positive list.

c. Include relevant independent assessments or evaluations of the program's effectiveness, if available.

A1.4.2 | Gold Standard will review submissions and may request additional information before making a determination. Approved programs will be added to this Appendix through methodology updates.

A1.5 | General Notes

A1.5.1 | Inclusion on this positive list does not exempt projects from other applicable Gold Standard requirements.

A1.5.2 | Gold Standard will conduct periodic reviews of listed programs to ensure continued effectiveness.

A1.5.3 | Project developers must demonstrate that the biomass fermentation facility is in current compliance with the listed program at each verification.

A1.5.4 | The standards on this positive list will be reviewed at minimum every three years to ensure they continue to meet the criteria for inclusion.

A1.6 | Justification For Inclusion of Current Eligible Programs

a. United States Environmental Protection Agency Renewable Fuel Standard (US EPA RFS2)

The U.S. RFS2 satisfies the assessment criteria described in a based on the following determinations:

— **Prevention of Direct Land-Use Change (Clear Cutoff Date):**

The RFS2, established under the Energy Independence and Security Act of 2007, prohibits the use of renewable biomass sourced from land that was cleared or cultivated after December 19, 2007. Only feedstocks grown on land that was already in agricultural use prior to this cutoff date – or converted from agricultural use after the cutoff date – are eligible, thereby preventing direct land-use change such as deforestation or conversion of grasslands for biofuel production. This cutoff date is codified in federal law and ensures that the program does not incentivize new conversion of natural ecosystems for biomass feedstock supply.[12,13]

— **Definition of Renewable Biomass (Land Use, Sustainability, Conservation):**

RFS2 provides a statutory definition of "renewable biomass" that restricts eligible feedstocks to those from existing agricultural land as of the 2007 cutoff, certain wastes, and specific forest residues. Biomass from sensitive or protected lands, or from federal forestlands, is excluded. This definition ensures that only sustainably

[12] U.S. Congress. Energy Independence and Security Act of 2007, Pub. L. 110-140, December 19, 2007. https://www.govinfo.gov/content/pkg/PLAW-110publ140/html/PLAW-110publ140.htm

[13] Schnepf, Randy, and Brent D. Yacobucci. Renewable Fuel Standard (RFS): Overview and Issues. CRS Report R40155. Congressional Research Service, March 14, 2013. https://sgp.fas.org/crs/misc/R40155.pdf

managed agricultural and forestry resources are used, aligning with conservation and land use sustainability requirements.[13,14]

- **Verification Requirements (Documentation, Audits, Transparency):**
  RFS2 mandates comprehensive compliance and verification procedures. Producers must register with the EPA, maintain detailed records, and use EPA's Moderated Transaction System to track Renewable Identification Numbers (RINs) for each batch of fuel. The Quality Assurance Program (QAP) allows for independent third-party audits of RIN validity. EPA conducts oversight, audits, and publishes compliance data, ensuring transparency and robust verification throughout the supply chain.[15]
- **Legal Enforceability and Compliance Mechanisms:**
  RFS2 is a federally enforceable regulation under the Clean Air Act. Obligated parties face strict compliance obligations, and violations are subject to significant civil penalties and enforcement actions by the EPA, including fines, revocation of registration, and criminal prosecution for fraud. The program's enforceability is demonstrated by documented enforcement cases and the imposition of penalties for non-compliance.[16]
- **Operational Track Record (≥2 Years) and Evidence of Enforcement:**
  RFS2 has been operational since 2010, with more than a decade of implementation and enforcement history. EPA regularly monitors compliance and has taken enforcement actions against violators, demonstrating an effective track record of oversight and legal enforcement.[16]

b. European Union Renewable Energy Directive II (EU RED II)

The EU RED II satisfies the assessment criteria described in a based on the following determinations:

- **Prevention of Direct Land-Use Change (Clear Cutoff Date):**
  RED II prohibits the use of biomass for biofuels from land that was converted after January 1, 2008, from high biodiversity value or high carbon stock. Article 29 of RED II ensures that feedstocks from recently cleared forests, wetlands, or

[14] U.S. Environmental Protection Agency (EPA). Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule. 75 Federal Register 14670 (March 26, 2010). https://www.federalregister.gov/documents/2010/03/26/2010-3851/regulation-of-fuels-and-fuel-additives-changes-to-renewable-fuel-standard-program

[15] U.S. Environmental Protection Agency (EPA). "Quality Assurance Plans under the Renewable Fuel Standard Program." EPA Compliance Information webpage, last updated 2024. https://www.epa.gov/renewable-fuel-standard-program/quality-assurance-plans-under-renewable-fuel-standard-program

[16] U.S. Environmental Protection Agency (EPA). "Civil Enforcement of the Renewable Fuel Standard Program." EPA, November 3, 2022. https://www.epa.gov/enforcement/civil-enforcement-renewable-fuel-standard-program

peatlands are ineligible, thereby safeguarding natural ecosystems and aligning with the positive list's requirements.[17,18]

- **Definition of Renewable Biomass (Land Use, Sustainability, Conservation):**
  RED II sets comprehensive sustainability criteria for eligible biomass, including land-category exclusions, sustainable management practices, and conservation compliance. Only feedstocks from land that met eligibility criteria as of January 2008 and managed according to best practices are permitted. The directive also protects peatlands and areas designated for nature protection, ensuring compliance with conservation and land use sustainability requirements.[17,18]
- **Verification Requirements (Documentation, Audits, Transparency):**
  RED II mandates a robust verification system, including mass-balance chain-of-custody, documentation, and independent third-party audits under recognized voluntary certification schemes. The Union database and national authorities provide traceability and transparency, while the European Commission oversees the reliability and impartiality of certification schemes.[19]
- **Legal Enforceability and Compliance Mechanisms:**
  RED II's sustainability criteria are legally binding across all EU Member States, with compliance required for market access and incentives. Enforcement is carried out through national authorities, the European Commission, and recognized certification schemes. Non-compliance results in loss of eligibility and, in cases of fraud, legal penalties or suspension of certification schemes.
- **Operational Track Record (≥2 Years) and Evidence of Enforcement:**
  RED II has been in force since 2021, building on the previous EU Renewable Energy Directive (2009). The EU has over a decade of experience enforcing sustainability criteria for biofuels, with RED II strengthening these requirements. There is clear evidence of regular audits, enforcement actions, and ongoing oversight by the European Commission and Member States.

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[17] European Union. Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Official Journal of the European Union L328 (21 December 2018).

[18] European Commission, Joint Research Centre. "Renewable Energy – Recast to 2030 (RED II)." In Reference Regulatory Framework, updated 2020.

[19] European Commission, DG Energy. "Recognition of voluntary schemes under Article 30(4) of the revised Renewable Energy Directive." Letter to voluntary scheme operators, July 31, 2020.

DOCUMENT HISTORY

Version	Date	Description
2.0	28 May 2025	Provisions for leakage and renewability of biomass revised and editorial fixes.
1.0	09 April 2024	First version