GLOBAL CARBON COUNCIL

Driving Climate Actions

Draft methodology for project activities involving the capture, transport and geological storage of carbon dioxide

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Contents

1. BASELINE AND MONITORING METHODOLOGIES OF GCC 4
2. SOURCE/S OF THIS BASELINE AND MONITORING METHODOLOGY 4
3. DESCRIPTION OF KEY TERMS 8
4. APPLICABLE PROJECT ACTIVITIES AND THEIR ELIGIBILITY CONDITIONS 10
5. SECTORAL SCOPE APPLICABLE TO GCC VERIFIER 14
6. PROJECT BOUNDARY 14
7. IDENTIFICATION AND CHARACTERIZATION OF THE GEOLOGICAL STORAGE SITE 19
8. BASELINE SCENARIO 21
9. ADDITIONALITY 23
10. BASELINE EMISSIONS 28
11. PROJECT EMISSIONS 40
12. LEAKAGE EMISSIONS 57
13. EMISSION REDUCTIONS 59
14. MONITORING METHODOLOGY 59

1. Baseline and monitoring methodologies of GCC

1. The Global Carbon Council (GCC) is the Middle East and North Africa (MENA) region's first and only voluntary carbon offsetting program that aims to contribute to a vision of sustainable and low carbon economy of the region and help to catalyse climate actions on the ground. Please refer to https://www.globalcarboncouncil.com/ for details.

2. GCC methodologies facilitate the project owners of eligible greenhouse gas (GHG) mitigation projects to calculate the emission reduction and/or removal of their projects, monitor the emission reductions/removals, develop the project submission in accordance with the methodologies and, ultimately, access the global carbon market.

3. This methodology applies to project activities that reduce GHG emissions to, or remove GHGs from, the atmosphere by capturing carbon dioxide (CO_2) that would otherwise be released to, or remain in, the atmosphere, transport it via a pipeline, rail or road tanker, and inject it into an appropriately selected and well-managed geological storage site(s) for long-term isolation from the atmosphere.

4. The design of this methodology allows project owners to rapidly calculate, ex post, the gross and net GHG removals achieved by a registered activity, which can assist in the differentiation of net emission reduction and net removals, and support the possible future use of credit labelling.

2. Source/s of this baseline and monitoring methodology

5. For the development of GCC methodologies, the requirements of the "GCC Program Manual" (paragraphs 43-46) and "Standard for Development of Methodologies" are applied. The determination of baseline scenario and baseline emissions are consistent with UNFCCC's Clean Development Mechanism (CDM) guideline "Guideline for determining baseline for measure(s)" referred to in the above standard and take note of the ongoing dialogue around Article 6.2 and Article 6.4 of the Paris Agreement (among others).[1]

6. With respect to demonstrating additionality, the methodology makes reference to the CDM "TOOL01: Tool for the demonstration and assessment of additionality". Specific supplemental guidelines for CO_2 capture/technological CO_2 removal and geological storage are also included relating to Step 0 (Demonstration of whether the proposed

[1] Including latest draft versions of the following Article 6.4 documents available at the time of writing: *Requirements for the development and assessment of mechanism methodologies* and *Activities involving removals under the Article 6.4 mechanism*.

project activity is the first-of-its-kind), Step 1, Sub-step 1b (Consistency with mandatory laws and regulations) and Step 2 (Investment analysis).

7. Subject to host country laws and regulations as described in paragraph 15(d)(ii), the geological storage site for the relevant GCC activity must be characterised, selected, evaluated, assessed and designed etc in accordance with the “GCC Guidance for Geological CO_2 Storage v1.0” (GGCS). Approaches therein draw from requirements previously agreed by Parties to the UNFCCC Kyoto Protocol per the *Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities.*[2]

8. This methodology also refers to the use of latest approved versions of the following CDM tools and guidelines:

- TOOL01: Tool for the demonstration and assessment of additionality
- TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion
- TOOL05: Baseline, project or leakage emissions from electricity consumption and monitoring of electricity generation
- TOOL07: Tool to calculate the emission factor for an electricity system
- TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream
- TOOL16: Project and leakage emissions from biomass
- TOOL23: Additionality of first-of-its-kind project activities

These tools can be found at: https://cdm.unfccc.int/Reference/tools/index.html

9. In accordance with *Guidance on cooperative approaches referred to in Article 6, paragraph 2, of the Paris Agreement*,[3] mitigation outcomes created by geological CO_2 storage project activities applying this methodology must be measured using the methodologies and metrics assessed by the Intergovernmental Panel on Climate Change (IPCC). Subject to host country laws and regulations as described in paragraph 15(d)(ii), to support compliance with IPCC approaches, reports prepared in accordance with the GGCS should be submitted by project owners alongside the Project Submission Form (PSF), covering:

(a) Geological Storage Site Selection & Characterisation Report (see GGCS, Section 1)

(b) Risk and Safety Assessment (see GGCS, Section 2)

(c) Environmental and Socio-economic Impact Assessment (see GGCS, Section 3)

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[2] UNFCCC, Decision 10/CMP.7. Annex B, para 1.

[3] UNFCCC, Decision 2/CMA.3. Annex I, para 1(c)

(d) Monitoring Requirements (see GGCS, Section 4)

(e) Site Development and Management Plans (see GGCS, Section 5)

10. Preparation of these reports aligns with the following requirements set down in Section 5.10 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereafter: 2006 IPCC Guidelines), Volume 2, Chapter 5 (Carbon Dioxide Transport, Injection and Geological Storage):

(a) Report on the methods and results of the site characterization.

(b) Report on the methods and results of modelling.

(c) A description of the proposed monitoring programme including appropriate background measurements.

And annual reporting:

(a) The mass of CO_2 injected during the reporting year.

(b) The mass of CO_2 stored during the reporting year.

(c) The cumulative mass of CO_2 stored at the site.

(d) The source(s) of the CO_2 and the infrastructure involved in the whole chain of operations between source and storage reservoir.

(e) A report detailing the rationale, methodology, monitoring frequency and results of the monitoring programme – to include the mass of any fugitive emissions of CO_2 and any other greenhouse gases to the atmosphere or seabed from the storage site during the reporting year.

(f) A report on any adjustment of the modelling and forward modelling of the site that was necessary in the light of the monitoring results; The mass of any fugitive emissions of CO_2 and any other greenhouse gases to the atmosphere or seabed from the storage site during the reporting year; Descriptions of the monitoring programmes and monitoring methods used, the monitoring frequency and their results; Results of third-party verification of the monitoring programme and methods.

11. The materials prepared in accordance this methodology and the accompanying GGCS therefore fulfil host country reporting and documentation requirements relating to implementation of the *Modalities, procedures and guidelines for the transparency*

framework for action and support referred to in Article 13 of the Paris Agreement in respect of using methodologies, parameters and data from the 2006 IPCC Guidelines.[4]

12. This methodology has been developed cognizant of the guiding principles set out in the International Emissions Trading Association (IETA) High Level Criteria for Crediting Carbon Geostorage activities (version 1.0).[5]

[4] UNFCCC, Decision 18/CMA.1. Annex C.

[5] https://www.ieta.org/initiatives/high-level-criteria-for-carbon-geostorage-activities

3. Description of key terms

13. The following description of key terms apply to the projects using this methodology:

Sr. No.	Key Term	Description
1	Bioenergy carbon capture and storage (BECCS)	The application of CCS to a bioenergy facility that emits biogenic CO_2.
2	Biogenic CO_2	CO_2 that is generated from the combustion of fuels derived from biomass or the decay (fermentation) of biomass.
3	Carbon dioxide capture and storage (CCS)	The capture of CO_2 from anthropogenic sources of emissions, and its subsequent transport to, and injection into a sub-surface geological storage site for the purpose of long-term isolation from the atmosphere.
4	Cessation of injection	The ending of CO_2 injection activities in the geological storage site, and the appropriate plugging of wells linked to the geological storage site.
5	Direct air carbon capture and storage (DACCS)	The capture of CO_2 directly from the air (atmosphere), and its subsequent transport to, and injection into a sub-surface geological storage site for the purpose of long-term isolation from the atmosphere.
6	Fossil CO_2	CO_2 that is generated from the combustion of fossil fuels (e.g., coal, oil, natural gas) or from the processing of fossil carbon in raw material feedstocks (e.g., limestone; raw natural gas)
7	Geological storage site	A paired geological formation, or a series of such formations, consisting of an injection formation of appropriate porosity and permeability into which CO_2 can be injected, coupled with an overlying caprock formation of low porosity and permeability and sufficient thickness that can prevent the upward movement of CO_2 from the injection formation.

8	History matching	The process of comparing observed results from the monitoring and measurement of a geological storage site with the results of the predictive numerical modelling of the behaviour of CO_2 injected into the geological storage site, and the use of the observed results to calibrate and update numerical models and modelling results. It can involve multiple iterations.
9	Injection formation	A carefully surveyed and selected geological formation of relatively high porosity and permeability into which CO_2 is injected for the purpose of long-term storage.
10	Liability	The legal responsibility arising from the project activity or the relevant geological storage site, including for a net reversal of storage.
11	Net reversal of storage	For a verification period during the crediting period, the accumulated verified reductions in anthropogenic emissions by sources of CO_2 and CO_2 removals by sinks that have occurred as a result of the project activity are negative (i.e., the seepage from the geological storage site of the project activity exceeds the emission reductions or removals achieved by the project activity over the duration of the verification period); For a verification period after the cessation of injection, seepage has occurred from the geological storage site of the project activity.
12	Operational phase	The period/time that begins when CO_2 injection commences and ends when CO_2 injection permanently ceases.
13	Post-injection phase	The period/time that follows the cessation of injection and ends at the point of site closure.
14	Remedial measures	Actions and measures intended to stop or control any unintended physical leakage or seepage of CO_2, to restore the integrity of a geological storage site, or to restore long-term environmental quality significantly affected by a project activity involving geological storage of CO_2.

15	Seepage	Migration CO_2 from outside of the defined boundaries of the geological storage site to shallower strata and ultimately to the atmosphere (or surface water and/or seawater in the case of CO_2 storage sites located under the seabed)
16	Significant deviation	Circumstances where monitoring of the geological storage complex indicates major variances between actual conditions relative to pre-injection predictions and observations.
17	Site closure	The point/time at which the owner or operator of a geological storage site is released from responsibilities applicable in the post-injection phase.
18	Site development and management plan	Documented description of how a geological storage site will be operated and managed.
19	Storage complex	Includes the geological storage site and surrounding geological domains that can have an effect on overall storage integrity and security, including faults, fissures, fractures, legacy wells, overburden and any other secondary containment formations.
20	Underlying activity	Process(es) occurring at a project activity site that produces a product or service and in doing so generates CO_2
21	Verification period	The period time between the submission of verified Monitoring Reports by project owners.

4. Applicable project activities and their eligibility conditions

14. This methodology applies to projects involving the following combination of activities:

(a) CO_2 capture:

(i) Reduction of GHG emissions to the atmosphere by capturing CO_2 from eligible CO_2 sources

(ii) Removal of GHGs from the atmosphere by direct air capture (DAC) of CO_2

(iii) Removal of GHGs from the atmosphere by capturing biogenic CO_2 (e.g., bioenergy with carbon capture and storage; BECCS)

(b) Transport of captured CO_2 by pipeline, rail or road tanker, and

(c) Injection of the captured CO_2 into an appropriately selected and well-managed geological storage site for long-term isolation from the atmosphere.

15. The methodology is applicable under the following conditions:

(a) Source of CO_2:

(i) Eligible sources for the capture of CO_2:

- High purity industrial process sources (e.g., vent emissions from natural gas processing/sweetening, steam methane reformers, ethylene oxide production facilities; bioethanol production);
- Combustion emission sources, as follows:
  - o Fossil fuel- or biomass-fired electric generating facilities or waste-to-energy facilities equipped with pre-combustion, post-combustion or oxy-fired technologies;
  - o Industrial facilities with fossil fuel- or biomass-fired heaters, boilers and kilns (e.g., refineries, cement production, steel production, biorefineries).
- The atmosphere (in the case of direct air capture (DAC) facilities).

(ii) No material may be added to the CO_2 stream for the purposes of disposal (e.g. for the purposes of incidental disposal of toxic or hazardous waste);

(iii) No CO_2 from sources originating from outside of the project activity boundary may be injected into the geological storage site;[6]

(iv) In the case of coal-fired electricity generation, only existing facilities may apply this methodology, and only in circumstances where the host country has passed laws or regulations that prohibit any new coal-fired electric generating facility development (e.g., phase-down agreements).

(b) Project types:

[6] In project circumstances where additional captured CO_2 sources wish to connect to an already registered project activity (e.g. as in evolution to a “hub” project), entities are encouraged to propose modifications to the methodology to accommodate such arrangements (e.g. in respect of how buffer contributions and liability aspects will be handled).

(i) This methodology is applicable to both retrofit and new-build underlying activities, where:

- *Retrofit* relates to CCS/BECCS being installed at an existing facility where the underlying activity has an operational history of at least three years prior to the date of publication of version 1.0 of this methodology ('brownfield').
- *New-build* relates to CCS/BECCS being installed at a newly built facility where the underlying activity has no operational history ('greenfield'). This includes facilities with less than three years' operational history prior to the date of publication of the version 1.0 of this methodology.

(ii) This methodology may be applied in circumstances where the capture process increases the amount of CO_2 generated by the underlying activity (e.g., electric generating facilities) or where the CO_2 generation is not increased (e.g., high purity CO_2 off gas streams from gas processing facilities).

(c) Transport of CO_2:

(i) The CO_2 is transported by pipeline(s) or by rail, road or ship tanker

(d) Storage of CO_2 in a geological storage site:

(i) The storage complex must:

- Be either a saline aquifer and/or a depleted, non-producing, oil and/or gas reservoir(s);
- At the time of the submission of the request for registration:
  - have been subject to tests, analysis, modelling (or other available relevant evidence) which indicate that the injected CO_2 will be completely and permanently stored such that, under the proposed conditions of use, no significant risk of seepage or risk to human health or the environment exists;
  - have been surveyed, identified and permitted in compliance with relevant national laws, regulations and standards applicable to the exploration, survey, development of, and utilisation of, subsurface resources and/or protection of subsurface resources in the host country, and cognizant of the requirements for national GHG inventory compilation in Decision 18/CMA.1 and the 2006 IPCC Guidelines (see paragraphs 9-(a) above);
- Be developed, operated and closed following the appropriate procedures, including monitoring;
- Be subject to appropriate allocation of liability in the event of a net reversal of storage, including provisions for the transfer of liability for a net reversal of storage in accordance with Section 14.3 (Monitoring during the post-injection phase).

(ii) In jurisdictions where the above requirements for the storage complex are entirely fulfilled by local regulations, the local regulations shall prevail.[7] Project owners are still advised to be guided by the requirements documented in the GGCS, Sections 1 to 5, and align these with local laws and regulatory standards and requirements where applicable.

(iii) In jurisdictions where any of the above requirements for the storage complex are not specified in local regulations, the following shall apply:[7]

- Information and data pursuant to the requirements shall be documented in accordance with the GGCS:
    - Geological Storage Site Selection & Characterization Report
    - Risk and Safety Assessment
    - Environmental and Socio-economic Impact Assessment
    - Monitoring Requirements (design report; Monitoring Reports)
    - Storage Site Development and Management Plan
- Development, operation and cessation of injection shall follow the conditions of use (procedures and practices etc) set out in the reports prepared in accordance with Section 5 of the GGCS.

(iv) The storage complex must not:

- Be located in international waters;
- Present the risk of contaminating potable water resources;
- Traverse an international boundary (only projects that source and store CO_2 in the same host country may apply this methodology i.e., no transboundary movement of CO_2 is allowable);[8]

[7] Evidence of permission to geologically store CO_2 within the proposed storage complex, issued by a national competent authority to the project owner, must be submitted alongside the Project Submission Form (PSF). The permit must, as a minimum: (i) grant to the project owner up until the point of liability transfer, access rights to utilise the subsurface pore space within the storage site in which the CO_2 will be stored, (ii) be prepared cognizant of the tests, analysis, modelling or other relevant evidence per the GGCS, and (iii) describe and confirm agreement of liability arrangements between project owner and host jurisdiction for any seepage, including in the event of a net reversal of storage in the post-injection phase in accordance with Section 14.3 (Monitoring during the post-injection phase).

[8] In project circumstances requiring the transboundary movement of CO_2, entities are encouraged to propose modifications to the methodology to accommodate such arrangements (e.g. where the underlying project activity involves the capture of CO_2 in one jurisdiction, and its transport across a national border for the purposes of long-term (permanent) CO_2 storage in a different jurisdiction). Particular consideration shall be given to the appropriate permitting and liability arrangements for such circumstances.

(e) Projects involving the utilization of captured CO_2 shall not apply this methodology.

16. Five percent (5%) of ACCs due to project owners upon successful verification of activities registered under this methodology shall be withheld in a buffer account maintained by the GCC, which shall be drawn upon in the event of a net reversal of storage (para. 174-176).

17. The project owner may change over the project life cycle up to five years prior to cessation of injection. In such cases, the former project operator shall be responsible for ensuring that all necessary documentation, materials, and processes are transferred to the subsequent project owner. The subsequent project owner shall be responsible for the effective transition of management systems and processes. Transferred records shall be retained by the subsequent project owner, and copies of the transferred records should be retained by the former project owner until the point of liability transfer (Section 14.3).

18. In addition, the applicability conditions included in the tools referred to above apply.

5. Sectoral Scope applicable to GCC verifier

19. Only a third-party verifier approved under GCC for the Sectoral Scope 16: “Carbon Capture and Storage of CO_2 in Geological Formations” can conduct Project Verification or Emission Reduction Verification of GCC projects that apply this methodology.

6. Project Boundary

20. The project boundary is the physical delineation of the proposed CCS/DACCS/BECCS project activity and the specification of GHGs and sources under the control of the project owners that are significant and reasonably attributable to the underlying project activity.

21. The physical extent of the project boundary encompasses all above-ground components, including, where applicable, the following:

(a) The facility (underlying project activity) where the CO_2 is captured;

(b) The CO_2 capture equipment;

(c) Any CO_2 treatment facilities;

(d) Transportation equipment, including pipelines and booster stations along a pipeline, or offloading facilities in the case of transportation by rail, road or ship tanker;

(e) Any reception facilities or holding tanks at the injection site;

(f) The CO_2 injection facility.

22. The project boundary shall also encompass subsurface components within the storage complex, including the geological storage site, connected infrastructure (e.g., wells injection, observation, production, abandoned wells etc.), any pressure front associated with displaced brines, and all potential sources of seepage, as determined during the characterization and selection of the geological storage site. The boundary must encompass the vertical and lateral limits of the geological storage site that are expected when the CO_2 plume stabilizes over the long term during the post-injection phase and take account of the overburden and surrounding domains.

23. The project boundary must be carefully considered in order that only those emissions sources reasonably attributable to the project activity are included. GHG emissions arising from the underlying activity that are not directly associated with or affected by the project activity should not be included in the project boundary (e.g., heat and power generation associated with the underlying activity). Where such an activity provides co-services to both the underlying activity and the project activity, GHG emission attributable to the project activity must be allocated accordingly.

Figure 1: Physical project boundary (CCS/BECCS)

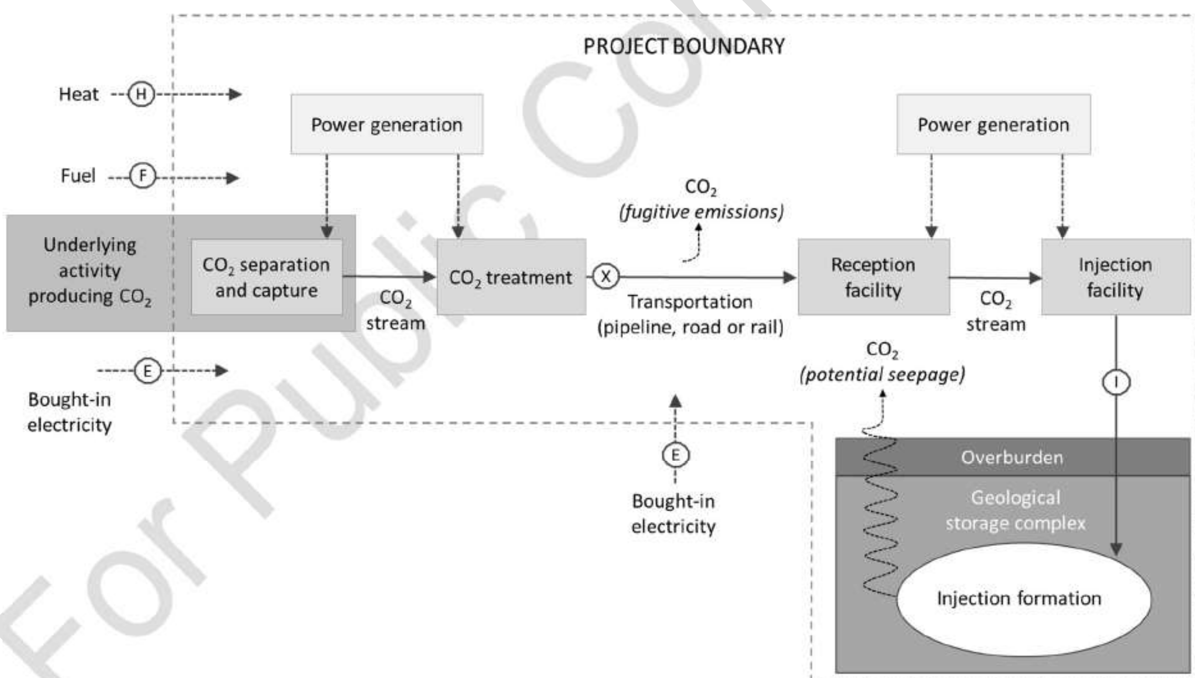
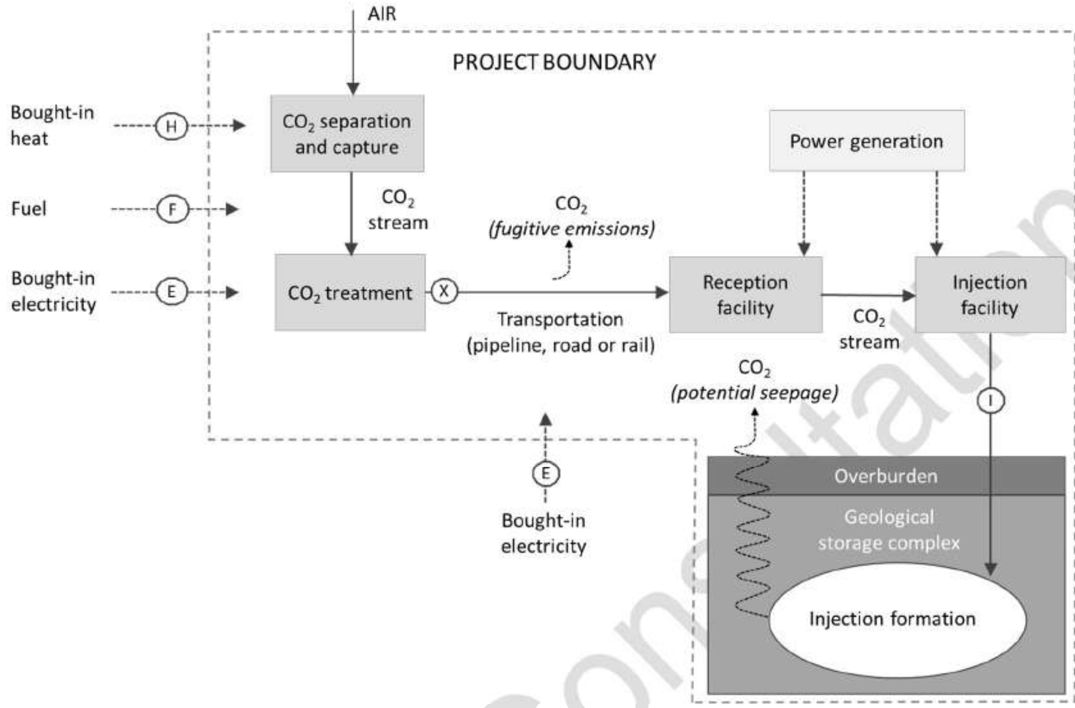


Figure 2: Physical project boundary (DACCS)



24. The GHG emissions included in or excluded from the project boundary are shown below in Table 1.

Table 1: Emissions sources included in or excluded from the project boundary

Source		Gas	Included?	Justification / Explanation
Baseline	CO_2 emissions to atmosphere *or* CO_2 remaining in the atmosphere (i.e., no baseline)	CO_2	Yes	Either: (a) the CO_2 source stream that would be emitted to the atmosphere absent of the capture activity (only source of baseline emissions) calculated using relevant CDM tools; or (b) the CO_2 remaining in the atmosphere absent of the removal activity (equivalent to an emission or removal baseline of zero). *Note*: CO_2 emissions from the processing/combustion of biogenic material in the energy sector are zero-rated. These emissions are already reported in the LULUCF sector upon harvesting of the biomass.[9] The capture and geological storage of biogenic CO_2 therefore leads to carbon removal from the atmosphere [10] (i.e. the transfer of CO_2 from the short-term atmosphere-biosphere cycle to the long-cycle geological carbon pool).
		CH_4	No	Excluded for simplification. Conservative assumption.
		N_2O	No	Excluded for simplification. Conservative assumption.
Project Activity	Negative emissions resulting from the removal of atmospheric CO_2	CO_2	Yes	Crediting of CO_2 removals that would otherwise remain in the atmosphere.
		CH_4	No	Not applicable
		N_2O	No	Not applicable
	Emissions from fossil fuel combustion for the provision of heat, mechanical and electrical power for CO_2 capture, compression, transport and injection of the CO_2 stream.	CO_2	Yes	Most sites will likely use onsite generated heat, electricity and mechanical power for CO_2 capture, treatment, compression etc. that will likely be derived from fossil fuel combustion. Calculated using the CDM "TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
		CH_4	No	Negligible, excluded for simplification.
		N_2O	No	Negligible, excluded for simplification.

9 Under IPCC guidelines, the land use, land use change and forestry (LULUCF) sector accounts for terrestrial carbon stocks, where biomass stock increases (growth) are counted as a removal, and biomass stock decreases (harvesting, fire, pestilence) are counted as an emission. The net position of growth and harvesting determines whether the LULUCF sector in a country is a net remover or emitter. As a result, unlike fossil fuel combustion emissions, biomass combustion emissions are allocated an emissions factor of zero (0) to avoid double counting the emissions in both LULUCF and energy sector accounts (i.e. the CO_2 emissions from combusted biomass was already recorded upon harvesting).

10 2006 IPCC Guidelines for National Greenhouse Gas Inventories. (Volume 2, Chapter 2, p. 2.37).

	Emissions from imported electricity or heat for CO_2 capture, compression, transport and injection of the CO_2 stream.	CO_2	Yes	Some facilities may need to import heat or electricity to power CO_2 capture (e.g., DAC). These sources of energy may be generated from fossil fuels. Calculated using the CDM "TOOL03: Tool to calculate baseline, project and/or leakage emissions from electricity consumption" and the CDM "TOOL05: Baseline, project or leakage emissions from electricity consumption and monitoring of electricity generation"
		CH_4	No	Negligible, excluded for simplification.
		N_2O	No	Negligible, excluded for simplification.
	Fugitive emissions from CO_2 capture, processing, transport (loading/unloading) and injection.	CO_2	Yes	Losses of captured CO_2 may occur downstream of the point of capture and measurement point "X". These losses need to be accounted, irrespective of source (fossil, biogenic or direct air CO_2)
		CH_4	No	Negligible, excluded for simplification.
		N_2O	No	Negligible, excluded for simplification.
	Seepage emissions from the geological storage site/complex.	CO_2	Yes	Potential source of project emissions. The risk of stored CO_2 being re-released to atmosphere needs to manage through monitoring.
		CH_4	No	Negligible, excluded for simplification.
		N_2O	No	Negligible, excluded for simplification.

7. Identification and Characterization of the Geological Storage Site

25. Subject to para. 15(d)(ii), project owners shall apply the following steps to characterize the target geological storage site(s) and the storage complex:

Step 1: data and information collection, compilation and evaluation

26. This step shall involve the collection of sufficient data and information to characterize the geological storage site and storage complex and determine potential seepage pathways. The collected data and information shall be evaluated in accordance with the GGCS in order to make a preliminary assessment of the site's storage capacity and to assess the viability of monitoring. The data and information shall be evaluated for its quality and, where required, new data shall be collected.

Step 2: characterization of the geological storage site architecture and surrounding domains

27. This step shall involve the assessment of known and inferred structures within the injection formation(s) and caprock formation(s) that would act as barriers to, or facilitators of, the migration of injected CO_2. This step shall involve the compilation of (a) numerical three-dimensional static earth model(s) of the geological storage site as outlined in the GGCS. The uncertainty associated with key parameters used to build the model shall be assessed.

28. The numerical three-dimensional static earth model(s) shall be used to characterise, inter alia:

    (a) The structure of geological containment within the storage complex;

    (b) All relevant geological properties of the injection formation(s);

    (c) The caprock formation(s) and overburden;

    (d) The fracture system;

    (e) The areal and vertical extent of the geological storage complex (e.g., the injection formation, the caprock formation, overburden, secondary containment zones and surrounding domains);

    (f) The storage capacity in the injection formation(s);

    (g) The fluid distribution and physical properties;

    (h) Other relevant characteristics.

Step 3: characterization of dynamic behaviour, sensitivity characterization and risk assessment

29. This step shall involve an assessment of how the injected CO_2 can be expected to behave within the geological storage site and the architecture and surrounding domains of the storage complex, with a particular focus on the risk of seepage.

30. This step shall utilize numerical dynamic modelling of the injected CO_2 using the static model developed in Step 2 above to assess coupled processes (i.e., the interaction between each single process in the model), and, where possible, reactive processes (e.g., the interaction of injected CO_2 within situ minerals in the numerical model), and short- and long-term simulations.

31. Such numerical modelling shall be used to provide insight into the pressure and extent of CO_2 in the geological storage site over time, the risk of fracturing the caprock formation(s) and the risk of seepage. Multiple simulations shall be conducted to identify the sensitivity of the assessments to assumptions made. The simulations carried out in this step shall form the basis for the risk and safety assessment.

Step 4: establishment of a site development and management plan

32. Drawing on Steps 1–3 above, a site development and management plan shall be established (see GGCS, Section 5). The plan shall address the proposed conditions of use for the geological storage site and include, inter alia, descriptions of:

    (a) The pre-development condition of the site, including base-level environmental data compiled in accordance with the GGCS, Section 4, Part B.III.

    (b) The preparation of the site;

    (c) Well construction, such as materials and techniques used, and the location, trajectory and depth of each well;

    (d) Maximum allowable storage capacity, and the anticipated total tonnage of stored CO_2 arising from the planned project activity;

    (e) Injection rates and the maximum allowable near-wellbore pressure;

    (f) Operating and maintenance programmes and protocols;

    (g) The timing and management of cessation of injection, the post-injection phase of the proposed CCS/DACCS/BECCS project, including site closure and related activities.

33. Steps 1 to 3 above for the identification and characterization of the geological storage sites shall be described following the format and guidance provided in the GGCS (Section 1),

and documented in a **Geological Storage Site Selection & Characterisation Report** submitted in conjunction with the PSF as part of the project registration procedure. The Geological Storage Site Selection & Characterisation Report shall include a **Risk and Safety Assessment** compiled in accordance with the GGCS (Section 2).

34. If a single PSF relates to CO_2 injection into a number of sites,[11] separate Geological Storage Site Selection & Characterisation Reports should be prepared and attached for each of the sites.

35. Step 4 above for the establishment of a site development and management plan shall be described following the format and guidance provided in the GGCS (Section 5), and documented in a **Site Development and Management Plan** submitted in conjunction with the PSF as part of the overall project registration procedure.

36. Project owners must also undertake an **Environmental and Socio-economic Impact Assessment** of the proposed project activity, following the format and guidance provided in the GGCS (Section 3), and submit the report in conjunction with the PSF as part of the overall project registration procedure.

8. Baseline scenario

37. The baseline scenario for CCS/DACCS/BECCS project activities applying this methodology is that of a similar type of underlying activity, with similar levels of output, that would occur in the absence of the financial incentive to capture (or remove) and store CO_2 offered by project crediting under GCC.

38. The choice of baseline approach for eligible CCS/DACCS/BECCS project activities is determined by two key variable characteristics:[12]

    (a) Whether the project activity involves CO_2 capture as a retrofit (brownfield) or as a new-build (greenfield) application at the facility performing the underlying activity (this determines whether there is historic emissions data available for the facility); and

[11] Geological storage sites are considered as separate if there is no geographical overlap of the geological storage site boundary.

[12] Based on GCC requirements for baseline approaches to be established according to paragraph 48(a),48(b) or 48(c) of the modalities and procedures for a clean development mechanism (Decision 3/CMP.1) (a) Existing actual or historical emissions, as applicable [48(a)]; (b) Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment [48(b)]; (c) The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category [48(c)].

(b) Whether the capture process leads to an increase in CO_2 production from the facility performing the underlying activity (this determines whether or not actual emissions during project operation can be used for calculating baseline emissions)

39. Based on the above characteristics, project owners shall apply the baseline approach and baseline emissions calculation adopting one of the three cases set out in Table 2. Project owners should clearly explain and justify the choice of baseline case, cognizant of the characteristics outlined in Table 2.

Table 2: Baseline approach and baseline emissions calculation by project type

Retrofit or new-build project?	**Does capture affect CO_2 production?**	**Baseline approach***	**Baseline emissions calculation**	
Retrofit	No	48(a)	Actual emissions measured in each project year	**Case 1**
Retrofit	Yes	48(a)	Historical emissions (average of 3 years)	**Case 2**
New-build	No	48(a)	Actual emissions measured in each project year	**Case 1**
New-build	Yes	48(c)	Average emissions of similar underlying activities undertaken in the previous five years, in similar circumstances, and whose performance is among the top 20 per cent of their category	**Case 3**

* The baseline approaches correspond to those set out in the Annex to Decision 3/CMA.3 (the “RMPs”), paragraph 36(iii) [Case 1 and 2] and paragraph 36(ii) [Case 3]. The approaches here are not, however, “adjusted downwards” to avoid eroding the financial flows to project operators, which could result in premature termination of the CO_2 capture and storage operation.

40. In respect of the choice of baseline scenario highlighted in Table 2, the following examples can be used guide decisions:

(a) **Case 1:** this situation applies to the capture of high purity CO_2 industrial process sources where the amount of CO_2 generated by the process is not affected by the use of CO_2 capture equipment (e.g., process vents at existing or new build natural gas sweetening facilities, steam methane reformers or ethylene oxide production etc. where CO_2 separation (capture) is part of the underlying activity).

This case also applies to DAC facilities, which are always new-build with a historical baseline scenario of zero removals.

(b) **Case 2**: this situation applies to existing electric generating facilities (e.g., fossil or biomass) or industrial facilities (e.g., cement kiln, steel works) with 3 or more years of operational data, where the amount of CO_2 generated by the facility will be affected by the CO_2 capture process (e.g., the energy penalty of capture).

(c) **Case 3**: this situation applies to any new build facility, an existing facility with less than three years' operational data, or a significant modification/repowering of an existing facility, that does not fall into either Case 1 or Case 2 above (e.g., new electric generation facilities including BECCS or industrial facilities, or capacity expansions to accommodate CO_2 capture facilities).

41. For DACCS and BECCS project activities, a baseline scenario of zero removals applies, based on the assumption that any removed CO_2 would otherwise remain in the atmosphere in the absence of the GCC project activity.[13]

42. Emission reductions are only claimable for a period of up to 30 years or up to the end of technical life of the underlying project activity, whichever is earlier.

9. Additionality

43. Project owners shall demonstrate additionality using the latest approved version of the CDM "TOOL01: Tool for the demonstration and assessment of additionality". In addition, supplemental CCS/BECCS-specific guidelines relating to Steps 0, 1 and 2 of TOOL01 shall be followed as outlined below.

44. In those cases where the proposed CCS/BECCS project activity will be subject to any incentives(s) aimed at GHG mitigation in the form of financial, fiscal or other forms of support impacting the project costs and/or revenues, project owners shall proceed directly to Step 1. Examples of such incentives include direct government support for CCS/BECCS deployment in the form of grants or tax incentives, and/or avoided emission costs arising from participation in carbon pricing instruments such as cap-and-trade schemes and carbon taxes.[14] Such incentives would have to be taken into account during financial analysis of the project activity for the demonstration of additionality.

45. If regulations requiring mandatory implementation of DACCS are locally absent, no direct economic incentive is considered to exist to support its deployment. The baseline scenario is therefore assumed to be the continuation of the current practice (i.e. no atmospheric removals). All DACCS projects are therefore considered to be automatically additional, and no further additionality demonstration is required.

[13] In the case of BECCS, the baseline would be the continued emission to the atmosphere of zero-rated biogenic CO_2, which becomes a removal when it is captured and stored – see Table 1.

[14] Note that as per the applicability conditions, project activities involving commercial CO_2 utilization are excluded from this methodology.

Step 0: Demonstration of whether the proposed project activity is the first-of-its-kind

46. The project owner shall consider whether the CCS/BECCS project activity applying this methodology is first-of-its-kind. In so doing, the project owner shall refer to the latest approved version of the CDM “TOOL23: Additionality of first-of-its-kind project activities” for definitions of “applicable geographical area” and “different technologies”.

47. For this methodology, a proposed project activity is considered first-of-its-kind in the applicable geographical area if:

(a) It is the first CCS or BECCS project; or

(b) It is the first large-scale CCS or BECCS project (typically considered to be storing greater than 1 million tonnes CO_2 per year); or

(c) It is the first to apply a new type of CO_2 capture technology or new type of geological storage medium that is of similar scale but different from technologies that are implemented by any other project, which have started commercial operation in the applicable geographical area before the start date of the proposed project activity;

48. If the outcome of Step 0 is that the project activity is determined to be “first-of-its-kind”, then the project activity is considered to be additional and therefore Steps 1 to 4 do not need to be applied.

Step 1: Identification of alternatives to the project activity consistent with mandatory laws and regulations

Sub-step 1a: Define alternatives to the project activity

49. Project owners shall identify all alternative scenarios to the project activity, including those providing: (a) similar output using different, low emission, processes and methods in the underlying activity, and (b) disposal or utilization of the CO_2 stream(s) generated by the underlying activity during facility operations. These alternatives shall be (a) available to the project owners, and (b) provide the same output as the proposed project activity.[15]

50. Possibilities may exist for alternative, low- or zero emissions, means of production to be implemented instead of the underlying activity producing CO_2, or for alternative means of

[15] *Output* refers to the goods or services produced by the underlying activity as part of normal commercial operations. For example, sweetened natural gas, refined oil or gas product, hydrogen, liquid fuel, chemical product(s). The output provided under the alternative scenarios should be the production of the same quality, grade or type that can be used in the same applications as the good produced by the project activity.

CO_2 disposal or utilization that could be implemented instead of geological storage of CO_2.[16] These alternative scenarios shall be informed by, and be consistent with, the required baseline approach (as determined under Baseline Scenario above) and include:

(a) S1: The proposed project activity being undertaken without being a registered GCC project activity.

(b) S2: Where applicable (i.e., for retrofits), the continuation of the current situation, *not* requiring any investment or expenses to maintain the current situation (e.g., continued release/venting to the atmosphere of the CO_2 stream(s) using existing equipment).

(c) S3: Where applicable (i.e., for retrofits), the continuation of the current situation, requiring an investment or expenses to maintain the current situation (e.g., investment into new CO_2 separation equipment to enable continued venting of the CO_2 stream(s)).

(d) S4: All other plausible and credible alternative scenarios to the GCC project activity scenario, including the common practices in the relevant sector for the underlying activity and disposal or utilization of the CO_2 stream(s) generated during operation of the underlying activity. These may include *inter alia*:

(i) Implementation of the underlying activity using alternative, low or zero emissions, means of production that are available and produce the same level of output.

(ii) Capture of CO_2 for the purpose of producing sales grade CO_2 in industrial or commercial applications (e.g., for use in the food or beverage industry, fire extinguishers, horticulture): project owners should consider the extent to which this is possible (or whether it is already taking place in the case of a retrofit), taking into account factors such as the proximity of the CO_2 source to centres of demand for product CO_2, as well as the size of that demand relative to the amount of CO_2 potentially available.

(iii) Capture of CO_2 for use in bulk urea or other chemicals production (e.g., polymers, carbonates, urea): project owners should consider the extent to which such pathways are available within the vicinity of the proposed project.[17]

(iv) Capture of CO_2 for the purpose of enhanced hydrocarbon recovery: project owners should consider the extent to which this is possible, taking into account factors such

[16] For example: by taking a slipstream of the source CO_2 or an alternative CO_2 source within the facility and using it for alternative purposes.

[17] CO_2 used in the production of urea is most commonly provided by ammonia production facilities within an integrated fertiliser production facility (typically steam methane reforming of natural gas in a Haber-Bosch process, which produces CO_2 as a byproduct). This is industry standard practice. Other sources of CO_2 can potentially be used where there is insufficient supply of onsite CO_2 relative to the mass of urea being produced (see CDM AM0027 or AM0063).

as the proximity of the CO_2 source to oil and/or gas reservoirs that are amenable to this type of tertiary recovery operation, and the quantity of CO_2 required. Where opportunities for tertiary oil and/or gas production exist, the suitability of CO_2 as opposed to other methods of recovery should be considered. Project owners shall explain any factors impacting upon the choice not to use CO_2 for EOR, or whether this could be a plan in future, taking into account specific demand for CO_2 (e.g., under water-alternating-gas methods) and economic viability (e.g., oil prices, opportunity cost of forgoing new field development).

(v) Capture of CO_2 for novel forms of utilisation: such uses may include, for example, using CO_2 to manufacture chemicals. Although demand from such uses is currently very limited worldwide, and such applications and technologies remain largely at the early pre-commercial stages of development, project owners should note whether such opportunities might be viable.

(vi) (Gas processing facilities or other situations requiring acid gas disposal): injection of CO_2 with other acid gases (e.g., H_2S) for the purpose of waste disposal of the latter (as opposed to incineration of the acid gas). Project owners should provide a clear indication as to any potential association of the project activity with acid gas disposal operations that could impact upon project economics.[18]

(vii)(Gas processing facilities): export of the natural gas without removing the CO_2. Project owners should provide information on gas supply contracts that establish the sales specification (grade) of the supplied natural gas (including its CO_2 concentration).

(e) S5: where applicable, the proposed project activity undertaken without being implemented as a GCC project activity to be implemented at a later point in time. Such a scenario may include the planned/announced introduction of national regulations or incentives directly aimed at the CCS/DACCS/BECCS deployment and/or indirectly serving to incentivise the uptake of the technology. These aspects should be assessed on a project specific basis using evidence such as license agreements or a review of national laws and regulations relating to GHG emissions.

51. **Outcome of Step 1a:** List of all realistic and credible alternative scenarios to the project activity.

[18] In some situations, CO_2 may be co-removed with other acid gases present in the hydrocarbon gas, in particular H_2S, or may be added to other H_2S streams for co-disposal (e.g. waste gas form geothermal energy plants). Where the former occurs, it can involve the removed H_2S being injected into geological formations with an incidental benefit of injecting and storing CO_2. In either case, co-disposal will affect project economics and, therefore, financial additionality. H_2S injection can be more costly than other forms of disposal and the effects of such activities on project viability should be evaluated on a project-by-project basis where applicable.

Sub-step 1b: Consistency with mandatory laws and regulations

52. The realistic and credible alternative scenario(s) identified under Sub-step 1a above shall be assessed for their compliance with all mandatory applicable laws and regulations. The alternative scenario(s) shall be in compliance with all mandatory applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG emissions reduction. Relevant areas of legislation may include, for example, license restrictions on the injection of acid gas under waste control legislation or the use of CO_2 within products.

53. **Outcome of Step 1b:** List of alternative scenarios to the project activity that are in compliance with mandatory legislation and regulations taking into account the enforcement in the region or country.

Step 2: Investment analysis

54. The purpose of this step is to determine whether the proposed project activity is unlikely to be the most financially attractive or is unlikely to be financially viable. Investment analysis shall be undertaken following the latest approved of the CDM "Guidelines on the assessment of investment analysis".

55. In undertaking the investment analysis, project owners shall account for:

    (a) Any type of incentives(s) aimed at GHG mitigation in the form of financial, fiscal or other forms of support impacting the project costs and/or revenues, as they may apply both to the alternative scenario(s) and also the project undertaken as a GCC project activity, as relevant. Examples of such incentives include direct government support for CCS/BECCS deployment in the form of grants or tax incentives, and/or avoided emission costs arising from participation in carbon pricing instruments such as cap-and-trade schemes and carbon taxes.

    (b) Any revenues resulting from the disposal or utilization of the CO_2 produced in the CO_2 stream(s) during facility operations. Because project activities involving commercial CO_2 utilization are excluded from this methodology, this would apply only to the alternative scenario(s), where relevant.

56. **Outcome of Step 2:** If it is concluded that either the proposed project activity is unlikely to be the most financially/economically attractive or is unlikely to be financially attractive, then project owners shall proceed to Step 4 (Common practice analysis) in the latest approved

version of the CDM "TOOL01: Tool for the demonstration and assessment of Additionality".[19] Otherwise, the project activity is considered not additional.

10. Baseline emissions

57. The approach to the calculation of baseline emissions is determined by the characteristics of the proposed geologic storage project activity, as specified in the baseline scenario (see above). Project owners shall apply the specified approach to the calculation of baseline emissions from the following:

(a) Actual emissions measured in each project year, *y* [Case 1]

(b) Historical emissions (average of three years) [Case 2]

(c) Average emissions of similar underlying activities undertaken in the previous five years, in similar circumstances, and whose performance is among the top 20 per cent of their category [Case 3]

58. The method to calculate baseline emissions for each case is outlined below.

Case 1: Actual emissions measured in each project year

59. Baseline emissions under this case are determined by the mass of CO_2 in stream(s) generated by the underlying activity in each project year that are captured and sent for geological storage in the project activity. These represent the amount of CO_2 that would otherwise be emitted to the atmosphere in the absence of the project activity.

60. Baseline emissions are therefore calculated as follows:

$$BE_y = BE_{VE,CO2,y}$$

Equation 1

Where:

BE_y = Baseline emissions in year *y* (tCO_2)

$BE_{VE,CO2,y}$ = Amount of CO_2 that would be released/vented to the atmosphere in the absence of the project activity in year y (tCO_2e/y)

61. The amount of CO_2 that would be released/vented to the atmosphere in the absence of the project activity is equivalent to the mass of CO_2 exported from the capture facility, $M_{X,y}$, shall be estimated as follows:

[19] Project owners may also choose to apply Step 3 (Barrier analysis), although this is not a requirement.

$$M_{X,y} = \sum F_{x,t} \times h_x \times 10^{-3}$$

Equation 2

Where,

$M_{X,y}$ = Mass of CO_2 exported from the capture facility at point X in each year y (tCO_2)

$F_{x,t}$ = Mass flow of CO_2 in the exported gas stream(s) in time interval t (kg/hour)

h_x = Number of hours of gas export per year (hours/year)

x = Measurement point "X" in Figure 1

62. The mass flow of the CO_2 in the exported gas stream, $F_{x,t}$, shall be calculated using the latest approved version of the CDM "TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream" according to the same procedures used to calculate $F_{i,t}$.

63. The parameters required to calculate $F_{x,t}$ as per the CDM "TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream" shall be monitored at point "X" in Figure 1, where the captured CO_2 is exported from the capture facility.

Treatment of the output and lifetime of facilities and equipment

64. Using the mass of CO_2 exported from the capture facility, $M_{X,y}$, to determine the baseline emissions could incentivise operators to increase the mass of CO_2 produced by the underlying activity.

65. To reduce the risk of overstating the baseline, project owners shall, in the PSF, address the following, according to the source of captured CO_2:

(a) **Industrial process emissions** (e.g., steam methane reforming or ethylene oxide production). In typical settings, process CO_2 emissions may only be increased through significant modifications to the underlying activity or site expansion.[20] Project proponents shall therefore provide documentary evidence (e.g., the plans for the CO_2 capture equipment including significant heat and energy sources, historical emissions, and other relevant information) to demonstrate that the amount of CO_2 to be captured corresponds to the CO_2 emissions of the processes forming the underlying activity absent of any changes in facility or equipment.

(b) **Natural gas processing emissions**. In some situations, process CO_2 emissions may be modified through the tie-in of new gas fields with higher CO_2 content than previously connected producing fields. For this reason, project proponents shall identify the

[20] In these situations, Case 3 (performance standard) would need to be applied to determine baseline emissions.

natural gas field development plan associated with the natural gas processing facility (field name/reservoir; production commencement date; production rate; field life, CO_2 concentration etc.), and describe how the different natural gas reservoirs will be produced (or "tied-in") to the facility across its operating life.

Forecasts of CO_2 content and processing emissions shall be reviewed during verification.

66. If the project proponent is unable to credibly demonstrate these requirements, they shall apply Case 2 (for retrofits) or Case 3 (for new builds) when establishing baseline emissions for the GCC activity.

67. In the case of natural gas processing, where verification indicates significant differences compared to the original processing CO_2 emissions forecasts prepared in the PSF (i.e., >10% increase), project proponents shall apply Case 3 for the monitoring period in question.[21]

Case 1(a): Direct air capture facilities

68. For DAC facilities, the baseline emissions shall be zero. The CO_2 removal effect is counted as a negative 'credit' in the project emissions according to the mass of atmospheric CO_2 captured and stored by the project activity, as calculated using *Equation 16*.

Case 2: Historical emissions (average of three years)

69. Baseline emissions under this case are determined by the historical CO_2 emissions produced annually from the facility prior to and up to the point in time of the retrofit of CO_2 capture. Because emissions performance (i.e., emission produced per unit of output) can vary from year to year, an average of three years' data is applied. This approach represents a reasonable estimate of the CO_2 emissions that would otherwise be emitted to the atmosphere in the absence of the project activity.

70. Project owners should first define the output (product) delivered by the facility and underlying activity from which CO_2 will be captured as part of the project activity, and the unit of output (e.g., tonnes of product, electricity generated etc).[15] These data shall be used as the basis for developing a project specific baseline emissions factor for use in calculating baseline emissions in each project year.

[21] Note: in accordance with the GCC Project Standard, excess issuance of ACCs is capped at 120% of the emission reductions estimated in the registered PSF.

(a) **Electric generating facilities**: the relevant product output is the net quantity of electricity generated and delivered to the grid, measured in megawatt-hours (MWh).

(b) **Other sectors/facility types**: the relevant product output is preferably denominated in unit mass (i.e. expressed as tonnes (t) output).[22]

71. Baseline emissions are calculated as follows:

$$BE_y = P_y \times EF_{BL}$$

Equation 3

Where,

BE_y = Baseline emissions in year y (tCO_2)

P_y = Product output in year y (MWh or t product)

EF_{BL} = Baseline emissions factor (tCO_2/MWh or tCO_2/t product)

The baseline emissions factor, EF_{BL} is calculated as follows

$$EF_{BL} = \frac{E_{HIST,3yr}}{P_{HIST,3yr}}$$

Equation 4

Where,

$E_{HIST,3yr}$ = Total emissions over three year period (tCO_2)

$P_{HIST,3yr}$ = Total product output over three year period (MWh or t product)

72. Historical emissions $E_{HIST,3yr}$ and historical product output, $P_{HIST,3yr}$ shall be summed from the three years of most recent and complete annual data available for the facility immediately prior to the start of the project activity.[23] Project owners shall compile the data used to determine these parameters by completing the table below (each calendar year shall be indicated):

[22] Where mass is not viable or relevant to the product in question, project owners may specify an alternative unit and provide reasons for doing so. If such circumstances the baseline emissions factor and product output parameters as outlined in this section must be expressed according to the chosen unit.

[23] Complete means a full calendar year of data. Emissions data should be collected in accordance with the CDM "TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"

Table 3: Historic facility data used to determine baseline emission factor

Year	Emissions (tCO_2)	Product output (MWh or t)
1		
2		
3		
Total	**=** $E_{HIST,3yr}$	**=** $P_{HIST,3yr}$

73. To ensure conservativeness in the baseline estimation, during project implementation project owners shall also monitor and calculate the mass of CO_2 injected in the geological formation, $M_{I,y}$, in accordance with *Equation 18*, and the lower of the result of *Equation 18* or *Equation 3* shall be applied as the baseline.

Case 2(a): Coal-fired electricity generation with CCS (retrofit)

74. In the case of retrofit of coal-fired electric generating facilities, the baseline emission factor (EF_{BL}) shall be discounted by a factor equivalent to the increase in the level of renewable energy penetration in the grid into which the project plant delivers electricity.[24] The factor will be quantified ex-post and will be assessed on an annual basis and used in the emission reduction estimation.

75. The baseline emissions factor for coal-fired plants, $EF_{BL(coal)}$, is thus calculated as follows:

$$EF_{BL(coal)} = \frac{E_{HIST,3yr}}{P_{HIST,3yr}} \times (1 - RE_{inc,y})$$

Equation 5

Where,

$EF_{BL(coal)}$ = Baseline emissions factor adjusted for renewable energy penetration rate in the host country in year *y* (tCO_2/MWh)

$RE_{inc,y}$ = Annual change in the share of grid connected renewable electric generating capacity in year *y* (%)

$E_{HIST,3yr}$ = Total emissions over three year period (tCO_2)

$P_{HIST,3yr}$ = Total net power output over three year period (MWh)

[24] Based on publicly available data issued by the grid authorities or the data published by national authorities, it is calculated as amount of relevant, grid-connected, installed capacity of renewable energy for the project as against the total installed capacity of all grid connected power generation expressed as %

76. The annual change in the share of grid connected renewable electricity generating capacity in year *y*, $RE_{inc,y}$, is calculated as follows:

$$RE_{inc,y} = RE_{MW,grid,y} - RE_{MW,grid,y-1}$$

Equation 6

Where,

$RE_{inc,y}$ = Annual change in the share of grid connected renewable electricity generating capacity in year *y* (%)

$RE_{MW,grid,y}$ = Share of renewable electricity in total grid capacity in year *y* (%)

$RE_{MW,grid,y-1}$ = Share of renewable electricity in total grid capacity in the previous year (%)

77. If data from national authorities indicates that the amount of renewable energy generating capacity connected to the national grid increased by x% in a year, the baseline emission factor will be discounted by x% for the calculation of baseline emissions corresponding to that year. In case of a decrease in capacity no adjustment is needed in the baseline emission factor.

Case 2(b): Biomass energy with carbon capture and storage, BECCS (retrofit)

78. In accordance with Table 1, the baseline emissions for retrofit BECCS facilities shall be zero. The CO_2 removal effect is counted as a negative emission 'credit' in the project emissions according to the mass of biogenic CO_2 captured and stored by the project activity (Step 4), calculated using *Equation 16*.

Cofiring biomass with fossil fuels and waste-to-energy facilities

79. In some electric generating facilities, biomass may only account for a fraction of the fuel combusted (e.g., waste-to-energy facilities). In such circumstances, the baseline emissions shall also be determined by the historical emissions as outlined for Case 2 in *Equation 3*.

Case 3: Average emissions of similar underlying activities undertaken in the previous three years, in similar circumstances, and whose performance is among the top 20 per cent of their category

80. Baseline emissions under this case are determined by applying a performance standard using similar underlying activities undertaken in similar circumstances.

81. As with Case 2 (see above), project owners are first required to define the product output delivered by the facility from which CO_2 will be captured as part of the project activity, and the unit of product output.[15] This provides the basis for development of a baseline emissions

factor using average data from similar underlying activities undertaken in similar circumstances.

82. Two separate sub-cases are outlined below, according to whether the project activity involves (a) an electric generating facility; or (b) other industrial facility.

Case 3(a): Electric generating facilities

83. For project activities capturing CO_2 from electric generating facilities, baseline emissions shall be calculated in accordance with the latest approved version of the CDM "TOOL05: Baseline, project or leakage emissions from electricity consumption and monitoring of electricity generation" (using the combined margin emission factor of the applicable electricity system).

84. With reference to para 49 and 50, In case of project activity capturing CO2 from a greenfield fossil fuel based power generating facility, all options to generate power from all other sources to be dealt with and the baseline fuel for power generation is to be qualitatively[25] / quantitatively evaluated, methodology is only applicable if the most likely scenario is the generation of power using the fuel in the underlying project activity only.

85. The baseline emissions, BE_y, are thus calculated as follows:

$$BE_y = EG_y \times EF_{grid,CM,y}$$

Equation 7

Where,

BE_y	= Baseline emissions in year y (tCO_2)
EG_y	= Net quantity of electricity generated and delivered to the grid by the project electric generating facility in year y (MWh)
$EF_{grid,CM,y}$	= Combined margin emission factor for the project electricity system in year y (tCO_2/MWh)

86. Project owners shall calculate the **combined margin** CO_2 emission factor for the project electricity system in year y, $EF_{grid,CM,y}$, following procedures and methods contained in the latest approved version of the CDM "TOOL07: Tool to calculate the emission factor for an electricity system".

[25] Eg. In the case of CCS project on a newly built gas based power generation facility, all other credible options of power generation using other input material like Oil and gas to be evaluated including the option of setting up renewable energy generation solutions. The options may be evaluated on qualitative basis like availability of resources eg. gas or other wind energy or solar irradiation or land area to setup the power generation units. The methodology is applicable only if it is demonstrated that a gas based power generation facility without CCS is the only other option available at the project site.

87. In applying TOOL07 to calculate the **build margin** CO_2 emission factor for the project electricity system in year *y*, $EF_{grid,BM,y}$, project owners shall:

(a) Apply Option 2 in respect of vintage of data (under Step 5 of TOOL07); and

(b) Include only grid electric generating facilities in the calculation of the build margin emissions factor (i.e., off-grid electric generating facilities shall not be included).

88. In applying TOOL07 to calculate the **operating margin** CO_2 emission factor for the project electricity system in year *y*, $EF_{grid,OM,y}$, project owners shall use either the:

(a) Method set out in TOOL07. Project owners shall provide the detailed calculations applied and justify choices made in line with the requirements and procedures set out therein; or

(b) Data and information on electricity supplied to the relevant grid in year *y*, as published by reliable sources (e.g. grid operator data; power distribution/supply company data; other sources such as government agencies that collect and collate emissions data from grid connect power plants etc). The data shall take account of average technical transmission and distribution losses.

89. In calculating the **combined margin** in accordance with TOOL07, the following default values should be used for W_{OM} and W_{BM}:

(a) projects in fossil fuel-fired electric generating facilities: W_{OM} = 0.50 and W_{BM} = 0.50

90. To ensure conservativeness in the baseline estimation, during project implementation project owners shall also monitor and calculate the mass of CO_2 injected in the geological formation ($M_{I,y}$) in accordance with *Equation 18*, and the lower of the result of *Equation 18* or *Equation 7* shall be applied as the baseline.

Case 3(a)(i): Biomass energy with carbon capture and storage, BECCS (new build)

91. In accordance with Table 1, the baseline emissions for new build BECCS facilities shall be zero. The CO_2 removal effect is counted as a negative emission ‘credit’ in the project emissions according to the mass of biogenic CO_2 captured and stored by the project activity (Step 4), calculated using *Equation 16*.

92. In addition, new build BECCS facilities may also count the potential avoided CO_2 emissions effects arising from the displacement of an equal amount of more carbon-intensive grid

electricity generation, as determined by application of the combined margin emission factor as outlined for Case 3(a) and *Equation 7*.[26]

Cofiring biomass with fossil fuels and waste-to-energy facilities

93. In some electric generating facilities, biomass may only account for a fraction of the fuel combusted (e.g., waste-to-energy facilities). In such circumstances, the baseline emissions shall also be determined by the combined margin emission factor as outlined for Case 3(a) and *Equation 7*.

Case 3(b): Other industrial facilities

94. For project activities capturing CO_2 from underlying activities other than electric generating facilities, project owners shall determine the baseline emissions factor using a benchmark approach. The benchmark shall be developed from the average emissions performance of similar underlying activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category.

95. With reference to para 49 and 50, In case of project activity capturing CO2 from a greenfield industrial facilities , all options to generate same output as the project plant from all other sources to be dealt with and they are to be qualitatively[27] / quantitatively evaluated, methodology is only applicable if the most likely scenario is the production of output as in the underlying plant using the resources/mechanism/technology as in the underlying project activity only.

96. In making the calculation of the benchmark, the following definitions apply:

    (a) 'Performance' means CO_2 emissions per unit product output (i.e., tCO_2 per t product), where CO_2 emissions comprise all *direct* CO_2 emissions from the underlying activity undertaken in the facility (i.e., process, combustion and, where known, fugitive emissions).

[26] Note that avoided emissions effect may be zero; for example, where the bioenergy electric generating facility displaces other zero-rated grid-based power generation such as wind, solar, hydro, nuclear. In this case, project owners do no not need to include this calculation.

[27] Eg. In the case of CCS project on a newly built NG reformer facility for Hydrogen generation. The options may be evaluated on qualitative basis like availability of alternate resources (e.g. Electrolyzers) for generation of H2 in the project site. The methodology is applicable only if it is demonstrated that Hydrogen generation using a Natural Gas steam reformer without CCS is the only other option available at the project site.

(b) ‘Average emissions performance’ means the weighted average performance (i.e., tCO_2 per t product) for the underlying activity undertaken in the facility, based on all years of production up to and including five years before the project activity submission.

(c) 20 per cent refers to 20 per cent of total production (output) within the category

97. Project owners shall define the product output from the facility from which CO_2 will be captured in the project activity. The unit of output shall be in tonnes (t) product.[28]

98. Project owners shall describe the “similar social, economic, environmental and technological circumstances” considered relevant to the facility, and clearly define the “category” considered to best represent the underlying industrial activity undertaken in the facility. This may be based upon the following types of considerations *inter alia*:

(a) Product type (e.g., cement, clinker, steel).

(b) Specific technology or process employed (noting that different technologies and processes can be employed to produce a given product, each with their own energy and/or emissions performance characteristics).

(c) Fuel type used for energy combustion in the facility (e.g., coal, gas, fuel oil, biomass, mixed waste).

(d) Size and/or configuration of the facility.

(e) Geographical or economic region.

99. The calculation of the baseline emissions factor shall be determined per the following procedure:

(a) Identify and list all facilities in the same category built over the last five years up to and including the date of PSF submission (or longer where no new facilities were built in the past five years).

(b) Collect historic data on product output and CO_2 emissions data for all identified facilities for the entire period up to and including five years before the project activity submission. If only emissions performance data are available (tCO_2 per t product), these can be used instead. If only rated capacity data are available instead of actual output data, then annual output can be estimated by applying a suitable average industry capacity factor to these. At least one full calendar year of data must be available for a facility for

[28] Where mass is not viable or relevant to the product in question, project owners may specify an alternative unit and provide reasons for doing so. If such circumstances the baseline emissions factor and product output parameters as outlined in this section must be expressed according to the chosen unit.

its inclusion within the list. Facilities may be included if one or more year of data is not available, so long as at least one full year of data is available, where this leads to a more conservative estimate of the baseline.

(c) Calculate the average emissions performance for each identified facility (tCO_2 per t product) based on the total available product output and the total CO_2 emissions data. This is done by dividing the total CO_2 emissions (tCO_2) by the total product output (t product) over the same period and for the same data years[29] to arrive at a weighted average performance value for each facility.

(d) Order the list of facilities in a table according to their average emissions performance, with the highest performing facilities at the top of the list (i.e., those with the *lowest* value of tCO_2 per t product).

(e) Identify the set of facilities, *SET*, from the top of the ordered table and which account for 20 per cent of production (output) as per the data collected (if 20 per cent falls on part of the output of a facility, then the output of that facility shall be fully included in the set calculation). If the defined region has less than five plants, then data from all the plants must be taken into consideration for baseline determination.

(f) Finally, calculate the benchmark emissions factor (tCO_2 per t product) based on the total historic CO_2 emissions (tCO_2) and total production (t product) data for the identified set of facilities, *SET* (described further below).

100. If no facilities can be identified within the category, or if the set of facilities, *SET*, contains only one facility, then project owners shall use a benchmark emissions factor from the most recently applied allocation benchmarks used in the European Union Emissions Trading Scheme (EU ETS) for the relevant facility type and technology/process. If a relevant benchmark does not exist from this source, then project owners may propose an alternative value, clearly indicating with evidence why this can be considered "best available technology" (BAT).

101. Project owners shall compile and present the information and historic data, as outlined in the procedure above, according to the two tables below:

[29] The same years of data must be used for both the output and emissions data, to avoid a mistaken skewing of facility performance.

Table 4: Historic data, all identified facilities within category

Facility name	Commissioning year	Product output (t)	CO_2 emissions (tCO_2)	Performance (tCO_2 per t product)
A				
B				
C				
D				
E				
F				
etc.				
Total				

Table 5: Historic data for top 20 percent of facilities by performance, *SET*

Facility name	Commissioning year	Product output (t)	Cumulative share of total output (%)	CO_2 emissions (tCO_2)	Performance (tCO_2 per t product)
A					
B					
C					
etc.					
Total		= $P_{HIST,SET}$		= $E_{HIST,SET}$	

102. The baseline emissions factor, EF_{BL}, *is* calculated from the table data above (Table 5) as follows:

$$EF_{BL} = \frac{E_{HIST,SET}}{P_{HIST,SET}}$$

Equation 8

Where,

$E_{HIST,SET}$ = Total historic CO_2 emissions from set of top performing facilities, *SET* (tCO_2)

$P_{HIST,SET}$ = Total historic production (output) from set of top performing facilities, *SET* (t product)

103. The baseline emissions are calculated as follows:

$$BE_y = P_y \times EF_{BL}$$

Equation 9

Where,

BE_y = Baseline emissions in year *y* (tCO_2)

P_y = Product output in year *y* (t product)

EF_{BL} = Baseline emissions factor (tCO_2/t product)

104. To ensure conservativeness in the baseline estimation, during project implementation project owners shall also monitor and calculate the mass of CO_2 injected in the geological formation ($M_{I,y}$) in accordance with *Equation 18*, and the lower of the result of *Equation 18* or *Equation 9* shall be applied as the baseline.

11. Project emissions

105. Project emissions include the following:

(a) CO_2 emissions due to fossil fuel combustion from stationary sources (i.e., used to power CO_2 capture, treatment, transportation by pipeline, reception and injection of the CO_2) and from mobile sources (e.g., in the transportation of CO_2 by rail, road and/or ship tanker) within the project boundary;

(b) CO_2 emissions from electricity consumption relating to the capture, treatment, transportation by pipeline or rail (if applicable), reception and injection of the CO_2;

(c) CO_2 emissions from bought-in heat consumption used for the capture of the CO_2;

(d) CO_2 removals arising from the injection and geological storage of biogenic CO_2 or direct air capture (accounted for as negative project emissions);

(e) Fugitive (non-seepage) CO_2 emissions occurring across the project activity due to losses (leaks) from pipelines, loading and unloading etc;

(f) Potential CO_2 emissions from seepage of CO_2 from the geological storage site, which can potentially occur at any time after injection commences.

106. These emission sources should be included and considered as project emissions within the project boundary irrespective of whether they fall outside the direct control of the project owners (e.g. even if project owners do not operate the transportation system).

107. Project emissions are calculated as follows:

$$PE_y = PE_{FC,y} + PE_{E,y} + PE_{H,y} + PE_{NEG,y} + PE_{F,y} + PE_{SP,y}$$

Equation 10

Where,

PE_y	= Project emissions in year *y* (tCO_2)
$PE_{FC,y}$	= Project emissions from fossil fuel combustion in year *y* (tCO_2)
$PE_{E,y}$	= Project emissions from bought-in electricity in year *y* (tCO_2)
$PE_{H,y}$	= Project emissions from bought-in heat in year *y* (tCO_2)
$PE_{NEG,y}$	= (Negative) project emissions from injection of biogenic CO_2 or direct air capture in year *y* (tCO_2)
$PE_{F,y}$	= Project emissions from fugitive CO_2 losses in year *y* (tCO_2)
$PE_{SP,y}$	= Project emissions from seepage in year *y* (tCO_2)

108. Project emissions are calculated according to the following steps:

Step 1: Determination of project emissions from fossil fuel combustion

Step 2: Determination of project emissions from bought-in electricity consumption

Step 3: Determination of project emissions from bought-in electricity consumption

Step 4: Determination of negative project emissions (removals) from injection of biogenic CO_2 or direct air capture

Step 5: Determination of project emissions from fugitive CO_2 losses

Step 6: Determination of project emissions from seepage

Step 1: Determination of project emissions from fossil fuel combustion

109. The determination of project emissions from fossil fuel combustion within the project boundary is divided into two sub-steps, one for calculation of emissions due to fossil fuel combustion from stationary sources and the second for calculation of emissions due to fossil fuel combustion from mobile sources.

110. Project emissions from fossil fuel combustion are calculated as follows:

$$PE_{FC,y} = \sum_j PE_{SS,j,y} + \sum_j PE_{MS,j,y}$$

Equation 11

Where,

$PE_{FC,y}$ = Project emissions from fossil fuel combustion in year *y* (tCO_2)

$PE_{SS,y}$	= Project emissions from fossil fuel combustion (stationary sources) in year y (tCO_2)
$PE_{MS,y}$	= Project emissions from fossil fuel combustion (mobile sources) in year y (tCO_2)
j	= Sources of fossil fuel combustion in the project activity

111. The substeps for calculating each component are described below.

Sub-step 1a: Project emissions from fossil fuel combustion (stationary sources)

112. Project emissions arising from the combustion of fossil fuels in stationary sources, $PE_{SS,y}$, are calculated in two main steps:

(a) First, the total mass of CO_2 generated within the project boundary is calculated (according to flows "F" in Figure 1, as used in underlying activity and including to power CO_2 capture, treatment, transportation by pipeline, reception and injection etc.).

(b) Second, the mass of CO_2 that is captured and exported from the capture process for geological storage (at point "X" in Figure 1) is subtracted from the total CO_2 generated,

as follows:

$$PE_{SS,y} = M_{F,j,y} - M_{X,y}$$

Equation 12

Where,

$M_{F,j,y}$	= Total mass of CO_2 generated by fossil fuel use in stationary combustion sources j inside the project boundary in year y (tCO_2).
$M_{X,y}$	= Mass of CO_2 exported from the capture facility in each year y (tCO_2)
x	= Measurement point "X" in Figure 1.

113. The total mass CO_2 generated by fossil fuel use in stationary combustion sources inside the project boundary shall be calculated by applying the latest approved version of the CDM "TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". Therein, the processes j should correspond to each single emission source considered within the boundary of the project activity. Project owners should document each emission source clearly and transparently.

114. The mass of CO_2 exported from the capture facility, $M_{X,y}$, shall be calculated following *Equation 2*.

Capture of high purity CO_2 industrial process sources

115. For either retrofit or new build project activities capturing only high purity CO_2 industrial process sources where the amount of CO_2 generated by the process is not affected by the use of CO_2 capture equipment,[30] project owners should clearly identify and describe the stationary fossil fuel combustion emission sources occurring inside the project boundary, *j*.

116. The following allocation shall apply to the identified stationary fossil fuel emissions sources inside the project boundary for the purposes of calculating the total mass of CO_2 generated from fossil fuel combustion, $M_{F,j,y}$ using *Equation 12*:

    (a) Emissions arising from the deployment of CCS, including any sources partially resulting from, or, in the case of retrofits, changes in existing emission sources arising from, the deployment of CCS, must be appropriately allocated and included as project emissions (e.g., relating power use to CO_2 clean-up and/or compression power requirements that would be absent in the baseline scenario);

    (b) Emissions resulting exclusively from the underlying activity, and which would therefore be present at the same level in the baseline scenario and unaffected by the deployment of CCS, may be excluded from project emissions.

Cofiring biomass with fossil fuels and waste-to-energy facilities

117. In some situations, fossil fuels may only account for a fraction of the fuel combusted (e.g., waste-to-energy facilities). In these circumstances, the mass of CO_2 exported from the capture facility, $M_{X,y}$, in *Equation 12* shall be moderated according to (i.e., multiplied by) the fraction of fossil carbon content as a percentage of total carbon content in the mixed fuels that are being combusted in the underlying activity (namely: 1 – ($R_{BC:FC}/100$)).

Sub-step 1b: Project emissions from fossil fuel combustion (mobile sources)

118. Project emissions originate from mobile sources combusting fossil fuels within the project boundary (e.g., transport of CO_2 by road, rail or shipping). Project owners may choose between two different approaches to determine emissions: an approach based on distance and transport type emissions factor (Option 1) or on fuel consumption (Option 2).

[30] For project activities under Baseline Scenario Case 1 and applying *Equation 1*

Option 1: use of transport type emissions factor(s)

119. Under this option, emissions are calculated on the basis of distance and the number of trips, and applying an emissions factor specific to the transport type (mode and/or vehicle), as follows:

$$PE_{MS,y} = \sum_i N_{trans,i,y} \times AVD_{trans,i,y} \times EF_{trans,km,CO2,i,y}$$

Equation 13

Where,

$PE_{MS,y}$ = Project emissions from fossil fuel combustion from mobile sources in year *y* (tCO_2yr)

$N_{trans,i,y}$ = Number of trips for transport type *i* during the year *y*

$AVD_{trans,i,y}$ = Average round trip distance for transport type *i* between point of loading of CO_2 onto rail or road tanker and the point of unloading of CO_2 at the site of injection during the year *y* (km)

$EF_{trans,km,CO2,i,y}$ = Emission factor for transport type *i* in year *y* (tCO_2/km)

120. Project owners shall justify the emissions factor used for each transport type *i* with reference to relevant data and information sources (e.g., technical studies, vehicle manufacturer information, vehicle inspection documentation) applying conservativeness as appropriate. Wherever possible, emission factors should reflect the actual vehicles models used instead of typical factors applied on the basis of vehicle categories/classes.

Option 2: fossil fuel consumption

121. Under this option, emissions are calculated based on the actual quantity of fossil fuel consumed for transportation, as follows:

$$PE_{MS,y} = \sum_i FC_{trans,i,y} \times NCV_{trans,i} \times EF_{trans,CO2,FF,i}$$

Equation 14

Where,

$PE_{MS,y}$ = Project emissions from fossil fuel combustion from mobile sources in year *y* (tCO_2yr)

$FC_{trans,i,y}$ = Fuel consumption of fuel type *i* for transportation of CO_2 during year *y* (mass or volume unit)

$NCV_{trans,i}$ = Net calorific value of the fossil fuel type *i* (GJ/ mass or volume unit)

$EF_{trans,CO2,FF,I}$ = CO_2 emission factor for fossil fuel type *i* (tCO_2/GJ)

Step 2: Determination of project emissions from electricity consumption

122. Electricity supplied by dedicated renewable energy sources built for use in the project activity (auto-generation) shall have an emission factor of zero, and do not need to be included in the calculation.

123. Project emissions, $PE_{E,y}$, in each project year y arising from the consumption of bought-in electricity from other sources should include all activities within the project boundary that import electricity (e.g. for CO_2 capture, treatment, transportation (pipeline, electric vehicle or electrified rail), reception and injection).

124. The project emissions from electricity, $PE_{E,y}$, are thus calculated as follows:

$$PE_{E,y} = \sum_{j} EC_y \times EF_{grid,CM,y}$$

Equation 15

Where,

$PE_{E,y}$ = Project emissions from electricity consumption in year y (tCO_2)

EC_y = Net quantity of electricity consumed across the capture, transport and storage chain within the project activity in year y (MWh)

$EF_{grid,CM,y}$ = Combined margin emission factor for the project electricity system in year y (tCO_2/MWh)

j = Sources of electricity consumption in the project

125. Project emissions from the use of bought-in electricity should be calculated according to the latest approved version of the CDM “TOOL05: Baseline, project or leakage emissions from electricity consumption and monitoring of electricity generation”, Scenario A, Option A1, namely: the combined margin emission factor of the applicable electricity system.

126. Therein, per the latest approved version of the CDM “TOOL07: Tool to calculate the emission factor for an electricity system”, in calculating the **combined margin** CO_2 emission factor for the project electricity system in year y, $EF_{grid,CM,y}$, the project owner shall:

(a) For the **build margin** CO_2 emission factor for the project electricity system in year y ($EF_{grid,BM,y}$); use the method from the latest approved version of TOOL07.

(b) For the **operating margin** CO_2 emission factor for the project electricity system in year y ($EF_{grid,OM,y}$); use either of the:

(i) Method set out in TOOL07. Project owners shall provide the detailed calculations applied and justify choices made in line with the requirements and procedures set out therein; or

(ii) Data and information on electricity supplied to the relevant grid in year *y*, as published by reliable sources (e.g. grid operator data; power distribution/supply company data; other sources such as government agencies that collect and collate emissions data from grid connect power plants etc). The data shall take account of average technical transmission and distribution losses.

127. In calculating the **combined margin** in accordance with TOOL07, the following default values should be used for W_{OM} and W_{BM}:

(a) projects in fossil fuel based power generation units: W_{OM} = 0.50 and W_{BM} = 0.50

128. Project emissions from bought-in electricity consumption are monitored at points shown by “E” in Figure 1.

Step 3: Determination of project emissions from heat consumption

129.

130. Project emissions, $PE_{H,y}$, in each project year *y* arising from the consumption of bought-in heat should include all sources of imported heat used for capture of CO_2.

131. Project emissions from the use of bought-in heat should be calculated applying the latest approved version of the CDM “TOOL03: Tool to calculate project or leakage emissions from fossil fuel consumption”.

132. Project emissions from bought-in heat consumption are monitored at points shown by “H” in Figure 1.

Step 4: Determination of negative project emissions (removals) from injection of biogenic CO_2 or direct air capture

133. Project activities involving the injection of biogenic CO_2 or direct air capture remove CO_2 from the atmosphere and permanently store it in the geosphere. This removal is accounted for as a negative project emission within this methodology whereby each tonne of CO_2 exported from the facility is calculated as a negative tonne of CO_2:

(a) First, the mass of CO_2 exported from the capture facility, $M_{X,y}$, is calculated in accordance with Equation 2.

(c) Second, the mass of CO_2 exported from the capture facility shall be converted to a negative emission,

as follows:

$$PE_{NEG,y} = (-1) \times M_{X,y}$$

Equation 16

Where,

$PE_{NEG,y}$ = Negative project emissions (removals) in each year y (tCO_2)

$M_{X,y}$ = Mass of CO_2 exported from the capture facility in each year y (tCO_2)

x = Measurement point "X" in Figure 1.

Cofiring biomass with fossil fuels and waste-to-energy facilities

134. In some situations, biomass may only account for a fraction of the fuel combusted (e.g., waste-to-energy facilities). In these circumstances, the mass of CO_2 exported from the capture facility, $M_{X,y}$, in *Equation 16* shall be moderated according to (i.e., multiplied by) the fraction of biogenic carbon content as a percentage of total carbon content in the mixed fuels that are being combusted in the underlying activity ($R_{BC:FC}/100$).

Step 5: Determination of project emissions from fugitive CO_2 emissions

135. Fugitive emissions of CO_2 can occur due to losses and leaks from pipelines, loading and unloading etc. These emissions shall be calculated using a mass balance approach based on the difference between the mass of CO_2 exported from the capture facility and the mass of CO_2 injected into the injection formation, as follows:

$$PE_{F,y} = M_{I,y} - M_{X,y}$$

Equation 17

Where,

$PE_{F,y}$ = Project emissions from fugitive losses in year y (tCO_2)

$M_{X,y}$ = Mass of CO_2 exported from the capture facility in each year y (tCO_2)

$M_{I,y}$ = Mass of CO_2 injected into injection formation at point I in year y (tCO_2yr)

136. The mass of CO_2 exported from the capture facility, $M_{X,y}$, shall be calculated in accordance with *Equation 2*.

137. The mass of CO_2 injected into the injection formation, $M_{I,y}$, shall be calculated as follows:

$$M_{I,y} = \sum F_{i,t} \times h_i \times 10^{-3}$$

Equation 18

Where,

$M_{I,y}$ = Mass of CO_2 injected into the injection formation in each year y (tCO_2)

$F_{i,t}$ = Mass flow of CO_2 in the injected gas stream(s) in time interval t (kg/hour)

h_i = Number of hours of gas injection per year (hours/year)

i = Measurement point “I” in Figure 1.

138. The mass flow of the CO_2 in the injected gas stream, $F_{i,t}$, shall be calculated using the latest approved version of the CDM “TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream”.

139. The parameters required to calculate $F_{i,t}$ as per TOOL08 shall be monitored at point “I” in Figure 1.

Step 6: Determination of project emissions from seepage

140. Seepage of CO_2 from the geological storage site back to the atmosphere (or surface water and/or seawater in the case of CO_2 storage sites located under the seabed) can potentially occur at any time after injection commences. Seepage can arise as a consequence of subsurface processes occurring after injection, such as diffusion (through caprocks) and migration (along fault planes and fissures or through operational or abandoned wells).

141. All of these potential emission sources can be effectively managed through good site selection and management, including effective monitoring (which serves to support zero-seepage assumptions regarding well selected and properly managed geological CO_2 storage sites), and the use of corrective measures to control any significant irregularities in the subsurface behaviour of the CO_2. Therefore, an effective monitoring plan for the management of project emissions from seepage involves two steps:

(a) Monitoring to determine safe operation of the storage site and to provide evidence of the absence of seepage based on:

(i) Operation of the storage site within the proposed conditions of use (as defined in the Site Development and Management Plan, see Section 5 of the GGCS);

(ii) Comparison of the predicted behaviour of CO_2 in the geological storage site storage with the monitored behaviour (history-matching);

(iii) Analysis of key features within the geological CO_2 storage site architecture and surrounding domains that can potentially affect CO_2 storage security and seepage; and;

(b) If monitoring suggests that seepage has occurred, undertaking monitoring to quantify the mass of CO_2 emitted due to seepage.

142. Seepage emissions should be considered as project emissions if they occur within the crediting period. Where seepage emissions give rise to a net reversal of storage, either within a crediting period or in the post-injection phase, the procedure described below (para. 174-176; Net reversal of storage) shall apply.

143. Determination of project emissions or a net reversal of storage from seepage shall be undertaken through two steps, as follows:

(a) **Sub-step 6a**: Monitoring and management of the geological storage site.

(d) **Sub-step 6b**: Quantification of the mass of any CO_2 released to the atmosphere from the geological storage site as a consequence of seepage.

Further details on the procedures for each sub-step are provided below.

Sub-step 6a – Monitoring and management of the geological storage site

144. In accordance with the procedure described above, the following aspects shall be determined in the **Geological Storage Site Selection and Characterisation Report** (compiled following guidance set out in the GGCS, Section 1) and the **Site Development and Management Plan** (compiled following guidance set out in the GGCS, Section 5):

(a) **Conditions of use**: describing the way in which injection operations shall be undertaken so as to minimise the risk of seepage, based on the specific characteristics of the geological storage complex determined during characterisation. This includes maximums of injection pressure and the maximum extent of the pressure front within the geological storage site and surrounding domains (relating to parameter(s) $P_{M,j/k/l}$)

(b) **CO_2 migration analysis:** describing the predicted fate and behaviour of CO_2 in the geological storage site, and the vertical and lateral boundaries of the dispersing CO_2 plume over time (relating to parameter(s) $PB_{CO2,V/L,p,t}$);

(c) **Geological storage site architecture analysis:** describing the known and inferred main features within the injection formation(s) and caprock formation(s) that would act as barriers to, or facilitators of, the migration and seepage of injected CO_2 outside of the predicted geological storage site boundaries (relating to parameters(s) $M_{SC,j/k/l,y}$);

145. Project owners shall design a subsurface **Monitoring Plan** – following the guidance provided in the GGCS, Section 4 – to support the analysis required for this sub-step during the operational and post-injection phases of the project activity. Monitoring shall support the determination of seepage through the following purposes:

(a) **Conditions of use**: to support zero-seepage assumptions by avoiding conditions that could lead to activation of pressure-driven or other processes within the injection formation, which in turn could lead to seepage (as determined in the **Site Development and Management Plan** as per the GGCS, Section 5);

(b) **CO_2 migration analysis**: to generate images of the geological storage complex and CO_2 plume which provide information regarding the behaviour of the injected CO_2 plume so as to support reviews of, and the basis for potential revisions to, the subsurface project boundaries post-commencement of injection operations (widely known as "history matching");[31] and;

(c) **Geological storage site architecture**: to provide early signs of significant deviations within and outside of the boundaries of a geological storage site as defined during geological storage site characterisation, including recognized migration and seepage pathways.

146. Further details on how part of the monitoring approach supports the determination of project emissions due to seepage are described below.

Conditions of use

147. Operational safety margins and appropriate conditions of use to avoid activating pressure-driven processes in the injection formation should be determined using the following calculation:

$$P_{PC,OL} = P_{PC,SL} \times P_{SF}$$

Equation 19

$$P_{PC,OL} < \{P_{M,j}, P_{M,k} \ldots\ldots P_{M,l}\}$$

Equation 20

Where,

$P_{PC,OL}$	= the maximum operational pressure limit of the injection formation (kPa)
$P_{PC,SL}$	= the pressure safety limit in the injection formation determined during geological storage site characterisation following the guidance in the GGCS, Section 1, and laid down in the conditions of use. It is based on variations in key pressure-driven mechanical formation features that can affect seepage as described above (kPa)
P_{SF}	= the pressure safety factor based on setting a safety margin between the operational limit and the safety margin (it is a ratio that must always be less than 1). The pressure safety factor selected must be justified in the risk analysis (see the GGCS, Section 2)
$P_{M,j/k/l}$	= Bottomhole (and/or wellhead where applicable) pressure in the injection formation continuously monitored in well *j/k/l* (including injection and monitoring wells) during the project activity (kPa)

[31] To the extent feasible in the given geological setting. Where direct imaging is not readily possible, other indirect methods should be used to provide inferred vertical and lateral limits of the subsurface CO_2 plume.

148. Note: Where pressure limits are linked to the temperature around the wellbore, the project owners may describe the above equation depending on the temperature. In addition, pressure limits may depend on the location in the geological storage reservoir. If different pressure limits need to be defined for different areas (e.g., different injection wells) in the injection formation, the project owners should present separate monitoring plans for the different areas.

149. Pressure in the injection formation shall be monitored and should not exceed levels which could induce the pressure driven processes which can affect storage security and seepage risk. If monitoring shows the maximum operational pressure limit is exceeded ($P_{M,j/k/l}$ > $P_{PC,OL}$), injection should cease. Injection cannot commence again until pressure levels in the injection formation reduce below the level described above.

150. Additional monitoring may be undertaken where necessary. For example, continuous monitoring of annulus pressures in well(s) can provide information about the mechanical integrity of the well and indicate the risk of back-flow up the well bore. This shall be documented following the guidance set out in the GGCS, Section 4.

Significant deviations in conditions of use

151. In some circumstances, it may be necessary to increase CO_2 injection pressure in order to induce micro fracturing of the injection formation so as to enhance injectivity of CO_2 (a process sometimes referred to as reservoir stimulation). Such operations should be undertaken under controlled conditions, over short durations, and should be documented in the Monitoring Report(s), covering:

(a) The pressure levels induced in the injection formation for this purpose;

(d) The duration over which higher pressures were induced;

(e) Monitoring data to demonstrate that the operations had no impact on storage security and features in the geological storage site (see significant deviations below);

(f) Update of the risk assessment and of the site development and management plan

152. Sustained periods of time during which the wellhead and downhole pressure exceed the maximum operation pressure of the injection formation (e.g., greater than five days) shall be considered a significant deviation, and the procedures outlined below must be followed (para. 165-168; Detection of significant deviations or evidence of seepage).

CO_2 migration analysis

153. History matching shall be used to confirm that there is agreement between the numerical modelling of the CO_2 plume distribution in the geological storage site (performance

assessment, as per the GGCS, Section 4) and the monitored behaviour of the CO_2 plume. The results of history-matching shall be summarised as follows:

$$PB_{CO2,V/L,y} = \{M_{CO2,j,y}, M_{CO2,k,y} \ldots.. M_{CO2,l,y}\}$$

Equation 21

$$PB_{CO2,V/L,y} \approx PB_{CO2,V/L,p,t}$$

Equation 22

Where,

$PB_{CO2,V/L,y}$ = Two and three-dimensional image(s) and description of the subsurface vertical and lateral boundary of the injected CO_2 plume determined through monitoring in year *y* (indicative upper and lower vertical boundaries in metres (m) below the surface may be used; lateral boundary may be dimensionless/descriptive or latitude/longitude coordinates).

$M_{CO2,j/k/l,y}$ = Surface and subsurface monitoring technique *j/k/l* applied to determine the presence and migration characteristics of the subsurface CO_2 plume and to generate two and three-dimensional image(s) and descriptions of the vertical and lateral boundaries of the CO_2 plume in year *y* (indicative upper and lower vertical boundaries in metres (m) below the surface may be used; lateral boundary may be dimensionless/descriptive or latitude/longitude coordinates) (following guidance in the GGCS, Section 4).

$PB_{CO2,V/L,p,t}$ = Two and three-dimensional image(s) and description of the subsurface vertical and lateral boundary of the injected CO_2 plume determined through computer simulation modelling following guidance in the GGCS, Section 1, at a either (a) a given point in time, or (b) mass of injected CO_2 equating to year *y* (indicative upper and lower vertical boundaries in metres (m) below the surface may be used; lateral boundary may be dimensionless/descriptive or latitude/longitude coordinates).

154. Where monitoring of CO_2 migration does not indicate any significant deviations (i.e., where $PB_{CO2,V/L,y} \approx PB_{CO2,V/L,p,t}$), storage operations can be assumed to be operating satisfactorily (subject to information gathered using other monitoring methods; $M_{SC,j/k/l,y}$ – see below).

155. If the results of analysis suggest that insufficient coverage is achieved in the monitoring plan design (e.g., gaps in knowledge regarding the subsurface project boundaries), the subsurface monitoring plan should be updated with new techniques and locations (following the guidance in the GGCS, Section 4).

156. Increasing convergence between predictions and observations over time (i.e., $PB_{CO2,V/L,y} = PB_{CO2,V/L,p,t}$) suggests a high-level of understanding of the subsurface, providing assurance over short, medium and long-term predictions of storage security (i.e., permanence).

Significant deviations in CO_2 migration

157. Detection of CO_2 at or beyond the maxima of the predefined subsurface upper vertical (i.e., migration of CO_2 into the caprock formation) and/or lateral boundary at a given time shall be considered as a significant deviation, and the procedures outlined below must be followed (para. 165-168; Detection of significant deviations or evidence of seepage).

158. Further, if differences between observed and predicted behaviour are apparent during history matching (i.e., where $PB_{CO2,V/L,y} \neq PB_{CO2,V/L,t}$) with respect to the following:

(a) CO_2 migration direction is significantly different from the predicted lateral and or vertical direction;

(b) CO_2 migration rates away from well(s) annulus/annuli through the formation significantly exceed those predicted in modelling,

159. And where any combination of the above is considered to pose a risk of CO_2 migrating from the predefined subsurface upper vertical and/or lateral boundary as described above, this shall be considered to be a significant deviation and the procedures defined below must be followed (para. 165-168; Detection of significant deviations or evidence of seepage).

Geological storage site architecture

160. Other monitoring techniques shall be applied to the geological storage site architecture (i.e., features), based on comparison with base-level survey data collected during site characterisation (the GGCS, Section 4, Part B.III). Examples include micro-seismic measurements in fault planes or fissures which could potentially be reactivated by CO_2 storage operations. These should be accounted for as follows:

$$F_{SC,x,y} = \{M_{SC,j,y}, M_{SC,k,y} \ldots M_{SC,l,y}\}$$

Equation 23

$$F_{SC,X,y} \approx BD_{SC}$$

Equation 24

Where,

$F_{SC,X,y}$ = feature "X" within the geological storage complex that can provide signs of deviations as monitored in year *y* (dimensionless). The list of features to monitor should be described as part of the monitoring plan (see guidance in the GGCS, Section 4) and should be defined based on the risk analysis as per the GGCS, Section 2.

$M_{SC,j/k/l,y}$ = subsurface monitoring technique *j/k/l* applied to features within the geological storage complex that could detect potential irregularities in year *y* (dimensions dependent on the particular technique applied)

$BD_{SC,\,j/k/l}$ = base level survey data describing the condition of feature *j/k/l* in the surface/subsurface generated during base survey data following guidance in the GGCS, Section 4, Part B.III (dimensions specific to each feature and measurement technique)

161. Where monitoring of features within the geological storage site does not indicate any significant deviations (i.e., $F_{SC,x,y} \approx BD_{SC}$), storage operations can be assumed to be operating satisfactorily (subject to information gathered using other monitoring methods; $M_{CO2,j/k/l,y}$).

Significant deviations in geological storage site architecture

162. By default, a significant deviation is considered to be circumstances where there is a greater than 10 per cent (%) deviation between baseline survey data used to measure conditions before injection and observed conditions as determined during monitoring. The project owners may propose a different deviation limit than 10% for any specific subsurface monitoring technique ($M_{SC,j/k/l,y}$), in which case the project owners should fully justify the choice of the deviation limit (in percentage or as an absolute figure) and document this deviation limit in the GGCS, Section 5.

163. Where deviations between observed and predicted behaviour occurs (i.e., where $F_{SC,y} \neq BD_{SC}$), further investigations should be undertaken to determine the source of the deviation, and whether it poses a seepage risk. Where a significant deviation is detected, injection operations should cease and the procedures below must be followed (para. 165-168; Detection of significant deviations or evidence of seepage).

164. If the results of monitoring and analysis suggest that insufficient coverage is achieved in the present monitoring plan design (i.e., lack of information on key subsurface features in the geological storage site), the subsurface monitoring plan should be updated with new techniques and locations (see the GGCS, Section 4, Part D).

Detection of significant deviations or evidence of seepage

165. In the event that significant deviations in the geological CO_2 storage site are observed in (i) the conditions of use of the site (ii) during CO_2 migration analysis and history matching, and/or (iii) through monitoring of key features in the geological storage site architecture, project owners should cease CO_2 injection.

166. Project owners shall provide an explanation for the reasons for significant deviation occurring, and reasons for continued injection if that has occurred. If the reasons for the significant deviation cannot be clearly elucidated, project owners must:

(a) Review the characterisation of the geological storage site in accordance with the guidance provided in the GGCS, Section 1;

(b) Revise the project boundary;

(c) Update the risk and safety assessment in accordance with the guidance provided in the GGCS, Section 2;

(d) Update the environmental and socio-economic impact assessments in accordance with the guidance provided in the GGCS, Section 3;

(e) Revise the monitoring plan in accordance with the guidance provided in the GGCS, Section 4, in order to improve the accuracy and/or completeness of data and information, include additional monitoring techniques and locations where necessary ($M_{CO2,j/k/l,y}$ and $M_{SC,j/k/l,y}$), and taking into account observed deviations determined during history matching, changes to the project boundary, changes to the risk and safety assessment, changes to the environmental and socio-economic impact assessments, new scientific knowledge and improvements in the best available technology;

(f) Update the Site development and management plan in accordance with the GGCS, Section 5, taking account of the results of the activities described in items (a–e) above, where appropriate.

167. In the event that seepage is detected, it must be quantified following the procedure in sub-step 6b below. After this time, no further Approved Carbon Credits (ACCs) shall be issued until remedial measures to stop further seepage have been carried out, and the analysis described in paragraph 166 has been undertaken so as to provide assurance that further seepage is not anticipated.

168. Where the analysis indicates that storage security and seepage risk are reduced to levels agreed at project registration, injection operations may re-commence. Results of this investigation and analysis should be reported in the Monitoring Report (see the GGCS, Section 4, Parts C and D).

Sub-step 6b - Quantification of any mass of CO_2 emitted to the atmosphere due to seepage

169. The procedure outlined in Sub-step 6a provides the basis for detecting seepage emissions from the CO_2 geological storage site. If monitoring detects evidence of seepage emissions, the level of emissions occurring since the last verification period should be calculated as follows:

$$PE_{SP,p} = \left[\sum_{k} S_{FLX,k,p} \times S_{t,k,p} \times S_{k,area}\right] \times 10^{-3}$$

Equation 25

Where,

$PE_{SP,y}$ = seepage emissions in year y (tCO_2)

$S_{FLX,k,y}$ = the flux rate of seepage source k in monitoring year y ($kgCO_2$-e/m² d^{-1})

$S_{t,k,y}$ = the duration that seepage source k is estimated to have been occurring in year y (days)

$S_{k,area}$ = the area over which the seepage from source k has been measured (m²). Any change in area over time shall be recorded and modifications to the calculations made accordingly

k = seepage sources determined in year y

170. The duration of seepage, $S_{t.k,y}$, shall be determined as follows:

$$S_{t.k,y} = T_{end} - T_{start}$$

Equation 26

Where,

T_{end} = the date by which remedial measures have been taken and seepage can no longer be detected (as per the monitoring plan, see guidance in the GGCS, Section 4)

T_{start} = one of the following dates:

(a) the last date when the site monitoring no evidence of seepage from the identified emission source. This may be up to five years, depending on the frequency of the submission of Monitoring Reports, or

(b) the date the CO_2 injection started as part of the project activity, when there is no available evidence to show that no seepage was previously detected, or

(c) other evidence which may reasonably be used

171. A specific seepage event for any geological storage site will need careful consideration of the most appropriate technologies and means to identify the emission pathway and source, estimate the flux rate, the areal extent of the seepage zone, and to determine its duration. Flux rates and durations should be determined according to the guidance outlined in the monitoring methodology (see Section 14.2 and guidance in the GGCS, Section 4). Estimates of flux rates and durations will be associated with uncertainties, which should be documented in the Monitoring Report. Project owners shall aim to limit uncertainty to within 7.5%.

172. Where the overall uncertainty of the applied quantification methodology exceeds 7.5%, each operator shall apply an adjustment, as follows:

$$PE_{SP,y} = S_{PQ,y} \times (1 + (Unc/100) - 0.075)$$

Equation 27

Where,

$PE_{SP,y}$ = seepage emissions in year y (tCO_2)

$S_{PQ,y}$ = the amount of CO_2 seepage determined through the monitoring and quantification method applied to the seepage event in question in year *y* (tCO_2)

Unc = the level of uncertainty associated with the monitoring and quantification method applied to the seepage event in question (%)

173. Any seepage that occurs during the crediting period(s) of a project activity shall be accounted for as project emissions in the calculation of the monitored reductions in anthropogenic emissions by sources of GHGs that have occurred as a result of the project activity.

Net reversal of storage

174. In the event of a net reversal of storage, the relevant amount of seepage emissions resulting from the net reversal of storage shall be quantified (sub-step 6b above) and an equivalent number of ACCs shall be withdrawn and cancelled from the GCC buffer account for geological carbon storage.

175. Replenishment of the buffer shall be carried out in accordance with the rules set out in the GCC Program Standard.

176. After post-injection monitoring has been discontinued in accordance with Section 14.3, the provisions governing a net reversal of storage shall no longer apply.

12. Leakage emissions

177. The following sources of leakage may be considered for prospective CCS/BECCS/DACCS activities:

(a) Emissions resulting from derating of a plant due to retrofit of CO_2 capture

(b) Emissions from biomass use

(c) Emissions from renewable electricity use

(d) Emissions from materials use

12.1 Leakage emissions from electricity generating plant de-rating

178. Leakage emissions may be considered where an existing electricity generation facility, including BECCS, that exports electricity to a power grid is de-rated because of the energy penalty imposed by the retrofit of CO_2 capture. In this situation, the facility output would drop and need to be compensated by other electric generating facilities connected to the same grid but falling outside of the project boundary.

179. The methodology already accounts for this loss of output by using an emissions rate to determine the baseline in the case of retrofits (Case 2; *Equation 3*). As such, leakage emissions do not need to be calculated under this methodology.

12.2 Leakage emissions from biomass use

180. In the case of BECCS activities, leakage resulting from the use of biomass shall be determined by applying the provisions from the TOOL16 for the following potential emission sources:

(a) Leakage emissions resulting from the cultivation of biomass in a dedicated plantation of a project activity that uses biomass (LE_{BC});

(b) Leakage emissions resulting from the transportation of biomass (LE_{BT});

(c) Leakage emissions resulting from the processing of biomass (LE_{BP});

(d) Leakage emissions resulting from the transportation of biomass residues (LE_{BRT}) if the project consumes biomass residues;

(e) Leakage emissions resulting from the processing of biomass residues (LE_{BRP}) if the project consumes biomass residues.

181. Existing biomass plants that retrofit CO_2 capture are excluded from the requirement to account for these sources of leakage.

12.3 Leakage emissions from renewable electricity use

182. In the case of activities using renewable electricity (bought-in from the electricity grid), project owners shall estimate the amount of electricity required for the project activity (MWh/yr) relative the total renewable electricity generation in the region (MWh/yr). Project owners shall consider the potential impacts of the forecast level of consumption, and confirm whether or not there is an abundance of renewable resources for electricity generation in the region so that impacts outside of the project boundary are unlikely to occur, or otherwise (e.g., in respect of the availability of existing and new renewable electricity generation).

12.4 Leakage emissions from materials use

183. Leakage emissions from the consumption of capture material. Depending on the technology applied there may be consumption of capture solvents, solid sorbents, catalysts or membranes in the capture plant due to need for periodic replacement due to degradation or loss of material.

184. The leakage emissions from the make-up /replacement of these materials is calculated as follows:

$$LE_{Mat,y} = \sum_{i} (Q_{Mat,i,y} \times EF_{Mat,i})$$

Where:

$LE_{Mat,y}$	= Leakage due to consumption of material use for CO_2 capture in the year y (tCO_2e)
$Q_{Mat,i,y}$	= Quantity of make up material *i* consumed in the project in the year *y* (kg or m^3)
$EF_{Mat,i}$	=GHG emissions from the production of CO_2 capture material (tCO_2e/kg or m^3)
i	= type of material used for CO_2 capture in the project

185. The emissions from the production of capture materials, $EF_{Mat,i}$, shall be calculated using an approved tool or a commercially available LCA tool which includes data based on peer-reviewed publications if the material is not directly represented in the tool. Alternatively, a qualified third party may conduct an LCA in accordance with ISO 14040 and 14044, latest editions, that uses either primary or published and peer-reviewed data.

13. Emission reductions

186. Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y$$

Equation 28

Where,

ER_y	= Emission reductions in year *y* (tCO_2)
BE_y	= Baseline emissions in year *y* (tCO_2)
PE_y	= Project emissions in year *y* (tCO_2)

187. Note: project activities could temporarily result in negative emission reductions (ER_y) in a particular year, for reasons not associated with seepage from the geological storage site (e.g., due to poor performance of CO_2 capture resulting in project emissions exceeding baseline emissions). In these circumstances, if a project activity temporarily results in negative emission reductions (i.e., an emissions increase) for reasons other than a net reversal of storage, any further ACCs will only be issued only when the negative emissions reduction have been compensated by subsequent positive emission reductions by the project activity.

14. Monitoring methodology

188. Monitoring requirements cover two types of parameters:

(a) Those that are determined ex ante, and therefore not monitored during the crediting period, and

(b) Those that are to be monitored during the crediting period.

189. Where applicable, monitoring parameters are distinguished for the operational phase and post-injection phase of the project.

190. Project owners shall submit a first verified Monitoring Report within a maximum of five years after the date of project registration. Thereafter, project owners must submit verified Monitoring Reports with a maximum verification period of five years until site closure.[32] Failure to submit a Monitoring Report within a verification period of five years shall result in the cancellation of project registration.[32]

191. Where verification periods exceed one year, Monitoring Reports shall provide both period total and annualised monitoring results and data for all methodological formulas and monitoring parameters.

192. All data collected as part of monitoring (including base survey data) should be archived electronically and be kept at least for two years after the end of the monitoring of the geological storage site (i.e., at least seven years after the end of the last crediting period or after the issuance of ACCs has ceased, whichever occurs first). All (100%) of the data should be monitored if not indicated otherwise in the tables below.

193. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards. The retention and the storage of the data should be documented following the guidance provided in the GGCS, Section 4.

194. In addition, the monitoring provisions in the CDM tools referred to in this methodology apply.

14.1 Parameters not monitored during the crediting period

Data / parameter Table 1

Data / parameter:	$E_{HIST,5yr}$
Data unit:	tCO_2
Description:	Total historic emissions from facility summed from the five years of most recent and complete (a full calendar year) annual data available for the facility.

[32] Subject to the requirements in paragraph 198 in the post-injection phase.

Source of data:	Output and / or GHG emissions data recorded for the facility as part of corporate reporting requirements (i.e., for environmental performance reporting and/or reporting to relevant authorities for complication of national GHG inventory). Where CO_2 emissions data are not readily available, these should be calculated on the basis of facility output (activity data) applying latest IPCC guidelines and applying highest Tier level reporting as possible.
Measurement procedures (if any):	-
Monitoring frequency:	-
QA/QC procedures:	-
Any comment:	-

Data / parameter Table 2

Data / parameter:	$P_{HIST,5yr}$
Data unit:	MWh (megawatt hours) or t (tonnes)
Description:	Total historic net power or defined product output from facility summed from the five years of most recent and complete (a full calendar year) annual data available for the facility.
Source of data:	Project owner records of annual production/output.
Measurement procedures (if any):	-
Monitoring frequency:	-
QA/QC procedures:	-
Any comment:	For products other than electricity, output data should be expressed in tonnes wherever possible (i.e., where output data is more commonly given in kg, this should be converted to tonnes). However, where this is not possible or is considered to be not suitable, project owners should give reasons and ensure that all associated calculations are adapted according to the chosen unit(s). If only rated capacity data are available instead of actual output data, then annual output can be estimated by applying a suitable average industry capacity factor to these.

Data / parameter Table 3

Data / parameter:	$E_{HIST,SET}$
Data unit:	tCO_2
Description:	Total historic CO_2 emissions from a set of facilities, *SET,* undertaking similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, whose performance is among the top 20 per cent of their category.

Source of data:	Applicable data sources may include e.g., corporate reports, national emission reporting, academic studies, benchmarking publications, industry publications and data provision references etc. If no facilities can be identified within the category, or if the set of facilities, *SET*, contains only one facility, then project owners shall use a benchmark emissions factor from the most recently applied allocation benchmarks used in the European Union Emissions Trading Scheme (EU ETS) for the relevant facility type and technology/process. This approach must also be followed if data is not available for the identified facilities. If a relevant benchmark does not exist from this source, then project owners may propose an alternative value, clearly indicating with evidence why this can be considered 'best available technology' (BAT).
Measurement procedures (if any):	-
Monitoring frequency:	-
QA/QC procedures:	-
Any comment:	See Base emissions Case 3 (b) for required procedures.

Data / parameter Table 4

Data / parameter:	$P_{HIST,SET}$
Data unit:	t product (output)
Description:	Total historic production (output) from set of facilities, *SET,* undertaking similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, whose performance is among the top 20 per cent of their category.
Source of data:	Applicable data sources may include e.g., corporate reports, national industrial or economic reporting, academic studies, benchmarking publications, industry publications and data provision references etc.
Measurement procedures (if any):	-
Monitoring frequency:	-
QA/QC procedures:	-
Any comment:	See Base emissions Case 3 (b) for required procedures.

Data / parameter Table 5

Data / parameter:	$EF_{trans,CO2,FF,i}$
Data unit:	tCO_2/GJ
Description:	CO_2 emission factor for fossil fuel type *i* for transport
Source of data:	Either conduct measurements or use accurate and reliable local or national data where available. Where such data is not available, use IPCC default emission factors (country-specific, if available) if they are deemed to reasonably represent local circumstances.

	Choose the value in a conservative manner and justify the choice.
Measurement procedures (if any):	-
Quality Procedure, if any:	-
Any comment:	-

Data / parameter Table 6

Data / parameter:	$PB_{CO2,V/L,p,t}$
Data unit:	Various
Description:	Two and three-dimensional image(s) and description of the subsurface vertical and lateral boundaries of injected CO_2 plume at a given point in time or mass of injected CO_2 equating to year *y* (indicative upper and lower vertical boundaries (in metres (m) below the surface may be used; lateral boundary may be dimensionless/descriptive or latitude/longitude coordinates).
Source of data:	Computer simulation modelling of geological storage site
Measurement procedures (if any):	Determined through computer simulation modelling based on geological storage site specific characteristics following guidance in the GGCS, Section 1.
Quality Procedure, if any:	-
Any comment:	-

Data / parameter Table 7

Data / parameter:	$BD_{SC,j/k/l}$
Data unit:	Dimensions specific to each feature and measurement technique
Description:	Base level survey data describing the condition of feature *j/k/l* n the subsurface generated during the site characterisation following guidance in the GGCS, Section 1, or during the base level data acquisition (following the guidance in the GGCS, Section 4).
Source of data:	Onsite measurements
Measurement procedures (if any):	Determined through geological survey of the geological storage site conditions following guidance in the GGCS, Section 1.
Quality Procedure, if any:	-
Any comment:	Purpose is to quantify the natural background variability of the risk indicators relevant to both deep subsurface and shallow/near-surface/surface systems so that subsequent operational monitoring measurements can be compared against these values to assess whether the system is or is not consistent with pre-injection conditions. Examples may include reservoir temperature and pressure, background seismicity, background magnetism, geochemistry and groundwater chemistry etc. Data shall be used to calibrate monitoring data collected during operational and post-injection phases.

Data / parameter Table 8

Data / parameter:	$P_{PC,SL}$
Data unit:	kPa (kilopascal)
Description:	Pressure safety limit in the injection formation.
Source of data:	Determined during geological storage site characterisation following the procedures outlined in the GGCS, Section 1, and laid down in the *conditions of use* for the geological storage site. Based on variations in key pressure-driven mechanical formation features that can affect seepage. Will vary according to project specific containment system conditions. Note that $P_{PC,SL}$ may depend on the temperature in the formation and on the location in the formation
Measurement procedures (if any):	Determined through a number of techniques including through techniques, including, but not limited to, MDT mini-frac measurements, step rate tests, diagnostic fracture injection test and other methods including data collected during well drilling (leak-off, formation integrity and/or stem tests). Reactivation pressure may need to be determined for any major features (faults, fractures) in the storage complex that could affect the efficacy of the CO_2 containment system.
Quality Procedure, if any:	-
Any comment:	The project owner will determine the fracture opening pressure of the injection formation.

Data / parameter Table 9

Data / parameter:	P_{SF}
Data unit:	per cent (%)
Description:	Pressure safety factor based on setting a safety margin on the operational limit and the safety margin (it is a ratio that must always be less than 1 i.e., 100%)
Source of data:	To be determined as part of the risk assessment (see guidance in the GGCS, Section 2), and laid down as a safety limit in the conditions of use for the geological storage site (see guidance the GGCS, Section 5). It should be based on expert judgment regarding the margins of error in the safety limit measurements.
Measurement procedures (if any):	As described in the risk assessment (see guidance in the GGCS, Section 2)
Quality Procedure, if any:	-
Any comment:	-

Data / parameter Table 10

Data / parameter:	$P_{PC,OL}$
Data unit:	kPa (kilopascal)
Description:	Maximum operational pressure limit of the injection formation

Source of data:	To be determined based on pressure safety limit and safety factor.
Measurement procedures (if any):	Determined based on the geological storage site characteristics and expert judgment.
Quality Procedure, if any:	-
Any comment:	-

Data / parameter Table 11

Data / parameter:	$EG_{HIST,AV}$
Data unit:	MWh
Description:	The average annual net electricity generation provided to the grid from the electric generating facility, based on the historic data collected for purpose of baseline emissions determination.
Source of data:	Project owner records of annual production/output.
Measurement procedures (if any):	-
Monitoring frequency:	-
QA/QC procedures:	Cross reference with 3rd party data sources (e.g., grid operator)
Any comment:	-

14.2 Parameters to be monitored during the crediting period

Data / parameter Table 12

Data / parameter:	$F_{i,t}$
Data unit:	kg/hour
Description:	Mass flow of CO_2 in the injected gas stream from injection facility; to be calculated in accordance with the CDM “TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream”. Required parameters to be measured at point “I” in Figure 1.
Source of data:	See CDM TOOL08
Measurement procedures (if any):	See CDM TOOL08
Monitoring frequency:	See CDM TOOL08
QA/QC procedures:	See CDM TOOL08
Any comment:	-

Data / parameter Table 13

Data / parameter:	h_i
Data unit:	hours/year
Description:	The number of hours of gas injection per year.
Source of data:	Operational data from injection facility,
Measurement procedures (if any):	-
Monitoring frequency:	Daily.
QA/QC procedures:	Can be cross-checked against contracts and invoices across the CO_2 chain, where separate entities undertake capture, transport and storage etc.
Any comment:	-

Data / parameter Table 14

Data / parameter:	$F_{X,t}$
Data unit:	kg/hour
Description:	Mass flow of CO_2 in the exported gas stream; to be calculated as per parameter $F_{i,t}$ in accordance with the CDM “TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream”. Required parameters to be measured at point “X” in Figure 1.
Source of data:	See CDM TOOL08
Measurement procedures (if any):	See CDM TOOL08
Monitoring frequency:	See CDM TOOL08
QA/QC procedures:	See CDM TOOL08
Any comment:	-

Data / parameter Table 15

Data / parameter:	h_X
Data unit:	hours/year
Description:	The number of hours of gas export from capture facility per year.
Source of data:	Operational data from capture facility.
Measurement procedures (if any):	-
Monitoring frequency:	Daily.
QA/QC procedures:	
Any comment:	-

Data / parameter Table 16

Data / parameter:	P_y
Data unit:	MWh or t product
Description:	The product output in year y
Source of data:	Operational data from facility.
Measurement procedures (if any):	-
Monitoring frequency:	At least annually.
QA/QC procedures:	To be cross checked against sales records, invoices, material records etc
Any comment:	Where the output is MWh, this is the net quantity of electricity generated and delivered to the grid by the facility in year y

Data / parameter Table 17

Data / parameter:	$RE_{MW,GR,y}$
Data unit:	%
Description:	Share of renewable electricity in total grid capacity in year *y*
Source of data:	Grid operator; other third-party reliable sources of information
Measurement procedures (if any):	Year-on-year data must be retained in order to calculate annual changes in percentage of grid connected renewable electric generating capacity
Monitoring frequency:	Annually.
QA/QC procedures:	-
Any comment:	Calculated by dividing total installed grid connected renewable electric generating capacity in year y (MW) by the grid electric generating capacity in year *y* (MW).

Data / parameter Table 18

Data / parameter:	EG_y
Data unit:	MWh
Description:	Net quantity of electricity generated and delivered to the grid by the project electric generating facility in year y
Source of data:	Operational data from facility.
Measurement procedures (if any):	-
Monitoring frequency:	At least monthly
QA/QC procedures:	To be cross checked against sales records, grid operator data etc.
Any comment:	-

Data / parameter Table 19

Data / parameter:	$EF_{grid,BM.y}$
Data unit:	tCO_2/MWh
Description:	Build margin CO_2 emission factor for the project electricity system in year *y;* to be calculated in accordance with the latest approved version of the CDM “TOOL07: Tool to calculate the emission factor for an electricity system”.
Source of data:	See CDM TOOL7
Measurement procedures (if any):	See CDM TOOL7
Monitoring frequency:	See CDM TOOL7
QA/QC procedures:	See CDM TOOL7
Any comment:	When applying TOOL07, project owners shall: Apply *Option 2* in respect of vintage of data (under Step 5 of TOOL07); and Include *only* grid electric generating facilities in the calculation of the BM emissions factor (i.e., off-grid electric generating facilities shall *not* be included).

Data / parameter Table 20

Data / parameter:	$EF_{grid,OM.y}$
Data unit:	tCO_2/MWh
Description:	Operating margin CO_2 emission factor for the project electricity system in year *y;* to be calculated in accordance with the latest approved version of the CDM “TOOL07: Tool to calculate the emission factor for an electricity system” or from other published reliable sources.
Source of data:	Either: (1) CDM TOOL07; or (2) Published data on average grid emission for the relevant year, from a reliable source
Measurement procedures (if any):	Either: (1) CDM TOOL07; or (2) Published data on average grid emission for the relevant year, from a reliable source
Monitoring frequency:	Either: (1) CDM TOOL07; or (2) Published data on average grid emission for the relevant year, from a reliable source
QA/QC procedures:	Either: (1) CDM TOOL07; or (2) Published data on average grid emission for the relevant year, from a reliable source
Any comment:	Reliable sources can include government agencies, grid operating companies, recognised 3rd party standards (e.g. CDM standardised baseline) etc. Project owners shall clearly refence all sources used, including the data used and links to the original documentation.

Data / parameter Table 21

Data / parameter:	$M_{F,j,y}$
Data unit:	tCO_2
Description:	Total mass of CO_2 generated by fossil fuel combustion from stationary sources (*j*) inside the project boundary in year *y* (as used in underlying activity and to power capture, treatment, transportation by pipeline, reception and injection of the CO_2 etc.); emissions to be calculated by applying the latest approved version of the CDM “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”.
Source of data:	See CDM TOOL03
Measurement procedures (if any):	See CDM TOOL03. Fuel consumption to be measured at points “F” in Figure 1.
Monitoring frequency:	See CDM TOOL03
QA/QC procedures:	See CDM TOOL03
Any comment:	The processes *j* should correspond to each single emission source considered within the boundary of the project activity. Project owners should document each emission source clearly and transparently.

Data / parameter Table 22

Data / parameter:	$N_{trans,i,y}$
Data unit:	-
Description:	Number of transport vehicle trips for transport type *i* during the year *y*
Source of data:	Records by project owners
Measurement procedures (if any):	-
Monitoring frequency:	Per trip
QA/QC procedures:	Vehicle log book
Any comment:	Separate data should be collected for each transport type *i*.

Data / parameter Table 23

Data / parameter:	$AVD_{transport,i,y}$
Data unit:	km
Description:	Average round trip distance for transport type i between point of loading of CO_2 onto rail or road tanker and the point of unloading of CO_2 at the site of injection during the year *y*
Source of data:	Records by project owners
Measurement procedures (if any):	Maps, vehicle meter logs etc
Monitoring frequency:	
QA/QC procedures:	-

Any comment:	-

Data / parameter Table 24

Data / parameter:	$EF_{trans,km,CO2,i,y}$
Data unit:	tCO_2/km
Description:	Emission factor for transport type *i* in year *y* (tCO_2/km) in year *y*
Source of data:	Project owners shall develop an emissions factor used for each transport type i through either: a) Conducting sample measurements of the fuel type, fuel consumption and distance travelled for all transport vehicle types, and calculating CO_2 emissions from fuel consumption by multiplying with appropriate net calorific values (NCV) and CO_2 emission factors (for net calorific values and CO_2 emission factors, use reliable national default values or, if not available, IPCC default values); or b) Use of. technical studies, vehicle manufacturer information, vehicle inspection documentation, applying conservativeness as appropriate. Wherever possible, emission factors should reflect the actual vehicles models used instead of typical factors applied on the basis of vehicle categories/classes.
Measurement procedures (if any):	-
Monitoring frequency:	At least annually
QA/QC procedures:	Cross-check measurement results with emission factors referred to in the literature.
Any comment:	-

Data / parameter Table 25

Data / parameter:	$FC_{transport,i,y}$
Data unit:	Mass or volume unit
Description:	Fuel consumption of fuel type i in vehicles for transportation of CO_2 during the year y
Source of data:	Fuel purchase receipts or fuel consumption meters in the transport vehicles
Measurement procedures (if any):	-
Monitoring frequency:	Continuously, aggregated annually
QA/QC procedures:	Cross-checking the calculated CO_2 emissions for plausibility with a simple calculation based on the distance approach (Option 1)
Any comment:	This parameter only needs to be monitored if Option 2 is chosen to estimate CO_2 emissions from transportation.

Data / parameter Table 26

Data / parameter:	$NCV_{transport,i}$
Data unit:	GJ / mass or volume unit
Description:	Net calorific value of fossil fuel type *i*
Source of data:	Either conduct measurements or use accurate and reliable local or national data where available. Where such data is not available, use IPCC default net calorific values (country-specific, if available) if they are deemed to reasonably represent local circumstances. Project owners should choose values in a conservative manner and justify the choice.
Measurement procedures (if any):	Measurements shall be carried out at reputed laboratories and according to relevant international standards.
Monitoring frequency:	In case of measurements: At least every six months, taking at least three samples for each measurement. In case of other data sources, project owners should review the appropriateness of the data annually.
QA/QC procedures:	Check consistency of measurements and local / national data with default values by the IPCC. If the values differ significantly from IPCC default values, collect additional information or conduct additional measurements.
Any comment:	-

Data / parameter Table 27

Data / parameter:	$PE_{E,y}$
Data unit:	tCO_2
Description:	Project emissions from bought-in electricity in year *y;* used for e.g., capture, treatment, transportation by pipeline, electric vehicle or electrified rail, reception and injection of the CO_2.; to be calculated as per the latest approved version of the CDM “TOOL05: Baseline, project or leakage emissions from electricity consumption and monitoring of electricity generation” and CDM “TOOL07: Tool to calculate the emission factor for an electricity system”
Source of data:	See CDM TOOL05 and TOOL07
Measurement procedures (if any):	See CDM TOOL05 and TOOL07. Imported electricity (MWh) to be monitored at points shown by “E” in Figure 1.
Monitoring frequency:	See CDM TOOL05 and TOOL07
QA/QC procedures:	See CDM TOOL05 and TOOL07
Any comment:	-

Data / parameter Table 28

Data / parameter:	$PE_{H,y}$
Data unit:	tCO_2
Description:	Project emissions from bought-in heat in year *y* used for CO_2 capture and any other purposes; to be calculated as per the latest approved version of the CDM “TOOL03: Tool to calculate project or leakage emissions from fossil fuel consumption”.
Source of data:	See CDM TOOL03
Measurement procedures (if any):	See CDM TOOL03. Imported heat (GJ) to be monitored at points shown by “H” in Figure 1.
Monitoring frequency:	See CDM TOOL03
QA/QC procedures:	See CDM TOOL03
Any comment:	-

Data / parameter Table 29

Data / parameter:	$R_{BC:FC}$
Data unit:	Ratio (%)
Description:	The percentage of CO_2 (mass) in the CO_2 streams sent for injection that is derived from biogenic sources, expressed as fraction of the overall mass of CO_2 in the stream sent for injection.
Source of data:	Laboratory analysis of the carbon content of fuels combusted in facilities co-firing biogenic material as fuel comingled with fossil fuel. Monitoring of the ratio of biomass derived and fossil derived fuels combusted in a facility.
Measurement procedures (if any):	Sampling of fuels combusted in the underlying activity subject to CO_2 capture
Monitoring frequency:	Monthly (or more frequent where possible)
QA/QC procedures:	Cross reference with regional data on waste mixture from relevant (industrial; municipal) sources and records of fuel purchase (biomass; fossil fuels).
Any comment:	-

Data / parameter Table 30

Data / parameter:	$M_{CO2,j/k/l,y}$
Data unit:	Indicative upper and lower vertical boundaries of the CO_2 plume in the storage site in metres (m) below ground level (BGL) may be used; lateral boundary may be dimensionless/descriptive or latitude/longitude coordinates.
Description:	Subsurface and surface monitoring technique *j/k/l* applied to determine the presence and migration characteristics of the subsurface CO_2 plume. The information should be used to generate two and three-dimensional image(s) and descriptions of the vertical and lateral boundaries of the CO_2 plume in year *y*
Source of data:	Onsite measurement

Measurement procedures (if any):	To be developed in accordance with the guidance in the GGCS, Section 4.
Monitoring frequency:	Intermittent (methods may also draw on continuous data streams e.g. pressure)
QA/QC procedures:	Observations of subsurface CO_2 migration characteristics must be compared with predicted behaviour of the CO_2 as made through computer simulation modelling prior to commencing injection operations at given intervals (e.g. five yearly, depending on complexity). See the GGCS, Sections 1 and 4, for further procedures.
Any comment:	To be determined on a project-by-project basis

Data / parameter Table 31

Data / parameter:	$M_{SC,j/k/l,y}$
Data unit:	Dimensions dependent on the particular technique(s) applied
Description:	Subsurface monitoring technique(s) *j/k/l* applied to features within the geological storage site which could detect potential irregularities in year *y*
Source of data:	Onsite measurement
Measurement procedures (if any):	To be developed in accordance with the guidance in the GGCS, Section 1 and detailed in the PSF submission. Examples of deep and shallow subsurface monitoring techniques are described in Table A5.1 and Table A5.2 in Annex 5.1 of the 2006 IPCC Guidelines. In accordance with the GGCS, Section 4, as a minimum the techniques listed therein shall be considered for their suitability.
Monitoring frequency:	Intermittent (methods may also draw on continuous data streams e.g. passive seismic sensors)
QA/QC procedures:	Observations of geological storage site features must be compared with base level survey data at given intervals (e.g. 5-yearly, depending on complexity), as documented in the plan for base level survey data. See the GGCS, Section 4, for further considerations.
Any comment:	To be determined on a project-by-project basis

Data / parameter Table 32

Data / parameter:	$P_{M,j/k/l}$
Data unit:	kPa (kilopascal)
Description:	Bottomhole (and/or wellhead) pressure in the injection formation continuously monitored in well(s) *j/k/l* at all times
Source of data:	Onsite measurement
Measurement procedures (if any):	Bottomhole and wellhead pressure should, where relevant, be monitored in injection and observation wells within the geological storage complex.
Monitoring frequency:	Continuous and/or intermittent

QA/QC procedures:	Individual readings to be cross-checked against wellhead pressure and other bottomhole measurements of pressure to ensure consistency of data. Pressure monitors to be calibrated frequently to ensure accuracy of readings.
Any comment:	This measurement should be associated with temperature measurement when relevant. To be cross-checked continuously against $P_{PC,OL}$

Data / parameter Table 33

Data / parameter:	$S_{FLX,k,y}$
Data unit:	$kgCO_2$-e/m² d^{-1}
Description:	Flux rate of seepage source *k* in year *y*
Source of data:	Specific measurements undertaken in response to the detection of seepage
Measurement procedures (if any):	Where seepage is detected, further investigations should be carried out to identify and characterise the seepage emission pathway (e.g., seepage through an active or abandoned well-bore; seepage along a fault plane; seepage due to permeation of the caprock formation and diffusion through the overburden). Emission pathways could consist of: • *Direct seepage or breach*: in a confined pathway such as a well-bore or fault plane; or • *Diffuse seepage*: through the pore system of the Overburden in the absence of effective sealing strata, through caprock degradation, or dissolution into pore fluids. The emission pathway and the resultant source(s) at the surface must be fully described and characterised during monitoring. The flux rate of each emission source linked to seepage should be estimated using methods appropriate for the identified pathway/emission source(s). These might require the application of a range of techniques including *inter alia*: • direct metering in well-bores (for confined seepage pathways such as within a well casing); • acoustic imaging techniques to provide a real assessment of potential sites of seepage; • use of submersibles vehicles (offshore) to identify and characterise bubbles or a CO_2 plume on the sea-bed; or • soil gas meters (onshore), corrected to account for background fluxes. A range of novel techniques or other proxy measures may be employed on a case-by-case basis, depending on the nature of the identified emission source(s) (see also Table A5.3 in Annex 5.1 to Volume 2, Chapter 5 of the 2006 IPCC Guidelines)
Monitoring frequency:	To be initiated on the detection of seepage during geological storage site monitoring ($M_{CO2,j/k/l,y}$; $M_{SC,j/kl,y}$)
QA/QC procedures:	-

Any comment:	For all methods employed to determine the flux rate of a seepage emission source, the project owners shall document the following in the Monitoring Report: • The description of the detailed methodology applied including independent review where relevant • the rationale for the choice of method employed, and • an assessment of the accuracy of the data collected with a description of the major sources of uncertainty in the estimates.[33] In estimating flux rates, account should be taken of both gaseous and dissolved CO_2 (e.g., CO_2 dissolved in water).

Data / parameter Table 34

Data / parameter:	$S_{k,area}$
Data unit:	Square metres (m²)
Description:	The area over which seepage from source *k* has been measured
Source of data:	Onsite measurement
Measurement procedures (if any):	The areal extent of the seepage zone should be determined from subsurface and surface monitoring data. Specific detailed investigations may be needed where the areal extent of the seepage source cannot be determined.
Monitoring frequency:	To be initiated on the detection of seepage during geological storage site monitoring
QA/QC procedures:	Subject to verification
Any comment:	For all methods employed to determine the flux rate of a seepage emission source, the project owners shall document the following in the Monitoring Report: • The description of the detailed methodology applied including independent review when relevant • The rationale for the choice of method employed, and • An assessment of the accuracy of the data collected with a description of the major sources of uncertainty in the estimates.[33]

Data / parameter Table 35

Data / parameter:	$S_{t,k,y}$
Data unit:	days
Description:	Duration that seepage source *k* is estimated to have been occurring in year *y*
Source of data:	Onsite measurement

[33] Uncertainty may be estimated following *ISO Guide to the expression of uncertainty in measurement* (JCGM 100:2008)

Measurement procedures (if any):	$S_{t.k,y}$ is measured as the difference in days between the two dates T_{start} and $T_{end,}$ where T_{start} is chosen from one of the following dates: • the last date when the site monitoring showed no evidence of seepage from the identified emission source. This may be up to a maximum of five years, depending on the frequency of the submission of Monitoring Reports, or • the date the CO_2 injection started as part of the project activity, when there is no available evidence to show that no seepage was previously detected, or • other evidence which may reasonable be used and T_{end} is the date by which remedial measures have been take and seepage can no longer be detected
Monitoring frequency:	To be initiated on the detection of seepage during geological Storage site monitoring
QA/QC procedures:	Subject to verification.
Any comment:	-

Data / parameter Table 36

Data / parameter:	$Q_{Mat,i,y}$
Data unit:	Kg or M3
Description:	Quantity of make-up material "I" consumed in the CCS plant in the year y.
Source of data:	Receipts/invoices or flow meter or weighing scale/equipment readings, whichever is applicable
Measurement procedures (if any):	As per the flow meter or weighing equipment. Manufacturers must be compliant with ISO standards. Alternatively, the sum of all receipts/invoices for capture materials over the given year y must be used
Monitoring frequency:	Aggregated annually.
QA/QC procedures:	Flow meters must be routinely calibrated, inspected, and maintained according to manufacturer specifications
Any comment:	-

Data / parameter Table 37

Data / parameter:	$EF_{Mat,i}$
Data unit:	Tco2e/M3 or Tco2e/Kg
Description:	GHG emissions for the production of makeup material I

Source of data:	Emissions from the production of capture material must be calculated using: 1) Compliance market-approved tool. Examples of open-source Compliance tools: CA-GREET, GHGenius; 2) A third-party audited assessment that is in line with ISO 14044 guidelines can be used to calculate the emissions; or 3) Data published in peer-reviewed literature, such as scientific journals
Measurement procedures (if any):	NA
Monitoring frequency:	Annual
QA/QC procedures:	Must be latest data sets available , in case of peer reviewed literature, the publication must have been within the last 2 years from the date of submission to GCC
Any comment:	-

14.3 Monitoring during the post-injection phase

195. The project owner shall continue monitoring and report the verified results of monitoring to the GCC for a minimum of five years after the cessation of injection.

196. If evidence derived from monitoring, as contained in verified Monitoring Reports, indicates that the risk of seepage is sufficiently low and that permanent storage is highly likely to be achieved (i.e., the subsurface CO_2 plume within the injection formation is stable, converges with the predicted long-term distribution within the injection formation and there is convergence between the models of CO_2 distribution and measurements made in accordance with the monitoring plan, as per *Equation 21* and *Equation 22*), site closure can occur and the project owner may discontinue monitoring (see also the GGCS, Section 4).

197. Once the conditions in paragraph 196 are met, and no sooner than five years after the cessation of injection, the host country shall be liable for undertaking any future monitoring as per paragraph 4(v) of Volume 2, Chapter, 5, Section 5.7.1, of the IPCC 2006 Guidelines (or subsequent revisions thereto) – see also the GGCS, Section 4, Part C.

198. In situations where the conditions in paragraph 196 are not met after five years, the project owner shall continue monitoring and submit Monitoring Reports on the verified results of monitoring to the GCC in two-year increments, until such conditions are met.

199. In accordance with paragraph 15(d)(ii), where local regulations or the specifics of any permit issued by a host country competent authority differ from the post-injection monitoring arrangements set out in paragraphs 195 to 198, the local regulations and/or specific permit conditions shall prevail.

DOCUMENT HISTORY

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