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Mechanism methodology

Electricity generation from renewable sources connected to an electricity system

Version 01.0

Sectoral scope(s): 01

United Nations
Framework Convention on
Climate Change

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1. Introduction

1.1. Scope

1. This mechanism methodology applies to Article 6.4 activities that generate electricity from certain types of renewable energy sources connected to an electricity system, including hydropower without the construction of a new reservoir, hydropower constructed in an existing reservoir without changing the volume and surface area of an existing reservoir, wind, solar, and geothermal.

2. Article 6.4 Emission Reductions (A6.4ERs) issued based on this mechanism methodology represent emission reductions that are not subject to reversal risks.

1.2. Entry into force and validity

3. This mechanism methodology enters into force on 30 July 2026.

4. This mechanism methodology remains valid for five years, until 29 July 2031, unless an earlier date applies if the mechanism methodology is revised or withdrawn in accordance with the "Procedure: Development, revision and clarification of methodologies and methodological tools" (A6.4-PROC-METH-001).[1]

1.3. Applicability of sectoral scopes

5. Designated operational entities (DOEs) validating and verifying Article 6.4 activities that use this mechanism methodology shall apply sectoral scope 1: Energy industries (renewable/ non-renewable sources).

2. Definitions

2.1. General terms

6. The following general terms apply in this mechanism methodology:

   (a) "Shall" is used to indicate requirements that must be followed;

   (b) "Should" is used to indicate that, among several options, one course of action is recommended as particularly suitable; and

   (c) "May" is used to indicate what is permitted.

2.2. Methodological terms and definitions

7. The following methodological terms and definitions apply in this mechanism methodology:

   (a) **Backup generator**: a generator used in an emergency or contingency event to meet electricity demand of the project equipment at the site of the project power plant;

[1] See https://unfccc.int/sites/default/files/resource/A6.4-PROC-METH-001.pdf.

(b) **Binary geothermal power plant**: a geothermal technology that utilizes heat from a geothermal fluid through heat exchangers to vaporise an organic fluid with a low boiling point (e.g., butane or pentane in the Organic Rankine Cycle (ORC) or an ammonia-water mixture in the Kalina cycle) and drive a turbine. Binary geothermal plants are categorised as closed cycle technologies;

(c) **Dry steam geothermal power plant:** a geothermal technology that directly utilises dry steam that is piped from production wells to the plant and then to the turbine. Dry steam geothermal plants are categorised as open cycle technologies;

(d) **Flash steam geothermal power plant:** a geothermal technology that is designed for high-temperature, water-dominated reservoirs. In these high-temperature reservoirs, the liquid water component boils, or "flashes", as pressure drops. Separated steam is piped to a turbine to generate electricity and the remaining hot water may be flashed again twice (double flash plant), or three times (triple flash plant) at progressively lower pressures and temperatures, to obtain more steam. Flash steam geothermal plants are categorised as open cycle technologies;

(e) **Greenfield power plant:** a new power plant that is constructed and operated at a site where no power plant was operated prior to the implementation of the Article 6.4 activity;

(f) **Hydraulic residence time:** the ratio of reservoir volume to mean inflow, representing the average time water remains within the reservoir taking into account various inflow conditions;

(g) **Installed power generation capacity (or installed capacity):** capacity, expressed in Watts or one of its multiples, for which a power unit has been designed to operate at nominal conditions. The installed power generation capacity of a power plant is the sum of the installed power generation capacities of its power units;

(h) **Peatlands:** wetland ecosystems where soils are dominated by peat. In peatlands net primary production exceeds organic matter decomposition as a result of waterlogged conditions, which leads to the accumulation of peat. In absence of a host country definition, peat shall be defined as soft, porous or compressed, sedimentary deposit of plant origin with high water content in the natural state (up to about 90 per cent);

(i) **Power plant/unit:** a facility that generates electric power. Several power units at one site comprise one power plant, whereas a power unit is characterized by the fact that it can operate independently from other power units at the same site. Where several identical power units (i.e., with the same capacity, age and efficiency) are installed at one site, they may be considered as one single power unit;

(j) **Reservoir:** a natural or artificial water body created to store water, often made by the construction of a dam;

(k) **Run-of-river hydropower plant:** a hydropower plant that draws the energy for electricity production mainly from the available flow of the river, such that the generation profile will, to varying degrees, be dictated by local river flow conditions;[2] and

(l) **Storage duration:** the equivalent time, expressed in hours, for which a hydropower plant can operate at rated turbine discharge using only its usable storage volume between maximum and minimum operating levels, assuming zero inflow.

8. Furthermore, the terms in the “Glossary: Article 6.4 mechanism terms” (A6.4-GLOS-GOV-001)[3] and the definitions and terms in this mechanism methodology referred to in section 3, shall apply.

3. Normative and informative references

9. The mechanism methodology is based on elements from version 22.0 of the Clean Development Mechanism (CDM) methodology “ACM0002: Grid-connected electricity generation from renewable sources"[4] and version 18.0 of the small-scale CDM methodology “AMS-I.D.: Grid connected renewable electricity generation”.[5]

10. The following documents are indispensable for the application of this mechanism methodology. When applying this mechanism methodology, a valid version of the documents listed below shall be used:

(a) “Methodological tool: Common practice analysis” (A6.4-AMT-001);[6]

(b) “Methodological tool: Investment analysis” (A6.4-AMT-002);[7]

(c) “Methodological tool: Emissions from electricity generation and consumption” (A6.4-AMT-007);[8] and

(d) “Methodological tool: Analysis of lock-in risk” (A6.4-AMT-008).[9]

[2] This definition is informed by the discussion on page 451 of the *Special Report on Renewable Energy Sources and Climate Change Mitigation* (IPCC, 2011).

[3] See https://unfccc.int/sites/default/files/resource/A6.4-Glossary.pdf.

[4] See https://cdm.unfccc.int/methodologies/DB/XB1TX7TAZ6SLWM9B7BC67THHVD16JV.

[5] See https://cdm.unfccc.int/methodologies/DB/W3TINZ7KKWCK7L8WTXFQQOFQQH4SBK.

[6] See https://unfccc.int/process-and-meetings/the-paris-agreement/article-6/article-64-pacm/mechanism-process/methodologies/a64-amt-001.

[7] See https://unfccc.int/process-and-meetings/the-paris-agreement/article-6/article-64-pacm/mechanism-process/methodologies/a64-amt-002.

[8] See https://unfccc.int/process-and-meetings/the-paris-agreement/article-6/article-64-pacm/mechanism-process/methodologies/a64-amt-007-emissions-from-electricity-generation-and-consumption.

[9] See https://unfccc.int/process-and-meetings/the-paris-agreement/article-6/article-64-pacm/mechanism-process/methodologies/a64-amt-008.

11. The following documents provide background information of this mechanism methodology:

    (a) Intergovernmental Panel on Climate Change (IPCC), Special Report on Renewable Energy Sources and Climate Change Mitigation (Cambridge and New York, Cambridge University Press, 2011);[10]

    (b) Intergovernmental Panel on Climate Change (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy. IPCC, Geneva, Switzerland;[11] and

    (c) Intergovernmental Panel on Climate Change (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1: General Guidance and Reporting. IPCC, Geneva, Switzerland.[12]

4. Applicability

12. This mechanism methodology is applicable to Article 6.4 activities that install a greenfield power plant that generates electricity from renewable sources and feeds all the net electricity generated into an electricity system. [13]

13. The types of renewable energy power plants eligible under this mechanism methodology are hydropower plants, wind power plants, solar photovoltaic power plants, solar thermal power plants, and geothermal power plants.

14. This methodology may also be applied to power plants that incorporate a battery energy storage system (BESS).[14] The BESS shall be:

    (a) Located at the same site as the renewable energy power plant;

    (b) Solely charged with electricity provided by the Article 6.4 renewable power generation plant; and

    (c) Installed before the electricity metering point for the Article 6.4 activity.

[10] See https://archive.ipcc.ch/pdf/special-reports/srren/SRREN_Full_Report.pdf.

[11] See https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html.

[12] See https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol1.html.

[13] This version of the mechanism methodology does not apply to activities at an existing power plant (e.g., capacity addition, retrofit, rehabilitation, or replacement), as it does not provide the procedures or requirements for establishing a baseline for such activities. The mechanism methodology may be revised in the future to include specific provisions for these types of activities. Activity participants are also encouraged to submit a revision to this mechanism methodology through the "Procedure: Development, revision and clarification of methodologies and methodological tools" (A6.4-PROC-METH-001)..

[14] The mechanism methodology may be revised in the future to include differentiation between plants with and without co-located BESS in future revisions of the methodology. Activity participants are also encouraged to submit a revision to this mechanism methodology through the "Procedure: Development, revision and clarification of methodologies and methodological tools" (A6.4-PROC-METH-001).

15. In the case of hydropower plants, one of the following conditions below shall apply:[15]

(a) The Article 6.4 activity involves the establishment of a run-of-river hydropower plant for which all of the following conditions are satisfied:[16]

(i) The storage duration is not larger than 24 hours;

(ii) The hydraulic residence time is below 2 days; and

(iii) The implementation of the Article 6.4 activity does not involve the flooding of forests[17] or peatlands; or

(b) The Article 6.4 activity is implemented at one or more existing reservoir(s) for which all of the following conditions are satisfied:

(i) One of the following two conditions apply:

a. The reservoir(s) have been established at least 10 years prior to the start date of the Article 6.4 activity; or

b. The reservoir(s) have been established at least 3 years prior to the start date of the Article 6.4 activity and it can be demonstrated that the reservoir(s) have been planned, approved and financed without a power plant.

(ii) The implementation of the Article 6.4 activity does not lead to an increase in the average volume of water in the existing reservoir, relative to pre-activity levels. This shall be assessed ex-ante in the PDD based on the design of the reservoir and the Article 6.4 activity. Where the volume of water changes within a calendar year due to seasonal variations, this requirement shall be satisfied throughout all seasons;

(iii) The implementation of the Article 6.4 activity does not reduce the availability of water for irrigation; and

[15] These conditions are introduced because this version of the methodology does not include provisions to estimate carbon dioxide, methane, and nitrous oxide emissions from reservoirs. It is assumed that the fulfilment of these conditions ensures that such emissions are very small. The mechanism methodology may be revised in the future to include specific provisions to estimate these emissions. Activity participants are also encouraged to submit a revision to this mechanism methodology through the "Procedure: Development, revision and clarification of methodologies and methodological tools" (A6.4-PROC-METH-001).

[16] These factors were identified based on different studies. Storage duration is commonly used to distinguish run-of-river plants. Hydraulic residence time influences methane emissions because longer water retention promotes stratification, oxygen depletion and anaerobic decomposition. Available research also suggests that the amount of available biomass influences emissions. See, for example: World Bank. 2017. Greenhouse Gases from Reservoirs Caused by Biogeochemical Processes. World Bank, Washington, DC, available at: https://documents1.worldbank.org/curated/en/739881515751628436/pdf/Greenhouse-gases-from-reservoirs-caused-by-biogeochemical-processes.pdf, and Tittel, J., Hüls, M. & Koschorreck, M. Terrestrial Vegetation Drives Methane Production in the Sediments of two German Reservoirs. Sci Rep 9, 15944 (2019), available at: https://doi.org/10.1038/s41598-019-52288-1.

[17] Under this mechanism methodology, a forest shall meet the national definition of forests of the applicable host Party.

(iv) The hydropower plant operates in full compliance with the reservoir's authorized operating rules and water rights.

16. In the case of hydropower plants, furthermore:

(a) The plant has an installed electricity generation capacity of up to 15 MW or, where available, any lower threshold used by the host Party for defining small-scale hydro power; and

(b) The implementation of the Article 6.4 activity is not designed in way that it could lead to a reduction in electricity generation at upstream or downstream hydropower plants that rely on the same water resource by demonstrating that the implementation of the activity does not change the water resource distribution within the water system.

17. In the case of solar photovoltaic power plants and solar thermal power plants, the power plants are not installed on land that has been classified as agricultural land or forestland by relevant authorities.

18. In the case of binary geothermal power plants, hydrocarbons and not any fluorinated gases are used as working fluid.

19. Furthermore, the mechanism methodology is only applicable under the following conditions:

(a) The activity participants have not entered into any agreements to supply the electricity from the Article 6.4 activity through the electricity system to specific consumers;[18]

(b) The equipment[19] installed under the Article 6.4 activity is:[20]

(i) Newly produced; and

(ii) Demonstrably unused, meaning that it has not previously been installed, commissioned, or operated in any other plant.

(c) Where the investment comparison analysis is applied in section 6.3 below, the most financially viable scenario is electricity generation by existing or new grid-connected power plants and, in the case of hydropower plants implemented at one or more existing reservoir(s), operating the reservoir(s) at its/their current size and using it/them for the same purpose as that prior to the implementation of the Article 6.4 activity;

[18] The mechanism methodology does not apply to activities that supply electricity to end-consumers, as the baseline scenario for such projects may not be defined as electricity supplied from the electricity system.

[19] Machinery and tools related to electricity generation facilities, e.g., power plant equipment such as photovoltaic modules, turbines, electric generators, pumps, motors or engines.

[20] This condition is introduced to avoid any leakage from baseline equipment transfer, consistent with paragraph 14(a) of version 01.0 of the "Standard: Addressing leakage in mechanism methodologies" (A6.4-STAN-METH-005).

(d) If the Article 6.4 project power plant is equipped with backup generator(s), the backup generator(s) is used solely for maintaining system continuity and safety during emergency or contingency events, and not for supplying electricity to end-users;

(e) The mechanism methodology is applied to a project;[21] and

(f) The mechanism methodology is used on a standalone basis and not in combination with other methodologies, unless the other methodology(ies) specify(ies) how the interaction with this mechanism methodology is taken into account.

20. The mechanism methodology is not applicable to:

(a) Activities that involve switching from fossil fuels to renewable energy sources at the site of the activity;

(b) Activities that involve any biomass consumption; and

(c) Activities that involve any fossil fuel consumption, except for the use in solar thermal power plants, geothermal power plants or back-up generator(s).

21. The above provisions shall be demonstrated as follows:

(a) The provisions in paragraphs 13, 14, 15(a), 15(b)(i)-(ii), 16, 17, 18, 19(b)-(f) and 20 shall be demonstrated in the Project Design Document (PDD) and be assessed at the initial validation; and

(b) The provisions in paragraphs 15(b)(iii)-(iv), 16, 17, 18, and 19(a)-(d) shall be demonstrated in each monitoring report and be assessed at each verification.

22. The applicability conditions included in the methodological tools referred to in paragraph 10 also apply.

5. Activity boundary

23. The activity boundary of the Article 6.4 activity shall include the site of the Article 6.4 project power plant and all power units physically connected to the electricity system[22] to which the Article 6.4 project power plant is connected.

24. Activity participants shall include in the PDD the location of the Article 6.4 activity in the form of Keyhole Markup Language (KML) files or similar formats, represented as one or more polygon(s), by specifying the coordinates of the geographic boundary using a known coordinate system or any other established method.

25. The greenhouse gases (GHGs) and emission sources included in or excluded from the activity boundary are shown in the table below.

[21] The mechanism methodology may be amended in the future to also cover activities implemented at other scales (e.g., programmes of activities, policies, sectoral approaches, etc).

[22] Refer to the “Methodological tool: Emissions from electricity generation and consumption” (A6.4-AMT-007) for definition of an electricity system.

Table. Emission sources included in or excluded from the activity boundary

	Source	GHG	Included?	Controlled / Related to / Affected by?	Justification / Explanation
BASELINE	CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the activity	CO_2	Yes	Affected by	The major source of emissions in the baseline
		CH_4	No	Affected by	Excluded for simplification and conservativeness
		N_2O	No	Affected by	
ACTIVITY	For dry or flash steam geothermal power plants, emissions of CH_4 and CO_2 from non-condensable gases contained in geothermal steam	CO_2	Yes	Controlled	Main emission source
		CH_4	Yes	Controlled	
		N_2O	No	Controlled	Excluded for simplification
	For binary geothermal power plants, fugitive emissions of CH_4 and CO_2 from non-condensable gases contained in geothermal steam	CO_2	Yes	Controlled	Main emission source
		CH_4	Yes	Controlled	
		N_2O	No	Controlled	Excluded for simplification
	For binary geothermal power plants, fugitive emissions of hydrocarbons such as n-butane and isopentane (working fluid) contained in the heat exchangers	Hydrocarbon refrigerant	Yes	Controlled	Main emission source
	Emissions from combustion of fossil fuels in solar thermal power plants, geothermal power plants or back-up generators	CO_2	Yes	Controlled	Main emission source
		CH_4	Yes	Controlled	Minor emission source
		N_2O	Yes	Controlled	
LEAKAGE	Upstream emissions from construction of the activity	CO_2	No	Affected by	Excluded for simplification, refer to the appendix for the reasoning
		CH_4	No	Affected by	
		N_2O	No	Affected by	
	Upstream emissions from the production, transport and installation of a BESS	CO_2	Yes	Affected by	Can be a significant emission source
		CH_4	Yes	Affected by	
		N_2O	Yes	Affected by	

	Source	GHG	Included?	Controlled / Related to / Affected by?	Justification / Explanation
	Wake effects of wind power plants	CO_2	Yes	Affected by	Accounted for when quantifying the amount of electricity generated
		CH_4	No	Affected by	Excluded for simplification
		N_2O	No	Affected by	
	Rebound effects	CO_2	No	Affected by	Excluded for simplification, refer to the appendix for the reasoning
		CH_4	No	Affected by	
		N_2O	No	Affected by	

6. Demonstration of additionality

26. To demonstrate additionality, activity participants shall apply:

(a) A regulatory analysis (subsection 6.1 below);

(b) A lock-in analysis (subsection 6.2 below);

(c) An investment analysis (subsection 6.2 below);

(d) A common practice analysis (subsection 6.4 below).

27. The proposed Article 6.4 activity shall only be considered additional if all four analyses are concluded positively.

6.1. Regulatory analysis

28. Activity participants shall review relevant legal requirements in the host Party applicable to the proposed Article 6.4 activity and possible alternative scenarios to the Article 6.4 activity, and shall demonstrate and justify, for each relevant legal requirement, that either:

(a) The law or regulation refers to or formally integrates the mechanism as an instrument for implementation;[23] or

(b) The emission reductions resulting from the Article 6.4 activity would not occur as a result of the legal requirement, by confirming that all of the following conditions are met:

(i) The legal requirement does not explicitly require the installation of renewable power plants at the site where the Article 6.4 activity is implemented;

(ii) The legal requirement does not indirectly require the implementation of the Article 6.4 activity, or another form of renewable electricity generation, such as through obligations for the activity participants to achieve a certain greenhouse gas performance; and

[23] For example, if regulations explicitly state that the Article 6.4 mechanism and the revenues generated from it are to be used as incentives to achieve emission reductions in a specific sector.

(iii) The Article 6.4 activity neither participates in a support scheme, nor is not subject to a penalty scheme, that is designed to achieve a quantitative target or outcome, such as a competitive bidding process (e.g., renewable electricity auctions) for the installation of a certain capacity of renewable power plants.

29. If one or more of the legal requirements identified in paragraph 28 do not meet the requirements of that paragraph, then A6.4ERs cannot be claimed.

30. Activity participants shall assess the requirements of paragraph 28 for each monitoring period. Crediting shall cease on the date when a new relevant legal requirement becomes applicable.

6.2. Assessment of lock-in risk

31. In the case of geothermal power plants, activity participants shall conduct a lock-in risk analysis using a valid version of the "Methodological tool: Analysis of lock-in risk" (A6.4-AMT-008).[24] In applying the tool, activity participants shall implement all of the following specifications:

(a) **Technology to be assessed:** assess the lock-in risk for geothermal power plants;

(b) **Lifetime:** consider the operational lifetime;

(c) **Calculation of the greenhouse gas emissions intensity:**[25]

(i) Calculate the emission intensity of the Article 6.4 activity by dividing the activity emissions determined in section 8 by the activity's annual electricity generation;

(ii) Use the emission factor of the electricity system, as determined in section 7.2.2 as the emission intensity for BAU; and

(iii) Take a value of zero for the emission intensity for the lowest-emissions intensity alternative.

(d) **Assessment of resources:** do not conduct this assessment;[26] and

[24] Data from Fridriksson et al. (2017) indicate an emission intensity range of 4 - 740 g/kWh for geothermal electricity generation. This suggests that some geothermal power plants have a high emission intensity and thus carry a lock-in risk. Therefore, a lock-in risk analysis is required for geothermal power generation projects. See Fridriksson, T., Mateos, A., Audinet, P. and Orucu, Y. (2017). *Greenhouse Gases from Geothermal Power Production*. ESMAP Technical Report 09/16. World Bank, Washington, DC.

[25] The mechanism methodology specifies how the emission intensity of the technology, the BAU emissions and the lowest emission intensity for the proposed Article 6.4 activity are calculated; therefore, the determination of comparable technologies and the applicable geographical area is not relevant.

[26] For renewable power plants, a resource important for mitigating climate change or achieving other policy objectives is land use. However, for a geothermal power plant, land is used primarily for the construction of wells, pipelines, and the plant itself, all of which are located in a limited area. Therefore, an assessment of possible inefficient use of resources is not required.

(e) **Scale assessment:** do not conduct a scale assessment.[27]

32. In the case of hydropower plants, solar power plants and wind power plants, activity participants do not need to conduct an assessment of lock-in risk as these technologies are not deemed to cause a lock-in risk under the applicability conditions of this mechanism methodology.

6.3. Investment analysis

33. Activity participants shall use a valid version of the "Methodological tool: Investment analysis" (A6.4-AMT-002) to conduct the investment analysis. In applying the tool, activity participants shall implement all of the following specifications:

(a) **Identification of alternative scenarios:** identify realistic and credible alternative scenarios to the proposed Article 6.4 activity, which shall include, but are not limited to, the following scenarios:

(i) For all type of activities, scenarios for electricity generation:

a. Implementation of the proposed Article 6.4 activity without registering it under the Article 6.4 mechanism;

b. Electricity generation by existing or new grid-connected power plants; and

c. Electricity generation by greenfield power plants of any type other than the Article 6.4 activity; and

(ii) For Article 6.4 activity implemented at a one or more existing reservoir(s), scenarios related to the existing reservoir(s) which shall be considered in conjunction with the scenario referred to in paragraph 33(a)(i)a:

a. Decommissioning the reservoir within the crediting period;

b. Retrofitting the reservoir to increase its size;

c. Retrofitting the reservoir to reduce its size; and

d. Operating the reservoir at its current size and using it for the same purpose as that prior to the implementation of the Article 6.4 activity throughout the crediting period.

(b) **Analysis method:** use the investment comparison analysis or, if the only alternative to the proposed Article 6.4 activity is electricity generation by existing or new grid-connected power plants and if the Article 6.4 activity is not implemented at one or more existing reservoir(s), use the benchmark analysis;

(c) **Financial indicator:** use the net present value (NPV) as the financial indicator where the investment comparison analysis is applied and choose an appropriate indicator where the benchmark analysis is applied, such as internal rate of return (IRR) or NPV;

[27] Given the overall electricity demand and the installed capacity of individual renewable power plants, a scale assessment is not required.

(d) **Implementation entity:** either assume that the Article 6.4 activity could be implemented by the activity participants or other entities, or demonstrate with appropriate evidence that, in the specific context of the proposed Article 6.4 activity, the activity can only be implemented by the activity participants and not by any other entities; and

(e) **Sensitivity analysis:** in conducting the sensitivity analysis, apply a variation of at least +/- 10 per cent to the input values which constitute more than 20 per cent of the total costs or total revenues. If it can be demonstrated by evidence that the input value has already been fixed, the variation may not be applied for sensitivity analysis.[28]

34. Where the investment comparison analysis is applied, activity participants shall also determine which of the scenarios is the most financially viable scenario. Where the sensitivity analysis shows that different scenarios could be the most financially viable, depending on the variation in the input values, the scenario with the lowest baseline emissions among these scenarios shall be identified as the most financially viable scenario.

6.4. Common practice analysis

35. Activity participants shall use a valid version of the “Methodological tool: Common practice analysis” (A6.4-AMT-001) to conduct the common practice analysis. In applying the tool, activity participants shall implement all of the following specifications:

(a) **Approach for common practice analysis:** approach A (which is based on the identification of existing “comparable activities” and differentiation between “similar” and “different” activities) shall be used;

(b) **Indicator of common practice:** the installed power generation capacity of power plants connected to (the) electricity system(s) within the applicable geographical area, expressed in MW, shall be used;

(c) **Stock-based or time-bound approach:** a time-bound approach shall be used (i.e., considering all comparable activities implemented within the reference period). The reference period shall be defined as the most recent 3 calendar years prior to the earlier of: (i) the start of operation of the Article 6.4 activity and (ii) the submission of the PDD for validation;

(d) **Applicable geographical area:** the physical boundary of the electricity system shall be used as the default applicable geographical area.[29] Where the applicable geographical area must be further widened in accordance with step 4 of the methodological tool (A6.4-AMT-001), the widening shall be conducted as follows:

(i) Use host country as applicable geographical area;

[28] For example, if the investment cost of the Article 6.4 activity can be demonstrated by contracts, the variation for the total investment is not needed.

[29] The electricity system shall be determined based on the Methodological tool: Emissions from electricity generation and consumption(A6.4-AMT-007).

(ii) Where the widening based on sub-paragraphs (i) above is not sufficient, or Article 6.4 activities implemented in a least developed country (LDC) or small island developing state (SIDS), the applicable geographical area shall consist of all LDCs and SIDS. For Article 6.4 activities implemented in countries other than LDCs or SIDS, the applicable geographical area shall correspond to the relevant continent; or

(iii) Where the widening based on sub-paragraphs (ii) above is still not sufficient, the applicable geographical area shall be global (i.e., including all countries);

(e) **Consideration of scale of output or capacity of the technology, measure, or practice:** all capacity sizes of comparable activities shall be used;

(f) **Common practice threshold:** the common practice factor thresholds to be applied under this mechanism methodology shall be:

(i) 5 per cent for Article 6.4 activities located in countries that are neither LDCs nor SIDS; and

(ii) 10 per cent for Article 6.4 activities located in countries that are LDCs or SIDS.

(g) **Comparable, similar and different activities:**

(i) Comparable activities shall be all power plants connected to the electricity system;

(ii) Similar activities shall be specified as follows:

a. For onshore wind power plants: all other onshore wind power plants;

b. For offshore wind power plants: all other offshore wind power plants;

c. For solar thermal power plants: all other solar thermal power plants;

d. For solar PV plants: all other solar PV power plants; [30]

e. For geothermal power plants: all other geothermal power plants; and

f. For hydropower plants: all other hydropower plants.

[30] The mechanism methodology may be revised in the future to include differentiation between plants with and without co-located BESS in future revisions of the methodology. Activity participants are also encouraged to submit a revision to this mechanism methodology through the “Procedure: Development, revision and clarification of methodologies and methodological tools” (A6.4-PROC-METH-001).

7. Baseline scenario

7.1. Selection of the baseline approaches from paragraph 36 of the rules, modalities and procedures

36. The following approach from the Rules, Modalities and Procedures (RMPs), as per decision 3/CMA.3, is used to determine the baseline in this mechanism methodology:[31]

☐ Best available technologies that represent an economically feasible and environmentally sound course of action, where appropriate.

☐ An ambitious benchmark approach where the baseline is set at least at the average emission level of the best performing comparable activities providing similar outputs and services in a defined scope in similar social, economic, environmental and technological circumstances.

☒ An approach based on existing actual or historical emissions, adjusted downwards to ensure alignment with paragraph 33 of the RMPs.

7.2. Application of the selected approach, prior to implementation of a downward adjustment

7.2.1. Procedure for the identification of the baseline scenario

37. The baseline scenario shall be deemed as electricity generation by existing and new grid-connected power plants and, in the case of hydropower plants implemented at one or more existing reservoir(s), operating the reservoir(s) at its/their current size and using it/them for the same purpose as that prior to the implementation of the Article 6.4 activity.

7.2.2. Calculation of the unadjusted baseline emissions from electricity generation from the Article 6.4 activity

38. Activity participants shall use a valid version of the “Methodological tool: Emissions from electricity generation and consumption” (A6.4-AMT-007) to calculate the unadjusted baseline emissions from electricity generation from the Article 6.4 activity in year y ($BE_{EG,y}$). In applying the methodological tool, activity participants shall implement all of the following specifications:

(a) **Electricity generation or consumption sources s:** the only source s to be considered for determining baseline emissions is the electricity generated by the Article 6.4 project power plant and fed into the electricity system;

(b) **Determination of the amount of electricity generated or consumed:** the electricity generation from the Article 6.4 activity ($EG_{PJ,y}$ or $EG_{PJ,h}$ in this mechanism methodology) corresponds to the general parameters $EG_{s,y}$ or $EG_{s,h}$ in the methodological tool (A6.4-AMT-007);

[31] The approach is selected considering that the electricity generation by existing or new grid-connected power plants may differ between Article 6.4 activities and regions, depending on the intermittent nature of the activity, the power generation technologies, and the natural resources (e.g., wind or precipitation) available in the respective electricity system.

(c) **Type of electricity generation sources:** for solar and wind power plants, the electricity generation shall be considered as intermittent, regardless of whether the plants are operated with an integrated BESS.[32] For geothermal power and hydropower plants, the electricity generation shall be considered as non-intermittent;

(d) **Applicable scenarios:** scenario A in step 2 of the methodological tool shall apply;

(e) **Whether Case 1 or Case 2 applies:** case 2 in step 4 of the methodological tool shall apply; and

(f) **Consideration of uncertainty:** baseline emissions prior to the application of the downward adjustment shall be determined without accounting for the uncertainty of the relevant parameters.

39. For solar thermal power plants, solar PV power plants, geothermal power plants and hydropower plants, the electricity generation eligible for crediting from the Article 6.4 activity ($EG_{PJ,y}$ or $EG_{PJ,h}$) shall correspond to the electricity generated by the Article 6.4 project power plant and fed into the electricity system ($EG_{plant,y}$ or $EG_{plant,h}$).

40. For wind power plants, the electricity generation eligible for crediting from the Article 6.4 activity ($EG_{PJ,y}$ or $EG_{PJ,h}$) shall be calculated based on the quantity of electricity generated by the Article 6.4 project power plant and fed into the electricity system ($EG_{plant,y}$ or $EG_{plant,h}$) and, where applicable, by discounting the reduction in electricity generation by other wind power plants due to wake effects in year y ($EG_{wake,y}$), as follows:

$$EG_{PJ,y} = EG_{plant,y} - EG_{wake,y}$$ Equation (1)

or

$$EG_{PJ,h} = EG_{plant,h} - \frac{EG_{wake,y}}{8{,}760}$$ Equation (2)

Where:

$EG_{PJ,y}$	=	Electricity generation eligible for crediting from the Article 6.4 activity in year *y* (MWh)
$EG_{plant,y}$	=	Quantity of electricity generated by the Article 6.4 project power plant and fed into the electricity system in year *y* (MWh)
$EG_{wake,y}$	=	Reduction in electricity generation by other wind power plants due to wake effects in year *y*, where applicable (MWh)
$EG_{PJ,h}$	=	Electricity generation eligible for crediting from the Article 6.4 activity in hour *h* (MWh)

[32] This provision is deemed to be a simplified and conservative approach. The mechanism methodology may be revised in the future to include specific provisions to account more accurately for the impact of using a BESS on the emission factor. Activity participants are also encouraged to submit a revision to this mechanism methodology through the “Procedure: Development, revision and clarification of methodologies and methodological tools” (A6.4-PROC-METH-001).

$EG_{plant,h}$	=	Quantity of electricity generated by the Article 6.4 project power plant and fed into the electricity system in hour h (MWh)
y	=	Calendar year of the crediting period
h	=	Hour within a calendar year of the crediting period

41. For wind power plants, the reduction in electricity generation by other wind power plants due to wake effects ($EG_{wake,y}$) does not need to be accounted for if:

    (a) The distance between the wind turbines installed under the Article 6.4 activity and any other wind power plants is greater than 50 kilometers for onshore wind power plants;

    (b) The distance between the wind turbines installed under the Article 6.4 activity and any other wind power plants is greater than 100 kilometers for offshore wind power plants;[33] or

    (c) The wake effects affect other wind power plants that are registered under Article 6.4 mechanism.

42. The distance between the wind turbines installed under the Article 6.4 activity and any other wind power plants in paragraph 41 shall be determined as the shortest horizontal distance between the convex hulls of the turbine positions of two wind power plants.

43. Where the conditions in paragraph 41 are not satisfied, activity participants shall determine $EG_{wake,y}$ based on a third-party assessment by a certified or suitably qualified expert through the application of wake models. The expert shall document the model employed and the input values used for the assessment and ensure that:

    (a) The model used has been peer-reviewed;

    (b) The input values used are either representative of local conditions at the site of the Article 6.4 project wind power plant, or are conservative; and

    (c) The output of the model is the reduction in the electricity generation in the other affected wind power plant(s).

44. The unadjusted baseline emissions from electricity generation from the Article 6.4 activity in year y ($BE_{EG,y}$) shall be calculated in accordance with step 10 of the methodological tool (A6.4-AMT-007), by multiplying the electricity generation eligible for crediting from the Article 6.4 activity ($EG_{PJ,y}$ or $EG_{PJ,h}$) with the respective emission factor for the electricity system.

7.3. Application of the downward adjustment

45. The downward adjusted baseline emissions from electricity generation shall be determined in the following steps:

    (a) Step 1: Determination of the initial downward adjustment ($DA_{initial}$);

[33] The MEP reviewed studies that provided different values for the wake effect and also consulted with industry experts. The MEP notes that the wake effect depends on the local conditions where the power plant is installed (e.g., geography, climate). The distance thresholds are considered by the MEP as a conservative approach where such wake effects can be deemed to be negligible.

(b) Step 2: Determination of the annual increase in the downward adjustment (*INDA*);

(c) Step 3: Determination of the downward adjusted baseline emissions ($BE_{adj,EG,y}$).

7.3.1. Step 1. Determination of the initial downward adjustment ($DA_{initial}$)

46. The sub-steps below shall be followed to determine the initial downward adjustment for baseline emissions from electricity generation ($DA_{initial}$).

7.3.1.1. Step 1.1. Determine the initial downward adjustment based on uncertainty ($DA_{initial,UNC}$)

47. Activity participants shall determine the initial downward adjustment as the uncertainty at the lower bound of the 95 per cent confidence interval relative to the central estimate of the estimated unadjusted baseline emissions from electricity generation from the Article 6.4 activity during the first crediting period ($UNC_{BE,EG,CP1}$), as follows:

$$DA_{initial,UNC} = UNC_{BE,EG,CP1} \quad \text{Equation (3)}$$

Where:

$DA_{initial,UNC}$	=	Initial downward adjustment for baseline emissions from electricity generation based on uncertainty (Dimensionless)
$UNC_{BE,EG,CP1}$	=	Uncertainty of the unadjusted baseline emissions from electricity generation during the first crediting period (fraction)

48. The uncertainty of the unadjusted baseline emissions from electricity generation during the first crediting period ($UNC_{BE,EG,CP1}$) shall be determined ex-ante in the PDD, following the relevant provisions in the “Methodological tool: Emissions from electricity generation and consumption” (A6.4-AMT-007). In applying the tool, activity participants shall consider uncertainty in both emission factor for electricity generation, following the provisions in the tool, and the electricity generation eligible for crediting from the Article 6.4 activity ($EG_{PJ,y}$ or $EG_{PJ,h}$). Activity participants shall document the uncertainties assigned to each parameter, specify assumptions made, and include any associated references for estimating the uncertainties of parameters in the PDD. This documentation and the derivation of the overall uncertainty through error propagation or Monte Carlo simulation methods, shall be provided together with the PDD (e.g., in a spreadsheet).

7.3.1.2. Step 1.2. Determine the minimum initial downward adjustment ($DA_{initial,min}$)

49. The minimum initial downward adjustment ($DA_{initial,min}$) shall be determined as follows:

$$DA_{initial,min} = \frac{\left(BE_{EG,y1} - AE_{y1}\right)}{BE_{EG,y1}} \times 0.1 \quad \text{Equation (4)}$$

Where:

$DA_{initial,min}$	=	Minimum initial downward adjustment for baseline emissions from electricity generation (dimensionless)
$BE_{EG,y1}$	=	Unadjusted baseline emissions from electricity generation in year y_1 (t CO_2eq)

AE_{y1}	=	Activity emissions in year *y1* (t CO_2eq)
0.1	=	Default factor to determine the minimum downward adjusted baseline provided in the “Standard: Setting the baseline in mechanism methodologies” (A6.4-STAN-METH-004)[34]
$y1$	=	Calendar year of the start date of the first crediting period

50. The unadjusted baseline emissions and the activity emissions in year *y1* shall be determined ex-ante in the PDD, consistent with the provisions in this section and section 8, respectively.

7.3.1.3. Step 1.3. Compare $DA_{initial,UNC}$ and $DA_{initial,min}$

51. To determine the initial downward adjustment ($DA_{initial}$), activity participants shall use the higher of the two values determined in steps 1.2 and 1.3 above, as follows:

$$DA_{initial} = max\left(DA_{initial,min}\ ;\ DA_{initial,UNC}\right) \qquad \text{Equation (5)}$$

Where:

$DA_{initial}$	=	Initial downward adjustment for baseline emissions from electricity generation (dimensionless)
$DA_{initial,min}$	=	Minimum initial downward adjustment for baseline emissions from electricity generation (dimensionless)
$DA_{initial,UNC}$	=	Initial downward adjustment for baseline emissions from electricity generation based on uncertainty (dimensionless)

7.3.2. Step 2. Determination of the annual increase in the downward adjustment (*INDA*)

52. A value of 0.01 shall be applied for the annual increase in the downward adjustment (*INDA)*. The first increase shall be applied in the calendar year following the calendar year of the start date of the first crediting period, following the provisions in step 3 below.

7.3.3. Step 3. Determination of the downward adjusted baseline emissions ($BE_{adj,EG,y}$)

53. For every calendar year *y* of the crediting period, the downward adjusted baseline emissions are determined as follows:

$$BE_{adj,EG,y} = BE_{EG,y} \times \left(1 - DA_y\right) \qquad \text{Equation (6)}$$

Where:

$BE_{adj,EG,y}$	=	Downward adjusted baseline emissions in the calendar year *y* (t CO_2eq)
$BE_{EG,y}$	=	Unadjusted baseline emissions from electricity generation from the Article 6.4 activity in calendar year *y* (t CO_2eq)
DA_y	=	Downward adjustment applicable to calendar year *y* (dimensionless)
y	=	Calendar year of the crediting period

[34] See https://unfccc.int/sites/default/files/resource/A6.4-STAN-METH-004.pdf.

54. The downward adjustment applicable to calendar year y (DA_y) shall be determined as follows:

(a) For the first calendar year of the crediting period (y_1), $DA_1 = DA_{intial}$.

(b) For the second and subsequent calendar years of the crediting period, DA_y shall be calculated as follows:

$$DA_y = DA_{initial} + INDA \times \left[\frac{cd_y}{nd_y} + (y - y1) - 1\right]$$ Equation (7)

Where:

DA_y	=	Downward adjustment applicable to calendar year y (dimensionless)
$INDA$	=	Annual increase in the downward adjustment (dimensionless)
cd_y	=	Number of crediting days in the calendar year y that belong to the subsequent year of the crediting period[35]
nd_y	=	Number of days in the calendar year y
y	=	Calendar year of the crediting period
$y1$	=	Calendar year of the start date of the first crediting period

(c) For the last calendar year y of the last crediting period, DA_y shall be calculated as follows:

$$DA_y = DA_{initial} + INDA \times [(y - y1) - 1]$$ Equation (8)

Where:

DA_y	=	Downward adjustment applicable to calendar year y (dimensionless)
$INDA$	=	Annual increase in the downward adjustment (dimensionless)
y	=	Calendar year of the crediting period
$y1$	=	Calendar year of the start date of the first crediting period

7.4. Determination of a conservative ‘business-as-usual’ (BAU) baseline and comparison of the downward adjusted baseline and the conservative business-as-usual baseline

55. The conservative business-as-usual (BAU) scenario for Article 6.4 activities eligible under this mechanism methodology shall be deemed to be the same as the baseline scenario, i.e., that the electricity delivered by the Article 6.4 activity to the electricity system would

[35] For example, if the start date of the first crediting period is 1 October 2025, then in the year 2028, this parameter includes the days from 1 October 2028 to 31 December 2028 (i.e. 92 days).

otherwise be generated by the operation of existing grid-connected power plants and by the addition of new generation sources.[36]

56. Since the conservative BAU scenario and the baseline scenario are the same, the conservative BAU emissions will always be higher than the downward adjusted baseline emissions, except for the calendar year of the start date of the first crediting period. Therefore, for that year the crediting baseline determined in equation (6) shall be multiplied by a factor of 0.99 to ensure that it is lower than the conservative BAU emissions. Activity participants do not need to calculate or compare the conservative BAU emissions in subsequent years.

8. Activity scenario

57. Activity emissions shall be calculated as follows:

$$AE_y = AE_{FC,y} + AE_{EC,y} + AE_{GP,y}$$ Equation (9)

Where:

AE_y	=	Activity emissions in year *y* (t CO_2eq)
$AE_{FC,y}$	=	Activity emissions from fossil fuel consumption in year *y* (t CO_2eq), where applicable
$AE_{EC,y}$	=	Activity emissions from electricity consumption in year *y* (t CO_2eq), where applicable
$AE_{GP,y}$	=	Activity emissions from the operation of dry, flash steam, or binary geothermal power plants in year *y* (t CO_2eq), where applicable

8.1. Activity emissions from fossil fuel consumption ($AE_{FC,y}$)

58. This emission source shall include any fossil fuel consumption occurring during the operation of the Article 6.4 project power plant. This may, for example, include emissions from the operation of backup generators or emissions arising from the maintenance of the Article 6.4 project power plant (e.g., emissions from fossil fuels used in ships or helicopters to maintain offshore wind power plants). Fossil fuel consumption associated with the construction or decommissioning of the Article 6.4 project power plant do not need to be considered. Emissions from the construction of the Article 6.4 project power plant shall not be included.

59. Activity participants shall describe the relevant emission sources in the PDD and justify that all relevant emissions sources from fossil fuel consumption have been considered.

60. This source of activity emissions shall be calculated as follows:

$$AE_{FC,y} = \sum_i \left(FC_{i,y} \times EF_{FC,CO2,i,y}\right) \times \left(1 + F_{CH4/N2O,i}\right)$$ Equation (10)

[36] Conservativeness is ensured because the “Methodological tool: Emissions from electricity generation and consumption” (A6.4-AMT-007) determines the emission factor for an electricity system reflecting the dynamic trends in the electricity system to which the Article 6.4 activity is connected.

Where:

$AE_{F,y}$	=	Activity emissions from fossil fuel consumption due to the Article 6.4 activity in year *y* (t CO_2eq)
$FC_{i,y}$	=	Quantity of fuel type *i* combusted during the year *y* (mass or volume unit)
$EF_{FC,CO2,i,y}$	=	CO_2 emission factor of fuel type *i* in year *y* (t CO_2eq / mass or volume unit)
$F_{CH4/N2O,i}$	=	Factor to account for CH_4 and N_2O emissions in relation to CO_2 emissions for fuel type i (dimensionless)
I	=	Fuel types combusted

61. The CO_2 emission factor may be calculated using one of the following three options, depending on the availability of data on the fossil fuel type *i*, as follows:

(a) Option A.1: calculated based on the chemical composition of the fossil fuel type *i*, if $FC_{i,y}$ is measured in a mass unit:

$$EF_{FC,CO2,i,y} = w_{c,i,y} \times 44/12 \quad \text{Equation (11)}$$

Where:

$EF_{FC,CO2,i,y}$	=	CO_2 emission factor of fuel type *i* in year *y* (t CO_2eq / mass or volume unit)
$w_{c,i,y}$	=	Mass fraction of carbon in fuel type *i* in year *y* (t C / mass unit of the fuel)
$44/12$	=	Unit conversion factor (t CO_2 / t C)

(b) Option A.2: calculated based on the chemical composition of the fossil fuel type *i*, if $FC_{i,y}$ is measured in a volume unit:

$$EF_{FC,CO2,i,y} = w_{c,i,y} \times \rho_{,i,y} \times 44/12 \quad \text{Equation (12)}$$

Where:

$EF_{FC,CO2,i,y}$	=	CO_2 emission factor of fuel type *i* in year *y* (t CO_2eq / mass or volume unit)
$w_{c,i,y}$	=	Mass fraction of carbon in fuel type *i* in year *y* (t C / mass or volume unit)
$\rho_{,i,y}$	=	Density of fuel type *i* in year *y* (mass unit / volume unit)
$44/12$	=	Unit conversion factor (t CO_2 / t C)

(c) Option B: Calculated based on net calorific value and CO_2 emission factor of the fuel type *i*, as follows:

$$EF_{FC,CO2,i,y} = NCV_{i,y} \times EF_{CO2,i,y} \quad \text{Equation (13)}$$

Where:

$EF_{FC,CO2,i,y}$	=	CO_2 emission factor of fuel type *i* in year *y* (t CO_2eq / mass or volume unit)

$NCV_{i,y}$	=	Net calorific value of the fuel type *i* in year *y* (GJ / mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fuel type *i* in year *y* (t CO_2 / GJ)

62. Activity participants shall use options A.1 or A.2, unless they can demonstrate that the necessary data are unavailable. If the necessary data are unavailable, activity participants may use option B.

8.2. Activity emissions from electricity consumption ($AE_{EC,y}$)

63. Activity participants shall use a valid version of the "Methodological tool: Emissions from electricity generation and consumption" (A6.4-AMT-007) to calculate activity emissions from electricity consumption in year *y* ($AE_{EC,y}$). In applying the tool, activity participants shall implement all of the following specifications:

(a) **Electricity generation or consumption sources:** the only source *s* to be considered for determining activity emissions from electricity consumption is the electricity consumed by the Article 6.4 project power plant from the electricity system;

(b) **Determination of the amount of electricity generated or consumed:** the quantity of electricity consumed by the Article 6.4 project power plant from the electricity system in year *y* corresponds to the general parameters $EC_{s,y}$ or $EC_{s,h}$ in the methodological tool;

(c) **Type of electricity consumption source s:** for solar and wind power plants, the electricity consumption shall be considered as electricity consumption sources depending on intermittent generation, regardless of whether the plants are operated with an integrated BESS. For geothermal power and hydropower plants, the electricity consumption shall be considered as electricity consumption sources not depending on intermittent generation;[37]

(d) **Applicable scenarios:** scenario A in step 2 of the methodological tool A6.4-AMT-007 shall apply;

(e) **Whether case 1 or case 2 applies:** case 1 in step 4 of the methodological tool A6.4-AMT-007 shall apply; and

(f) **Consideration of uncertainty:** the upper bound of the uncertainty interval of the emission factor shall be used, determined in accordance with the provisions in the methodological tool. Uncertainty in the quantity of electricity consumed does not need to be accounted for.

64. The activity emissions from electricity consumption in year *y* ($AE_{EC,y}$) shall be calculated in accordance with step 10 of the methodological tool A6.4-AMT-007.

[37] The mechanism methodology may be revised in the future to incorporate specific provisions for projects operated with a BESS. Activity participants are also encouraged to submit a revision to this mechanism methodology through the "Procedure: Development, revision and clarification of methodologies and methodological tools" (A6.4-PROC-METH-001).

65. In case the electricity consumption is netted from the total electricity generation in accordance with step 4 of the methodological tool A6.4-AMT-007, it shall not be included in activity emissions.

8.3. Activity emissions from the operation of geothermal power plants ($AE_{GP,y}$)

66. Activity emissions from the operation of geothermal power plants in year *y* ($AE_{GP,y}$) shall include the following emission sources:

(a) For dry or flash steam geothermal power plants, activity participants shall account for emissions of CO_2 and CH_4 due to the release of non-condensable gases from produced steam ($AE_{dry\ or\ flash\ steam,y}$). Non-condensable gases in geothermal reservoirs usually consist mainly of CO_2 and H_2S. They also contain a small quantity of hydrocarbons, which are predominantly CH_4. In dry or flash steam geothermal power projects, non-condensable gases flow with the steam into the power plant and come in touch with the atmosphere through the heat exchange process. In such a process, non-condensable and other gases within the geothermal fluid are partially released to the atmosphere. A small proportion of the CO_2 is converted into carbonate/bicarbonate in the cooling water circuit. In addition, parts of the non-condensable gases are re-injected into the geothermal reservoir. However, as a conservative approach, this mechanism methodology assumes that all non-condensable gases entering the power plant in dry or flash steam geothermal technologies are discharged to the atmosphere via the cooling tower. Fugitive CO_2 and CH_4 emissions due to well testing and well bleeding are not considered, as they are considered negligible (see appendix 1);

(b) For binary geothermal power plants, the underground fluid is re-injected back into the heat source without any exposure to the atmosphere. In this case, non-condensable and other gases within the geothermal fluid are kept within the outgoing geothermal fluid and sent back into the heat source. However, there may be some physical leakage from closed cycle pipes and wells. Therefore, activity participants shall account for emissions from physical leakage of non-condensable gases ($AE_{steam,y}$). In addition, activity participants shall account for emissions from physical leakage of the working fluid contained in heat exchangers ($AE_{working\ fluid,y}$).

67. Accordingly, $AE_{GP,y}$ shall be calculated as follows:

(a) For dry or flash steam geothermal power plants:

$$AE_{GP,y} = AE_{dry\ or\ flash\ steam,y} \qquad \text{Equation (14)}$$

Where:

$AE_{GP,y}$	=	Activity emissions from the operation of the project geothermal power plant in year *y* (t CO_2eq)
$AE_{dry\ or\ flash\ steam,y}$	=	Activity emissions from the release of non-condensable gases in a dry steam or flash steam project geothermal power plant in year *y* (t CO_2eq)

(b) For binary geothermal power plants:

$$AE_{GP,y} = AE_{steam,y} + AE_{working\ fluid,y}$$ Equation (15)

Where:

$AE_{GP,y}$	=	Activity emissions from the operation of the project geothermal power plant in year *y* (t CO_2eq)
$AE_{steam,y}$	=	Activity emissions from physical leakage of non-condensable gases in a binary project geothermal power plant in year *y* (t CO_2eq)
$AE_{working\ fluid,y}$	=	Activity emissions from physical leakage of working fluid contained in heat exchangers in a binary project geothermal power plant due to in year *y* (t CO_2eq)

68. Activity emissions from the release of non-condensable gases in a dry steam or flash steam project geothermal power plant in year *y* ($AE_{dry\ or\ flash\ steam,y}$) shall be calculated as follows:

$$AE_{dry\ or\ flash\ steam,y} = \left(w_{steam,CO2,y} + w_{steam,CH4,y} \times GWP_{CH4}\right) \times M_{steam,y}$$ Equation (16)

Where:

$AE_{dry\ or\ flash\ steam,y}$	=	Activity emissions from the release of non-condensable gases in a dry steam or flash steam project geothermal power plant in year *y* (t CO_2eq)
$w_{steam,CO2,y}$	=	Average mass fraction of CO_2 in the produced steam in year *y* (t CO_2 / t steam)
$w_{steam,CH4,y}$	=	Average mass fraction of CH_4 in the produced steam in year *y* (t CH_4 / t steam)
GWP_{CH4}	=	Global warming potential of CH_4 valid for the relevant commitment period (t CO_2eq / t CH_4)
$M_{steam,y}$	=	Quantity of steam produced in year *y* (t steam)

69. Activity emissions from physical leakage of non-condensable gases in a binary project geothermal power plant in year *y* ($AE_{steam,y}$) shall be calculated as follows:

$$AE_{steam,y} = \left(M_{Inflow,y} - M_{outflow,y}\right) \times \left(w_{steam,CO2,y} + w_{steam,CH4,y} \times GWP_{CH4}\right)$$ Equation (17)

Where:

$AE_{steam,y}$	=	Activity emissions from physical leakage of non-condensable gases in a binary project geothermal power plant in year *y* (t CO_2eq)
$M_{Inflow,y}$	=	Quantity of steam entering the geothermal plant in year *y* (t steam)
$M_{outflow,y}$	=	Quantity of steam leaving the geothermal plant in year *y* (t steam)
$w_{steam,CO2,y}$	=	Average mass fraction of CO_2 in the produced steam in year *y* (t CO_2 / t steam)
$w_{steam,CH4,y}$	=	Average mass fraction of CH_4 in the produced steam in year *y* (t CH_4 / t steam)

GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2eq / t CH_4)

70. Activity emissions from physical leakage of working fluid contained in heat exchangers in a binary project geothermal power plant due to in year *y* ($AE_{working\ fluid,y}$) shall be calculated as follows:

$$AE_{working\ fluid,y} = M_{working\ fluid,y} \times GWP_{working\ fluid} \quad \text{Equation (18)}$$

Where:

$AE_{working\ fluid,y}$	=	Activity emissions from physical leakage of working fluid contained in heat exchangers in a binary project geothermal power plant due to in year *y* (t CO_2eq)
$M_{working\ fluid,y}$	=	Quantity of working fluid leaked/reinjected in year *y* (t working fluid)
$GWP_{working\ fluid}$	=	Global Warming Potential for the working fluid used in the binary geothermal power plant (t CO_2eq / t working fluid)

9. Leakage

71. Leakage emissions include upstream emissions from the production, transport and installation of any BESS located at the same site as the renewable energy power plant. Any wake effects of wind power plants are, for simplicity, accounted for in determining the electricity generation from the Article 6.4 activity ($EG_{PJ,y}$ or $EG_{PJ,h}$) in section 7.2.2, and are thus not accounted for in this section. Other leakage emission sources do not need to be estimated. Further information on the consideration of other leakage emission sources is included in appendix 1.

72. Leakage emissions shall be calculated as follows:

$$LE_y = EG_{BESS,delivered,y} \times EF_{BESS,upstream} \quad \text{Equation (19)}$$

Where:

LE_y	=	Leakage emissions in year *y* (t CO_2eq)
$EG_{BESS,delivered,y}$	=	Quantity of electricity delivered by the BESS in year *y* (MWh)
$EF_{BESS,upstream}$	=	Emission factor for the upstream emissions from the production, transportation and installation of a BESS relative to the electricity delivered by the BESS (t CO_2eq / kWh)
y	=	Calendar years of the crediting period

10. Emission reductions

73. Emission reductions shall be determined as follows:

$$ER_y = BE_{EG,adj,y} - AE_y - LE_y \quad \text{Equation (20)}$$

Where:

ER_y	=	Emission reductions in year *y* (t CO_2eq)
$BE_{EG,adj,y}$	=	Downward adjusted baseline emissions from electricity generation from the Article 6.4 activity in year *y* (t CO_2eq)
AE_y	=	Activity emissions in year *y* (t CO_2eq)
LE_y	=	Leakage emissions in year *y* (t CO_2eq)
y	=	Calendar years of the crediting period

74. Note that in this mechanisms methodology the uncertainty of baseline emissions is addressed through the determination of the initial downward adjustment. With respect to activity emissions and leakage emissions, the methodology addresses uncertainty in the determination of individual parameters and through conservative assumptions (see also appendix 1). It is therefore not necessary to determine the overall uncertainty of the aggregated emission reductions.

11. Avoidance of double counting

75. Activity participants shall demonstrate that the Article 6.4 activity will not result in double counting by:

(a) Providing evidence, in each monitoring report, that the renewable electricity generated by the Article 6.4 activity, together with any associated mitigation outcomes and environmental attributes (e.g., issuance of renewable energy certificates with respect to the renewable electricity generated under the Article 6.4 activity), is not claimed under any other crediting mechanism or certification scheme. This may be ensured by either:

(i) Not issuing any such emission reduction or environmental attributes; or

(ii) Any issued emission reductions or environmental attributes are administratively cancelled without making any claim in association with the cancellation; and

(b) Demonstrating that the reported GHG emission reductions for which they intend to request issuance of A6.4ERs do not overlap with mandatory domestic mitigation schemes (e.g., emissions trading systems), or that measures are in place to ensure that any relevant impacts of the activity (e.g., the GHG emission reductions achieved or the kilowatt-hours of renewable electricity produced) are not counted towards the achievement of targets or obligations under the mandatory domestic mitigation scheme (e.g., by cancelling allowances from the emissions trading system before issuing carbon credits) if an overlap exists, by:

(i) Declaring and providing evidence in each monitoring report that the Article 6.4 activity and the activities displaced in the baseline scenario do not fall within the scope of any mandatory domestic mitigation scheme; or

(ii) Where the Article 6.4 activity or the activities displaced in the baseline scenario fall within the scope of a mandatory domestic mitigation scheme, activity participants shall provide evidence in each monitoring report that the mitigation outcomes of the Article 6.4 activity are not counted in the mandatory mitigation scheme to reduce the obligations of the entities covered by the scheme. For example, in the case of an emissions trading system covering electricity generation, a confirmation from the operator of the emissions trading system may be sought that a number of allowances equal to the A6.4ERs being requested for issuance for the electricity generation component were cancelled before the issuance of the A6.4ERs.

12. Demonstration of alignment with the policies, options and implementation plans of the Host Party with regard to its NDC and LT-LEDS and the long-term temperature goal of the Paris Agreement and long-term goals of the Paris Agreement

76. The activity participants applying this methodology shall ensure that the activity complies with paragraph 10 in Appendix of the “Standard: Setting the baseline in mechanism methodologies” (A6.4-STAN-METH-004).

13. Data and parameters not monitored

77. For parameters where the uncertainty was not provided, activity participants shall assume uncertainty based on expert judgement and justify the estimates.

Data / Parameter table 1.

Data / Parameter:	$F_{CH4/N2O,i}$
Description:	Factor to account for CH_4 and N_2O emissions in relation to CO_2 emissions for fuel type i
Data unit:	Dimensionless
Equations referred	Equation (10)
Purpose of data:	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage
Value(s) applied:	1.002
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	This value was derived from table 2.2 of volume 2, chapter 1 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Treatment of uncertainty	Not applicable (uncertainty was taken into account in determining the above value)
Additional comments	-

Data / Parameter table 2.

Data / Parameter:	$\boldsymbol{GWP_{CH4}}$		
Description:	Global warming potential of CH_4		
Data unit:	t CO_2eq / t CH_4		
Equations referred	Equations (16), (17)		
Purpose of data:	☐ Baseline Scenario	☒ Activity Scenario	☐ Leakage
Value(s) applied:	28		
Source of data	☐ Measured	☒ Other sources	
Choice of data or measurement methods and procedures	This value was derived from table 2.2 of volume 2, chapter 1 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories		
Treatment of uncertainty	Not applicable (uncertainty was taken into account in determining the above value)		
Additional comments	-		

Data / Parameter table 3.

Data / Parameter:	$\boldsymbol{GWP_{working\ fluid}}$		
Description:	Global Warming Potential for the working fluid used in the binary geothermal power plant		
Data unit:	t CO_2eq / t working fluid		
Equations referred	Equation (18)		
Purpose of data:	☐ Baseline Scenario	☒ Activity Scenario	☐ Leakage
Value(s) applied:	Default value depending on the type of working fluid		
Source of data	☐ Measured	☒ Other sources	
Choice of data or measurement methods and procedures	Default value and uncertainty from the IPCC Fifth Assessment Report (AR5). Shall be updated according to any future CMA decisions		
Treatment of uncertainty	N/A		
Additional comments	-		

Data / Parameter table 4.

Data / Parameter:	$\boldsymbol{EF_{BESS,upstream}}$
Description:	Emission factor for the upstream emissions from the production, transportation and installation of a BESS relative to the electricity delivered by the BESS

Data unit:	t CO_2eq / MWh
Equations referred	Equation (19)
Purpose of data:	☐ Baseline Scenario ☐ Activity Scenario ☒ Leakage
Value(s) applied:	0.06
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	The values are based on peer-reviewed technical papers and articles on life-cycle analysis of batteries and BESS
Treatment of uncertainty	NA. This value is deemed to be conservative under different circumstances
Additional comments	-

14. Data and parameters monitored

78. All data collected as part of monitoring should be archived electronically and kept for at least for two years after the end of the last crediting period. One hundred per cent of the data should be monitored, if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment, according to relevant industry standards.

79. The parameters $EG_{plant,y}$ and $EG_{plant,h}$, required to determine the unadjusted baseline emissions from electricity generation in year y ($BE_{EG,y}$), shall be monitored as per the monitoring provisions of the parameters $EG_{s,y}$ and $EG_{s,h}$ from the "Methodological tool: Emissions from electricity generation and consumption" (A6.4-AMT-007). Where a BESS is installed, this shall also include electricity delivered by the BESS to the electricity system.

80. The parameters $EG_{BESS,delivered,y}$, required to determine the leakage emissions in year y (LE_y) shall be monitored as per the monitoring provisions of the parameters $EG_{s,y}$ from the "Methodological tool: Emissions from electricity generation and consumption" (A6.4-AMT-007).

81. The parameters $EC_{s,y}$ and $EC_{s,h}$ shall be monitored as per the provisions from the "Methodological tool: Emissions from electricity generation and consumption" (A6.4-AMT-007).

Data / Parameter table 5.

Data / Parameter:	$EG_{wake,y}$
Description:	Reduction in electricity generation by other wind power plants due to wake effects in year *y*
Data unit:	MWh
Equation referred	Equations (1), (2)
Purpose of data	☒ Baseline Scenario ☐ Activity Scenario ☐ Leakage

Measurement methods and procedures	Determined based on a third-party assessment by a certified or suitably qualified expert	
Measurement and updating frequency	The modelling shall be conducted once prior to the first verification and shall be updated when new wind power plants start operations which do not fulfil the conditions specified in paragraph 41 of this mechanism methodology (e.g., their distance is lower than the thresholds and they are not registered as an Article 6.4 activity), but not more frequently than annually	
Entity responsible for measurement	Third-party assessment by a certified or suitably qualified expert	
Measuring instrument(s)	*Type of instrument*	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures	N/A	
Treatment of uncertainty	The outcome from the model shall be adjusted upwards by 50 per cent to account for uncertainties	
Additional comment	-	

Data / Parameter table 6.

Data / Parameter:	$FC_{i,y}$
Description:	Quantity of fuel type *i* combusted in process *j* during year *y*
Data unit:	Mass or volume units
Equation referred	Equation (10)
Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage
Measurement methods and procedures	• Use either mass or volume meters; • In cases where fuel is supplied from small daily tanks, ruler gauges can be used to determine mass or volume of fuel consumed, subject to the following conditions: the ruler gauge shall be part of the daily tank, shall be calibrated at least once a year and, shall have a logbook for recording measurements (on a daily basis or per shift); • Accessories such as transducers, sonar and piezoelectronic devices may be used if they are properly calibrated with the ruler gauge and maintained appropriately; and • In the case of daily tanks with pre-heaters for heavy oil, calibration shall be conducted under typical operational conditions
Measurement and updating frequency	Continuously
Entity responsible for measurement	Activity participants

<table>
<tr><td rowspan="4">Measuring instrument(s)</td><td>Type of instrument</td><td>Mass or volume meters, ruler gauges (installed in daily tanks), transducers, sonar and piezoelectronic devices</td></tr>
<tr><td>Accuracy class</td><td>As per manufacturer specification</td></tr>
<tr><td>Calibration requirements</td><td>Ruler gauges shall be calibrated at least once a year. Transducers, sonar and piezoelectronic devices shall be calibrated with the ruler gauge and maintained appropriately</td></tr>
<tr><td>Location</td><td>N/A</td></tr>
<tr><td>QA/QC procedures</td><td colspan="2">The recorded data shall be stored monthly in a central database with backup</td></tr>
<tr><td>Treatment of uncertainty</td><td colspan="2">Uncertainties are determined based on the measuring instruments</td></tr>
<tr><td>Additional comment</td><td colspan="2">• The consistency of metered fuel consumption quantities shall be cross-checked by an annual energy balance based on purchased quantities and stock changes;
• Where purchased fuel invoices can be attributed specifically to the Article 6.4 activity, the metered fuel consumption quantities shall also be cross-checked against available purchase invoices from financial records; and
• Where data gaps occur due to meter failure or other unforeseen reasons, activity participants may estimate the quantity of fuel using one of the following options, provided that the gap period does not exceed 30 consecutive days within six consecutive months:
- Purchased fuel or energy invoices/bills, where the purchased fuel can be attributed specifically to the Article 6.4 activity;
- Energy produced by the equipment, adjusted for efficiency. Conservative default values of 40 per cent for combustion engines and generators and 80 per cent for thermal heaters shall be used. Energy produced shall be measured directly or calculated based on operating hours; or
- The highest value of the parameter for the same calendar period in the previous years</td></tr>
</table>

Data / Parameter table 7.

Data / Parameter:	$NCV_{i,y}$
Description:	Net calorific value of the fuel type *i* in year *y*
Data unit:	GJ / mass or volume unit
Equation referred	Equation (13)
Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage
Measurement methods and procedures	• Option 1: Values provided by the fuel supplier (preferred source). The NCV of the fuel shall be obtained for each fuel delivery, from which weighted average annual values shall be calculated;

	• Option 2: Measurements by activity participants undertaken in line with national or international fuel standards (if supplier-provided values are not available). The NCV of the fuel shall be obtained for each fuel delivery, from which weighted average annual values shall be calculated; • Option 3: Regional or national default values (if supplier-provided values are not available and only for liquid fuels). Values shall be reviewed annually; • Option 4: Upper bound of the 95 per cent confidence interval from IPCC default values provided in table 1.2 of chapter 1, volume 2 (Energy), of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, if supplier-provided values are not available. Values shall be updated based on future revisions of the IPCC Guidelines	
Measurement and updating frequency	• Option 1: At each fuel delivery; • Option 2: At each fuel delivery; • Option 3: Annually; • Option 4: Updated based on future revisions of the IPCC Guidelines	
Entity responsible for measurement	Activity participants or fuel supplier	
Measuring instrument(s)	*Type of instrument*	As per the national or international standard if the parameter is measured by activity participants
	Accuracy class	As per the national or international standard if the parameter is measured by activity participants
	Calibration requirements	As per the national or international standard if the parameter is measured by activity participants
	Location	As per the national or international standard if the parameter is measured by activity participants
QA/QC procedures	The recorded data shall be stored monthly in a central database with backup	
Treatment of uncertainty	Verify whether the values under options 1, 2 and 3 fall within the uncertainty range of the IPCC default values as provided in table 1.2, volume 2 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. If the values fall below this range, additional information shall be obtained from the testing laboratory to justify the outcome, or additional measurements shall be conducted. Laboratories in options 1, 2 and 3 – shall have ISO/IEC 17025 accreditation or demonstrate compliance with similar quality standards	
Additional comment	-	

Data / Parameter table 8.

<table>
<tr><td>Data / Parameter:</td><td colspan="2">$\rho_{i,y}$</td></tr>
<tr><td>Description:</td><td colspan="2">Density of the fuel type i in year y</td></tr>
<tr><td>Data unit:</td><td colspan="2">Mass unit / volume unit of the fuel</td></tr>
<tr><td>Equation referred</td><td colspan="2">Equation (12)</td></tr>
<tr><td>Purpose of data</td><td colspan="2">☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage</td></tr>
<tr><td>Measurement methods and procedures</td><td colspan="2">• <u>Option 1:</u> Values provided by the fuel supplier (preferred source). The NCV of the fuel shall be obtained for each fuel delivery, from which weighted average annual values shall be calculated;
• <u>Option 2:</u> Measurements by activity participants undertaken in line with national or international fuel standards (if supplier-provided values are not available). The NCV of the fuel shall be obtained for each fuel delivery, from which weighted average annual values shall be calculated;
• <u>Option 3:</u> Regional or national default values (if supplier-provided values are not available and only for liquid fuels). Values shall be reviewed annually;
• <u>Option 4:</u> Upper bound of the 95 per cent confidence interval from IPCC default values provided in table 1.2 of chapter 1, volume 2 (Energy), of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, if supplier-provided values are not available. Values shall be updated based on future revisions of the IPCC Guidelines</td></tr>
<tr><td>Measurement and updating frequency</td><td colspan="2">• <u>Option 1:</u> At each fuel delivery;
• <u>Option 2:</u> At each fuel delivery;
• <u>Option 3:</u> Annually;
• <u>Option 4:</u> Updated based on future revisions of the IPCC Guidelines</td></tr>
<tr><td>Entity responsible for measurement</td><td colspan="2">Activity participants or fuel supplier</td></tr>
<tr><td rowspan="4">Measuring instrument(s)</td><td>Type of instrument</td><td>As per the national or international standard if the parameter is measured by activity participants</td></tr>
<tr><td>Accuracy class</td><td>As per the national or international standard if the parameter is measured by activity participants</td></tr>
<tr><td>Calibration requirements</td><td>As per the national or international standard if the parameter is measured by activity participants</td></tr>
<tr><td>Location</td><td>As per the national or international standard if the parameter is measured by activity participants</td></tr>
<tr><td>QA/QC procedures</td><td colspan="2">The recorded data shall be stored monthly in a central database with backup</td></tr>
</table>

Treatment of uncertainty	Verify whether the values under options 1, 2 and 3 fall within the uncertainty range of the IPCC default values as provided in table 1.2, volume 2 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. If the values fall below this range, additional information shall be obtained from the testing laboratory to justify the outcome, or additional measurements shall be conducted. Laboratories in options 1, 2 and 3 – shall have ISO/IEC 17025 accreditation or demonstrate compliance with similar quality standards
Additional comment	-

Data / Parameter table 9.

Data / Parameter:	$EF_{CO2,i,y}$	
Description:	CO_2 emission factor of fuel type *i* in year *y*	
Data unit:	t CO_2 / GJ	
Equation referred	Equation (13)	
Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage	
Measurement methods and procedures	• Option 1: Values provided by the fuel supplier (preferred source), in line with national or international standards. The $EF_{CO2e,i,y}$ of the fuel shall be obtained for each fuel delivery, from which weighted average annual values shall be calculated; • Option 2: Measurements by activity participants undertaken in line with national or international fuel standards (if supplier-provided values are not available). The $EF_{CO2e,i,y}$ of the fuel shall be obtained for each fuel delivery, from which weighted average annual values shall be calculated; • Option 3: Regional or national default values (if supplier-provided values are not available and only for liquid fuels). Values shall be reviewed annually; • Option 4: Upper bound of the 95 per cent confidence interval from IPCC default values provided in table 1.2 of chapter 1, volume 2 (Energy), of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, if supplier-provided values are not available. Values shall be updated based on future revisions of the IPCC Guidelines	
Measurement and updating frequency	• Option 1: At each fuel delivery; • Option 2: At each fuel delivery; • Option 3: Annually; • Option 4: Updated based on future revisions of the IPCC Guidelines	
Entity responsible for measurement	Activity participants or fuel supplier	
Measuring instrument(s)	*Type of instrument*	As per the national or international standard if the parameter is measured by activity participants

	Accuracy class	As per the national or international standard if the parameter is measured by activity participants
	Calibration requirements	As per the national or international standard if the parameter is measured by activity participants
	Location	As per the national or international standard if the parameter is measured by activity participants
QA/QC procedures	• The recorded data shall be stored monthly in a central database with backup; • Laboratories in options 1 and 2 shall have ISO/IEC 17025 accreditation or justify compliance with equivalent quality standards	
Treatment of uncertainty	Verify whether the values under options 1, 2 and 3 fall within the uncertainty range of the IPCC default values as provided in table 1.4, volume 2 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. If the values fall below this range, additional information shall be obtained from the testing laboratory to justify the outcome, or additional measurements shall be conducted	
Additional comment	For option 1, if the fuel supplier provides both the net calorific value (NCV) and CO_2 emission factor on the invoice and these values are based on measurements for the specific fuel delivered, the provided CO_2 emission factor shall be used. If another source is used for the CO_2 emission factor, or no CO_2 emission factor is provided, options 2, 3, or 4 shall be used	

Data / Parameter table 10.

Data / Parameter:	$w_{c,i,y}$
Description:	Mass fraction of carbon in fuel type *i* in year *y*
Data unit:	t C / mass unit of the fuel
Equation referred	Equations (11), (12)
Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage
Measurement methods and procedures	• <u>Option 1:</u> Values provided by the supplier of the fuel (preferred source); • <u>Option 2:</u> Measurements by activity participants undertaken in line with national or international fuel standards; • <u>Option 3:</u> Regional or national default values (if supplier-provided values are not available and only for liquid fuels)
Measurement and updating frequency	Continuous of for each fuel batch
Entity responsible for measurement	Activity participants or fuel supplier

Measuring instrument(s)	*Type of instrument*	As per the national or international standard if the parameter is measured by activity participants
	Accuracy class	As per the national or international standard if the parameter is measured by activity participants
	Calibration requirements	As per the national or international standard if the parameter is measured by activity participants
	Location	As per the national or international standard if the parameter is measured by activity participants
QA/QC procedures	The recorded data must be stored monthly in a central database with backup	
Treatment of uncertainty	Uncertainties are determined based on the measuring instruments	
Additional comment	Verify if the values measured or obtained from the fuel supplier fall within the uncertainty range derived from the product of the IPCC default values as provided in Table 1.2 and Table 1.3, Vol. 2 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. If the values fall below this range collect additional information shall be obtained from the testing laboratory to justify the outcome, or additional measurements shall be conducted. Laboratories performing measurements in Option 2 should have ISO17025 accreditation or demonstrate compliance with equivalent quality standards	

Data / Parameter table 11.

Data / Parameter:	$w_{steam,CO2,y}$
Description:	Average mass fraction of carbon dioxide in the produced steam in year *y*
Data unit:	t CO_2 / t steam
Equation referred	Equations (16), (17)
Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage
Measurement methods and procedures	• Non-condensable gases sampling shall be carried out in production wells or at the steam field-power plant interface either using “ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid for Purposes of Chemical Analysis” (as applicable to sampling single phase steam only) or an equivalent standard. • The CO_2 and CH_4 sampling and analysis procedure consists of collecting non-condensable gas samples from the main steam line with glass flasks, filled with sodium hydroxide solution and additional chemicals to prevent oxidation. H_2S and CO_2 dissolve in the solvent while the residual compounds remain in their gaseous phase. The gas portion is then analyzed using gas

	chromatography to determine the content of the residuals including CH_4. • All alkanes concentrations may be reported in terms of methane	
Measurement and updating frequency	At least every three months and more frequently, if necessary	
Entity responsible for measurement	Activity participants or third-party laboratory	
Measuring instrument(s)	*Type of instrument*	As per the “ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid for Purposes of Chemical Analysis” or equivalent
	Accuracy class	As per the “ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid for Purposes of Chemical Analysis” or equivalent
	Calibration requirements	As per the “ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid for Purposes of Chemical Analysis” or equivalent
	Location	N/A
QA/QC procedures	-	
Treatment of uncertainty	Uncertainties are determined based on the measuring instruments	
Additional comment	This parameter shall be monitored only for dry, flash steam and binary geothermal power projects	

Data / Parameter table 12.

Data / Parameter:	$\boldsymbol{w_{steam,CH4,y}}$	
Description:	Average mass fraction of methane in the produced steam in year *y*	
Data unit:	t CH_4 / t steam	
Equation referred	Equations (16), (17)	
Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage	
Measurement methods and procedures	As per the procedures outlined for $w_{steam,CO2,y}$	
Measurement and updating frequency	As per the procedures outlined for $w_{steam,CO2,y}$	
Entity responsible for measurement	As per the procedures outlined for $w_{steam,CO2,y}$	
Measuring instrument(s)	*Type of instrument*	As per the procedures outlined for $w_{steam,CO2,y}$

	Accuracy class	As per the procedures outlined for $w_{steam,CO2,y}$
	Calibration requirements	As per the procedures outlined for $w_{steam,CO2,y}$
	Location	N/A
QA/QC procedures	-	
Treatment of uncertainty	As per the procedures outlined for $w_{steam,CO2,y}$	
Additional comment	As per the procedures outlined for $w_{steam,CO2,y}$	

Data / Parameter table 13.

Data / Parameter:	$M_{steam,y}$	
Description:	Quantity of steam produced in year *y*	
Data unit:	t steam	
Equation referred	Equation (16)	
Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage	
Measurement methods and procedures	The steam quantity discharged from geothermal wells shall be measured with a Venturi flow meter (or other equipment with at least the same accuracy); Measurement of temperature and pressure upstream of the Venturi meter shall be conducted to define the steam properties, and the calculation of steam quantities shall be conducted on a continuous basis and shall be based on national or international standards	
Measurement and updating frequency	Continuously measured	
Entity responsible for measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Venturi flow meter or other equipment with at least the same accuracy
	Accuracy class	According to the national, international, or meter supplier's instructions
	Calibration requirements	Calibration shall be conducted according to the national, international, or manufacturer's instructions
	Location	Main steam line
QA/QC procedures	The recorded data must be stored daily in a central database with backup	

Treatment of uncertainty	Uncertainties are determined based on the measuring instruments
Additional comment	• The measurement results shall be summarized transparently in regular production reports; • Applicable to dry or flash steam geothermal power projects

Data / Parameter table 14.

Data / Parameter:	$M_{inflow,y}$	
Description:	Quantity of steam entering the geothermal plant in year *y*	
Data unit:	t steam	
Equation referred	Equation (17)	
Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage	
Measurement methods and procedures	• The steam quantity entering the power plant shall be measured with a Venturi flow meter (or other equipment with at least the same accuracy); • Measurement of temperature and pressure upstream of the Venturi meter shall be conducted to define the steam properties, and the calculation of steam quantities shall be conducted on a continuous basis and should be based on national or international standards	
Measurement and updating frequency	Continuously measured	
Entity responsible for measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Venturi flow meter or other equipment with at least the same accuracy
	Accuracy class	According to the national, international, or meter supplier’s instructions
	Calibration requirements	Calibration shall be conducted according to the national, international, or manufacturer’s instructions
	Location	At the steam supply line to the geothermal power plant
QA/QC procedures	The recorded data shall be stored daily in a central database with backup	
Treatment of uncertainty	Uncertainties are determined based on the measuring instruments	
Additional comment	• The measurement results shall be summarized transparently in regular production reports; • Applicable to dry or flash steam geothermal power projects	

Data / Parameter table 15.

Data / Parameter:	$\boldsymbol{M_{outflow,y}}$	
Description:	Quantity of steam leaving the geothermal plant in year *y*	
Data unit:	t steam	
Equation referred	Equation (17)	
Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage	
Measurement methods and procedures	• The steam quantity entering the power plant shall be measured with a Venturi flow meter (or other equipment with at least the same accuracy); • Measurement of temperature and pressure upstream of the Venturi meter shall be conducted to define the steam properties, and the calculation of steam quantities shall be conducted on a continuous basis and should be based on national or international standards	
Measurement and updating frequency	Continuously measured	
Entity responsible for measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Venturi flow meter or other equipment with at least the same accuracy
	Accuracy class	According to the national, international, or meter supplier's instructions
	Calibration requirements	Calibration shall be conducted according to the national, international, or manufacturer's instructions
	Location	At the steam line exiting the geothermal power plant
QA/QC procedures	The recorded data shall be stored daily in a central database with backup	
Treatment of uncertainty	Uncertainties are determined based on the measuring instruments	
Additional comment	• The measurement results shall be summarized transparently in regular production reports; • Applicable to dry or flash steam geothermal power projects	

Data / Parameter table 16.

Data / Parameter:	$\boldsymbol{M_{working\ fluid,y}}$
Description:	Quantity of working fluid leaked/reinjected in year *y*
Data unit:	t working fluid
Equation referred	Equation (18)

Purpose of data	☐ Baseline Scenario ☒ Activity Scenario ☐ Leakage	
Measurement methods and procedures	Measured via log books and maintenance reports of the plant	
Measurement and updating frequency	Annually measured	
Entity responsible for measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Mass flow meter or other equipment with at least the same accuracy
	Accuracy class	According to the national, international, or meter supplier's instructions
	Calibration requirements	Calibration shall be conducted according to the national, international, or manufacturer's instructions
	Location	Heat exchanger or working fluid storage equipment
QA/QC procedures	Measured based on the quantity of working fluid reinjected into the binary system of the geothermal plant. Cross check with the purchase invoices	
Treatment of uncertainty	Uncertainties are determined based on the measuring instruments	
Additional comment	Applicable to binary geothermal power projects	

Appendix 1. Background information on the inclusion and exclusion of emission sources

1. This appendix provides additional background information and justification for why certain baseline, project and leakage emission sources are not quantified in this mechanism methodology. For this purpose, this appendix first identifies in section 1 all relevant emissions sources, consistent with the appendix 1 of the “Standard: Setting the baseline in mechanism methodologies”(A6.4-STAN-METH-004) and with the “Standard: Addressing leakage in mechanism methodologies” (A6.4-STAN-METH-005); then, it assesses in section 2 the relevance of the identified emission sources and explains how they have been addressed, and then draws an overall conclusions on why the proposed selection of emission sources ensures conservativeness.

1. Identification of relevant emission sources

2. The physical boundary of Article 6.4 activities applying this mechanism methodology is specified in section 5 of the mechanism methodology as the site of the project power plant and all power units physically connected to the electricity system.

3. The mechanism methodology accounts for the following emission sources:

   (a) Baseline emissions: CO_2 emissions from the combustion of fossil fuel in fossil fuel fired power plants connected to the electricity system. This source is related to the Article 6.4 activity, as it is determined based on the emissions from the combustion of fossil fuels in power plants connected to the electricity system;

   (b) Activity emissions:

      (i) Emissions due to the combustion of fossil fuels in a backup generator. This source is controlled by the Article 6.4 activity, as the quantity of fuel consumed is under the direct control of the activity participants;

      (ii) Emissions from non-condensable gases contained in geothermal steam of dry or flash steam geothermal power plants. This source is controlled by the Article 6.4 activity, as the quantity of steam collected, is under the direct control of the activity participants;

      (iii) Fugitive emissions from non-condensable gases contained in geothermal steam of binary geothermal power plants. This source is controlled by the Article 6.4 activity, as the quantity of steam entering and leaving the power plant is under the direct control of the activity participants; and

      (iv) Fugitive emissions of working fluid contained in the heat exchangers of binary geothermal power plants. This source is controlled by the Article 6.4 activity, as the quantity of working fluid used to operate the heat exchanger is under the direct control of the activity participants; and

(c) Leakage emissions:

(i) Wake effects of wind power plants. This source of emission is affected by the Article 6.4 activity, as the construction of a wind power plant may result in wake effects on other wind power plants and reduce their electricity generation; and

(ii) Upstream emissions from the production, transport and installation of a BESS. This source is affected by the Article 6.4 activity.

4. Several additional emission sources were identified but are not accounted for in this version of the mechanism methodology:

(a) Baseline emissions:

(i) Non-CO_2 emissions from fossil fuel combustion of power plants in the electricity system;

(ii) Emissions from the operation of renewable power plants in the electricity system (e.g., biomass or geothermal power generation);

(iii) Upstream emissions from the construction of power plants in the electricity system. This source is affected by the Article 6.4 activity;

(iv) Upstream emissions from the production, processing and transportation of fossil fuels used in power plants in the electricity system. This source is affected by the Article 6.4 activity;

(b) Activity emissions: all emissions sources are accounted for;

(c) Leakage:

(i) Upstream emissions from the construction of the renewable power plant, including emissions associated with the manufacturing of equipment and the construction of the power plant. This source is affected by the Article 6.4 activity;

(ii) Baseline equipment transfer. This source of emission is affected by the Article 6.4 activity, as emissions would occur due to the use of the equipment at a site outside the project boundary and not under the control of the activity participants;

(iii) Competition for resource use consumed by the project power plant, including wind and water. This source of emission is affected by the Article 6.4 activity, as the construction of the project power plant may impact downstream and upstream water use from a river and may affect the quality of wind (i.e., the speed and turbulence of the air) used by downstream wind energy generators;

(iv) Diversion of existing production processes or outputs. This emission source is affected by the Article 6.4 activity, as the construction of the project power plant may displace the existing production activity to another location;

(v) Increases in release of GHGs from the environment as a result of the Article 6.4 activity. This emission source is affected by the Article 6.4 activity if construction of the project power plant results in deforestation; and

(vi) Increase in the level of service compared to the baseline scenario as a result of the implementation of the Article 6.4 activity (rebound effect). This emission source is affected by the Article 6.4 activity if the electricity generated by the project power plant lowers electricity prices, leading to an increased electricity consumption.

2. Relevance of unaccounted emission sources

5. This section analyses the relevance of the unaccounted emission sources identified.

2.1. Upstream emissions from the construction and operation of power plant

6. The table below provides an overview of upstream emissions from power plants. It shows that upstream emissions from fossil fuel power plants are generally higher than emissions from renewable power plants. Other literature sources and databases were also evaluated and confirmed that the values in the table are within plausible ranges found in the literature. Exclusion of this emission source is therefore deemed to be conservative.

Table. Comparison between the upstream emissions from the types of Article 6.4 activities eligible under this mechanism methodology and the upstream emissions from fossil fuel fired power plants[1]

Type of Article 6.4 project	Upstream emissions for the Article 6.4 project (g CO_2eq / kWh)	Upstream emissions for coal power plant (g CO_2eq / kWh)	Upstream emissions for natural gas power plant (g CO_2eq / kWh)
Wind onshore	12.15	163.68	78.12
Wind offshore	13.92		

[1] Adapted from United Nations Economic Commission for Europe (UNECE), Life Cycle Assessment of Electricity Generation Options (Geneva: United Nations, 2021). The report identifies the sources of upstream emissions as follows:

(a) Upstream emissions from coal and natural gas power plants: energy carrier supply chains, from extraction to combustion (including methane leakage); infrastructure construction, operation, and dismantling (energy inputs and waste production); and connection to the grid;

(b) Upstream emissions from concentrated solar power plants: infrastructure, site preparation and occupation, operation and maintenance, decommissioning (energy inputs and waste production) and connection to grid;

(c) Upstream emissions from photovoltaic power plants: infrastructure, site preparation and occupation, operation and maintenance, decommissioning (energy inputs and waste production) and connection to grid; and

(d) Upstream emissions from wind power plants: infrastructure, site preparation and occupation, operation and maintenance, decommissioning (energy inputs and waste production) and connection to grid.

Type of Article 6.4 project	Upstream emissions for the Article 6.4 project (g CO_2eq / kWh)	Upstream emissions for coal power plant (g CO_2eq / kWh)	Upstream emissions for natural gas power plant (g CO_2eq / kWh)
Solar PV (poly-Si) ground mounted	36.08		
Solar PV (poly-Si) roof mounted	36.70		
Solar PV (CIGS) – ground mounted	11.98		
Solar PV (CIGS) – roof mounted	11.40		
Concentrated solar – parabolic through	33.18		
Concentrated solar – central tower	14.76		
Hydro	10.47		
Geothermal – binary[2]	23 – 71		
Geothermal – dry or flash steam[2]	3.8 – 5.3		

2.2. Emissions from the combustion of fossil fuel in fossil fuel fired power plants connected to the electricity system

7. This is the main baseline emission source and, therefore, was included in the calculation of emission reductions. For such types of power plants, the main GHG emitted from the combustion of fossil fuels is CO_2, and the mechanism methodology does not consider emissions of CH_4 and N_2O since their concentrations in the exhaust gas are negligible.[3]

2.3. Leakage from the use of pre-used equipment

8. The mechanism methodology requires that the equipment installed under the Article 6.4 activity has previously not been used in any other plant but is newly produced, therefore this emission source is not included in the calculation of emission reductions.

[2] Adapted from Eberle, A; Heath, G; Nicholson, S; Carpenter, A. (2017) Systematic Review of Life Cycle Greenhouse Gas Emissions from Geothermal Electricity, U.S. National Renewable Energy Laboratory Technical Report NREL/TP-6A20-68474, https://docs.nlr.gov/docs/fy17osti/68474.pdf.

[3] The default CH_4 emission factor for the combustion of fossil fuels from the IPCC (2006) is in the range of 1-10 kg CH_4 / TJ (converted to 28-280 kg CO_2eq / TJ), whereas the N_2O emission factor from the same 2006 IPCC Guidelines is in the range of 0.6-2 kg N_2O / TJ (converted to 159-530 kg CO_2eq / TJ), which is significantly lower in scale when compared to the emissions of CO_2 (e.g., the CO_2 emission factor of natural gas is in the range of 54 300-58 300 kg CO_2eq / TJ).

2.4. Competition for water in case of hydro power plants

9. For hydropower plants implemented in an existing reservoir, the mechanism methodology requires activity participants to demonstrate the following to avoid any leakage due to competition for water:

    (a) The implementation of the Article 6.4 activity does not lead to a reduction in electricity generation at upstream or downstream hydropower plants that rely on the same water resource;

    (b) For plants with an existing reservoir:

        (i) The implementation of the Article 6.4 activity does not change average volume of water in the reservoir;

        (ii) The implementation of the Article 6.4 activity does not reduce the availability of water for irrigation; and

        (iii) The hydropower plant operates in full compliance with the reservoir's authorized operating rules and water rights.

2.5. Increase in the level of service as a result of the implementation of the Article 6.4 activity (rebound effect)

10. Due to the low operating costs of some renewable power plants, the expansion of renewable power generation may displace power generation in those plants that have the highest marginal costs of electricity generation, which can lead to lower electricity prices (in some countries, this situation has led to an increasing number of hours where electricity prices are close to zero or negative).

11. The extent of such effects is likely to be highly variable and to depend on the context and country (e.g., demand for electricity may increase anyway due to increased electrification of infrastructure). In some situations, these effects could be significant. Nevertheless, this emission source is not considered here for simplicity, given that other conservative assumptions, in particular the neglect of upstream emissions from electricity generation in the baseline may outweigh this emission source.

12. This issue may be reconsidered, based on further data, in future revisions of this mechanism methodology.

3. Conclusion

13. The main unaccounted emission sources include upstream emissions from the construction and operation of power plants, and potentially rebound effects. Given that upstream emissions from fossil fuel power plants are generally higher than those from renewable power plants, the selected approach is deemed to be conservative.

Appendix 2. Numerical example of the determination of the downward adjustment

1. The following assumptions are made for the numerical example:

   (a) The start date of the crediting period for an Article 6.4 activity is on 01/10/2025, meaning the calendar year of the start date of the first crediting period (*y1*) is 2025;

   (b) The unadjusted baseline emissions in the calendar year of the start date of the first crediting period (BE_{y1}) are equal to 100 t CO_2eq. These emissions are calculated for the period between 01/10/2025 and 31/12/2025;

   (c) The initial downward adjustment ($DA_{initial}$) is equal to 10 per cent of the baseline emissions in year *y1*;

   (d) The annual increase in the downward adjustment is equal to 1 per cent of the baseline emissions in year y1; and

   (e) The type of crediting period selected by the Article 6.4 activity is renewable, and the end of the crediting period is on 30/09/2030.

2. As per step 2 under section 7.3.4, the annual increase in the downward adjustment (*INDA*) is equal to 0.01 and shall be applied in the calendar year following the calendar year of the start date of the first crediting period, i.e., 2026.

3. As per step 3, the downward adjusted baseline emissions during the crediting period are calculated as follows:

   (a) For the calendar year of the start date of the first crediting period:

$$BE_{adj,EG,y} = BE_{EG,y} \times \left(1 - DA_y\right), \text{and}$$

$$DA_y = DA_{initial} + INDA \times \left[\frac{cd_y}{nd_y} + (y - y1) - 1\right]$$

Therefore,

$$BE_{adj,EG,y} = BE_{EG,y} \times \left\{1 - \left[DA_{initial} + INDA \times \left(\frac{cd_y}{nd_y} + y - y1 - 1\right)\right]\right\}$$

   (b) For the last calendar year *y* of the last crediting period, DA_y shall be calculated based on equation (17) as follows:

$$DA_y = DA_{initial} + INDA \times [(y - y1) - 1]$$

4. The yearly downward adjusted baseline emissions determined for the example in paragraph 1 of this appendix and determined based on the equations above are exemplified in the table below, where:

   (a) The baseline emissions between 2026 and the 2029 are equal to 396.74 t CO_2eq/year, determined by multiplying 100 t CO_2eq by 365 days, and dividing the result by 92 days;

(b) The baseline emissions between for the calendar year 2030 are equal to 296.74 t CO_2eq / year, determined by multiplying 396.74 t CO_2eq by 273 days, and dividing the result by 365 days;

(c) cd_y is equal to 92 days for non-leap years and 93 days for leap years; and

(d) nd_y is equal to 365 days for non-leap years and 366 days for leap years.

Table. Numerical example of the calculation of the downward adjusted baseline emissions

Calendar year *y*	$BE_{EG,y}$ **(t CO_2eq)**	$DA_{initial}$ **(per cent)**	***INDA***	cd_y **(days)**	nd_y **(days)**	DA_y **(per cent)**	$BE_{adj,EG,y1}$ **(t CO_2eq)**
2025 (01/10/2025 – 31/12/2025)	100	10	-	-	-	10	90.00
2026	396.74		0.01	92	365	10.25	356.07
2027	396.74		0.01	92	365	11.25	352.10
2028	396.74		0.01	93	366	12.25	348.12
2029	396.74		0.01	92	365	13.25	344.16
2030 (01/01/2030 – 30/09/2030)	296.74		0.01	92	365	14.00	255.20
2025 (01/10/2025 – 31/12/2025)	100		-	-	-	10	90.00

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