CLEAN DEVELOPMENT MECHANISM

CDM-MP91-A01

Draft Large-scale Methodology

AM00XX: Hydrogen production from electrolysis of water

Version 02.0

Sectoral scope(s): 01 and 05

United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. A request for new methodology "NM0381: Emission reduction by hydrogen production from renewable energy sources", was submitted by China United Hydrogen Technology Research Institute Co., Ltd., Long yuan (Beijing) Carbon Asset Management Technology Co., Ltd. and Shanghai Environment and Energy ExchangeCo., Ltd. on 25 May 2022.

2. The Executive Board of the Clean Development Mechanism (hereinafter referred to as the Board) considered this methodology at its 117th meeting and requested the CDM Methodologies Panel (MP) to work further on the methodology, taking into account the feedback provided by the Board at this meeting and report back at a future meeting including, inter alia:

   (a) Assess how to address greenhouse gas emissions occurring from point of production to point of use of project hydrogen, including cases where hydrogen or ammonia may be exported beyond the national boundaries. In doing so, consider whether emissions leakage should be addressed;

   (b) Include guidance on the baseline based on the use of the hydrogen (i.e. determine the baseline emissions considering which fossil fuels are displaced at the user end due the use of project hydrogen);

   (c) In applying TOOL05 and TOOL07 to determine the applicable emission factor for the use of grid electricity for hydrogen production, consider the temporal issues that may affect the conservativeness of the grid emission factor (e.g. diurnal or seasonal variation of solar and wind energy share in the grid). Alternatively, assess whether specifying option A2 in paragraph 20 of TOOL05 (i.e. default 1.3 tCO_2e/MWh) would be a simpler and conservative option.

2. Purpose

3. The purpose of this document is to address the comments from the Board.

3. Key issues and proposed solutions

4. The following changes were proposed to the draft methodology:

   (a) Introducing two types of consumers of the project hydrogen: existing captive consumers and general consumers;

   (b) Inclusion of equations and methods to calculate baseline emissions for the supply of project hydrogen to the two types of consumers:

      (i) For existing captive consumers, the baseline emission factor is determined based on minimum between default values per technology estimated based

on information in IEA (2023)[1] and an emission factor calculated based on 3-years historical data from the baseline hydrogen plant;

(ii) For general consumers, the baseline emission factor is determined based on the average emissions of the top-20% commercial hydrogen production plants implemented in the previous five years in the host country, or, alternatively, based on the estimated average emission intensity from 2021 to 2030, using the data in IEA (2023) for global hydrogen production.

(c) Inclusion of project emissions from the transportation of hydrogen to existing captive consumers; and

(d) Inclusion of a section containing the non-monitored parameters.

5. The issues raised by the Board are addressed as follows:

(a) The methodology envisages the replacement of baseline hydrogen by the hydrogen produced by the project activity, meaning the baseline and project processes to e.g. compress and transport the hydrogen would be the same; therefore, emissions also are assumed to be the same. One exception is made for the supply of hydrogen to existing captive consumers, where emissions associated with the transportation need to be taken into account in case of incremental distance between the hydrogen production plant and the captive consumer in the project scenario;

(b) As explained above, the scope of the methodology is the replacement of production of hydrogen in the baseline by the hydrogen produced by the project and not the impact at the user end of changing a baseline source for hydrogen; i.e., the methodology assumes that the consumer would have consumed hydrogen produced from another source in the absence of the project;

(c) The Meth Panel considered the temporal issues that may affect the conservativeness of the grid emission factor (e.g. diurnal or seasonal variation of solar and wind energy share in the grid). The assessment found that assuming that intermittent renewable energy generation can not deployed in a complementatry way (considering solar, wind, hydroelectricity and other renewable sources) does not seem to be generally accurate, and as a matter of fact different renewable

[1] International Energy Agency (IEA). (2023). *Towards hydrogen definitions based on their emissions intensity.* Available at https://iea.blob.core.windows.net/assets/acc7a642-e42b-4972-8893-2f03bf0bfa03/Towardshydrogendefinitionsbasedontheiremissionsintensity.pdf, accessed on 05 July 2023.

energy sources are complementary in some countries and regions[2,3,4] . Further, the methodology includes the requirement that electricity consumed from the grid shall represent a maximum of 10% of the electricity consumed from the captive renewable power plant by the electrolyser hydrogen production plant. Therefore, the Meth Panel recommends to make reference to the full TOOL05 in the methodology.

4. Impacts

6. The draft methodology, if approved, will become the first methodology to allow development of Clean Development Mechanism projects producing hydrogen from water electrolysis.

5. Subsequent work and timelines

7. The draft version of the methodology is recommended by the Methodologies Panel (MP) for consideration by the Board at its 117th meeting. No further work is envisaged.

6. Recommendations to the Board

8. The MP recommends that the Board adopt this new methodology, to be made effective at the time of the Board's approval.

[2] In Germany, the *Statistisches Bundesamt* produced a graphic of electricity generation from different sources suing data from 2023 (https://www.destatis.de/EN/Press/2023/03/PE23_090_43312.html) where it illustrates that generation of wind and solar generation are complementary.

[3] BID – Banco Interamericano de Desarrollo. (2019). *La complementariedad de la generación hidroeléctrica con las energías renovables no convencionales y la importancia de la integración regional: La experiencia de Uruguay.* Available at https://publications.iadb.org/publications/spanish/document/La_complementariedad_de_la_generaci%C3%B3n_hidroel%C3%A9ctrica_con_las_energ%C3%ADas_renovables_no_convencionales_y_la_importancia_de_la_integraci%C3%B3n_regional_La_experiencia_de_Uruguay_es.pdf, accessed on 06 July 2023. This publication identified that wind and solar are complementary to hydro generation in Uruguay.

[4] Unidad de Planeación Minero Energética – UPME. (2015). *Integración de las energías renovables no convencionales en Colombia*. Available at https://www1.upme.gov.co/DemandaEnergetica/INTEGRACION_ENERGIAS_RENOVANLES_WEB.pdf, accessed on 06 July 2023. This publication discusses the benefits of the complementarity between wind and hydro sources in Colombia.

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1. Introduction

1. The following table describes the key elements of the methodology:

Table 1. Methodology key elements

Typical projects	Production of hydrogen through electrolysis of water using electricity from a captive renewable power plant only, or a mix of electricity predominantly from a captive renewable plant and residually from the electric grid. The~~, replacing the production of~~ hydrogen ~~through steam reforming of synthesis gas (syngas)~~ produced is supplied either to an existing captive consumer~~from the gasification of coal~~ or general consumers~~steam reforming of natural gas~~.
Type of GHG emissions mitigation action	• Fuel or feedstock switch • Renewable energy

2. Scope, applicability, and entry into force

2.1. Scope

2. The methodology applies~~is applicable~~ to project activities where hydrogen is produced by electrolysis of water~~,~~ and ~~where in the absence of the project activity the hydrogen would be produced through steam reforming of syngas produced by the gasification of coal,~~ is supplied either to existing captive consumers or ~~through steam reforming of natural gas.~~ to general consumers. The electricity consumed by the electrolyser hydrogen production plant shall be sourced from a captive renewable power plant only, or from a mix of electricity predominantly from a captive renewable power plant and residually from the electric grid.

2.2. Applicability

3. This methodology is applicable to project activities that include the construction of a new captive renewable power plant and a new electrolyser hydrogen production plant. Retrofitting, rehabilitation (or refurbishment), replacement or capacity addition of an existing electrolyser hydrogen production plant or of an existing captive renewable power plant are not covered by this methodology.

4. The hydrogen produced by the project activity (hereinafter referred as 'project hydrogen') is supplied either to an existing captive consumer(s) or supplied to general consumers. Existing captive consumers of project hydrogen shall be located in the host country and identified ex-ante in the project design document (PDD). Projects that supply project hydrogen to both captive consumers and general consumers are not eligible under this methodology.

5. The captive renewable power plant shall be wind or solar. Purchase of renewable electricity via renewable electricity certificates are not covered by this methodology.

6. The project activity shall ensure that the ratio between the electricity consumed from the grid ($EC_{PJ,grid,y}$) and the electricity consumed from the captive renewable power plant ($EC_{PJ,captive,y}$) by the electrolyser hydrogen production plant is below 0.1 on an annual

basis. The designated operation entity (DOE) shall confirm that this ratio requirement is met by comparing the data on the electricity consumed from the two sources annually.

7. The project participant shall demonstrate that double counting of emission reductions will not occur, e.g. via a contractual agreement with the consumer of the hydrogen produced. The steps to be taken to avoid double counting shall be documented in the project design document.

8. The methodology is applicable only if the most plausible baseline scenarios identified after applying "TOOL02: Combined tool to identify the baseline scenario and demonstrate additionality" are "P4：Production of hydrogen from the steam reforming of syngas produced from the gasification of coal", "P5: Production of hydrogen from the steam reforming of natural gas" or "P6: Production of hydrogen from the steam reforming of syngas produced from the gasification of oil in general".~~:~~

9. The project shall use no more than 5 per cent of the water available locally, to ensure that the water used in the electrolysis will not compete with other uses.

10. The applicability conditions included in the tools referred to below also apply.

2.3. Entry into force

11. The date of entry into force is the date of the publication of the EB ### meeting report on ## Month 2023.

2.4. Applicability of sectoral scopes

12. Designated operational entities validating and verifying clean development mechanism (CDM) project activities and programmes that use this methodology shall apply sectoral scopes 01 and 05.

3. Normative references

13. This baseline and monitoring methodology is based on the proposed new methodology NM0381 "Emission reduction by hydrogen production from renewable energy sources" by China United Hydrogen Technology ResearchInstitute Co., Ltd., Long yuan (Beijing) Carbon Asset Management Technology Co., Ltd. and Shanghai Environment and Energy ExchangeCo., Ltd.

14. This methodology also refers to the latest approved versions of the following tools:

    (a) "TOOLO1: Tool for the demonstration and assessment of additionality" (hereinafter referred to as TOOL01);

    (b) "TOOL02: Combined tool to identify the baseline scenario and demonstrate additionality" (hereinafter referred to as TOOL02);

    (c) "TOOL03: Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" (hereinafter referred to as TOOL03);

    (d) "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (hereinafter referred to as TOOL05);

    (e) "TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (hereinafter referred to as TOOL08);

(f) "TOOL12: Project and leakage emissions from transportation of freight" (hereinafter referred to as TOOL12).

15. For more information regarding the proposed new methodology and the tools, as well as their consideration by the CDM Executive Board, please refer to <https://cdm.unfccc.int/methodologies/PAmethodologies/pnm/pending> and <https://cdm.unfccc.int/Reference/tools/index.html>, respectively.

3.1. Selected approach from paragraph 48 of the CDM modalities and procedures

16. "Existing actual or historical emissions, as applicable";

17. "Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment"; or

18. "The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category".

4. Definitions

19. The definitions contained in the Glossary of CDM terms shall apply.

20. For the purpose of this methodology, the following definitions apply:

(a) **Existing captive consumer:** an existing facility that consumes hydrogen as a feedstock for an industrial process in the pre-project scenario, and switches to the project hydrogen under the project activity. In the absence of the project activity, the hydrogen consumed by this existing facility would have been produced through steam reforming of syngas produced from the gasification of coal, or from steam reforming of natural gas or of oil. Examples of facilities include, among others, ammonia plants and oil refineries;

(b) **Electrolyser hydrogen production plant:** a facility that produces hydrogen from the electrolysis of water. Under this methodology, the hydrogen production plant includes the desalted water station, electrolytic cell, hydrogen compressor, gas-liquid processor, hydrogen purification unit and other ancillary equipment;

(c) **Gasification of coal:** an industrial process where coal is converted into syngas through a process of gasification;

(d) **General consumer:** consumers other than an existing captive consumer, as described above. This includes greenfield captive consumers and unidentified consumers (e.g. merchant hydrogen);

(e) **Steam reforming of syngas:** an industrial process where the syngas produced from the gasification of coal or oil reacts with steam in the presence of a catalyst to produce hydrogen, carbon monoxide and releases carbon dioxide as a by-product;

(f) **Steam reforming of natural gas:** an industrial process where natural gas reacts with steam in the presence of a catalyst to produce hydrogen, carbon monoxide and releases carbon dioxide as a by-product.

5. Baseline methodology

5.1. Project boundary

21. The spatial extent of the project boundary encompasses:

(a) The electrolyser hydrogen production plant;

(b) The captive renewable power plant;

(c) All power plants/units connected physically to the electric grid to which the hydrogen production plant is connected; and

(d) The existing captive consumer of the project hydrogen, where relevant.

22. The greenhouse gases included in or excluded from the project boundary are shown in Table 2.

Table 2. Emission sources included in or excluded from the project boundary

Source		Gas	Included	Justification/Explanation
Baseline	Emissions from hydrogen production ~~through gasification of coal or steam reforming of natural gas~~	CO_2	Yes	Main emission source
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
Project activity	Emissions from the electricity consumption by the electrolyser hydrogen production plant	CO_2	Yes	Might be an important emission source
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Emissions from the consumption of fossil fuels by the electrolyser hydrogen production plant (e.g. by the desalination plant)	CO_2	Yes	Might be an important emission source
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Emissions from the consumption of fossil fuels to transport the project hydrogen by road	CO_2	Yes	Might be an important emission source
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Emissions from the consumption of electricity to transport the project hydrogen by pipeline	CO_2	Yes	Might be an important emission source
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification

5.2. Identification of the baseline scenario and demonstration of additionality

23. Project participants shall apply the latest approved version of TOOL02 to identify the baseline scenario among all reasonable potential alternative scenarios that could provide similar output/services as the proposed project activity and to demonstrate additionality.

24. In applying Step 1 of TOOL02, baseline alternatives for the production of hydrogen, the project participant shall take into consideration, inter alia, the following alternatives:

(a) P1: The proposed project activity undertaken without being registered as a CDM project activity;

(b) P2: Production of hydrogen through electrolysis of water using electricity from the grid only;

(c) P3: Production of hydrogen through electrolysis of water using electricity from a captive power plant that is neither solar nor wind;

(d) P4: Production of hydrogen from the steam reforming of syngas produced from the gasification of coal;

(e) P5: Production of hydrogen from the steam reforming of natural gas;

(f) P6: Production of hydrogen from the steam reforming of syngas produced from the gasification of oil;

(g) P7: Production of hydrogen as a by-product of industrial processes (e.g. as chlor alkali, coking, steel);

(h) P8: Production of hydrogen from chemical raw materials (e.g. methanol, ethanol, liquid ammonia cracking);

(i) P9: Production of hydrogen from the gasification of biomass;

(j) P10: Production of hydrogen from photochemical process.

5.3. Baseline emissions

5.3.1. Activities supplying the project hydrogen to existing captive consumers

25. The baseline emissions from activities supplying the project hydrogen to existing captive consumers are calculated as the product between the quantity of project ~~based on the~~ hydrogen produced and the emission factor of an existing baseline hydrogen production plant~~from plants built over the most recent five years in the host country~~, as per the equation below.

$$BE_y = M_{H2,PJ,y} \times EF_{H2,BL,captive} \frac{\sum_t M_{H2,t,5-years,y} \times EF_{BL,t,5-years,y}}{\sum_t M_{H2,t,5-years,y}} \quad \text{Equation (1)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2)
$M_{H2,PJ,y}$	=	Mass of pure hydrogen produced by project activity and consumed by existing captive consumers in year *y* (tH_2)
$EF_{H2,BL,captive}$ ~~$EF_{BL,t,5-years,y}$~~	=	Emission factor of the existing baseline hydrogen production plant (tCO_2e/tH_2)~~Baseline emission factor for the production of hydrogen in the host country by hydrogen production plants i in year y built over the most recent five years (tCO2/tH2), excluding registered CDM project activities~~

i	=	Group of most recent hydrogen production plants built over the most recent five years

26. ~~In order to address possible change in~~ The baseline emission factor of the ~~mode of~~ existing baseline hydrogen production plant ($EF_{H2,BL,captive}$)~~over time, the emission intensity of the baseline $EF_{H2,5-years,y}$~~ shall be ~~determined ex-post (annually) using one of the options~~ the minimum between (a) and (b) below:

(a) Use the following values estimated based on IEA (2023)[5]:

(i) 22 tCO_2e/tH_2 if the baseline scenario is the production of hydrogen from coal (scenario P4);

(ii) 10 tCO_2e/tH_2 if the baseline scenario is the production of hydrogen from natural gas (scenario P5) or from oil (scenario P6).

(b) The emission factor determined based on three years historical data of electricity and fossil fuel consumed and hydrogen produced by the existing baseline hydrogen production plant, following the equation below:

$$EF_{H2,BL,captive} = \sum_{t-3}^{t-1} \frac{\left(EC_{H2,BL,t} \times EF_{EF,BL,t}\right) + \left(\sum_i FC_{i,BL,t} \times NCV_i \times EF_{CO2,i}\right)}{M_{H2,BL,t}}$$ Equation (2)

Where:

$EC_{H2,BL,t}$	=	Electricity consumed by the existing baseline hydrogen production plant in year *t* (MWh)
$EF_{EF,BL,t}$	=	Emission factor of the electricity source supplying electricity to the existing baseline hydrogen production plant in year *t* (tCO_2e/MWh)
$FC_{i,BL,t}$	=	Fossil fuel type *i* consumed by the existing baseline hydrogen production plant in year *t* (mass or volume units)
NCV_i	=	Net calorific value of the fossil fuel *i* (GJ/mass or volume units)
$EF_{CO2,i}$	=	CO_2 emission factor of the fossil fuel *i* (tCO_2/GJ)
$M_{H2,BL,t}$	=	Mass of pure hydrogen produced by the existing baseline hydrogen production plant in year *t* (tH_2). Follow provisions and equations from paragraphs 26(a) and 28 below.
t	=	Calendar year of the start date of the project activity

~~(a) Option A: Using the most recent official national data or official data relevant to the region if national data are not published. Data shall include but are not limited to annual hydrogen production by different plants, as well as their processes, quantity and type of energy consumed, as well as year of construction and start date of operation. This is the preferred option;~~

[5] International Energy Agency (IEA). (2023). *Towards hydrogen definitions based on their emissions intensity.* Available at https://iea.blob.core.windows.net/assets/acc7a642-e42b-4972-8893-2f03bf0bfa03/Towardshydrogendefinitionsbasedontheiremissionsintensity.pdf, accessed on 05 July 2023. See pages 9 and 40. For hydrogen produced from oil, the emission factor was conservatively assumed to be equal to the emission factor from the use of natural gas.

~~(b) Option B: Using the emission factors from different hydrogen production technologies published by the International Energy Agency (IEA) or by the International Renewable Energy Agency (IRENA). This option should only be applied if the data to determine Option A are not available. The project participant shall demonstrate that emission factors for respective hydrogen production technologies are conservative in the context of the host country, in particular where hydrogen production plants include water hydrolysis with electricity consumed from the grid.~~

27. If the project activity measures hydrogen production in volume units in standard temperature and pressure (STP), $M_{H2,y}$ is calculated according to the equation below:

$$M_{H2,PJ,y} = \sum_{t=1}^{y} V_{0,t} \times v_{H2,t} \times \frac{2}{22.4} \times 10^{-3}$$ Equation (3)

Where:

$V_{0,t}$	=	The volumetric flow of gas in STP in time interval *t* (Sm^3)
$v_{H2,t}$	=	Volumetric fraction of hydrogen in time interval *t* (m^3H_2/m^3_{gas})
t	=	The time-period of data reading (e.g. minute, hour, month)
22.4	=	Volume of gas in standard conditions (Sm^3/kmol)
2	=	Mass of one mole of hydrogen (kg/kmol)

28. If the project cannot directly monitor the volume of hydrogen under standard conditions, it can be converted through the following formula:

$$V_{0,t} = \frac{V_{H2,t} \times P_{H2,t} \times 273.15}{101{,}325 \times (273.15 + T_{H2,t})}$$ Equation (4)

Where:

$V_{H2,t}$	=	Volumetric flow of hydrogen at operational conditions in the time interval *t* (m^3)
$P_{H2,t}$	=	Pressure of compressed hydrogen in the time interval *t* (Pa)
$T_{H2,t}$	=	Temperature of compressed hydrogen in the time interval *t* (K)

5.3.2. Activities supplying project hydrogen to general consumers

29. The baseline emissions from activities supplying the project hydrogen to general consumers are calculated based on the quantity of project hydrogen produced and a baseline emission factor, as per the equation below.

$$BE_y = M_{H2,PJ,y} \times EF_{H2,BL,general,y}$$ Equation (5)

Where:

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

$M_{H2,PJ,y}$	=	Mass of pure hydrogen produced by project activity in year *y* (tH_2)
$EF_{H2,BL,general,y}$	=	Baseline emission factor for the project hydrogen supplied to general consumers in year *y* (tCO_2/tH_2)

30. $EF_{H2,BL,general,y}$ is be determined by applying one of the two following options:

(a) Option A: The average emission factor of the top-20% performing commercial hydrogen production plants built over the most recent five years in the host country in terms of emissions intensity, including registered CDM project activities, and determined ex-post using the most recent official data from the country or the region if national data are not published. Data shall include but are not limited to annual hydrogen production by different commercial plants, as well as their processes, quantity and type of energy consumed, as well as year of construction and start date of operation. This is the preferred option and it can be applied only if a minimum of three commercial hydrogen production plants are identified built over the most recent five years in the host country. The emission factor is determined based on the equation below:

$$EF_{H2,BL,general,y} = \frac{\sum_i M_{H2,i,5-years,y} \times EF_{BL,i,5-years,y}}{\sum_i M_{H2,i,5-years,y}} \quad \text{Equation (6)}$$

Where:

$M_{H2,i,5-years,y}$	=	Quantity of pure hydrogen produced in the host country by the commercial hydrogen production plants *i* in year *y* built over the most recent five years (tH_2), including registered CDM project activities
$EF_{BL,i,5-years,y}$	=	Emission factor for the production of hydrogen in the host country by commercial hydrogen production plants *i* in year *y* built over the most recent five years (tCO_2/tH_2), including registered CDM project activities
i	=	Top-20% performance in terms of emissions intensity of commercial hydrogen production plants built over the most recent five years (minimum of three plants), inlcuding registered CDM project activities

(b) Option B: Where there have been fewer than three hydrogen plants built over the past five years in the host country or where the data to apply the Option A above is not available, use the equation below derived from estimated average emissions intensity of global hydrogen found in IEA (2023) through to 2030:[5]

$$EF_{H2,BL,general,y} = EF_{H2,avg-global,2021} \times 0.93^{(y-2021)} \quad \text{Equation (7)}$$

Where:

$EF_{H2,avg-global,2021}$	=	Average emissions intensity of global hydrogen production in 2021 (tCO_2/t_{H2}). Apply a value of 12 (IEA, 2023).
y	=	Calendar year of the crediting period

31. The parameter $M_{H2,PJ,y}$ is determined based on paragraphs (a) and 28 above.

5.4. Project emissions

32. Project emissions include the emissions from electricity consumption other than that from the captive renewable power plant, emissions ~~and~~ from any fossil fuel consumed (e.g. by the desalination plant) and emisisons from the incremental transportation of project hydrogen to existing captive consumers, and are calculated as follows:

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{transport,y}$$ Equation (8)

Where:

PE_y	=	Project emissions in year *y* (tCO_2e)
$PE_{EC,y}$	=	Project emissions from the consumption of electricity from sources other than the captive renewable power plant to operate the electrolyser hydrogen production plant in year *y* (tCO_2e). Determined as per TOOL05.
$PE_{FC,y}$	=	Project emissions from the consumption of fossil fuels to operate the electrolyser hydrogen production plant in year *y* (tCO_2e). Determined as per TOOL03.
$PE_{transport,y}$	=	Project emissions due to incremental transportation of hydrogen to existing captive consumers in year *y* (tCO_2e)

5.4.1. Project emissions due to incremental transportation of hydrogen

33. Project emissions due to incremental road and pipeline transportation of project hydrogen ($\boldsymbol{PE_{transport,y}}$) shall be calculated as follows only if the transportation distance between the baseline hydrogen production plant and the existing captive consumer within the host country is shorter than the distane between the project hydrogen production plant and the captive consumer:

$$PE_{transport,y} = PE_{road,y} + PE_{pipeline,y}$$ Equation (9)

Where:

$PE_{road,y}$	=	Project emissions due to incremental road transportation of hydrogen in year *y* (tCO_2e)
$PE_{pipeline,y}$	=	Project emissions due to transportation of hydrogen via pipelines in year *y* (tCO_2e)

34. In case the project hydrogen is transported via road, the project emissions shall be calculated based on the TOOL12, and the parameter $D_{f,m}$ in the tool shall correspond to the difference of the return trip distances between (i) the baseline hydrogen production plant and the existing captive consumer and (ii) the electrolysis hydrogen production plant and the captive consumer.

35. In case the hydrogen is transported using pipelines, project emissions due to operation of pipelines to transport the hydrogen shall be calculated as follows.

$$PE_{pipeline,y} = EC_{H2,pipeline,y} \times EF_y$$ Equation (10)

Where:

$EC_{H2,pipeline,y}$	=	Electricity consumed for operating pipelines that transport the hydrogen in year *y* (MWh)
EF_y	=	Electricity emission factor in year *y* (tCO_2/MWh) determined as per TOOL05

5.5. Leakage

36. No Leakage is considered under this methodology.

5.6. Emission reductions

37. Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \text{Equation (11)}$$

Where:

ER_y	=	Emission reductions in year *y* (tCO_2e)
BE_y	=	Baseline emissions in year *y* (tCO_2e)
PE_y	=	Project emissions in year *y* (tCO_2e)
LE_y	=	Leakage emissions in year *y* (tCO_2e)

6. Monitoring methodology

6.1. Data and parameters not monitored

38. In addition to the parameters listed in the tables below, the~~The~~ provisions on data and parameters not monitored that are contained in the tools referred to in this methodology, and which are needed to calculate emission reductions, apply.

Data / Parameter table 1.

Data / Parameter:	$EC_{H2,BL,t}$
Data unit:	MWh
Description:	Electricity consumed by the existing baseline hydrogen production plant in year *t*
Source of data:	Measured following the provisions of the parameter $EC_{BL,k,y}$ from the TOOL05
Value to be applied	-
Any comment:	Based on the provisions of the parameter $EC_{BL,k,y}$ from the TOOL05

Data / Parameter table 2.

Data / Parameter:	$EF_{EF,BL,t}$
Data unit:	tCO_2e/MWh
Description:	Emission factor of the electricity source supplying electricity to the existing baseline hydrogen production plant in year *t*

Source of data:	Determined following the provisions of the parameter $EF_{EF,k,y}$ from the TOOL05
Value to be applied	-
Any comment:	Based on the provisions of the parameter $EF_{EF,k,y}$ from the TOOL05

Data / Parameter table 3.

Data / Parameter:	$\boldsymbol{FC_{i,BL,t}}$
Data unit:	Mass or volume units
Description:	Fossil fuel type *i* consumed by the existing baseline hydrogen production plant in year *t*
Source of data:	Measured following the provisions of the parameter $FC_{i,j,y}$ from the TOOL03.
Value to be applied	-
Any comment:	Based on the provisions of the parameter $FC_{i,j,y}$ from the TOOL03

Data / Parameter table 4.

Data / Parameter:	$\boldsymbol{NCV_i}$
Data unit:	GJ/mass or volume units
Description:	Net calorific value of the fossil fuel *i*
Source of data:	Determined following the provisions of the parameter $NCV_{i,y}$ from the TOOL03
Value to be applied	-
Any comment:	Based on the provisions of the parameter $NCV_{i,y}$ from the TOOL03

Data / Parameter table 5.

Data / Parameter:	$\boldsymbol{EF_{CO2,i}}$
Data unit:	tCO_2/GJ
Description:	CO_2 emission factor of the fossil fuel *i*
Source of data:	Determined following the provisions of the parameter $EF_{CO2,i,y}$ from the TOOL03
Value to be applied	-
Any comment:	Based on the provisions of the parameter $EF_{CO2,i,y}$ from the TOOL03

Data / Parameter table 6.

Data / Parameter:	$\boldsymbol{M_{H2,BL,t}}$
Data unit:	tH_2
Description:	Mass of pure hydrogen produced by the existing baseline hydrogen production plant in year *t*
Source of data:	Apply provisions and equations from paragraphs (a) and 28
Value to be applied	-
Any comment:	-

6.2. Data and parameters monitored

39. All data collected as part of monitoring should be archived electronically and kept for at least two years after the end of the last crediting period. All of the data in the tables below should be monitored unless otherwise indicated. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards.

40. In addition to~~,~~ the parameters listed in the tables below, the procedures~~provisions on monitoring~~ contained in the tools referred to in this methodology also apply.

Data / Parameter table 7.

Data / Parameter:	$M_{H2,i,5-years,y}$
Data unit:	tH_2
Description:	Quantity of pure hydrogen produced in the host country by the commercial hydrogen production plants *i* in year *y* built over the most recent five years, including~~excluding~~ registered CDM project activities
Source of data:	Official national data, or official data relevant to the region if national data are not published
Measurement procedures (if any):	-
Monitoring frequency:	Annually
QA/QC procedures:	The data should be disaggregated in different production processes *i*.
Any comment:	Data shall include but are not limited to: annual hydrogen production by different plants, as well as their processes, quantity and type of energy consumed, as well as year of construction and start of operation

Data / Parameter table 2.

Data / Parameter:	$EF_{BL,i,5-years,y}$
Data unit:	tCO_2/t_{H2}
Description:	Baseline emission factor for the production of hydrogen in the host country by commercial hydrogen production plants *i* in year *y* built over the most recent five years, including~~excluding~~ registered CDM project activities

Source of data:	~~(a) Option A:~~The emissions intensity of top-20% commercial hydrogen production plants built over the most recent five years in the host country, including registered CDM project activities, and determined ex-post using the most recent official national data or official data relevant to the region if national data are not published. ~~Data shall include but are not limited to: annual hydrogen production by different plants, as well as their processes, quantity and type of energy consumed, as well as year of construction and start date of operation. This is the preferred option;~~ ~~(b) Option B: using the emission factors from different hydrogen production technologies published by IEA or by IRENA.1 This option should only be applied if the data to determine Option A are not available. The project participant shall demonstrate that emission factors for respective hydrogen production technologies are conservative in the context of the host country, in particular where hydrogen production plants include hydrolysis with electricity consumed from the grid.~~
Measurement procedures (if any):	-
Monitoring frequency:	Yearly
QA/QC procedures:	-
Any comment:	Only applicable if a minimum of three hydrogen production plants are identified, and data~~Data~~ shall include but are not limited to~~:~~ annual hydrogen production by different plants, as well as their processes, quantity and type of energy consumed, as well as year of construction and start date of operation

Data / Parameter table 3.

Data / Parameter:	$V_{0,t}$
Data unit:	Sm^3
Description:	The volumetric flow of gas in STP in time interval *t*
Source of data:	As per the TOOL08
Measurement procedures (if any):	As per the TOOL08.
Monitoring frequency:	As per the TOOL08
QA/QC procedures:	As per the TOOL08
Any comment:	Project participants shall specify whether the flow is measured on wet or dry basis and follow the monitoring provisions of the parameters $V_{t,wb}$ or $V_{t,db}$ from TOOL08 accordingly

Data / Parameter table 4.

Data / Parameter:	$v_{H2,t}$
Data unit:	m^3_{H2}/m^3_{gas}
Description:	Volumetric fraction of hydrogen in time interval *t*
Source of data:	As per TOOL08
Measurement procedures (if any):	As per TOOL08
Monitoring frequency:	As per TOOL08

QA/QC procedures:	As per TOOL08
Any comment:	Project participants shall specify whether the flow is measured on wet or dry basis and follow the monitoring provisions of the parameters $v_{t,i,wb}$ or $v_{t,i,db}$ from the TOOL08 accordingly

Data / Parameter table 5.

Data / Parameter:	$V_{H2,t}$
Data unit:	Volumetric flow of the hydrogen at operational conditions in the time interval *t*
Description:	m^3
Source of data:	As per TOOL08
Measurement procedures (if any):	As per TOOL08
Monitoring frequency:	As per TOOL08
QA/QC procedures:	As per TOOL08
Any comment:	Project participants shall specify whether the flow is measured on wet or dry basis and follow the monitoring provisions of the parameters $V_{t,wb}$ or $V_{t,db}$ from the TOOL08 accordingly

Data / Parameter table 6.

Data / Parameter:	$P_{H2,t}$
Data unit:	Pa
Description:	Pressure of the compressed hydrogen in time the interval *t*
Source of data:	As per TOOL08
Measurement procedures (if any):	As per TOOL08
Monitoring frequency:	As per TOOL08
QA/QC procedures:	As per TOOL08
Any comment:	As per TOOL08

Data / Parameter table 7.

Data / Parameter:	$T_{H2,t}$
Data unit:	K
Description:	Temperature of the compressed hydrogen in the time interval *t*
Source of data:	As per TOOL08
Measurement procedures (if any):	As per TOOL08
Monitoring frequency:	As per TOOL08
QA/QC procedures:	As per TOOL08
Any comment:	As per TOOL08

Data / Parameter table 8.

Data / Parameter:	$PE_{EC,y}$
Data unit:	tCO_2e/year

Description:	Project emissions from the consumption of electricity from sources other than the captive renewable power plant (grid electricity) to operate the electrolyser hydrogen production plant in year y
Source of data:	As per TOOL05
Measurement procedures (if any):	As per TOOL05
Monitoring frequency:	As per TOOL05
QA/QC procedures:	As per TOOL05
Any comment:	As per TOOL05

Data / Parameter table 9.

Data / Parameter:	$PE_{FC,y}$
Data unit:	tCO_2e/year
Description:	Project emissions from the consumption of fossil fuels to operate the electrolyser hydrogen production plant in year y
Source of data:	As per TOOL03
Measurement procedures (if any):	As per TOOL03
Monitoring frequency:	As per TOOL03
QA/QC procedures:	As per TOOL03
Any comment:	As per TOOL03

Data / Parameter table 10.

Data / Parameter:	$EC_{PJ,grid,y}$; $EC_{PJ,captive,y}$; $EC_{H2,pipeline,y}$
Data unit:	MWh
Description:	$EC_{PJ,grid,y}$: Electricity consumed by the hydrogen production plant from the grid in year *y* $EC_{PJ,captive,y}$: Electricity consumed by the hydrogen production plant from the captive renewable power plant in year *y* $EC_{H2,pipeline,y}$: Electricity consumed for operating pipelines that transport the hydrogen in year *y*
Source of data:	The monitoring of these parameters shall follow the monitoring of $EC_{PJ,j,y}$ from TOOL05
Measurement procedures (if any):	The monitoring of these parameters shall follow the monitoring of $EC_{PJ,j,y}$ from TOOL05
Monitoring frequency:	The monitoring of these parameters shall follow the monitoring of $EC_{PJ,j,y}$ from TOOL05
QA/QC procedures:	The monitoring of these parameters shall follow the monitoring of $EC_{PJ,j,y}$ from TOOL05
Any comment:	These parameters are used to check the compliance of the project with paragraph 6 of the methodology

Data / Parameter table 101.

Data / Parameter:	$PE_{road,y}$
Data unit:	tCO_2e

Description:	Project emissions due to road transportation of hydrogen in year *y*
Source of data:	As per TOOL12
Measurement procedures (if any):	As per TOOL12
Monitoring frequency:	As per TOOL12
QA/QC procedures:	As per TOOL12
Any comment:	The parmeter $D_{f,m}$ in the tool shall correspond to the difference of the return trip distances between (i) the baseline hydrogen production plant and the existing captive consumer and (ii) the electrolysis hydrogen production plant and the captive consumer

Data / Parameter table 102.

Data / Parameter:	EF_y
Data unit:	tCO_2/MWh
Description:	Electricity emission factor in year *y*
Source of data:	As per TOOL05
Measurement procedures (if any):	As per TOOL05
Monitoring frequency:	As per TOOL05
QA/QC procedures:	As per TOOL05
Any comment:	As per TOOL05

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Document information

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