CLEAN DEVELOPMENT MECHANISM

CDM-MP90-A02

Draft Small-scale Methodology

SSC-III.xx: Hydrogen fuel cell vehicles

Version 03.0

Sectoral scope(s): 07

United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. A request for new methodology "SSC-NM0107: Hydrogen fuel cell logistics truck project in Foshan City" was submitted by Climate Bridge (Shanghai) Ltd in December 2021.

2. Purpose

2. The proposal submits a new methodology applicable to the project activities that aim to introduce hydrogen fuel cell vehicles (HFCVs) replacing baseline fleet vehicles with equivalent capacity.

3. Key issues and proposed solutions

3. The proposed draft methodology is applicable to the project activities introducing HFCVs for passenger and freight transportation. The methodology is applicable only to fleet vehicles such as buses, commuter vans, taxis for public transport, and trucks for freight transport, waste collection or food delivery.

4. The hydrogen consumed by project vehicles shall be: (i) green hydrogen produced by electrolysis of water using renewable electricity; (ii) hydrogen produced by electrolysis of water using grid electricity; or (iii) by-product hydrogen that would have been flared or vented in the absence of the project activity.

5. The use of by-product hydrogen in the project scenario is capped at the maximum annual quantity of the by-product hydrogen that was flared or vented over the three-year period immediately prior to the start of the project activity.

6. The project activity shall provide the same level of service provided on comparable routes by the baseline fleet vehicles.

3.1. Comments from the 116th meeting of the Executive Board

7. The Executive Board of the clean development mechanism (hereinafter referred to as the Board) provided the following comments at its 116th meeting (EB 116) and requested the Methodologies Panel (hereinafter referred to as MP) to further work on the draft revised methodology.

8. **Comment 1: Emissions due to physical leaks of hydrogen to the atmosphere and a plan to minimize physical leaks of hydrogen:** The Board raised concerns over global warming effects of hydrogen specifically due to physical leaks of hydrogen to the atmosphere, acknowledging that hydrogen is not a listed greenhouse gas under the Kyoto Protocol. Further, the Board suggested that the MP consider including a requirement in the methodology to have a plan on minimizing hydrogen leakage from the project activity.

9. **Reply to comment 1:** The MP noted the concern from the Board regarding the hydrogen leaks to the atmosphere from the hydrogen value chain, including production, compression, storage, transportation and use. The MP proposed to include a requirement

for the project participant to demonstrate that it has implemented a plan that ensures minimizing physical leaks of hydrogen. (Refer to data/parameter 17 for further details.) Further, the MP recommended that if a project participant failed to demonstrate full implementation of such a plan, it shall account for project emissions[1] due to physical leaks of hydrogen calculated by multiplying: (i) rated hydrogen consumption of the project vehicles; (ii) annual total distance travelled by project vehicles; (iii) default value of 5 per cent for physical leaks of hydrogen to the atmosphere from project activity; and (iv) global warming potential (GWP) of hydrogen.

10. Regarding the default value for physical leaks of hydrogen to the atmosphere, the MP proposed a conservative default value of 5 per cent of the total consumption by the project vehicels based on a compilation of findings from seven studies included in a study[2] Further, the MP suggests that if a project participant would like to use another value, a request for revision to this methodology may be submitted.

11. Regarding the GWP of hydrogen, the MP noted that the Intergovernmental Panel on Climate Change (IPCC) in its 4th assessment report has referenced a value of 5.8, which is calculated as an indirect 100-year GWP for the tropospheric effects of hydrogen and includes the effects of methane lifetime and tropospheric ozone. Although the MP noted that a few recently published journal papers and studies[3] have mentioned the GWP of hydrogen of up to 11, taking into consideration the impact of hydrogen in the stratosphere (which is not considered in the studies referred to in the IPCC's 4th assessment report). The MP recommended to use the value published by the IPCC as it has been subjected to a rigorous international peer-review process.

12. **Comment 2: Baseline scenario for new routes:** The Board requested the MP to clarify how the composition of the category of baseline fleet vehicles will be determined in case of baseline scenario for new routes.

13. **Reply to comment 2:** The MP noted the concern raised by the Board and agreed to clarify that in case of baseline scenario for new routes, the comparable vehicles refer to the category of baseline fleet vehicles that were sold as new vehicles in a three-year period immediately prior to the start of the project activity and used for the same transportation service in the applicable geographical region. The respective specific fuel consumption (SFC) and specific electricity consumption (SEC) are calculated following the requirements under option B for determination of $SFC_{i,j}$ (refer to data/parameter table 1), or $SEC_{i.EV}$ or $SEC_{i.HV}$ (refer to data/parameter 4). Refer to paragraph 19 of the draft methodology for further details.

14. **Comment 3: Electric vehicles as one of the types of baseline fleet vehicles:** The Board requested the MP to clarify how emission reductions will be achieved by replacing

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[1] This is the first time project emissions due to use of a non-Kyoto gas is considered in a clean development mechansims methodology.

[2] Title of the study: Hydrogen emissions from the hydrogen value chain-emissions profile and impact to global warming, Author: Jasmin Cooper, Luke Dubey, Semra Bakkaloglu, Adam Hawkes, Publication: Science of The Total Environment, Publisher: Elsevier, Date: 15 July 2022.

[3] These journals and studies are available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067144/atmospheric-implications-of-increased-hydrogen-use.pdf; and https://acp.copernicus.org/articles/22/9349/2022/acp-22-9349-2022.pdf

electric vehicles (EVs) by HFCVs as project vehicles, noting that HFCVs will require more electricity than EVs.

15. **Reply to comment 3:** The MP, acknowledging that replacing EVs with HFCVs in many cases may not result in emission reductions, considers that the exclusion of EVs as one of the baseline fleet vehicles could potentially result in a less conservative baseline. This is true in cases where the baseline fleet consists of a mix of fossil fuel vehicles and EVs and if the project participant determines the baseline only considering the fossil fuel vehicles. There is also a possibility that some project participants would perceive the methodology not aplicable where EVs exist in the baseline. Therefore, MP recommends that the calculation for EVs be retianed as one of the types of baseline fleet vehicles. Further, it should be noted that the methodology is not applicable for replacement of EVs which were exclusively using renewable electricity, as there will be no baseline emissions in such cases.

4. Impacts

16. The draft methodology, if approved, will be first methodology that will allow the development of clean development mechanism projects using hydrogen fuel cell technology for transport purposes; such projects have strong relevance for reducing greenhouse gas emissions in this sector.

5. Subsequent work and timelines

17. The draft version of the methodology is recommended by the MP for consideration by the Board at its 117th meeting. No further work is envisaged.

6. Recommendations to the Board

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

TABLE OF CONTENTS **Page**

1. Introduction

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

Table 1. Methodology key elements

Typical project(s)	Operation of hydrogen fuel cell vehicles for providing transportation services
Type of GHG emissions mitigation action	Fuel switch: • Displacement of more GHG-intensive vehicles

2. Scope, applicability and entry into force

2.1. Scope

2. This methodology applies to project activities introducing hydrogen fuel cell vehicles for passenger and freight transportation.

2.2. Applicability

3. Only fleet vehicles are eligible under this methodology. The vehicle categories of baseline fleet vehicles covered by the methodology include, but are not limited to:

(a) Buses, commuter vans or taxis used for public transport;

(b) Trucks for freight transport, food delivery or waste collection.

4. The methodology is applicable to fleet vehicles using the following types of baseline fleet vehicles which are classified per fuel used for their operation:

(a) Fossil fuel-based vehicles;

(b) Electric vehicles;

(c) Hybrid vehicles with electrical and internal combustion motive systems.

5. For replacement of existing baseline fleet vehicles of given categories, the project participants shall demonstrate that the project vehicles would have provided the same level of service on comparable routes as in the baseline scenario. The project participants, using the following approaches, shall demonstrate that the level of service provided by the project and baseline fleet vehicles are comparable:

(a) Project and baseline fleet vehicles belong to the same vehicle category;

(b) The frequency of operations is not decreased by the project activity;

(c) The characteristics of the travel route such as distance, start and end points and the route itself are sufficient to service the level of passenger/freight transport previously provided;

(d) Project and baseline fleet vehicles have comparable passenger or load-carrying capacity with a variation of no more than 20 per cent.

6. The methodology is not applicable to the project activities that involve replacemenrt of electric vehicles that are charged exclusively using renewable electricity as there will be no baseline emissions in such cases.

7. The project participants shall demonstrate that double-counting of emission reductions will not occur, e.g. via a contractual agreement with each relevant counterparty such as hydrogen fuel cell vehicle manufacturer(s), hydrogen fuel cell vehicle owner(s), hydrogen fueling station(s), hydrogen producer(s), renewable energy power plant(s). The project participants shall maintain a comprehensive inventory of project vehicles, including the unique identification of the vehicles. The steps undertaken to avoid double-counting shall be documented in the project design document.

8. Hydrogen consumed by project vehicles shall be one of the following:

   (a) Green hydrogen produced by electrolysis of water using renewable electricity, where the renewable electricity would not have been generated in the baseline scenario, i.e. a dedicated greenfield renewable energy generation plant is built together with the hydrogen production facility to supply electricity to the hydrogen production facility;

   (b) Hydrogen produced by electrolysis of water using grid electricity;

   (c) By-product hydrogen that is generated at a processing plant (e.g. chlor-alkali plant). It shall be demonstrated that such hydrogen would have been flared or vented in the absence of the project activity. Historical measurements of hydrogen flared or vented from the facility which produces by-product hydrogen shall be used to demonstrate that this condition is met.

9. Where by-product hydrogen is used, the quantity of hydrogen permitted for crediting under the project is capped at the maximum annual quantity of by-product hydrogen that was flared or vented by the by-product hydrogen production facility over the three years immediately prior to the start of the project activity.

2.3. Entry into force

10. The date of entry into force is the date of the publication of the EB XX meeting report on dd Month YYYY.

2.4. Applicability of sectoral scopes

11. For validation and verification of clean development mechanism (CDM) projects and programme of activities by a designated operational entity using this methodology, the application of sectoral scope 07 is mandatory.

3. Normative references

12. This methodology is based on the proposed small-scale methodology “SSC-NM107: Emission reduction by hydrogen fuel cell vehicles” submitted by Climate Bridge (Shanghai) Ltd.

13. Project participants shall apply the "General guidelines for SSC CDM methodologies” and the “TOOL21 Demonstration of additionality of small-scale project activities” (hereinafter

referred to as TOOL21) mutatis mutandis.

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

    (a) "ACM0002: Grid-connected electricity generation from renewable sources" (hereinafter referred to as ACM0002);

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

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

    (d) "TOOL19: Demonstration of additionality of microscale project activities" (hereinafter referred to as TOOL19).

4. Definitions

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

16. The following definitions shall apply:

    (a) **By-product hydrogen production facility** – a processing plant (e.g. chlor-alkali plants) which produces hydrogen as a by-product that is used in the project activity;

    (b) **Electric vehicles** – a category of vehicles that is only powered by a battery that is charged externally using an electric plug;

    (c) **Fleet vehicles** – vehicles that are dedicated to transporting passengers or freight by a specific operator, such as logistic vehicles operated by a courier company or public transport buses operated by a transport company;

    (d) **Fossil fuel-based vehicles** – vehicles that use petroleum-based fuels such as gasoline, diesel, compressed natural gas or liquified petroleum gas as a fuel for their internal combustion engine;

    (e) **Green hydrogen** – an energy carrier that is produced by renewable energy-powered electrolysis of water;

    (f) **Hydrogen fuel cell vehicles**[4] – a category of vehicles that uses a propulsion system similar to that of electric vehicles, where energy stored as hydrogen is converted into electricity by a fuel cell;

    (g) **Hydrogen production facility** – a facility that produces hydrogen through electrolysis of water using electricity from a renewable energy source or from a grid;

    (h) **Hybrid vehicles** – a category of vehicles that combines an internal combustion engine and one or more electric motors. The vehicles may or may not have a facility for charging externally using an electric plug.

[4] Also known as fuel cell electric vehicles.

5. Baseline methodology

5.1. Project boundary

17. The project boundary includes:

    (a) The hydrogen fuel cell vehicles that are introduced under the project activity (i.e. project vehicles);

    (b) The geographical boundaries in which the project vehicles are operated;

    (c) The hydrogen production facility, including the facilities where hydrogen is produced as a by-product and vented or flared in absence of the project activity;

    (d) A dedicated greenfield renewable energy power plant(s) that supplies renewable electricity to the hydrogen production facility for green hydrogen production;

    (e) The grid-connected power plants supplying electricity to: (i) the hydrogen production facility in case the hydrogen is produced using grid electricity; (ii) the charging station, including the hydrogen storage facility; and (iii) the pipelines that are used to transport hydrogen to the fueling stations and/or hydrogen storage facility;

    (f) The vehicles and/or a pipeline network used to transport hydrogen to the fueling stations and/or hydrogen storage facility from the hydrogen production facility;

    (g) Auxiliary facilities, such as hydrogen fueling stations, that are used by the project vehicles.

5.2. Baseline

18. The baseline scenario is the operation of the comparable vehicles (the comparability of baseline and project vehicles to be demonstrated as per paragraph 5 above) that would have been used to provide the same transportation service.

19. In the case of application of hydrogen fuel cell vehicles to new route(s), the comparable vehicles refer to the category of the baseline fleet vehicles that were sold as new vehicles in the past three years before the start of the project activity and that would have been used for the same transportation service in the applicable geographical region. In such cases, their specific fuel consumption ($SFC_{i,j}$) or specific electricity consumption ($SEC_{i.EV}$) shall be calculated following the requirements under option B for determination of $SFC_{i,j}$ (refer to data/parameter table 1), or $SEC_{i.EV}$ or $SEC_{i.HV}$ (refer to data/parameter 4).

5.3. Additionality

20. For the specific case of this methodology, additionality is demonstrated using one of the options below:

5.3.1. Option 1

21. Demonstrate that the project activity would not be implemented without the CDM due to the existence of one or more barrier(s) listed in TOOL21. The barrier(s) can be demonstrated for buyers/users and/or charging service providers for the hydrogen fuel cell

vehicles even if the manufacturer or retailer of the hydrogen fuel cell vehicles is implementing the project.

22. In the case that a project involves installation of a dedicated renewable energy plant and a dedicated hydrogen facility, and the project participant chooses to demonstrate the additionality by applying the investment analysis, the total investment for installation of a renewable energy plant shall be considered together with the investment for setting up a hydrogen production facility and hydrogen fueling station, including storage facility.

23. In the case that a project involves the use of by-product hydrogen that would have been vented or flared in the baseline, and the project participant chooses to demonstrate the additionality by applying the investment analysis, the investment required to capture and purify the by-product hydrogen shall be considered together with the investment for setting up a hydrogen fueling station, including storage facility.

5.3.2. Option 2

24. Demonstrate ex-ante that the market penetration of project vehicles is equal to or less than 2.5 per cent of annual sales of the vehicles of the same category (e.g. if project vehicles are hydrogen fuel cell buses, market penetration of hydrogen fuel cell buses is equal to or less than 2.5 per cent of all motorized buses, irrespective of the manufacturer) in the applicable geographical region. To determine the penetration of hydrogen fuel cell vehicles, the “Appendix: Determination of penetration of proposed technology/measure” of TOOL19 shall be followed.

5.4. Baseline emissions

25. Baseline emissions are the sum of emissions from the operation of the fossil fuel-based, electric, and/or hybrid vehicles that are replaced by the project vehicles. The baseline emissions are calculated as follows:

$$BE_y = BE_{FFV,y} + BE_{EV,y} + BE_{HV,y} \quad \text{Equation (1)}$$

Where:

$BE_{FFV,y}$	=	Baseline emissions due to the operation of fossil fuel-based vehicles in year *y* (t CO_2)
$BE_{EV,y}$	=	Baseline emissions due to the operation of electric vehicles in year *y* (t CO_2)
$BE_{HV,y}$	=	Baseline emissions due to the operation of hybrid vehicles in year *y* (t CO_2)

26. Baseline emissions shall be calculated based on the unit of service provided by the project vehicles (distance travelled by the project vehicles) multiplied by the emission factor for the baseline fleet vehicle to provide the same unit of service as per the following

equations.The baseline emissions are calculated separately for each baseline fleet vehicle category *i* depending on the fuel they used for their operation:

(a) In cases of fossil fuel-based vehicles:

$$BE_{FFV,y} = \sum_{i} EF_{BL,km,i,j,y} \times TD_{i,j,y} \times 10^{-6} \quad \text{Equation (2)}$$

Where:

$EF_{BL,km,i,j,y}$	=	Emission factor for baseline fleet vehicle category *i* consuming fossil fuel type *j* in year y (g CO_2/km)
$TD_{i,j,y}$	=	Annual total distance travelled by project vehicles of category *i* that replaced vehicles consuming fossil fuel type *j* in the year *y* (km)

(b) In cases of electric vehicles:

$$BE_{EV,y} = \sum_{i} EF_{BL,km,i,EV,y} \times TD_{i,EV,y} \times 10^{-6} \quad \text{Equation (3)}$$

Where:

$EF_{BL,km,i,EV,y}$	=	Emission factor for baseline fleet vehicle category *i* consuming electricity in year y (g CO_2/km)
$TD_{i,EV,y}$	=	Annual total distance travelled by project vehicles of category *i* that replaced electric vehicles in the year *y* (km)

(c) In cases of hybrid vehicles:

$$BE_{HV,y} = \sum_{i} EF_{BL,km,i,HV,y} \times TD_{i,HV,y} \times 10^{-6} \quad \text{Equation (4)}$$

Where:

$EF_{BL,km,i,HV,y}$	=	Emission factor for baseline fleet vehicle category *i* consuming electricity and /or fossil-fuel in hybrid mode in year y (g CO_2/km)
$TD_{i,HV,y}$	=	Annual total distance travelled by project vehicles of category *i* that replaced hybrid vehicles in the year *y* (km)

27. The emission factor for baseline fleet vehicle category *i* shall be determined ex post as follows:

(a) In cases of fossil fuel-based vehicles:

$$EF_{BL,km,i,j,y} = \sum_{j} \left(SFC_{i,j} \times NCV_{i,j} \times EF_{i,j}\right) \times IR_{i,y}{}^{t+y-1} \quad \text{Equation (5)}$$

Where:

$SFC_{i,j}$	=	Specific fuel consumption of baseline fleet vehicle category *i* consuming fossil fuel type *j* (g/km)
$NCV_{i,j}$	=	Net calorific value of fossil fuel type *j* consumed by baseline fleet vehicle category *i* (J/g)
$EF_{i,j}$	=	Emission factor of fossil fuel type *j* consumed by baseline fleet vehicle category *i* (g CO_2/J)
$IR_{i,y}{}^{t+y-1}$	=	Technology improvement factor for baseline fleet vehicle category *i* in year y
t	=	Time difference (in years) between the year for which data related to SFC, NCV and EF of fossil fuel is available for vehicle category *i* and the start date of the project activity
y	=	Crediting year when emission reductions are estimated

(b) In cases of electric vehicles:

$$EF_{BL,km,i,EV,y} = \sum_{EV} \left(SEC_{i,EV} \times EF_{CO2,ELEC,i}\right) \times IR_{i,y}{}^{t+y-1} \quad \text{Equation (6)}$$

$SEC_{i,EV}$	=	Specific electricity consumption of baseline fleet vehicle category *i* consuming electricity (kWh/km)
$EF_{CO2,ELEC,i}$	=	Emission factor of electricity consumed by baseline fleet vehicle category *i* (g CO_2/kWh)

(c) In cases of hybrid vehicles:

$$EF_{BL,km,i,HV,y} = \sum_{HV} \left[\left(SFC_{i,j} \times NCV_{i,j} \times EF_{i,j}\right) + \left(SEC_{i,HV} \times EF_{CO2,ELEC,i}\right)\right] \times IR_{i,y}{}^{t+y-1} \quad \text{Equation (7)}$$

28. The specific fuel consumption of baseline fleet vehicle category *i* consuming fossil-fuel type *j* ($SFC_{i,j}$) and specific electricity consumption of baseline fleet vehicle category *i* consuming electricity ($SEC_{i,EV}$ and $SEC_{i,HV}$) shall be determined as per the monitoring methodology section below.

5.5. Project emissions

29. Project emissions shall be calculated as follows.

$$PE_y = PE_{elec,y} + PE_{RE,y} + PE_{trans,y} + PE_{H2-leaks,y} \quad \text{Equation (8)}$$

Where:

PE_y	=	Project emissions in year *y* (t CO_2)
$PE_{elec,y}$	=	Project emissions due electricity consumption in year *y* (t CO_2)

$PE_{RE,y}$ = Project emissions due to operation of the renewable energy plants supplying electricity to the hydrogen production facility (t CO_2)

$PE_{trans,y}$ = Project emissions due to transportation and storage of hydrogen to be used in the project activity in year *y* (t CO_2)

$PE_{H2-leaks,y}$ = Project emissions due to physical leaks of hydrogen in the project activity in year *y* (t CO_2)

5.5.1. Project emissions due to electricity consumption

30. Project emissions due to grid electricity consumption for hydrogen production and electricity consumption by the storage facility of hydrogen at the charging/fuel stations are calculated as follows:

$$PE_{elec,y} = PE_{p,y} + PE_{cs,y} \quad \text{Equation (9)}$$

Where:

$PE_{p,y}$ = Project emissions due to grid electricity consumption for hydrogen production in year *y* (t CO_2)

$PE_{cs,y}$ = Project emissions due to electricity consumption for compression and storage of hydrogen at the hydrogen production facility and charging/fuel stations in year *y* (t CO_2)

5.5.1.1. Project emissions due to electricity consumption for hydrogen production

31. The project emissions due to hydrogen production are calculated as follows:

$$PE_{p,y} = EC_{H2,p,y} \times EF_{EL,y} \quad \text{Equation (10)}$$

Where:

$EC_{H2,p,y}$ = Electricity consumption by the green hydrogen production facility in year *y* (MWh)

$EF_{EL,y}$ = Electricity emission factor in year *y* (t CO_2/MWh) determined as per TOOL05

5.5.1.2. Project emissions due to electricity consumption for hydrogen compression and storage

32. The project emissions due to electricity consumption by the hydrogen compression and storage at the hydrogen production facility and charging/fuel stations are calculated as follows:

$$PE_{cs,y} = EC_{H2,cs,y} \times EF_{EL,y} \quad \text{Equation (11)}$$

Where:

$EC_{H2,cs,y}$ = Electricity consumption by the hydrogen compression and storage at the hydrogen production facility and charging/fuel stations in year *y* (MWh)

33. In case the storage facility uses renewable electricity from the dedicated renewable energy plant, the project emissions due to electricity consumption at the storage facility are considered as zero.

5.5.2. Project emissions due to the operation of renewable energy plants

34. In the case of a renewable energy supply from a dedicated renewable energy plant such as a geothermal power plant and/or hydroelectric power plant, project emissions shall include emissions due to the operation of these plants. The project emissions shall be calculated as per the requirements provided under ACM0002.

5.5.3. Project emissions due to transportation of hydrogen

35. Project emissions due to road and pipeline transportation of green hydrogen shall be calculated as follows:

$$PE_{transport,y} = PE_{road,y} + PE_{pipeline,y}$$ Equation (12)

Where:

$PE_{transport,y}$ = Project emissions due to transportation of hydrogen (t CO_2)

$PE_{road,y}$ = Project emissions due to road transportation of hydrogen (t CO_2)

$PE_{pipeline,y}$ = Project emissions due to transportation of hydrogen via pipelines (t CO_2)

36. In case the hydrogen is transported via road, the project emissions shall be calculated as per the requirements provided under TOOL12.

37. In case the hydrogen is transported using pipelines, project emissions due to operation of pipelines to transport the hydrogen to the hydrogen charging/fuel stations shall be calculated as follows.

$$PE_{pipeline,y} = EC_{H2,pipeline,y} \times EF_y$$ Equation (13)

Where:

$EC_{H2,pipeline,y}$ = Electricity consumption for operating pipelines that transport the hydrogen to the hydrogen charging/fuel stations in year *y* (MWh)

EF_y = Electricity emission factor in year *y* (t CO_2/MWh) determined as per TOOL05

5.5.4. Project emissions due to physical leaks of hydrogen

38. The project participant shall document in the project design document a plan to minimize physical leaks of hydrogen in its value chain including production, compression, storage, transportation and use. The monitoring report shall demonstrate the implementation of this plan, which should be verified by the designated operating entity through site visits and/or documentation review.

39. If the project participant failed to demonstrate full implementation of the plan to minimize physical leaks of hydrogen, then the project participant shall calculate the project emissions due to physical leaks of hydrogen from its value chain as follows:

$$PE_{H2-leaks,y} = \sum_{i,j} SHC_i \times \left(TD_{i,j,y} + TD_{i,EV,y} + TD_{i,HV,y}\right) \times 10^{-3} \times PL_{H2} \times GWP_{H2} \quad \text{Equation (14)}$$

Where:

SHC_i	=	Specific hydrogen fuel consumption by project vehicles of category *i* in the year *y* (kg-H_2/km)
PL_{H2}	=	Physical leaks of hydrogen in hydrogen value chain as a percentage of the total consumption
GWP_{H2}	=	Global warming potential of hydrogen (t CO_2/t H_2).

5.6. Leakage

40. No leakage is considered under this methodology.

5.7. Data and parameters not monitored

41. In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

Data / Parameter table 1.

Data / Parameter:	***SFC$_{i,j}$***
Data unit:	g/km
Description:	Specific fuel consumption of baseline fleet vehicle category *i* consuming fossil fuel type *j*
Source of data:	(a) **Option A:** The most recent operational data of the vehicles under baseline operational conditions. The average of at least one year of operational data of the vehicle(s) under baseline operating conditions; or (b) **Option B:** Manufacturer's specification of the top 20 per cent of comparable vehicles operated for passenger/freight transportation in the project region; or (c) **Option C:** Most recent[5] publicly available statistics, such as host country statistics or reports (released by transportation department or other authorities), relevant industry association reports or peer-reviewed literature, values in relevant national standards, Intergovernmental Panel on Climate Change (IPCC)
Any comment:	-

[5] Data that were published no more than three years before the start of the validation of the project activity.

Data / Parameter table 2.

Data / Parameter:	$NCV_{i,j}$
Data unit:	J/g
Description:	Net calorific value of fossil fuel type *j* consumed by baseline fleet vehicle category *i*
Source of data:	The following data sources' latest available data may be used, in order of priority: (a) Values provided by the fuel supplier; (b) Regional or national default values; (c) IPCC default values at the upper limits of the 95 per cent confidence intervals as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Any comment:	-

Data / Parameter table 3.

Data / Parameter:	$EF_{i,j}$
Data unit:	g CO_2/J
Description:	Emission factor of fossil fuel type *j* consumed by baseline fleet vehicle category *i*
Source of data:	The following data sources' latest available data may be used, in order of priority: (a) Values provided by the fuel supplier; (b) Regional or national default values; (c) IPCC default values at the lower limits of the 95 per cent confidence intervals as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Any comment:	In the case of baseline fleet vehicles using fossil fuel blended with bio-diesel, the emission factor of the fossil fuel shall be a weighted average based on the percentage of bio-diesel blended with the fossil fuel.

Data / Parameter table 4.

Data / Parameter:	$SEC_{i,EV}$ **or** $SEC_{i,HV}$
Data unit:	kWh/km
Description:	Specific electricity consumption of baseline fleet vehicle category *i* consuming electricity
Source of data:	(a) **Option A:** The most recent operational data of the vehicles under baseline operational conditions. The average of at least one year of operational data of the vehicle(s) under baseline operating conditions; or (b) **Option B:** Manufacturer's specification of the top 20 per cent of comparable vehicles operated for passenger/freight transportation in the project region; or (c) **Option C:** Most recent[6] publicly available statistics, such as host country statistics or reports (released by transportation department or other authorities), relevant industry association reports or peer-reviewed literature, values in relevant national standards, IPCC
Any comment:	-

Data / Parameter table 5.

Data / Parameter:	$EF_{CO2,ELEC,I}$
Data unit:	g CO_2/kWh
Description:	Emission factor of electricity consumed by baseline fleet vehicle category *i*
Source of data:	Emission factor of electricity consumed by baseline fleet vehicle is determined using one of the following options: (a) If the electricity for charging the baseline fleet vehicle is supplied by renewable power plant, the emission factor is 0; (b) If grid electricity is used, the emission factor can be calculated as per requirements under TOOL05
Any comment:	-

Data / Parameter table 6.

Data / Parameter:	$IR_{i,y}^{t+y-1}$
Data unit:	-
Description:	Technology improvement factor for baseline fleet vehicle category *i* in year *y*
Source of data:	The improvement rate is applied to each calendar year. The default value of the technology improvement factor for all baseline fleet vehicle categories is 0.99.
Any comment:	-

[6] Data that were published no more than three years before the start of the validation of the project activity.

Data / Parameter table 7.

Data / Parameter:	**By-product hydrogen vented or flared in the baseline scenario**
Data unit:	Volume or mass unit
Description:	Maximum annual quantity of the by-product hydrogen that was vented or flared in the baseline scenario
Source of data:	Historical measurements from the by-product hydrogen production facility
Any comment:	The value is fixed at the time of validation and is based on the values of three years immediately prior to the start of the project activity. The quantity of the by-product hydrogen that will be used in the project scenario shall not be more than this value.

Data / Parameter table 8.

Data / Parameter:	$\boldsymbol{GWP_{H2}}$
Data unit:	t CO_2/t H_2
Description:	Global Warming Potential (GWP) of hydrogen
Source of data:	IPCC AR4 WG1 as under chapeter 2.10.3.6
Value to be applied	5.8
Any comment:	The GWP value is calculated as an indirect 100-year GWP.

Data / Parameter table 9.

Data / Parameter:	$\boldsymbol{PL_{H2}}$
Data unit:	Percentage
Description:	Physical leaks of hydrogen from the hydrogen value chain as percentage of the total consumption
Source of data:	A study “Hydrogen emissions from the hydrogen value chain-emissions profile and impact to global warming” by Jasmin Cooper, Luke Dubey, Semra Bakkaloglu, Adam Hawkes, published at “Science of The Total Environment”, by Elsevier B.V. on 15 July 2022.
Value to be applied	5
Any comment:	The project participants may propose another value through a request for revision of this methodology.

6. Monitoring methodology

42. Relevant parameters shall be monitored and recorded during the crediting period as indicated in the section below. The applicable requirements specified in the “General guidelines for SSC CDM methodologies” are also an integral part of the monitoring guidelines specified below and therefore shall be followed by the project participants.

6.1. Data and parameters monitored

Data / Parameter table 10.

Data / Parameter:	**By-product hydrogen used in the project scenario**
Data unit:	Volume or mass unit
Description:	The by-product hydrogen that is used in the project vehicles
Source of data:	Measurements from the hydrogen charging station
Measurement procedures (if any):	Measured using a flow meter
Monitoring frequency:	Continuous monitoring and at least monthly recording
QA/QC procedures:	Cross-checked with the quantity of the by-product hydrogen that was purchased from the project industrial facility
Any comment:	The quantity of the by-product hydrogen that will be used in the project scenario shall not be more than the maximum annual quantity of the by-product hydrogen that was vented or flared in the baseline scenario

Data / Parameter table 11.

Data / Parameter:	$TD_{i,j,y}$ **or** $TD_{i,EV,y}$ **or** $TD_{i,HV,y}$
Data unit:	km
Description:	$TD_{i,j,y}$ – Annual total distance travelled by project vehicles of category *i* that replaced vehicles consuming fossil fuel type *j* in the year *y* $TD_{i,EV,y}$ – Annual total distance travelled by project vehicles of category *i* that replaced electric vehicles in the year *y* $TD_{i,HV,y}$ – Annual total distance travelled by project vehicles of category *i* that replaced hybrid vehicles in the year *y*
Source of data:	Measurement
Measurement procedures (if any):	Monitor travel distance of every vehicle through vehicle odometer or any other appropriate sources (e.g. on-line sources)
Monitoring frequency:	Continuous monitoring and at least monthly recording
QA/QC procedures:	Cross-checked with global positioning system (GPS) data if available
Any comment:	-

Data / Parameter table 12.

Data / Parameter:	$EF_{EL,y}$
Data unit:	t CO_2/MWh
Description:	Electricity emission factor in year y
Source of data:	Determined as per requirements under TOOL05
Measurement procedures (if any):	As per requirements under TOOL05
Monitoring frequency:	As per requirements under TOOL05
QA/QC procedures:	As per requirements under TOOL05
Any comment:	-

Data / Parameter table 13.

Data / Parameter:	$EC_{H2,p,y}$
Data unit:	MWh
Description:	Electricity consumption by the hydrogen production facility in year *y*
Source of data:	Measurement
Measurement procedures (if any):	As per requirements under TOOL05 for parameter $EC_{PJ,j,y}$
Monitoring frequency:	As per requirements under TOOL05 for parameter $EC_{PJ,j,y}$
QA/QC procedures:	As per requirements under TOOL05 for parameter $EC_{PJ,j,y}$
Any comment:	-

Data / Parameter table 14.

Data / Parameter:	$EC_{H2,cs,y}$
Data unit:	MWh
Description:	Electricity consumption by the hydrogen compression and storage facility at the hydrogen charging/fuel stations in year *y*
Source of data:	Measurement
Measurement procedures (if any):	As per requirements under TOOL05 for parameter $EC_{PJ,j,y}$
Monitoring frequency:	As per requirements under TOOL05 for parameter $EC_{PJ,j,y}$
QA/QC procedures:	As per requirements under TOOL05 for parameter $EC_{PJ,j,y}$
Any comment:	-

Data / Parameter table 15.

Data / Parameter:	$EC_{H2,pipeline,y}$
Data unit:	MWh
Description:	Electricity consumption by the pipelines that transport the hydrogen to the hydrogen charging/fuel stations in year *y*
Source of data:	Measurement
Measurement procedures (if any):	As per requirements under TOOL05 for parameter $EC_{PJ,j,y}$
Monitoring frequency:	As per requirements under TOOL05 for parameter $EC_{PJ,j,y}$
QA/QC procedures:	As per requirements under TOOL05 for parameter $EC_{PJ,j,y}$
Any comment:	-

Data / Parameter table 16.

Data / Parameter:	SHC_i
Data unit:	kg-H_2/km
Description:	Specific hydrogen fuel consumption by project vehicles of category *i* in the year *y*
Source of data:	Measurement
Measurement procedures (if any):	-

Monitoring frequency:	Annual
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 17.

Data / Parameter:	**Implementation of hydrogen leak minimization plan**
Data unit:	-
Description:	Implementation of the plan to minimize physical leaks of hydrogen in the hydrogen value chain
Source of data:	Records of the implementation of hydrogen leak minimization plan
Measurement procedures (if any):	The monitoring report shall demonstrate the implementation of this plan, which should be verified by the designated operating entity through site visits and/or documentation review.
Monitoring frequency	-
QA/QC procedures:	-
Any comment:	-

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Document information

Version	*Date*	*Description*
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