Project Design Document Form

Project Design Document Form	
Project Information	
Project Title	Hydrogen Production Project Using Methane Extracted from Biogas (Napier Grass), Rajasthan
Name of the non-obligated entity (legal entity name)	Firstgreen Consulting Private Limited
PDD version number	01
PDD completion date	18/01/2026
Sectoral Scope	Energy Industries – Fuel Production (Hydrogen)
Applied methodologies and tools	BM IN02.002 – Hydrogen production using methane extracted from biogas
Estimated annual emission reductions or net removals over the crediting period (tCO2e/year)	17,423
Date of PDD Submission	09/02/2026
Section 1: Project Description	

A.1. **Title of Project Activity**

Hydrogen Production Project Using Methane Extracted from Biogas Generated from Napier Grass

A.2. **Compliance with minimum project eligibility**

The proposed project activity complies with all minimum eligibility requirements of the Indian Carbon Market (ICM) and is fully consistent with the scope and applicability conditions of Methodology BM IN02.002 – "Hydrogen production using methane extracted from biogas", adopted on 27 March 2025.

The project involves the installation of a biogas purification system to isolate methane from biogas, which is subsequently used for hydrogen production, thereby displacing hydrogen produced using liquefied petroleum gas (LPG) as both feedstock and fuel. The project is implemented by a non obligated entity on a voluntary basis and is not mandated by any law or regulation.

A.2.1. **Regulatory Compliance**

The project activity complies with all applicable national, state, and local regulations, including environmental, safety, and operational requirements. There is no regulatory obligation in India requiring hydrogen production from biogenic methane or mandating the replacement of LPG-based hydrogen production with renewable alternatives.

The project activity is implemented voluntarily and aligns with national decarbonisation and clean energy objectives; however, such policy frameworks are enabling and promotional in nature and do not constitute a binding regulatory requirement. The project therefore satisfies the regulatory compliance criterion under the Indian Carbon Market.

A.2.2. **Project Start Date**

The project start date is defined as the date on which the project participant took an irreversible decision to proceed with the implementation of the project activity, as evidenced by the finalization and formal approval of the Detailed Project Report (DPR) for the project plants. The completion of the DPR represents the point at which the technical design, capacity configuration, financial structure, and implementation plan were conclusively established, thereby committing the project participant to project execution.

Project Start Date: **07/10/2025**

A.2.3. **Sector Scope (s)**

In accordance with Section 2.4 of BM IN02.002, the project activity falls under the mandatory sectoral scope:

Sectoral Scope 02: Industries

The project involves hydrogen production for industrial energy and process applications and therefore meets the sectoral scope applicability requirement for validation and verification under ICM.

A.2.4. **Exclusivity**

The project activity is implemented exclusively under the Indian Carbon Market. The emission reductions achieved by the project will be claimed only under the ICM framework. The project is not registered, and does not intend to be registered, under any other domestic or international carbon crediting mechanisms, including but not limited to Verra (VCS), Gold Standard, or the Clean Development Mechanism (CDM).

A.2.5. **Prevention of Double Counting**

The project participant confirms that:

- The project activity is not registered under any other offset or crediting mechanism.
- Emission reductions generated by the project will be issued, transferred, and retired exclusively within the ICM registry.
- No emission reductions from the project activity will be claimed by any other entity or under any other mechanism.
- The project does not involve the transfer of mitigation outcomes for international purposes.

Robust internal accounting and monitoring systems will be maintained to ensure no double counting of emission reductions, in line with the requirements of the Carbon Credit Trading Scheme.

A.3. **Non-obligated entity**

A.3.1. **Ownership of Project**

The project is wholly owned by Firstgreen Consulting Pvt. Ltd., a legally incorporated entity under the applicable laws of India. The Project Owner holds full ownership of the project assets, including the biogas generation facility, biogas purification system, hydrogen production unit, and associated infrastructure.

All emission reductions generated by the project activity are owned by the Project Owner, subject to issuance under the Indian Carbon Market registry.

A.3.2. **Non-obligated entity**

Firstgreen Consulting Pvt. Ltd. is the non-obligated entity responsible for the implementation of the project activity. The entity is not mandated by any regulation to undertake the project activity and is implementing the project on a voluntary basis. The non-obligated entity confirms that:

- It is not an obligated entity under the CCTS,
- It has not transferred project ownership or emission reduction rights to any other obligated entity, and
- It retains exclusive rights over the emission reductions generated by the project.

A.3.3. **Managing Entity**

The project will be managed by GreenFirst, appointed by the Project Owner. The Managing Entity is responsible for day-to-day project management, operational oversight, and coordination of activities related to biogas production, methane purification, hydrogen production, monitoring, and reporting.

The Managing Entity operates under a contractual arrangement with the Project Owner and does not hold ownership rights over the project or the emission reductions generated.

A.3.4. **Roles and Responsibilities of Participants**

The roles and responsibilities of the key participants involved in the project activity are outlined below:

Project Owner / Non-obligated Entity – Firstgreen Consulting Pvt. Ltd.

- Overall ownership of the project and all associated physical and intangible assets
- Strategic decision-making, financial investment, and long-term project oversight
- Ownership, management, and exclusive rights over the greenhouse gas (GHG) emission reductions generated by the project activity
- Ensuring compliance with the requirements of the Indian Carbon Market (ICM), the Carbon Credit Trading Scheme (CCTS), and all applicable national, state, and local regulations
- Coordination with the Managing Entity, technology providers, and verification bodies to ensure successful implementation and credit issuance

Managing Entity / Operator – GreenFirst

- Day-to-day operation and maintenance of the project facilities, including the biogas plant, methane purification system, and hydrogen production unit
- Implementation of standard operating procedures (SOPs) related to biogas purification, methane handling, and hydrogen production
- Collection, recording, storage, and archiving of monitoring data in accordance with BM IN02.002 and applicable ICM monitoring requirements
- Preparation of operational records and support documentation for validation, verification, and registry processes
- Coordination with technology providers and feedstock suppliers to ensure uninterrupted and efficient project operations

Feedstock Suppliers (Farmers / Aggregators / Farmer Producer Organisations – FPOs)

- Cultivation and supply of Napier grass in accordance with agreed agronomic practices and contractual specifications
- Ensuring timely delivery of feedstock with required quality and quantity parameters
- Compliance with contractual terms related to sustainability, land use, and supply schedules

A.4. **Detailed Description of Project Activity**

A.4.1 **Title**

Hydrogen Production Using Methane Extracted from Biogas Generated from Napier Grass

A.4.2. **Objective and Purpose**

The objective of the project activity is to produce low-carbon hydrogen by utilising methane extracted from biogas generated through anaerobic digestion of Napier grass (Pennisetum purpureum). The project replaces hydrogen production based on liquefied petroleum gas (LPG), which is conventionally used as both feedstock and fuel in hydrogen production units.

The purpose of the project is to:

- Deploy anaerobic digestion and biogas purification technologies to isolate methane from biogas,
- Utilise biogenic methane for hydrogen production, thereby avoiding fossil-based hydrogen generation,
- Reduce greenhouse gas (GHG) emissions by displacing LPG-based hydrogen,

- Promote sustainable biomass utilisation and rural economic development through contract farming of Napier grass.

The project is implemented voluntarily and contributes to India's clean energy and decarbonisation objectives without being mandated by any regulation.

A.4.3. **Project Location**

A.4.3.1. **State**

Rajasthan

A.4.3.2. **City/Town**

Suratgarh and Hanumangarh

A.4.3.3. **District**

Ganganagar District (Suratgarh site), Hanumangarh District (Hanumangarh site)

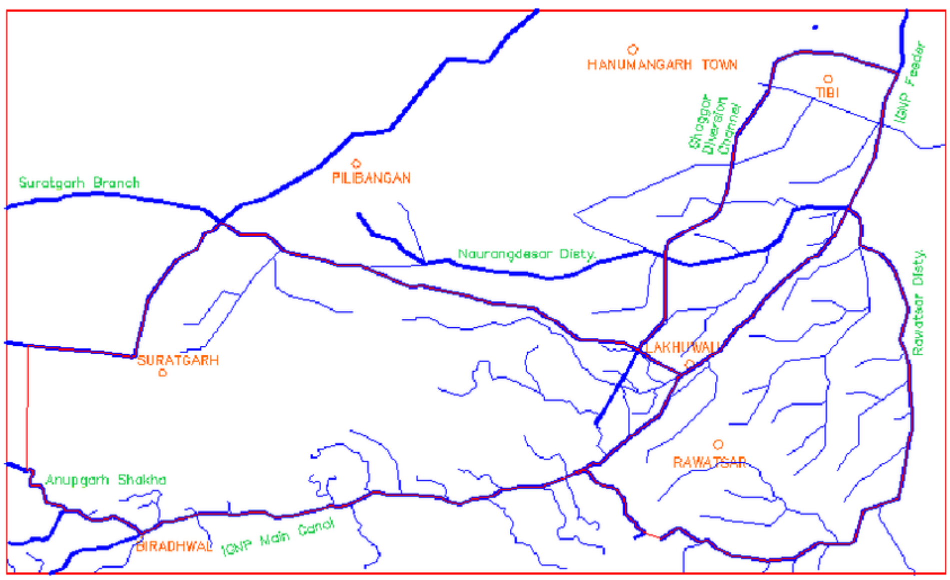
Both districts fall within the canal-irrigated belt served by the Indira Gandhi Canal system, ensuring reliable water availability for Napier grass cultivation.

A.4.3.4. **Geographical Coordinates**

Suratgarh: 29.32° N, 73.90° E

Hanumangarh: 29.58° N, 74.33° E

A.4.3.5. **Local Map**



A.4.4 **Technologies/measures to be employed and/or implemented**

The project activity involves the deployment of a set of integrated technologies and measures to produce hydrogen using methane extracted from biogas generated through anaerobic digestion of Napier grass. The key technologies and measures to be employed are described below.

a) **Feedstock Cultivation and Supply**

Napier grass (Pennisetum purpureum, Co-4 variety) will be cultivated on approximately 500 acres of agricultural land through contract farming and/or leased land arrangements. Napier grass has been selected due to its high biomass yield, favourable bio methanation characteristics, adaptability to local agro-climatic conditions, and non-competition with food crops. Harvesting will be carried out at intervals of approximately 100–120 days to ensure optimal total solids content and biogas yield. Napier grass (Co-4 variety) is ideal for Bio-CNG due to:

- High yield: 150–200 tonnes/acre/year under drip irrigation.
- Biogas potential: 70–80 m³/tonne at 27–35% total solids.

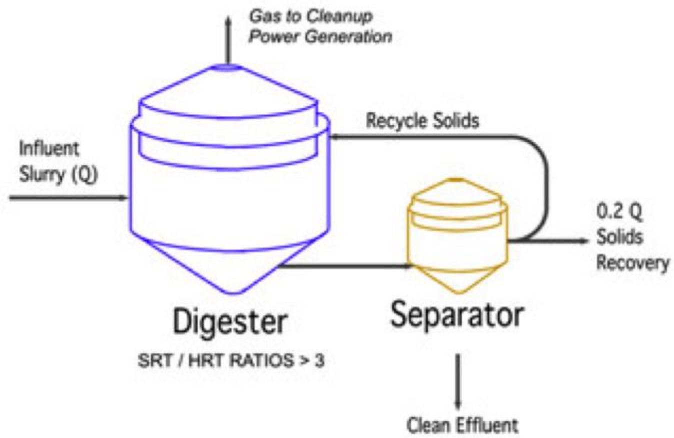
- Low water use: 50% less than lucerne, thriving in saline soils.

b) **Feedstock Preparation System**

Harvested Napier grass will be transported to the project site and processed through a mechanical chopping and handling system to reduce particle size (approximately 2–3 cm). This preparation improves biodegradability and enhances the efficiency and stability of the anaerobic digestion process.

c) **Anaerobic Digestion System**

The prepared feedstock will be processed in a High-Load Reactor (HLR) anaerobic digestion system. The HLR technology is designed for high organic loading rates and reduced hydraulic retention time, enabling efficient biogas generation with lower reactor volume compared to conventional digesters.

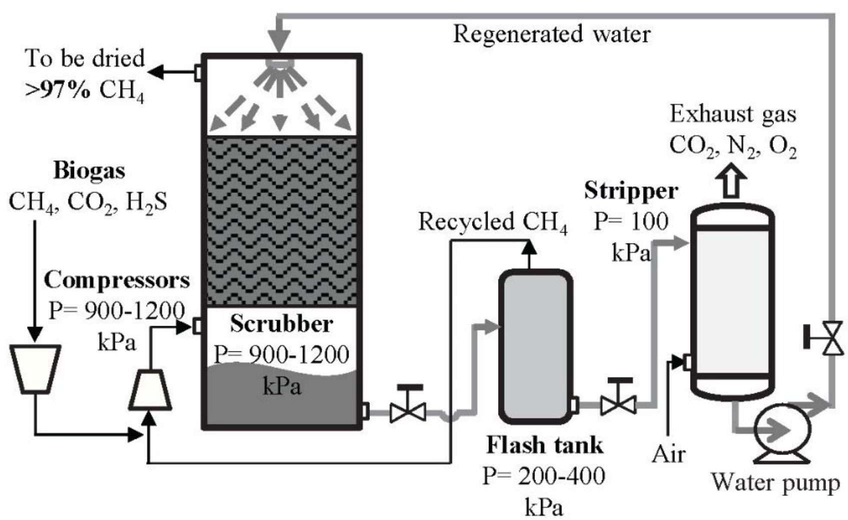


Key features include:

- Controlled thermophilic operating conditions (around 52°C),
- Stable microbial activity and high methane yield,
- Continuous feeding and digestate withdrawal.

The digestion process produces biogas with an average methane concentration of approximately 52%.

d) **Biogas Purification and Methane Isolation System**



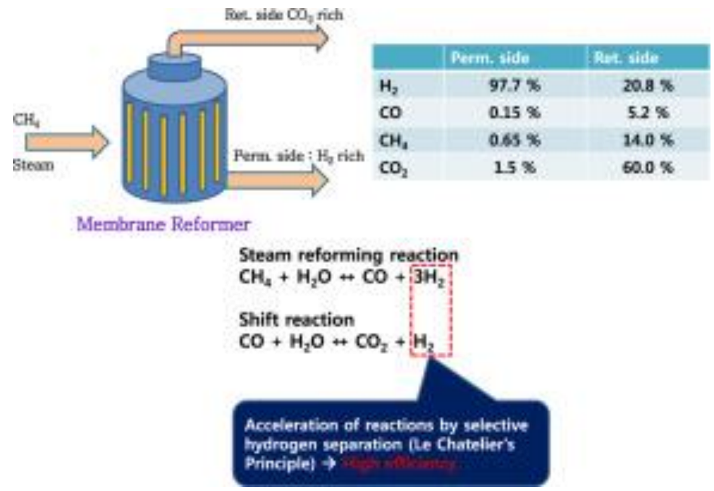
The raw biogas generated in the anaerobic digester will be treated through a biogas purification system comprising:

- Moisture removal and cooling,
- Desulphurisation for hydrogen sulphide removal,
- Gas upgrading using water scrubbing and/or pressure swing adsorption (PSA).

This system isolates methane from biogas to a high purity level suitable for downstream hydrogen production. The purification unit is a core component of the project activity under BM IN02.002.

e) **Hydrogen Production Unit**

The purified methane extracted from biogas will be used as the primary input for a hydrogen production unit installed within the project boundary. The hydrogen production system converts biogenic methane into hydrogen through an appropriate reforming process, replacing hydrogen that would otherwise be produced using liquefied petroleum gas (LPG) as both feedstock and fuel.

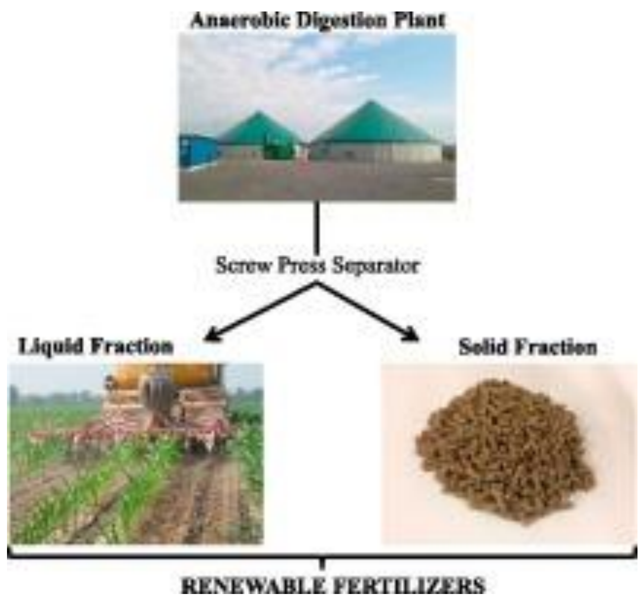


The project configuration includes:

- Dedicated hydrogen production equipment,
- Associated gas handling, control, and safety systems,
- Provision for LPG use only as a standby fuel, where required for operational reliability.

f) **Digestate Handling and Utilisation**

Digestate generated from the anaerobic digestion process will be mechanically separated into solid and liquid fractions. The solid fraction will be processed and utilised as organic fertiliser, while the liquid fraction may be reused for irrigation or recirculated within the process, contributing to resource efficiency and waste minimisation.



g) **Auxiliary Systems and Utilities**

Auxiliary systems include electrical power supply, control and monitoring instrumentation, safety systems, and water management facilities required for stable operation of the digestion, purification, and hydrogen production units.

A.4.5. **Technologies/measures existing prior to the implementation of the project (if applicable)**

Prior to the implementation of the project activity, no biogas generation, biogas purification, methane recovery, or hydrogen production technologies existed at the project site.

The project sites at Suratgarh and Hanumangarh represent greenfield installations, where no facilities for anaerobic digestion, biogas handling, methane isolation, or hydrogen production were in operation prior to the commencement of the project.

In the absence of the project activity, biogenic organic matter in the form of Napier grass would not have been processed for biogas or hydrogen production at the project site, and no renewable methane-based hydrogen production infrastructure would have been established.

Accordingly:

- There is no diversion of biogas from existing thermal, electrical, or chemical uses, and
- No pre-existing technologies relevant to the project activity existed prior to project implementation.

This is fully consistent with the applicability conditions of BM IN02.002, particularly the requirement that the project does not divert biogas already being used for energy generation or other chemical processes.

A.4.6. **Description of how the project activity will achieve GHG emission reductions and/or removals.**

The project activity achieves greenhouse gas (GHG) emission reductions by displacing hydrogen production based on liquefied petroleum gas (LPG) with hydrogen produced using methane extracted from biogas generated through anaerobic digestion of biogenic biomass.

Baseline Scenario

In the absence of the project activity, hydrogen required for industrial and energy-related applications would be produced using LPG as both feedstock and fuel. The baseline hydrogen production process involves:

- Consumption of LPG as a chemical feedstock for hydrogen generation, and
- Combustion of LPG to provide the thermal energy required for the hydrogen production process.

This baseline results in direct fossil CO_2 emissions from both LPG feedstock conversion and LPG combustion.

Project Scenario

Under the project scenario:

- Napier grass is anaerobically digested to produce biogas.
- Methane is isolated from the biogas using a biogas purification system.
- The extracted methane, being of biogenic origin, is used as the primary input for hydrogen production.
- LPG use is avoided except for limited standby or auxiliary purposes, where applicable.

As the carbon contained in the methane originates from recently absorbed atmospheric CO_2 through biomass growth, its use for hydrogen production does not result in net fossil CO_2 emissions.

GHG Emission Reduction Mechanism

The project activity results in GHG emission reductions through the following mechanisms:

1. Avoidance of fossil CO_2 emissions from LPG feedstock

Hydrogen production using biogenic methane avoids CO_2 emissions that would otherwise occur from the use of LPG as a feedstock in the baseline hydrogen production process.

2. Avoidance of fossil CO_2 emissions from LPG combustion

The project avoids combustion of LPG that would have been required to supply thermal energy for baseline hydrogen production.

3. Utilisation of biogenic methane

The methane used for hydrogen production is derived from biogenic organic matter and therefore does not introduce new fossil carbon into the atmosphere.

Project emissions associated with auxiliary electricity consumption and any standby LPG use are accounted for in accordance with the applicable ICM tools and deducted from baseline emissions.

Consistency with Methodology BM IN02.002

The emission reduction approach described above is fully consistent with the scope and applicability of BM IN02.002, as:

- Methane is extracted from biogas and used for hydrogen production,
- Hydrogen produced using LPG as both feedstock and fuel is displaced,
- There is no diversion of biogas from existing productive uses, and
- Hydrogen production through electrolysis is not part of the project activity.

A.4.7. GHG Reduction

A.4.7.1. Explanation on GHG reduction

The GHG emission reductions achieved by the project activity are calculated as the difference between baseline emissions, project emissions, and leakage emissions, in accordance with BM IN02.002 and the applicable ICM tools.

The annual GHG emission reductions are determined using the following equation:

$$ER_y = BE_y - PE_y - LE_y$$

Where:

- ER_y = Net GHG emission reductions in year y (tCO_2e/year)
- BE_y = Baseline emissions in year y (tCO_2e/year)
- PE_y = Project emissions in year y (tCO_2e/year)
- LE_y = Leakage emissions in year y (tCO_2e/year)

Baseline Emissions (BE_Y)

In the baseline scenario, hydrogen is produced using LPG as feedstock and fuel. Baseline emissions therefore comprise:

- CO_2 emissions from LPG used as feedstock, calculated using stoichiometric carbon balance and the CO_2 generation potential per mole of hydrogen produced, as prescribed in BM IN02.002 (Equations 1, 5 and 6); and
- CO_2 emissions from LPG used as fuel for providing thermal energy to the hydrogen production process, calculated using BM IN02.002 (Equation 7).

For the bundled project activity (two identical plants), the total annual baseline emissions are calculated as:

$$BE_y = BE_{LPG,feedstock,y} + BE_{LPG,fuel,y}$$

Based on the methodology-compliant calculations presented in the Baseline Emission Sheet, the total baseline emissions are:

$$BE_y = 18{,}006 \text{ tCO}_2\text{/year}$$

Project Emissions (PE_Y)

Under the project scenario, hydrogen is produced using methane extracted from biogas, which is of biogenic origin. Emissions arising from the use of biogenic methane are not counted as anthropogenic project emissions under the methodology.

Project emissions arise only from grid electricity consumption used for auxiliary equipment such as biogas upgrading, compression, and hydrogen production systems.

Project emissions from electricity consumption are calculated in accordance with BM-T-003 (Scenario A: Electricity consumption from the grid) using the following equation:

$$PE_{EC,y} = EC_{PJ,y} \times EF_{grid,CM,y} \times (1 + TDL_y)$$

Where:

- $EC_{PJ,y}$= Annual electricity consumption (MWh/year)
- $EF_{grid,CM,y}$= Grid combined margin emission factor (tCO_2/MWh)
- TDL_y= Transmission and distribution loss factor

Using DPR-based electricity consumption values and the applicable grid emission factor, total project emissions for the bundled project are:

$$PE_y = 583 \text{ tCO}_2\text{/year}$$

Leakage Emissions (LE_Y)

No leakage emission sources are identified for the project activity, as the project does not cause diversion of existing fuel use or displacement of emissions outside the project boundary. Therefore:

$$LE_y = 0$$

Net GHG Emission Reductions (ER_Y)

Substituting the calculated values into the emission reduction equation:

$$ER_y = 18{,}006 - 583 - 0$$

$$\boxed{ER_y = 17{,}423 \text{ tCO}_2e\text{/year}}$$

Thus, the project activity achieves annual GHG emission reductions of approximately 17,357 tCO_2e, which are measurable, verifiable, and attributable to the displacement of LPG-based hydrogen production by renewable hydrogen produced using methane extracted from biogas.

A.4.7.2. **Justification on how reduction is above Business as usual Scenario**

The greenhouse gas (GHG) emission reductions achieved by the project activity are above the business-as-usual (BAU) scenario, as the project displaces conventional LPG-based hydrogen production, which represents the dominant and most plausible baseline practice in the applicable geographical region.

In the absence of the project activity, hydrogen demand would continue to be met through hydrogen production using LPG as both feedstock and fuel, or through procurement from third-party LPG-based hydrogen suppliers. This BAU scenario is characterised by fossil fuel use and associated CO_2 emissions arising from both chemical conversion and fuel combustion processes.

The project activity deviates from this BAU scenario by introducing hydrogen production using methane extracted from biogas, a renewable and biogenic energy source. Under the project scenario, LPG is fully replaced by biogenic methane for hydrogen production, thereby avoiding fossil CO_2 emissions that would otherwise occur under BAU conditions. As emissions from biogenic methane are not counted as anthropogenic emissions under the applicable methodology, this fuel substitution results in substantial net GHG emission reductions.

The project activity is not mandated by any regulation and is not common practice in the region. Biogas-based hydrogen production involves higher capital investment, technological complexity, and operational risks compared to conventional LPG-based hydrogen systems. In the absence of carbon credits under the Indian Carbon Market, the continuation of LPG-based hydrogen production would remain the most economically attractive option.

Therefore, the GHG emission reductions achieved by the project activity would not occur in the absence of the project, and are clearly additional and above the business-as-usual scenario. The project's emission reductions arise directly from the displacement of fossil-fuel-based hydrogen production with renewable hydrogen derived from biogenic methane, in line with the objectives of the Indian Carbon Market.

A.4.7.3. **Estimated Annual GHG Reduction**

The estimated annual greenhouse gas (GHG) emission reductions from the project activity have been calculated based on the difference between baseline emissions and project emissions. Leakage emissions are considered to be zero.

For the bundled project activity comprising two identical hydrogen production units, the estimated annual emissions are summarised below.

Annual GHG Emissions and Reductions

Baseline Emissions	**Project Emissions**	**Leakage Emissions**	**Net annual GHG emission reductions (tCO_2e/year)**
18,006	**583**	**0**	**17,423**

The annual GHG Emission Reduction is 17,357 tCO_{2e}/year.

A.4.7.4. **Estimated GHG reduction over crediting period**

Year	**Baseline Emissions (tCO_2e)**	**Project Emissions (tCO_2e)**	**Leakage Emissions (tCO_2e)**	**Emission Reductions (tCO_2e)**
1	18,006	583	0	17,423
2	18,006	583	0	17,423
3	18,006	583	0	17,423
4	18,006	583	0	17,423
5	18,006	583	0	17,423
6	18,006	583	0	17,423
7	18,006	583	0	17,423
8	18,006	583	0	17,423
9	18,006	583	0	17,423
10	18,006	583	0	17,423
Total **(10 years)**	1,80,060	5,830	0	**174,230**

Accordingly, the project activity is expected to generate total GHG emission reductions of approximately 174,230 tCO_2e over the ten-year fixed crediting period.

A.4.8. **Project Implementation Timeline**

The project implementation has been planned and executed in a phased manner, covering feedstock development, construction of biogas and hydrogen production facilities, commissioning, and commencement of commercial operations.

Milestone	Description
Project conceptualisation	Identification of project concept, site selection, and feasibility assessment
Feedstock development	Contract farming / land arrangements for Napier grass cultivation
Detailed engineering & procurement	Finalisation of technical design, procurement of anaerobic digestion, biogas upgrading, and hydrogen production equipment
Construction & installation	Civil works, installation of digesters, biogas purification system, hydrogen production unit, and auxiliary infrastructure
Commissioning & trial runs	System integration, testing, and performance stabilisation
Commercial operation date (COD)	Commencement of regular hydrogen production using methane extracted from biogas

The emission reductions are claimed only for the post-registration crediting period in accordance with ICM rules.

A.4.9. **Details of Project Funding**

The project activity is funded through a combination of equity investment by the project owner and debt financing, where applicable. The project involves significant upfront capital expenditure related to biogas production, biogas upgrading, hydrogen production systems, and associated infrastructure.

The financial viability of the project is constrained by higher capital and operational costs compared to conventional LPG-based hydrogen production. Revenues from the sale of carbon credits under the Indian Carbon Market form an important supplementary revenue stream that improves the financial attractiveness of the project and supports long-term operational sustainability.

No public grants or subsidies that would undermine the additionality of the project activity are being claimed for the emission reductions under the Indian Carbon Market.

A.4.10. **Project Bundling (if applicable)**

The project activity is implemented as a bundled project comprising two identical hydrogen production units located at different sites. Each unit operates independently but applies the same technology, feedstock type, capacity, baseline scenario, and monitoring approach.

Emission reductions have been calculated separately for each unit and aggregated at the bundled project level in accordance with Indian Carbon Market requirements. Bundling has been applied solely for administrative and registration efficiency and does not affect the integrity, measurability, or verifiability of emission reductions.

Section II: Project – Crediting Period

B.1. Project Development Cycle

B.1.1. Date on Decision on implementation of Project

The decision to implement the project activity was taken after completion of technical and financial feasibility assessments and confirmation of feedstock availability. The decision was based on the intent to develop a renewable hydrogen production project utilising methane extracted from biogas and to seek registration under the Indian Carbon Market.

Date of decision: 10/06/2025

B.2.2. Project Start Date

The project start date refers to the date on which project implementation planning was formally finalised, including the approval of the Detailed Project Report (DPR), confirmation of site development plans, finalisation of key equipment specifications, and readiness for initiation of construction works for the biogas and hydrogen production facilities.

Project start date: 07/10/2025

B.2.3. Expected Lifetime of the project

The project activity involves infrastructure-intensive assets including anaerobic digesters, biogas upgrading systems, and hydrogen production units. Based on manufacturer specifications and industry practice, the expected operational lifetime of the project is:

Expected project lifetime: 20–25 years

This lifetime exceeds the proposed crediting period.

B.2. Crediting Period

B.2.1. Type of Crediting period opted

The project activity opts for a fixed crediting period of 10 years under the Indian Carbon Market.

B.2.2. Fixed Crediting Period

B.2.2.1. Start date of Crediting Period

Start date of crediting period: *06/07/2027*

B.2.2.2. End Date of Crediting Period

End date of crediting period: *05/07/2037*

B.3.3. Renewable Crediting Period

B.3.3.1. Start date of Crediting Period

Not Applicable as the project activity opts for a fixed crediting period

B.3.3.2. End Date of Crediting Period

Not Applicable as the project activity opts for a fixed crediting period

B.3.3.3. Length of Crediting Period

Not Applicable as the project activity opts for a fixed crediting period

Section III: Methodology

C.1. **Selection of Methodology**

C.1.1. **Details on approved methodology applied**

The project activity applies **BM IN02.002: Hydrogen production using methane extracted from biogas v1.0** approved Indian Carbon Market (ICM) methodology.

This methodology is applicable to project activities that involve the installation of biogas purification systems to isolate methane from biogas for the purpose of hydrogen production, thereby displacing the use of liquefied petroleum gas (LPG) as both feedstock and fuel in a conventional hydrogen production unit.

C.1.2. **Justification of application of methodology**

Methodology Applicability Condition	Project Activity Justification
As per clause 5(a) of Applicability of BM IN02.002 Methodology, A biogas purification system to isolate methane from biogas, which is being flared in the baseline situation for the production of hydrogen displacing liquefied petroleum gas (LPG) as both feedstock and fuel in a hydrogen production unit;	Applicable as the project installs anaerobic digestion and biogas purification systems to extract methane from biogas, which is subsequently used for hydrogen production.
As per clause 5(b) of Applicability of BM IN02.002 Methodology, a biogas purification system in combination with installation of new measures that recover methane from biogenic organic matter from wastewater treatment plant or landfills, using technologies/measures covered in BM WA03.001.	Not Applicable as the project installs anaerobic digestion and biogas purification systems to extract methane from biogas, which is subsequently used for hydrogen production.
As per clause 6 of Applicability of BM IN02.002 Methodology, emission reductions resulting from the installation of methane recovery system shall be calculated as per BM WA03.001	Not applicable. The project does not recover methane from wastewater or landfill sources. Emission reductions are calculated using BM IN02.002 equations relevant to LPG displacement
As per clause 7 of Applicability of BM IN02.002 Methodology, there is no diversion of biogas that is already being used for thermal or electrical energy generation or utilized in any other (chemical) process in the baseline	In the baseline scenario, biogas is not utilised for any productive thermal, electrical, or chemical use. The project does not divert biogas from existing applications.
As per clause 8 of Applicability of BM IN02.002 Methodology, the project activity complies with all local regulations including all safety related measures.	The project complies with all applicable environmental, industrial, and safety regulations, including standards applicable to biogas handling and hydrogen production as per international and national standards
As per clause 9 of Applicability of BM IN02.002 Methodology, this methodology is not applicable to technologies displacing	Not Applicable as the project does not involve hydrogen production through electrolysis.

the production of hydrogen from electrolysis.	Hydrogen is produced exclusively using methane extracted from biogas.
As per clause 11 of BM IN02.002 Methodology, for validation and verification of ICM projects and programme of activities by a designated ACVA using this methodology, application of sectoral scope "02: Industries" is mandatory	As per clause 9 of Applicability of BM IN02.002 Methodology
As per clause 12 of BM IN02.002 Methodology, Application of BM-T-001, BM-T-002, BM-T-003 are relevant.	The project applies BM-T-001 (baseline & additionality) and BM-T-003 (electricity emissions). BM-T-002 is not applicable as no fossil fuel combustion occurs in the project scenario.

C.2. Application of Methodology

C.2.1. Details on application of methodology

The project activity applies the approved Indian Carbon Market (ICM) methodology BM IN02.002: Hydrogen production using methane extracted from biogas to quantify greenhouse gas (GHG) emission reductions achieved through the substitution of fossil LPG with biogenic methane for hydrogen production.

The methodology is applied following the structured sequence prescribed in BM IN02.002, which includes:

1. Identification of the most plausible baseline scenario for hydrogen production;
2. Definition of the project scenario involving hydrogen production using methane extracted from biogas;
3. Quantification of baseline emissions from LPG used as both feedstock and fuel;
4. Quantification of project emissions arising from fossil-based inputs within the project boundary;
5. Determination of net emission reductions as the difference between baseline emissions and project emissions, with no leakage emissions identified.

The methodology is applied consistently to each bundled unit, with emission reductions calculated on a per-unit basis and aggregated at the bundled project level.

C.2.2 Description of baseline scenario

In accordance with BM IN02.002, the baseline scenario corresponds to hydrogen production using liquefied petroleum gas (LPG) as both feedstock and fuel in a conventional hydrogen production unit based on steam reforming and shift conversion reactions.

Under the baseline scenario:

- LPG is used as a chemical feedstock to produce hydrogen, resulting in process-related fossil CO_2 emissions; and
- LPG is combusted to provide the thermal energy required for hydrogen production, resulting in additional fossil CO_2 emissions.

This baseline technology is:

- Technically mature and commercially proven;
- Widely used for small- to medium-scale hydrogen production;
- Supported by established LPG supply chains in the region.

The baseline scenario does not involve renewable or biogenic energy sources and relies entirely on fossil fuel inputs. CO_2 emissions under the baseline increase proportionally with hydrogen output.

C.2.3. **Justification of selection of baseline scenario**

The selection of LPG-based hydrogen production as the baseline scenario is justified in accordance with **BM-T-001** and the baseline identification principles embedded in BM IN02.002.

Identification of Plausible Alternatives

The following alternatives were identified for meeting hydrogen demand:

Alternative	Description
S1	Hydrogen production using LPG as feedstock and fuel
S2	Procurement of hydrogen from third-party fossil-fuel-based producers
S3	Non-implementation of the project with continued reliance on fossil hydrogen

All alternatives are technically feasible and comply with applicable regulations.

Assessment of Most Plausible Baseline

Among the identified alternatives:

- LPG-based hydrogen production represents the most commonly deployed and economically attractive option;
- Fossil-fuel-based hydrogen systems benefit from lower capital requirements and established operational practices;
- Hydrogen production using biogenic methane is not mandated by regulation and is not common practice.

Accordingly, LPG-based hydrogen production is selected as the baseline scenario, as it represents the most realistic and credible counterfactual in the absence of the project activity.

C.2.4. **Description of how emission in project scenario is reduced as compared to baseline**

The project scenario differs fundamentally from the baseline through the replacement of fossil LPG with methane extracted from biogas as both feedstock and fuel for hydrogen production.

Baseline vs Project Scenario Comparison

Aspect	Baseline Scenario	Project Scenario
Hydrogen feedstock	LPG (fossil)	Methane from biogas (biogenic)
Process fuel	LPG	Biogenic methane
Nature of CO_2 emissions	Fossil CO_2	Biogenic CO_2 (not counted)
Electricity use	Not relevant	Grid electricity for auxiliaries

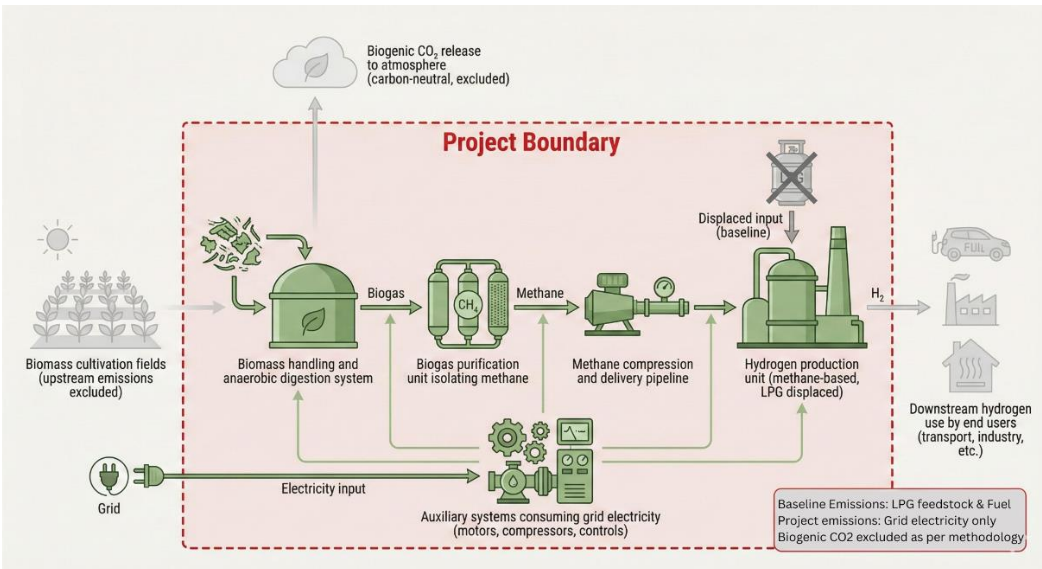
In the project scenario:

- Fossil CO_2 emissions from LPG feedstock conversion are completely avoided;
- Fossil CO_2 emissions from LPG combustion are completely avoided;
- Remaining emissions are limited to indirect emissions from grid electricity consumption.

As CO_2 emissions from biogenic methane are considered carbon-neutral under the methodology, the project results in a substantial net reduction in anthropogenic GHG emissions relative to the baseline scenario.

C.2.5. **Description of Project Boundary**

The project boundary is defined in accordance with BM IN02.002 and encompasses all physical locations and processes relevant to baseline and project emissions.



Included within the Project Boundary

- Biomass handling and anaerobic digestion systems;
- Biogas purification units used to isolate methane;
- Methane compression and delivery systems;
- Hydrogen production units displacing LPG;
- Auxiliary systems consuming grid electricity.

Excluded from the Project Boundary

- Upstream emissions from biomass cultivation;
- Emissions from biogenic CO_2 release;
- Downstream use of hydrogen by end users.

Emission Source	Baseline	Project
LPG feedstock emissions	Included	Not applicable
LPG fuel combustion	Included	Not applicable
Biogenic methane use	Not applicable	Included (biogenic)
Grid electricity	Not applicable	Included
Leakage sources	Not applicable	None

The defined project boundary ensures comprehensive and conservative accounting of all relevant emission sources while remaining consistent with the scope and applicability of BM IN02.002.

C.3 Demonstration of Additionality

The additionality of the project activity is demonstrated in accordance with the approved ICM tool BM-T-001: Combined tool to identify the baseline scenario and demonstrate additionality. The tool is applied to establish that the project activity would not have occurred in the absence of incentives from the Indian Carbon Market, and that the identified emission reductions are additional to the business-as-usual scenario.

The demonstration of additionality follows the steps below:

1. Identification of the baseline scenario (already established in Section C.2);
2. Assessment of regulatory surplus;
3. Barrier analysis;
4. Investment analysis (qualitative);
5. Common practice analysis.

Identification of Baseline Scenario

As established in Section C.2.2 and C.2.3, the baseline scenario corresponds to hydrogen production using LPG as both feedstock and fuel. This scenario represents the most plausible alternative to the project activity and is consistent with prevailing industry practices.

The baseline scenario is:

- Technically feasible;
- Economically attractive;
- Not restricted by regulation.

The project activity therefore requires further assessment to demonstrate additionality.

Regulatory Surplus

The project activity is not mandated by any existing law, regulation, or policy at the national, state, or local level.

There are currently:

- No regulations requiring hydrogen production to be based on biogenic methane;
- No mandates requiring substitution of LPG with renewable methane for hydrogen production;
- No obligations under Indian law that would compel implementation of this project.

Accordingly, the project activity represents a voluntary action and satisfies the regulatory surplus requirement under BM-T-001.

Barrier Analysis

The project activity faces several barriers that would prevent its implementation under business-as-usual conditions.

Technological Barriers

- Hydrogen production using biogenic methane requires integration of anaerobic digestion, biogas purification, and hydrogen production systems, which is technically more complex than conventional LPG-based systems.
- Limited operational experience exists in India for hydrogen production at this scale using biogenic methane.

- Higher risks related to feedstock variability, biogas quality, and system reliability compared to LPG systems.

These barriers discourage adoption of the project technology in the absence of carbon market incentives.

Financial and Economic Barriers

- The project involves significantly higher upfront capital expenditure due to:
    - Anaerobic digesters;
    - Biogas purification units;
    - Methane handling and compression systems.
- Operating costs are higher due to feedstock procurement, handling, and processing.
- LPG-based hydrogen systems benefit from:
    - Lower capital costs;
    - Established fuel supply chains;
    - Lower perceived operational risk.

Without revenues from carbon credits, the project is financially less attractive compared to the baseline scenario.

Institutional and Market Barriers

- Lack of established commercial precedents for biogas-based hydrogen projects in the region.
- Limited availability of skilled operators and service providers.
- Absence of guaranteed price premiums for renewable hydrogen in the local market.

These barriers further reinforce the continuation of LPG-based hydrogen production under BAU conditions.

Investment Analysis

A qualitative investment analysis is applied in accordance with BM-T-001.

The project activity exhibits:

- Higher capital costs than LPG-based hydrogen systems;
- Longer payback periods;
- Higher operational risk due to feedstock dependency.

In addition to the qualitative assessment, a quantitative investment analysis was conducted using project-specific financial data. The analysis demonstrates that without carbon credits, the project achieves an IRR significantly below the benchmark IRR, and is financially unattractive. With inclusion of carbon credit revenues, the project IRR improves, but remains below the benchmark IRR, even under conservative assumptions for carbon pricing and operating performance. Accordingly, the project does not meet expectations without carbon credit support and is therefore considered financially additional. A sensitivity analysis was conducted on carbon credit prices to test the robustness of the investment analysis. The results indicate that the project IRR remains below the benchmark return in the absence of carbon revenues and under low carbon price scenarios. The project becomes financially viable only when carbon prices reach moderate levels, confirming that revenues from emission reductions are decisive for project implementation

Common Practice Analysis

The project activity is **not common practice** in the applicable geographical region.

- Hydrogen production in the region is predominantly fossil-fuel-based (LPG or natural gas).

- Biogenic methane-based hydrogen production projects are extremely limited and not widely replicated.
- Where biogas projects exist, they are typically used for power generation or direct thermal use, not hydrogen production.

Therefore, the project activity clearly deviates from prevailing practices and cannot be considered common practice.

C.4 Addressing non-permanence and risks of reversals

C.4.1 Identification of risk or reversal

The project activity achieves greenhouse gas (GHG) emission reductions through the displacement of fossil LPG with biogenic methane in hydrogen production. As the project does not involve carbon sequestration or long-term carbon storage, risks related to non-permanence and reversals are inherently low.

For the present project activity, potential risks that could affect the continuity of emission reductions include:

- Temporary interruption of biogas or hydrogen production operations;
- Disruption in biomass feedstock supply;
- Technical failure of anaerobic digestion, biogas purification, or hydrogen production systems;
- Regulatory or policy changes affecting project operations.

The project does not involve biological carbon sequestration, land-use change, or long-term carbon storage. Therefore, classical permanence-related reversal risks do not apply.

C.4.2 Reversal risk assessment

Each identified risk has been assessed based on its likelihood and potential impact on issued emission reductions.

Reversal Risk Assessment

Identified Risk	Likelihood	Impact on Issued ERs	Overall Risk
Operational interruption	Low	None (affects only future ERs)	Low
Feedstock supply disruption	Low	None (short-term impact only)	Low
Technology failure	Low	None (temporary loss of production)	Low
Regulatory changes	Low	None (no retroactive impact)	Low

C.4.3 Reversals risk mitigation plan

The project proponent has implemented the following measures to mitigate identified risks and ensure continuity of emission reductions:

Risk Category	Mitigation Measure	Description
Technology risk	Robust technology selection	Deployment of proven and commercially established anaerobic digestion, biogas purification, and hydrogen production technologies with demonstrated operational performance.
Operational risk	Preventive maintenance systems	Implementation of regular inspection, preventive maintenance schedules, and continuous operational monitoring to minimise equipment downtime and ensure stable performance.
Feedstock risk	Feedstock security measures	Long-term feedstock supply arrangements combined with diversification of biomass sources to reduce dependency on any single supplier or feedstock stream.
Management risk	Operational managemen t	Engagement of trained operational personnel supported by documented standard operating procedures (SOPs) for plant operation, maintenance, and safety.
Regulatory risk	Regulatory compliance	Continuous compliance with applicable environmental, safety, and industrial regulations, including periodic reporting and audits, to ensure uninterrupted project operation.

C.4.4 **Remediation of reversals**

In the unlikely event of any disruption affecting project operations:

- Emission reductions would not be claimed for the affected period;
- Monitoring and reporting would transparently reflect reduced or zero emission reductions during the disruption;
- Normal operation would resume only after corrective actions are implemented.

As the project does not generate permanent carbon stocks, no remediation actions such as credit cancellation, replacement, or buffer deductions are required. Issued emission reductions remain valid and unaffected.

Section IV: Estimation of GHG Emission Reduction

D.1. **GHG Emission from Baseline and Project Activity**

D.1.1. **Estimate of GHG emissions**

GHG emission reductions from the project activity are calculated in accordance with the approved Indian Carbon Market methodology BM IN02.002 (Biogas-based Hydrogen Production) and the applicable ICM tools. The emission reductions result from the displacement of LPG-based hydrogen production with hydrogen produced using biogenic methane extracted from biogas, along with consideration of project emissions from auxiliary electricity consumption.

The estimation follows the general equation:

$$\textbf{Emission Reductions (ER)} = \textbf{Baseline Emissions (BE)} - \textbf{Project Emissions (PE)} - \textbf{Leakage Emissions (LE)}$$

The estimation of baseline GHG emissions has been carried out in strict accordance with the approved Indian Carbon Market methodology BM IN02.002 – Biogas-based Hydrogen Production, applying the equations and procedures specified therein. The baseline represents hydrogen production using liquefied petroleum gas (LPG) as both feedstock and fuel, which is displaced by hydrogen produced from biogenic methane extracted from biogas in the project scenario.

Baseline GHG emissions comprise two distinct components:

1. CO_2 emissions from LPG used as **feedstock** for hydrogen production; and
2. CO_2 emissions from LPG used as **fuel** in the hydrogen production reactors.

Each component is estimated separately, following the methodology-prescribed steps described below.

Identification of Baseline Hydrogen Production Quantity

In accordance with BM IN02.002, the baseline hydrogen production corresponds to the quantity of hydrogen that would have been produced using LPG in the absence of the project activity.

The hydrogen production quantity displaced by the project is equal to the hydrogen produced from methane extracted from biogas in the project scenario. This quantity is expressed in molar terms, as required by the methodology.

Determination of LPG Composition

As per Paragraphs 22–24 of BM IN02.002, LPG is assumed to consist of a mixture of propane (C_3H_8) and butane (C_4H_{10}). Based on standard LPG composition used in industrial hydrogen production, the following molar fractions are applied:

- Propane (m_1) = 60%
- Butane (m_2) = 40%

These fractions are used consistently in all subsequent stoichiometric calculations.

Calculation of Hydrogen Production Potential of LPG

The hydrogen production potential per mole of LPG is calculated using Equation (5) of BM IN02.002:

$$R_{H_2/LPG} = \frac{10m_1 + 13m_2}{100}$$

Substituting the LPG composition:

$$R_{H_2/LPG} = \frac{(10 \times 60) + (13 \times 40)}{100}$$

$$R_{H_2/LPG} = \frac{(600 + 520)}{100} = \mathbf{11.2\ kmol\ H_2\ /\ kmol\ LPG}$$

This value represents the molar quantity of hydrogen that would be produced per mole of LPG in the baseline scenario.

Calculation of CO_2 Generation Potential per Mole of Hydrogen

The CO_2 generation potential per mole of hydrogen produced from LPG is calculated using Equation (6) of the methodology:

$$R_{CO_2/H_2} = \frac{3m_1 + 4m_2}{10m_1 + 13m_2}$$

Substituting the LPG composition:

$$R_{CO_2/H_2} = \frac{(3 \times 60) + (4 \times 40)}{(10 \times 60) + (13 \times 40)}$$

$$R_{CO_2/H_2} = \frac{180 + 160}{600 + 520}$$

$$R_{CO_2/H_2} = \mathbf{0.303571\ kmol\ CO_2\ /kmol\ H_2}$$

This factor represents the intrinsic CO_2 formation per mole of hydrogen produced using LPG as feedstock.

Calculation of Baseline CO_2 Emissions from LPG Feedstock

Baseline CO_2 emissions from LPG used as feedstock are calculated using Equation (1) of BM IN02.002:

$$BE_{LPG,FEED} = R_{CO_2/H_2} \times m_{H_2,BIO} \times MW_{CO_2} \times C_1$$

Where:

- $m_{H_2,BIO}$ = molar quantity of hydrogen produced annually from methane extracted from biogas (kmol H_2);
- MW_{CO_2} = 44 kg/kmol;
- C_1 = 0.001 (kg to tonne conversion).

Using the hydrogen production values derived and applying the above equation, baseline emissions from LPG feedstock displacement are calculated as:

BE_(LPG, FEED) **= 8,000.525 tCO_2/year** (per plant)

Calculation of Baseline CO_2 Emissions from LPG Used as Fuel

Baseline CO_2 emissions from LPG combusted as fuel in the hydrogen production reactors are calculated using Equation (7) of BM IN02.002:

$$BE_{LPG,FUEL} = SFC_{LPG} \times V_{H_2,BIO} \times EF_{LPG} \times C_2$$

Where:

- SFC_{LPG} *= specific LPG consumption (kg LPG/Nm^3 H_2);*
- $V_{H_2,BIO}$ *= annual hydrogen volume produced from biogenic methane (Nm^3);*
- EF_{LPG} *= emission factor of LPG (kg CO_2/kg LPG);*
- C_2 *= 0.001 (kg to* tonne conversion).

All parameters are taken from design specifications and methodology defaults. Applying these values yields:

BE_(LPG, FUEL) = **1,002.535 tCO_2/year** (per plant)

Aggregation of Total Baseline Emissions

Total baseline GHG emissions are obtained by summing the feedstock and fuel components, in accordance with Paragraph 17 of BM IN02.002:

$$BE_{TOTAL} = 8{,}000.525 + 1{,}002.535$$

= **9,003.06 tCO_2/year** (per plant)

Application to Bundled Project Activity

The registered project activity comprises two identical Bio-CNG / biogenic methane plants, operating under identical technical and operational conditions.

Therefore, total baseline emissions for the bundled project are calculated as:

$$BE_{TOTAL,BUNDLED} = 9{,}003.06 \times 2 = \mathbf{18,006.12\ \ tCO2/year}$$

D.1.2. **Estimated leakage emissions**

In accordance with the applicable provisions of BM IN02.002, the project activity does not result in any identifiable leakage emissions. The project does not divert biogas or methane from any pre-existing energy or industrial use, nor does it cause displacement of fuels or feedstocks leading to increased emissions outside the project boundary. Upstream emissions associated with biomass cultivation and downstream emissions from hydrogen use are excluded from leakage consideration under the methodology.

Accordingly, no leakage sources are applicable to the project activity, and leakage emissions are conservatively estimated as zero.

Estimated Leakage Emissions **(LE)=0 tCO_2/year**

D.1.3. **Estimated Project emissions**

Project emissions are calculated in accordance with BM-T-003: Tool to calculate project or leakage CO_2 emissions from electricity consumption, as referenced under BM IN02.002.

The project activity does not involve the use of any fossil fuels such as LPG or diesel within the project boundary. Therefore, the only source of project emissions is grid electricity consumption used for auxiliary systems.

Project emissions from electricity consumption are calculated using the standard equation prescribed under BM-T-003:

$$PE_{EC,y} = EC_{PJ,y} \times EF_{Grid,CM,y} \times (1 + TDL)$$

Where:

- $EC_{PJ,y}$= annual electricity consumption (MWh/year)
- $EF_{Grid,CM,y}$= grid emission factor (tCO_2/MWh)
- TDL= transmission and distribution loss factor

Auxiliary electricity consumption: 1,000 kWh/day

Operating days: 330 days/year

Annual electricity consumption: 330 MWh/year

Grid emission factor (EF_Grid, CM,y): 0.82 tCO_2/MWh

Transmission and distribution losses: 20%

Project Emissions Calculation (Single Plant)

$$PE_{EC} = \text{Electricity Consumption} \times EF_{Grid} \times (1 + TDL)$$
$$PE_{EC} = 330 \times 0.736 \times 1.20$$
$$PE_{EC} = \mathbf{291\ tCO_2/year}$$

Project Emissions (Bundled Project – Two Identical Plants)

$$PE_{EC,\ total} = 291 \times 2 = 583\ \mathbf{tCO_2/year}$$

D.1.4. **Estimate of GHG emissions in baseline**

For the bundled project activity comprising two identical Bio-CNG / biogenic methane plants, total baseline emissions are calculated as:

$$BE_{total,\ bundled} = 9{,}003.06 \times 2 = \mathbf{18{,}006.12\ tCO_2/year}$$

D.1.5. **Estimate GHG reduction**

Annual emission reductions are calculated as:

$$\mathbf{ER = BE - PE - LE}$$

$$\mathbf{ER_{annual}} = 18{,}006.12 - 583 - 0$$
$$\mathbf{ER_{annual}} = \mathbf{17{,}423\ tCO_2/year}$$

Section V: Data Parameters Monitoring

E.1. **Data and parameters fixed ex ante**

E.1.1	Data / Parameter:	EF_{LPG}
E.1.2	Description:	CO_2 Emission factor of LPG
E.1.3	Data Unit:	kg-CO_2/kg LPG
E.1.4	Equation(s) Referred:	Equation 7
E.1.5	Purpose of Data	CO_2 emission calculation
E.1.5.1	Baseline/Project/Leakage	Baseline emissions
E.1.5.4	Value (s) Applied	2.987
E.1.5.5	Source of data:	IPCC Default value
E.1.5.6	Measurement procedures (if any):	The emission factor is based on IPCC default value
E.1.5.7	Any comment	Conservative

E.1.1	Data / Parameter:	SFC_{LPG}
E.1.2	Description:	Specific fuel consumption of LPG in the baseline hydrogen production process
E.1.3	Data unit:	kg-LPG/Nm^3-H_2
E.1.4	Equation(s) Referred:	Equation (7)
E.1.5	Purpose of Data:	To calculate baseline CO_2 emissions from LPG used as fuel in the hydrogen production unit

E.1.5.1	Baseline / Project / Leakage:	Baseline
E.1.5.4	Value(s) Applied:	0.025
E.1.5.5	Source of data:	Hydrogen plant design specifications
E.1.5.6	Measurement procedures (if any):	Specific fuel consumption of LPG is based on one of the following options: (c) Manufacturer's specification.
E.1.5.7	Any comment:	NA

E.1.1	Data / Parameter:	$EF_{Grid,CM,y}$
E.1.2	Data unit:	tCO_2/MWh
E.1.3	Description:	Combined margin grid emission factor applicable to the electricity grid supplying the project
E.1.4	Equation(s) Referred:	BM-T-003 Tool
E.1.5	Purpose of Data:	Calculation of project CO_2 emissions arising from electricity consumption
E.1.5.2	Baseline / Project / Leakage:	Project
E.1.5.4	Value(s) Applied:	0.736
E.1.5.5	Source of data:	Central Electricity Authority (CEA)
E.1.5.6	Measurement procedures (if any):	The combined margin grid emission factor is selected based on the latest available values published by the Central Electricity Authority (CEA). The value is fixed ex-ante and applied throughout the crediting period.
E.1.5.7	Any comment:	No comments

E.1.1	Data / Parameter:	TDL
E.1.2	Data unit:	%
E.1.3	Description:	Transmission and distribution loss factor applicable to electricity supplied from the grid
E.1.4	Equation(s) Referred:	BM-T-003
E.1.5	Purpose of Data:	Adjustment of grid electricity consumption to account for transmission and distribution losses when calculating project emissions
E.1.5.2	Baseline / Project / Leakage:	Project
E.1.5.4	Value(s) Applied:	20%
E.1.5.5	Source of data:	Default value
E.1.5.6	Measurement procedures (if any):	The transmission and distribution loss factor is applied as a fixed default value in accordance with BM-T-003 and is not monitored during the crediting period.
E.1.5.7	Any comment:	Not Applicable

E.2. **Data and parameters to be monitored**

E.2.1 Data/parameter

E.2.1	Data / Parameter	V_{H2}, BIO
E.2.2	Description	Volume of hydrogen produced from methane extracted from biogas under normal conditions
E.2.3	Data Unit	Nm^3-H_2
E.2.4	Equations Referred	Equation (7), Equation (8), Equation (11)
E.2.5	Purpose of Data	For Baseline emission calculation

E.2.5.1	Baseline emission/removals	Determination of baseline CO_2 emissions from LPG used as fuel and feedstock displaced by biogenic hydrogen production
E.2.5.2	Project emission/removals	Not applicable
E.2.5.3	Leakage emissions	Not applicable
E.2.6	Value(s) Applied	Monitored ex-post
E.2.7	Source of Data	Hydrogen production unit operational records
E.2.8	Measurement / Calculation Methods and Procedures	Continuous measurement of hydrogen output on a volumetric basis under normal conditions using calibrated flow meters
E.2.9	Entity / Person Responsible for the Measurement	Project Operator / Plant Operations Team
E.2.10	Measuring Instrument(s)	
E.2.10.1	Type	Hydrogen gas flow meter
E.2.10.2	Accuracy	±1–2% of reading
E.2.10.3	Calibration Requirements	Periodic calibration as per manufacturer's specifications and national standards
E.2.10.4	Location	Installed at the outlet of the hydrogen production unit
E.2.11	QA/QC Procedures Applied	Cross-checking of meter readings with production logs; periodic calibration verification; data plausibility checks
E.2.12	Comments / Remarks (if any)	Continuous monitoring ensures accurate determination of displaced baseline hydrogen production

E.2.1	Data / Parameter	m_1
E.2.2	Description	Molar fraction of propane (C_3H_8) in liquefied petroleum gas (LPG)
E.2.3	Data Unit	% (mol/mol)

E.2.4	Equations Referred	Equation (5), Equation (6), Equation (10)
E.2.5	Purpose of Data	For baseline emission calculation
E.2.5.1	Baseline emission/removals	Determination of hydrogen production potential and CO_2 generation potential of LPG in the baseline hydrogen production process
E.2.5.2	Project emission/removals	Not applicable
E.2.5.3	Leakage emissions	Not applicable
E.2.6	Value(s) Applied	60%
E.2.7	Source of Data	Standard LPG composition specifications
E.2.8	Measurement / Calculation Methods and Procedures	Fixed ex-ante value based on standard LPG composition; no ex-post monitoring required
E.2.9	Entity / Person Responsible for the Measurement	Not applicable (fixed parameter)
E.2.10	Measuring Instrument(s)	Not applicable
E.2.10.1	Type	Not applicable
E.2.10.2	Accuracy	Not applicable
E.2.10.3	Calibration Requirements	Not applicable
E.2.10.4	Location	Not applicable
E.2.11	QA/QC Procedures Applied	Consistency check with assumptions and methodology requirements
E.2.12	Comments / Remarks (if any)	Conservative fixed composition applied in line with BM IN02.002

E.2.1	Data / Parameter	m_2
E.2.2	Description	Molar fraction of butane (C_4H_{10}) in liquefied petroleum gas (LPG)
E.2.3	Data Unit	% (mol/mol)
E.2.4	Equations Referred	Equation (5), Equation (6), Equation (10)
E.2.5	Purpose of Data	For baseline emission calculation
E.2.5.1	Baseline emission/removals	Determination of hydrogen production potential and CO_2 generation potential of LPG in the baseline hydrogen production process
E.2.5.2	Project emission/removals	Not applicable
E.2.5.3	Leakage emissions	Not applicable
E.2.6	Value(s) Applied	40%
E.2.7	Source of Data	Standard LPG composition specifications
E.2.8	Measurement / Calculation Methods and Procedures	Fixed ex-ante value based on standard LPG composition; no ex-post monitoring required
E.2.9	Entity / Person Responsible for the Measurement	Not applicable (fixed parameter)
E.2.10	Measuring Instrument(s)	Not applicable
E.2.10.1	Type	Not applicable
E.2.10.2	Accuracy	Not applicable
E.2.10.3	Calibration Requirements	Not applicable
E.2.10.4	Location	Not applicable
E.2.11	QA/QC Procedures Applied	Consistency check with DPR assumptions and methodology requirements
E.2.12	Comments / Remarks (if any)	Conservative fixed composition applied in line with BM IN02.002

E.2.1	Data / Parameter	PE_{elec}
E.2.2	Description	Project CO_2 emissions arising from electricity consumption in year y
E.2.3	Data Unit	tCO_2/year
E.2.4	Equations Referred	BM-T-003
E.2.5	Purpose of Data	For project emission calculation
E.2.5.1	Baseline emission/removals	Not applicable
E.2.5.2	Project emission/removals	Determination of CO_2 emissions resulting from grid electricity consumption for auxiliary systems
E.2.5.3	Leakage emissions	Not applicable
E.2.6	Value(s) Applied	583
E.2.7	Source of Data	Electricity consumption records and grid emission factor data
E.2.8	Measurement / Calculation Methods and Procedures	Calculated using monitored electricity consumption multiplied by the applicable combined margin grid emission factor and adjusted for transmission and distribution losses, in accordance with BM-T-003
E.2.9	Entity / Person Responsible for the Measurement	Project Operator / Plant Operations Team
E.2.10	Measuring Instrument(s)	Electricity energy meter
E.2.10.1	Type	Electronic energy meter
E.2.10.2	Accuracy	As per utility / national standards
E.2.10.3	Calibration Requirements	Periodic calibration as per manufacturer and regulatory requirements
E.2.10.4	Location	Installed at the grid electricity connection point of the project facility
E.2.11	QA/QC Procedures Applied	Cross-verification of meter readings with electricity bills; consistency checks across reporting periods

E.2.12	Comments / Remarks (if any)	Calculated strictly in accordance with BM-T-003

E.3. **Sampling Plan**

The project activity involves continuous metering of key parameters such as hydrogen production volume and electricity consumption. Therefore, statistical sampling is not required for the primary parameters used in the calculation of baseline, project, and leakage emissions.

However, where applicable, a data aggregation and verification approach is adopted to ensure data integrity, completeness, and representativeness

Data Collection and Aggregation Procedure:

- Hydrogen production is measured continuously using calibrated hydrogen flow meters installed at the outlet of the hydrogen production unit.
- Electricity consumption is recorded using electronic energy meters installed at the grid interconnection point.
- Meter readings are recorded at regular intervals (daily/monthly) and aggregated annually for emission calculations.
- Since 100% of relevant data points are captured, sampling is not required to estimate means or totals.

Section VI: Sustainable Development

F.1. **Environment and Social Safeguards (as per A6.4 SD Tool)**

The project activity has been assessed against applicable environmental and social safeguard requirements under the Indian Carbon Market. The project involves the production of hydrogen using methane extracted from biogas derived from renewable biomass and does not involve land-use change, involuntary resettlement, hazardous waste generation, or activities with adverse social impacts.

Key safeguard considerations include:

- Use of non-food, purpose-grown biomass (Napier grass) to avoid competition with food crops.
- Compliance with applicable environmental, safety, and industrial regulations.
- No displacement of local communities or livelihoods.
- Improved waste-to-energy utilization and reduction of fossil fuel dependence.

The project therefore contributes positively to environmental and social outcomes and does not result in any significant adverse impacts.

F.2. **Quantification of Impact due to Project Activity (as per NIF Framework by MoSPI)**

The project contributes to multiple Sustainable Development Goals (SDGs). The project contributes to SDG 7, SDG 8, SDG 12 and SDG 13.

Quantified Sustainable Development Impacts

SDG	SDG Goal Description	SDG Indicator	Quantified Impact	Units /Products
SDG 7	Ensure access to affordable, reliable, sustainable and modern energy for all	7.1 - By 2030, ensure universal access to affordable, reliable and modern energy services	2,396 kg H_2/day (biogenic)	Clean source of energy – Hydrogen production per day
SDG 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.	8.5 - By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	40	Number of jobs created
SDG 12	Responsible Consumption and Production	12.5 - By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	100	Tonnes of Waste reduced through recycling and reuse
SDG 13	Climate Action	13.2 - Total GHG emission reductions per year	17,423 tCO_2	Total GHG Emission Reductions per year

Key Quantified SDG Contributions Explained

SDG 13 – Climate Action

The project delivers measurable climate mitigation benefits by displacing LPG-based hydrogen production with hydrogen produced from biogenic methane.

Total Annual GHG Emission Reductions: **17,423 tCO_2.**

SDG 7 – Affordable and Clean Energy

The project produces renewable hydrogen derived from biomass-based biogas, contributing to diversification of clean energy sources and reduction of fossil fuel dependency. The clean source of energy production through the project:

Hydrogen production per day (biogenic): **2,396 kg**

SDG 8 – Decent Work and Economic Growth

The project generates local employment opportunities in biomass cultivation, plant operation, maintenance, and logistics, supporting rural and semi-urban economic development.

Total Annual jobs created through the project: **40**

SDG 12 – Responsible Consumption and Production

The project supports responsible energy production by improving resource efficiency and reducing waste through reuse and recycling of Napier grass.

Annual tonnes of waste reduced through recycling and reuse: **100**

Section VII: Local Stakeholder Consultation

G.1. Local Stakeholder Consultation

G.1.1. Stakeholder Mapping

The Local stakeholder consultation will be conducted to ensure that stakeholders likely to be affected by the project activity are informed about the project, provided an opportunity to express their views, and have their concerns duly considered during project design and implementation.

The following stakeholders are identified as relevant to the project activity based on proximity, potential impact, and interest:

Stakeholder Category	Description
Local community members	Residents living in and around the project area
Farmers / biomass suppliers	Individuals and groups involved in cultivation and supply of biomass feedstock
Local Panchayat / local administration	Elected representatives and local governance bodies
Project workers	Personnel involved in plant construction and operations
Project developer / operator	Project owner and managing entity representatives

G.1.2. Mode of conducting stakeholder consultation

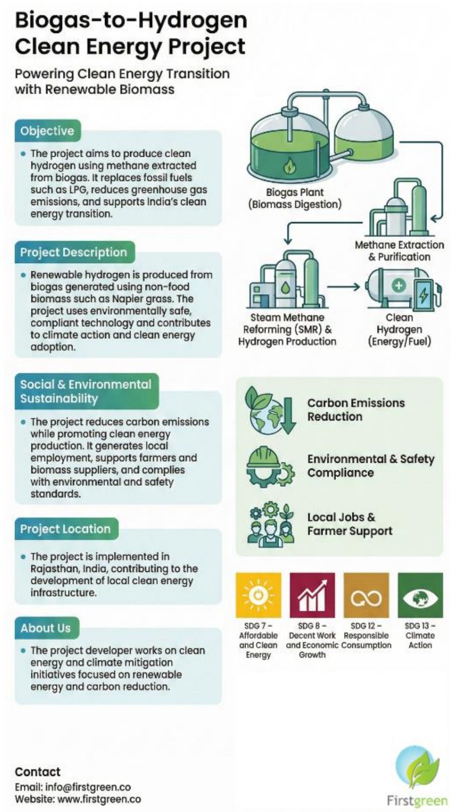
Stakeholder consultation will be conducted through a combination of the following methods:

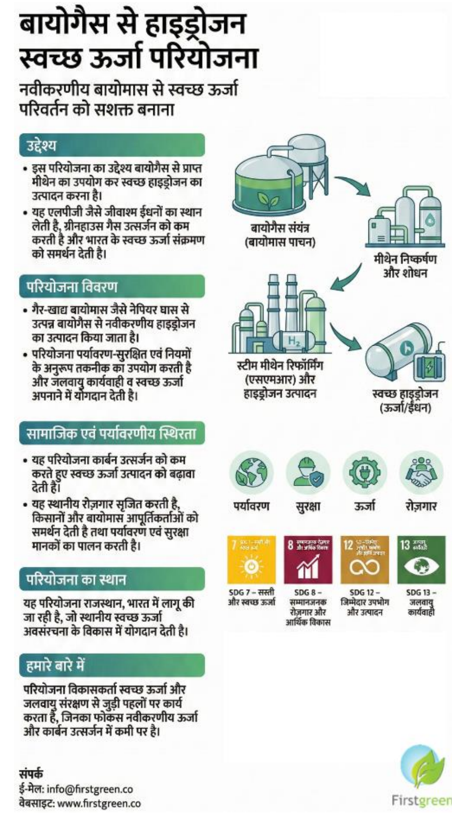
- In-person meetings with local community representatives and farmers
- Group discussions with biomass suppliers and workers
- Informal interactions facilitated by local coordinators

Consultations will be carried out in the local language, ensuring that stakeholders could freely express their views and understand project-related information.

G.1.3. **Details on Consultation**

The Project posters having the details regarding the project will be distributed to relevant stakeholders for better understanding of the project activity.





During the consultation process, stakeholders will be provided with comprehensive and transparent information regarding the project activity. This will include an explanation of the nature and purpose of the project, highlighting its objective to produce clean hydrogen using methane extracted from biogas and its role in supporting clean energy and climate mitigation goals. Stakeholders will also be informed about the type of feedstock to be used, specifically non-food renewable biomass, and the proposed sourcing approach, including local procurement and contractual arrangements with farmers and suppliers.

In addition, the consultation will cover the expected environmental and social impacts of the project, emphasizing the reduction of greenhouse gas emissions, the use of environmentally safe technologies, and compliance with applicable environmental and safety regulations. Information will be shared on employment opportunities and local economic benefits, including potential job creation during construction and operational phases and opportunities for local participation in biomass supply and ancillary services. The safety measures and regulatory compliance framework governing the project will also be explained to address any concerns related to plant operations and community safety.

Stakeholders will be actively encouraged to ask questions, share their views, and provide feedback throughout the consultation. Participation in the consultation process will be voluntary, conducted in an inclusive manner, and no stakeholder will be excluded. All feedback received will be duly noted and considered during project planning and implementation. The feedback form format is provided below:

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Local Stakeholder Consultation – Feedback Form

Hydrogen Production Using Methane Extracted from Biogas

Respondent Details

- **Name of Respondent:** ____________________
- **Gender:** ☐ Male ☐ Female ☐ Other
- **Village / Town:** ____________________
- **District:** ____________________
- **State:** Rajasthan
- **Category of Stakeholder:**
  ☐ Local Resident ☐ Farmer / Biomass Supplier ☐ Worker ☐ Local Representative ☐ Other (specify): ____________________

Stakeholder Feedback

A. General Awareness

Question	Yes	No
Are you aware of the Biogas-to-Hydrogen Clean Energy Project in your area?	☐	☐
Was the project objective explained clearly during the consultation?	☐	☐

B. Social Impact

Question	Yes	No
Do you believe this project will create local employment opportunities?	☐	☐
Will the project support farmers or biomass suppliers in the region?	☐	☐
Do you believe the project will contribute to local economic development?	☐	☐
Do you feel the project will have positive social benefits for the community?	☐	☐

C. Environmental Positive Impact

Question	Yes	No
Do you believe the project will help reduce greenhouse gas emissions?	☐	☐
Do you think the project will contribute to climate change mitigation?	☐	☐
Will the project promote clean and renewable energy in the area?	☐	☐
Do you believe the project will help reduce air pollution?	☐	☐

D. Environmental & Safety Concerns

Question	Yes	No
Do you have any concerns about environmental impacts of the project?	☐	☐
Do you have any concerns related to safety of the project operations?	☐	☐
Do you believe appropriate safety measures have been explained?	☐	☐

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E. Open-Ended Feedback

What is your overall impression of the project?

____

____

What do you like about the project?

____

____

What concerns or suggestions do you have regarding the project?

____

____

Any other comments or feedback:

____

____

Declaration

I confirm that I have participated voluntarily in the stakeholder consultation and that my views have been recorded freely.

Signature / Thumb Impression of Respondent	Signature of Project Representative / Host
____________________	____________________
Date: ____________	Date: ____________

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स्थानीय हितधारक परामर्श – प्रतिक्रिया प्रपत्र (फीडबैक फ़ॉर्म)

बायोगैस से हाइड्रोजन स्वच्छ ऊर्जा परियोजना

प्रतिभागी विवरण

- **प्रतिभागी का नाम:** ____________________
- **लिंग:** □ पुरुष □ महिला □ अन्य
- **ग्राम / कस्बा:** ____________________
- **जिला:** ____________________
- **राज्य:** राजस्थान
- **हितधारक की श्रेणी:** □ स्थानीय निवासी □ किसान / बायोमास आपूर्तिकर्ता □ श्रमिक □ स्थानीय प्रतिनिधि □ अन्य (कृपया उल्लेख करें): ____________

हितधारक प्रतिक्रिया

A. सामान्य जानकारी

प्रश्न	हाँ	नहीं
क्या आप अपने क्षेत्र में बायोगैस से हाइड्रोजन स्वच्छ ऊर्जा परियोजना के बारे में जानते हैं?	□	□
क्या परामर्श के दौरान परियोजना का उद्देश्य स्पष्ट रूप से समझाया गया?	□	□

B. सामाजिक प्रभाव

प्रश्न	हाँ	नहीं
क्या आपको लगता है कि यह परियोजना स्थानीय रोज़गार के अवसर उत्पन्न करेगी?	□	□
क्या यह परियोजना क्षेत्र के किसानों या बायोमास आपूर्तिकर्ताओं को लाभ पहुँचाएगी?	□	□
क्या आपको लगता है कि यह परियोजना स्थानीय आर्थिक विकास में योगदान देगी?	□	□
क्या आपके अनुसार परियोजना से समुदाय को सकारात्मक सामाजिक लाभ होंगे?	□	□

C. पर्यावरणीय सकारात्मक प्रभाव

प्रश्न	हाँ	नहीं
क्या आपको लगता है कि यह परियोजना ग्रीनहाउस गैस उत्सर्जन को कम करने में मदद करेगी?	□	□
क्या यह परियोजना जलवायु परिवर्तन को कम करने में योगदान देगी?	□	□
क्या यह परियोजना क्षेत्र में स्वच्छ और नवीकरणीय ऊर्जा को बढ़ावा देगी?	□	□
क्या आपको लगता है कि इससे वायु प्रदूषण में कमी आएगी?	□	□

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D. पर्यावरण एवं सुरक्षा संबंधी चिंताएँ

प्रश्न	हाँ	नहीं
क्या आपको परियोजना से संबंधित किसी पर्यावरणीय प्रभाव को लेकर कोई चिंता है?	□	□
क्या आपको परियोजना के संचालन की सुरक्षा को लेकर कोई चिंता है?	□	□
क्या आपको लगता है कि सुरक्षा उपायों की जानकारी पर्याप्त रूप से दी गई है?	□	□

E. खुले सुझाव / प्रतिक्रिया

परियोजना के बारे में आपकी समग्र राय:

____

____

परियोजना के कौन-से पहलू आपको अच्छे लगे?

____

____

परियोजना से संबंधित आपकी कोई चिंता या सुझाव:

____

____

कोई अन्य टिप्पणी / सुझाव:

____

____

घोषणा

मैं पुष्टि करता/करती हूँ कि मैंने इस परामर्श प्रक्रिया में स्वेच्छा से भाग लिया है और मेरी राय स्वतंत्र रूप से दर्ज की गई है।

प्रतिभागी के हस्ताक्षर / अंगूठे का निशान	परियोजना प्रतिनिधि के हस्ताक्षर
____________________	____________________
तिथि: ____________	तिथि: ____________

G.1.4. Summary of comments

This section will be updated after the Local Stakeholder Consultation Meeting.

G.1.5. Summary on how comments are addressed

This section will be updated after the Local Stakeholder Consultation Meeting.