Gold Standard for the Global Goals

METHODOLOGY

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GREEN HYDROGEN PRODUCTION

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SUMMARY

This methodology is applicable to activities that reduce or avoid greenhouse gas (GHG)-emissions from hydrogen production by replacing fossil-fuel-intensive conventional processes with low-carbon alternatives. It applies to newly built (greenfield) or retrofitted (brownfield) industrial facilities that produce green hydrogen via water electrolysis, powered exclusively or primarily by renewable electricity. The methodology quantifies emission reductions through the direct measurement (metering) of the electricity consumed and the exact volume of green hydrogen produced and verifiably dispatched to eligible end-uses.

Key methodological components:

- **Baseline Setting**: Utilises Best Available Technology (BAT) benchmarks to ensure emission reductions are measured conservatively against modern, highly efficient conventional plants.
- **Additionality & Lock-in Risk**: Incorporating rigorous assessments to ensure activities demonstrate an ongoing financial need for carbon revenue and actively avoid creating long-term infrastructural dependencies on fossil fuels.
- **Emissions Accounting:** Includes accounting for activity emissions from electricity and fuel use, water treatment and pumping, and fugitive hydrogen leaks. The methodology also addresses leakage from embodied infrastructure emissions, land-use change, transferred baseline equipment, and resource competition.

- **Water Use and Environmental Safeguards:** Requires non-potable water prioritisation, hydrological risk assessment, regulatory approvals, brine and discharge management, and safeguards to avoid adverse impacts on local communities, ecosystems, and competing users.
- **Encouraging Ambition over Time**: Application of a Downward Adjustment Factor (DAF) to progressively lower the crediting baseline, automatically aligning the activity's ambition with the host country's evolving Net-Zero targets.

ACKNOWLEDGEMENTS

This methodology was developed by Gold Standard with the invaluable guidance of experts and key stakeholders. We would like to specifically acknowledge the contributions of our expert reviewers, including the Methodology Expert Group (MEG) and the Technical Advisory Committee (TAC) members.

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1| KEY INFORMATION

1.1.1 | The following table describes the key information for the application of this methodology.

Table 1. Key information

Term	Description
Activity summary	The activity involves the production of green hydrogen exclusively for eligible end-uses, replacing conventional, fossil-fuel-intensive hydrogen production. The activity produces hydrogen via water electrolysis. The production process shall be powered entirely or predominantly by renewable electricity. Emission reductions shall be quantified through the direct measurement (metering) of the electricity consumed and the exact volume of green hydrogen produced, measured against a Best Available Technology (BAT) baseline and adjusted downwards over time.
Mitigation activity type	☒ Emission reductions
Applicable activity scale	☒ Micro scale (≤10,000 tCO_2e per year) ☒ Small scale (≤60,000 tCO_2e per year) ☒ Large scale (>60,000 tCO_2e per year)
Sectoral scope	Sectoral Scope 1 (Energy Industries); Sectoral Scope 5 (Chemical Industries)
Activity Requirement	Energy Systems and Efficiency (ESE) Activity Requirements [Under Consultation]
Activity start date	The start date shall be the earliest date on which the activity developer has committed to expenditures related to the implementation, equipment procurement, or construction of the proposed activity
Crediting Period start date	The start date of the crediting period shall be the date of the start of commercial production of green hydrogen, or a maximum of two years prior to the date of design certification, whichever occurs later.
Crediting period length	Five years, renewable twice (maximum 15 years). If any legal mandate requiring the activity comes into force (and is enforced), the activity can be credited only until the date the legal requirements take effect.
Geographical applicability	Global

Limitations	The methodology strictly restricts crediting to hydrogen dispatched for eligible end-uses that do not prolong fossil fuel reliance. The methodology strictly excludes hydrogen produced using fossil fuels (e.g., Steam Methane Reforming or coal gasification). This includes "blue" hydrogen equipped with Carbon Capture and Storage (CCS) or Carbon Capture and Utilisation (CCU). Hydrogen derived from the gasification or pyrolysis of biomass or waste feedstocks is also excluded.

2| DEFINITIONS

2.1.1 | The definition listed in the GS4GG Glossary, shall apply in addition to those listed below:

Table 2. Terms and definitions

Term	Definition
Best Available Technology (BAT)	The most economically viable and environmentally sound technology currently operating at scale in the relevant geographical scope. For the purposes of this methodology, BAT is determined using the five-criteria framework detailed in the Supplementary Information and is operationalised as a specific emission factor (EF_{BAT}) representing the direct process and combustion emission intensity of the most efficient (Best Available Technology) conventional plants.
Commercial Operation Date (COD)	The date on which a renewable energy facility has completed commissioning tests and begins delivering electricity to the grid (if applicable) or directly to the activity.
Conventional Hydrogen production	Production of hydrogen (H_2) using fossil fuels (e.g., natural gas, coal, oil) as the feedstock or energy source, typically through processes like Steam Methane Reforming (SMR), Autothermal Reforming (ATR), or coal gasification with or without Carbon Capture and Storage (CCS) or Carbon Capture and Utilization (CCU) technologies employed.
Exclusive Renewable Energy Facility	A renewable energy facility constructed for the primary purpose of supplying electricity to the activity. The electricity is not supplied or attributed to any other consumer or market claim. The facility may be located on or off-site but shall meet all requirements of Section 3.2.
Eligible End-Use	A verifiable downstream application for the produced green hydrogen that directly displaces fossil fuels without creating infrastructural carbon lock-in. End-uses that prolong fossil-fuel extraction or unabated combustion (e.g., Enhanced Oil Recovery,

	or broad blending into unabated domestic natural gas networks) are strictly excluded from crediting.
Existing Dedicated Consumer	An existing facility that, prior to the activity, consumed fossil-fuel-based hydrogen (also referred to as grey hydrogen) as a feedstock or energy source in an industrial process (e.g., ammonia synthesis, oil refining). In the activity, the facility switches to using green hydrogen.
Green Hydrogen	Hydrogen (H_2) produced via a process pathway designed to result in near-zero greenhouse gas emissions. For the purposes of this methodology, this specifically refers to hydrogen produced exclusively via water electrolysis powered exclusively by renewable electricity.
Locally available drinking water	Refers to the amount of potable water (safe for human consumption) that can be sustainably accessed from a defined geographic area. This geographic area, defined at the design certification stage, may refer to a water utility's service area, an administrative boundary (such as a city or county), or a hydrological unit such as a watershed or basin, where relevant. The selected boundary reflects the most appropriate scale at which water availability, allocation, and competing uses are managed. The justification for the selected boundary shall be provided in the Project Design Document (PDD).
Placed In Service (PIS) Date	The date the green hydrogen facility (or a functionally independent component thereof) is ready and available for hydrogen production. This date is determined by obtaining necessary operating permits, the completion of commissioning or performance tests, and documented readiness for regular operation.
Renewable Energy / Electricity	For the purposes of this methodology, renewable electricity refers to electricity generated from sources including solar photovoltaic, solar thermal, wind, and geothermal. To qualify for zero-emission accounting under this methodology, the electricity generated from these sources shall meet specific criteria regarding its origin, additionality to the grid (if applicable), hourly temporal correlation matching with the activity’s consumption [unless exempted under the methodological tool applied for quantification of Grid emission factor], and traceability as detailed in this methodology, to qualify for zero-emission accounting within the activity boundary. The purchase of generic, unbundled renewable electricity certificates (RECs) or guarantees of origin (GOs) of any form does not qualify as an eligible source of renewable electricity under this

	methodology, as they do not provide a direct, verifiable link to the activity's specific energy consumption. Where electricity is stored, the activity must demonstrate traceability between the electricity generated and the electricity used for hydrogen production, including accounting for storage losses. A scenario may involve the construction of an exclusive renewable energy facility built specifically to serve the load of the activity but located off-site. In such cases, the non-physical delivery of this exclusive renewable electricity to the activity via a grid connection may be considered acceptable under specific conditions. These conditions require robust contractual arrangements demonstrating that the electricity consumed by the activity originates from the exclusive renewable energy facility. Acceptable contractual mechanisms can include one or more Power Purchase Agreements (PPAs), including virtual PPAs, or other verifiable contractual instruments that ensure exclusivity and prevent double counting of the renewable attributes of the electricity generated.
Allocated Renewable Energy Facility	A renewable energy facility that supplies electricity to the activity and other consumers. Under this methodology, the facility shall supply and allocate at least 70% of its net annual generation to the activity, with contractual and technical safeguards to ensure clear attribution, temporal matching, and avoidance of double counting.
Steam Methane Reforming (SMR)	The conventional and carbon-intensive process for producing hydrogen from natural gas, which involves reacting methane (CH_4) with steam at high temperatures to produce hydrogen (H_2), carbon monoxide (CO), and carbon dioxide (CO_2).
Water Electrolysis	The process of using electricity to split water (H_2O) into hydrogen (H_2) and oxygen (O_2). Types include Alkaline Water Electrolysis (AWE), Proton Exchange Membrane (PEM) Electrolysis, and Solid Oxide Electrolysis (SOE).

3| SCOPE, APPLICABILITY, AND ENTRY INTO FORCE

3.1 | Scope

3.1.1 | This methodology is globally applicable to activities that produce green hydrogen for eligible end-uses. It facilitates the reduction of greenhouse gas (GHG) emissions by substituting fossil-fuel-intensive conventional hydrogen production (e.g., Steam Methane Reforming or coal gasification) with a clean process pathway. This pathway shall utilise green hydrogen produced exclusively via water electrolysis, powered entirely or predominantly by zero-emission renewable electricity.

3.2 | Applicability

3.2.1 | This methodology applies to activities that satisfy all the applicability criteria below. Failure to meet any of these conditions renders the methodology inapplicable. Activity developers shall demonstrate compliance at validation, and the Validation and Verification Body (VVB) shall confirm continued compliance at each monitoring period.

3.2.2 | **Process Pathway:** The activity shall produce hydrogen (H_2) exclusively via electrolysis of water (e.g., using Alkaline Water Electrolysis (AWE), Proton Exchange Membrane (PEM) electrolysis, Solid Oxide Electrolysis Cells (SOEC), or Anion Exchange Membrane (AEM) electrolysis), powered by eligible renewable energy sources.

3.2.3 | **Activity Type:**

a. **Greenfield or Brownfield:** The activity may involve:
   - the construction of a newly built (greenfield) green hydrogen facility, including the capacity addition of a new physical production unit within an existing green hydrogen complex, provided the new unit has a distinct Placed-In-Service (PIS) date and dedicated additional renewable supply; or the retrofitting (brownfield) of an existing industrial facility by installing a new greenfield electrolyser to replace fossil-based hydrogen production equipment.
   - the retrofitting, rehabilitation, or capacity addition of an existing electrolyser facility, provided that the existing facility was previously supplied by non-renewable electricity with a carbon intensity above the Best Available Technology (BAT) benchmark..

b. **Service Levels:** For brownfield retrofits, the activity shall continue to produce the same type of output and shall not result in a reduction of overall service levels or production capacity compared to the baseline scenario.

c. **Partial replacement:** Where the activity displaces only a portion of an existing facility's fossil-based hydrogen production, emission reductions shall be credited only in respect of the fossil production actually displaced by the green hydrogen in each monitoring period, determined from metered green-hydrogen output against the documented historical fossil output. The remaining fossil production is excluded from the activity boundary and receives no crediting.

d. **Phased transition:** Where an activity implements a phased transition from fossil to green hydrogen production over more than one year, each phase shall be treated on the partial-replacement basis above: crediting in each period reflects the fossil production displaced in that period, and the decommissioning requirements apply to fossil capacity as it is retired. The phased implementation schedule shall be documented at validation.

e. **Modularity:** The eligible activity may involve small-scale, modular green hydrogen production sites, close to where the outputs will be used, or larger centralised hydrogen facilities.

f. **Clear Separation:** In cases where green hydrogen production supplements an existing conventional facility, the activity shall ensure clear physical separation and robust smart-metering to precisely distinguish green hydrogen from conventional output. The VVB shall confirm the integrity of this tracking system.

g. **Dedicated Consumers:** The hydrogen produced shall be supplied to eligible dedicated consumer(s) identified ex-ante in the Project Design Document (PDD). Prior to the implementation of the activity, the hydrogen supplied to the existing consumer(s) shall have been produced through gasification of coal, or steam reforming of natural gas or oil for at least the past 3 years. The activity developer shall establish strict Consumer Inclusion Criteria within the PDD. To qualify as an eligible consumer, the inclusion criteria shall mandate that:

    i. **Historical Fossil Displacement:** For consumers substituting existing hydrogen demand, the developer shall demonstrate that the consumer had previously utilised hydrogen produced via the gasification of coal, or steam reforming of natural gas/oil, for at least the three (3) years prior to receiving green hydrogen. For consumers representing new demand, the hydrogen shall be utilised for an approved Eligible End-Use that structurally displaces fossil fuels in hard-to-abate sectors (e.g., heavy industry, chemical synthesis, maritime shipping).

    ii. **New-demand counterfactual:** Where the hydrogen produced by the activity supplies an eligible end use that did not previously exist and was not previously met by conventional hydrogen or another fuel, the activity developer shall demonstrate the counterfactual against which reductions are claimed. Reductions may be credited only to the extent that the activity displaces conventional hydrogen production or a more emission-intensive fuel that would otherwise have met that demand; hydrogen supplied to wholly new demand with no more-emission-intensive counterfactual shall not be credited on the Best Available Technology baseline. The counterfactual shall be documented at validation and verified by the VVB.

    iii. **Chain of custody:** The activity developer shall maintain an unbroken, auditable chain of custody linking each unit of hydrogen credited to its delivery to a verified eligible end use. Where hydrogen is sold, transferred or converted (including to a derivative such as ammonia or methanol), the chain of custody shall follow the hydrogen to the point of eligible end use, and the activity developer shall demonstrate that the same hydrogen, or its attributes, is not claimed under any other crediting activity or scheme. The chain of custody shall be verified by the VVB at each monitoring period, and its confirmation folded into the annual double-counting declaration of Section 11

iv. **Excluded End-Uses:** The green hydrogen shall strictly not be supplied to consumers utilising it for Enhanced Oil Recovery (EOR), the extraction or processing of unconventional fossil fuels, or untargeted blending into unabated domestic natural gas networks.

v. **Verification and Consequence of Non-Compliance:** During each monitoring period, the activity developer shall provide the VVB with verifiable evidence (e.g., commercial contracts, mass-balance transfer records, historical fuel receipts) demonstrating that all consumers (both existing and newly added) satisfy the predefined Consumer Inclusion Criteria. If the activity developer fails to demonstrate compliance for any specific consumer during verification, or if the end-use cannot be definitively verified, the volume of hydrogen dispatched to that non-compliant consumer shall be deemed strictly ineligible. This volume shall be excluded from the calculation of creditable emission reductions (operationalised via the $Q_{eligible,y}$ monitored parameter).

3.2.4 | **Energy Source and Auxiliary Systems:** The electrical energy consumed for all significant process stages within the activity boundary, including, but not limited to, water electrolysis, hydrogen compression, purification, and directly associated auxiliary systems, shall be demonstrated to originate solely from renewable energy sources as defined in this methodology. Furthermore, all auxiliary systems (e.g., heating, cooling, compression, hydrogen storage and transport systems) shall utilise zero-emission technologies. The use of fossil-fuel-combusting equipment (including methane-based compressors or pipelines is prohibited.

a. **Grid Electricity:** Grid electricity may be used as a backup or supplementary power source only when renewable energy generation is insufficient (i.e. when on-site/contracted renewable output drops below the electrolyser's required load), or temporarily unavailable (due to unplanned outages). The annual consumption of grid electricity by the activity (including all subprocesses for hydrogen production) shall not exceed 10% of the total annual electricity consumption of the activity. Grid electricity consumed within the 10% cap shall qualify the associated hydrogen volume as green only where the emission factor of the host grid is below 0.2 tCO_2e/MWh. Where the grid emission factor is at or above 0.2 tCO_2e/MWh, grid electricity consumed by the activity shall be charged at that actual emission factor and shall not attract any zero-emission treatment. In all cases, grid electricity consumed is fully accounted under Section 8. The VVB shall verify compliance with this requirement for each monitoring year.

3.2.5 | If the net annual consumption of grid electricity by the activity exceeds 10% of the total net annual electricity consumption in a given monitoring year, the following shall apply:

a. **Ineligibility for Crediting**: Hydrogen production volume attributed to grid electricity consumed beyond the 10% annual threshold shall not qualify for carbon credit issuance. All GHG emissions associated with the total grid electricity consumed shall be fully quantified and accounted for as activity emissions.

   i. **Mandatory Corrective Action:** The VVB shall require the activity developer to develop and implement a detailed corrective action plan to address the root causes of excessive grid electricity consumption and ensure future compliance. Non-adherence may result in further sanctions or continued non-qualification.

   ii. **Potential for Full Activity Disqualification***:* Persistent or significant non-compliance, defined as exceeding the allowed 10% cap in three years of a 5-year period, or any single year exceeding 15%, without an approved corrective action plan, may result in the complete disqualification of the entire activity's output for the non-compliant monitoring year.

b. **Off-Site Renewable Energy (PPAs):** If exclusive off-site renewable energy facilities supply the activity, the electricity shall only qualify as zero-emission if all the following criteria are met:

   i. **Origin & Contractual Timing:** The renewable energy facility's Commercial Operation Date (COD) shall be within 24 months of the green hydrogen facility's Placed-In-Service (PIS) date. This window may be extended by up to a further 12 months, to a maximum of 36 months, where the activity developer documents delay outside its control (grid-connection correspondence, permitting records, regulatory filings, an independent engineering report, or a revised implementation timeline). During any extension period, grid electricity is charged at the grid emission factor and counts against the grid-electricity cap. A Power Purchase Agreement (PPA) or equivalent verifiable contractual instrument shall be mutually executed prior to the start of the crediting period. The facility must be powered exclusively by, newly built (additional) renewable energy generation assets. If the activity procures electricity from an existing (pre-commissioned) renewable energy facility via a PPA, the developer shall demonstrate that the host country grid's renewable generation capacity has not decreased as a result of the PPA arrangement. This may be demonstrated by showing that total grid-connected renewable capacity has been maintained or increased during the monitoring period. If this cannot be demonstrated, a conservative estimate of the displaced grid renewable energy shall be accounted for as leakage using the grid marginal emission factor.

ii. **Deliverability:** The renewable energy facility and any associated energy storage shall be located in the same electricity grid region as the green hydrogen activity.

iii. **Temporal Matching**: Renewable energy generation and activity's electricity consumption shall be matched and tracked on an hourly basis. Where hourly matching certification is not yet available in the host market, an activity may apply monthly matching on a transitional basis until the earlier of the first renewal of the crediting period or 31 December 2030, after which hourly matching is mandatory. In either case, any hour (or, under the transitional tier, any period) of consumption not matched to the activity's contracted renewable generation shall be charged at the applicable grid emission factor and shall count against the grid-electricity cap of Section 3. Traceability shall be demonstrated as detailed in this methodology.

iv. **Exclusive Claims**: The PPA shall legally prevent the double-claiming of the renewable attributes (e.g., the generator cannot sell Renewable Energy Certificates (RECs) or Guarantees of Origin (GOs) to a third party for the power supplied to the activity).

3.2.6 | **Allocated Renewable Energy Facility:** Where an off-site renewable energy facility supplies to both the activity and additional consumers, the following shall apply:

a. The activity shall consume at least 70% of the annual net generation of the renewable energy facility.
b. This 70% share is measured as net annual generation delivered to the activity at the point of delivery, consistent with the deliverability requirement
c. This share shall be demonstrated by verifiable contractual agreements (e.g. PPAs or equivalent supply agreements) that clearly allocate the specific volume to the activity, and prevent double claiming of renewable attributes.
d. The activity shall meet the deliverability and hourly temporal matching requirements for the activity's attributable share.
e. Only the volume of green hydrogen produced directly using the allocated and temporally matched share of electricity shall be eligible for emission reductions.
f. If supply to the activity falls below 70% in any monitoring year, emission reduction for that year may be disallowed.

3.2.7 | **Feedstock Constraints:** The sole feedstock for hydrogen production within the activity boundary shall be water. The use of any fossil fuels (e.g., natural gas, coal, oil) as a feedstock for hydrogen generation is strictly prohibited.

3.2.8 | **Eligible End-Use Safeguards:** To prevent carbon lock-in, the hydrogen produced by the activity shall be dispatched and utilised exclusively for Eligible End-Uses that actively displace fossil fuels in hard-to-abate sectors (e.g., heavy industry, chemical synthesis, refining, maritime shipping, long-haul transport). The activity developer shall implement and document a robust monitoring approach (e.g., mass-balance tracking, off-taker contracts, audited sales receipts) to verify the final downstream use of the hydrogen.

a. **Excluded End-Uses:** The activity shall strictly not issue credits for green hydrogen utilised for Enhanced Oil Recovery (EOR), the extraction or processing of unconventional fossil fuels, or untargeted blending into unabated domestic natural gas networks (where it primarily serves to extend the economic life of fossil gas infrastructure rather than driving deep decarbonisation).

3.2.9 | **Water use limitation:** To ensure the massive water demand for industrial electrolysis does not exacerbate local water scarcity or displace essential human, ecological, or agricultural uses, the activity developer shall strictly comply with both a volumetric ceiling on potable water and a location-based water stress risk assessment.

a. **Absolute Volumetric Ceiling (5% Cap on Potable Water):** To protect human consumption, the activity's abstraction of municipal potable (drinking) water or water from dedicated community aquifers shall not exceed the lesser of the following two thresholds:

i. 5% of the activity's total annual water demand; OR

ii. 5% of the officially documented annual capacity of the local municipal water supply system (or the sustainable yield of the relevant community aquifer). The developer shall provide official utility capacity declarations, government hydrological records, or an independent hydro-geological study to definitively quantify this denominator.

b. **WRI Aqueduct Risk Assessment** (Geographic Filter for All Freshwater): In addition to the 5% ceiling on potable water, the activity's broader abstraction of any local raw freshwater (e.g., rivers, lakes, non-potable groundwater) shall be strictly governed by the Baseline Water Stress (BWS) classification of the exact activity location. At validation, the developer shall determine this classification using latest version of the WRI Aqueduct Water Risk Atlas:

i. **Low to Medium-High Stress Regions (BWS < 20%):** The activity is permitted to abstract local raw freshwater for its core electrolysis process, strictly provided it complies with local water abstraction licences, GS4GG Safeguarding Principle 8 (Water Resources), and the 5% cap on potable water defined above.

ii. **High to Extremely High Stress Regions (BWS ≥ 20%):** If located in a highly stressed catchment, the activity shall prioritise sourcing 100% of its process water from non-competing alternatives, such as renewable-powered seawater desalination or reclaimed municipal wastewater. The activity may only abstract local raw freshwater if a bespoke, independent Environmental and Social Impact Assessment (ESIA) demonstrates that the specific abstraction will not lower the regional water table, disrupt ecological flows, or compromise community access to water resources. (The 5% cap on potable water for human staff sanitary needs remains permitted within this category.)

c. **Desalination Energy and Brine Safeguard:** If desalinated seawater is utilised as a process water source, the electrical energy consumed by the desalination plant and associated pumping and treatment infrastructure shall be fully accounted for within the activity boundary and powered entirely by renewable energy (per Section 3.2.4). Furthermore, safe brine disposal mechanisms that demonstrably cause no harm to marine ecosystems shall be implemented in accordance with national environmental regulations and verified by the VVB.

3.2.10 | **Third-party water supply:** Where potable or process water is supplied by a third-party desalination or treatment facility whose electricity source is not under the activity developer's control, and audited emission-factor data for that facility are not available, the activity shall apply the conservative seawater-reverse-osmosis default of 4.5 kWh/m^3 to the associated water volume, and shall account for the resulting emissions at the applicable grid emission factor. Where the supplier's audited electricity intensity is available and verified, that value shall be used in place of the default.

3.2.11 | **Desalination and water-treatment power**: The desalination and water-treatment electricity may be supplied from the grid where it falls within the 10% grid-electricity cap (Section 3.2.4) and the host-grid emission factor is below 0.2 tCO_2e/MWh; where the grid emission factor is at or above 0.2 tCO_2e/MWh, this electricity shall be charged at that emission factor.

3.2.12 | **Decommissioning of Existing Equipment (Brownfield):** If a greenfield electrolyser is installed within an existing facility that previously used fossil-based hydrogen production, the existing fossil-based hydrogen production equipment shall be decommissioned, destroyed, or verifiably rendered permanently inoperable. If this equipment is transferred or continues to operate, its emissions shall be accounted for as leakage. The VVB shall verify compliance.

3.2.13 | Compliance with the 5% volumetric ceiling, the applicable WRI Aqueduct BWS classification, and (where applicable) the desalination energy and brine safeguards shall be verified by the VVB at initial validation and re-verified at each crediting period renewal using the most current official hydrological data and WRI Aqueduct dataset version available at the time.

3.2.14 | **Oxygen Co-product:** Oxygen produced as a by-product of electrolysis may be utilized or sold. However, no emission reduction credits can be claimed under any carbon market mechanism. If oxygen is captured and utilized by the activity or other users, any emissions benefit (e.g., displaced conventional oxygen production) is considered a co-benefit outside the scope of this methodology’s GHG accounting. Activity developers may document such benefits for SDG impact claims.

3.2.15 | **Exclusions:** This methodology is explicitly not applicable to activities involving:

a. Hydrogen production using fossil fuels, including processes like Steam Methane Reforming (SMR), Autothermal Reforming (ATR), or coal gasification, irrespective of whether Carbon Capture and Storage (CCS) or Carbon Capture and Utilization (CCU) technologies are employed (i.e., pathways commonly referred to as "grey," "brown," or "blue" hydrogen are excluded).
b. Hydrogen production derived from the gasification or pyrolysis of biomass or waste feedstocks.
c. Hydrogen production using alternative or novel technologies such as direct electrochemical water splitting without renewable electricity, or thermochemical cycles, unless this methodology is explicitly revised to include such pathways.

3.2.16 | The renewable generation facility supplying the activity, and any storage associated with it, shall not be registered as, or form part of, a separate GHG-crediting activity under any programme for any period during which its generation is claimed under this methodology. The activity developer shall provide a signed declaration to this effect at validation and at each monitoring period, verified by the VVB. This declaration shall be folded into the annual double-counting confirmation of Section 11.3

3.3 | Entry into force

3.3.1 | The date of entry into force is the publication date of this methodology.

3.4 | Mandatory Compliance and Safeguards

3.4.1 | **GS4GG Requirements**: The activity shall adhere to the latest version of GS4GG Principles & Requirements, Safeguarding Principles & Requirements, and applicable Activity Requirements (such as the Energy Systems and Efficiency). This involves an upfront assessment of potential risks and the implementation of a mitigation strategy.

3.4.2 | **Regulatory Compliance:** The activity shall comply with all applicable national and local laws, regulations, and environmental standards in the host country.

3.4.3 | **Double counting:** The activity developer shall demonstrate conclusively that emission reductions generated by the activity will not be double-counted. This includes establishing clear contractual agreements with all relevant stakeholders in the supply chain (e.g., renewable energy suppliers, hydrogen off-takers) to ensure unique ownership and claiming of emission reduction attributes. The developer shall prove there is no overlap with mandatory domestic mitigation schemes, or other frameworks or environmental markets (e.g., RECs, GOs, green hydrogen certification schemes, Low-Carbon Fuel Standards). The activity design document shall detail the specific measures implemented to prevent double-counting.

3.4.4 | **Community Health and Safety (Safeguarding Principle 3):** The activity developer shall implement a comprehensive emergency preparedness and response plan. The developer shall proactively manage and mitigate risks associated with the high-pressure operation, storage, transport, and potential fugitive leakage of hydrogen gas, including the risk of ignition, embrittlement of materials, and asphyxiation in enclosed spaces. This includes implementing continuous, automated Leak Detection and Repair (LDAR) protocols integrated into the facility's supervisory control and data acquisition (SCADA) systems, conforming to international hydrogen safety codes (e.g., NFPA 2).

3.4.5 | **Land Acquisition and Involuntary Resettlement (Safeguarding Principle 4)**: Where the activity or its associated dedicated renewable energy infrastructure requires significant land acquisition, the developer shall comply with GS4GG Safeguarding Principle 4 regarding land acquisition, ensuring legitimate tenure is respected and involuntary physical or economic displacement is avoided.

3.4.6 | **Water Resources (Safeguarding Principle 8):** In addition to the strict volumetric water stress limitations outlined in Section 3.2.9, the activity shall comply with all host country environmental regulations concerning water abstraction, thermal pollution, and safe discharge. The activity shall not negatively impact local water availability or quality for surrounding communities or ecosystems.

3.4.7 | **Hazardous and Non-Hazardous Waste (Safeguarding Principle 9):** The activity shall demonstrate the capability for the safe, environmentally sound handling, recycling, or disposal of any hazardous waste generated by the activity (e.g., degraded electrolyser membranes, spent catalysts, or concentrated brine from water treatment).

3.4.8 | **Biodiversity and Ecosystem Services:** Activity developers shall identify and manage risks to biodiversity, critical habitats, and ecosystem services associated with both the hydrogen facility and any dedicated renewable electricity and transmission infrastructure, consistent with applicable safeguarding requirements and good international industry practice (e.g., avoidance of sensitive/protected areas and appropriate mitigation hierarchies). Where land clearance or land-use change is associated with the activity, the activity developer shall describe avoidance and mitigation measures.

4| NORMATIVE REFERENCES

4.1.1 | This methodology has been developed in accordance with the latest approved versions of the following standards, procedures, and tools.

a. **GS4GG Requirements and Procedures**
   i. GS4GG Principles and Requirements (V2.1)
   ii. Safeguarding Principles and Requirements (V2.1)
   iii. Energy Systems and Efficiency Activity Requirements [Under Consultation / Latest Approved Version]
   iv. Procedure for Development, Revision, and Clarification of Methodologies and Methodological Tools (V2.0)

b. **GS4GG Methodologies, Standards, and Tools**

i. Supplementary Information: Green Hydrogen Production
ii. Methodology Standard: Requirements for Additionality Demonstration (V1.0)
iii. Methodology Standard: Requirements for Baseline Setting (V1.0)
iv. Methodology Standard: Requirements for Addressing Leakage in Methodologies (V1.0)
v. Methodology Standard: Requirements for Methodology Development (V1.0)
vi. Tool 01: Emissions from Fossil Fuel Combustion (V1.0)
vii. Tool 02: Emissions from Freight Transportation (V1.0)
viii. Tool 05: Downward Adjustment Factor (DAF) Determination (V1.0)
ix. Tool 06: Common Practice Analysis (V1.0)
x. Tool 08: Technical Addendum to A6.4-AMT-006 (V1.0)
xi. Tool 09: Analysis of lock-in risk (V1.0)
xii. Tool 10: Technical Addendum to A6.4-AMT-007 (V1.0)

c. **CDM/ PACM A6.4 Methodology/Tool**

References to CDM tools are valid until equivalent tools are published under Gold Standard (GS4GG) or the Article 6.4 Mechanism (A6.4)/Paris Agreement Crediting Mechanism (PACM).

i. Methodology: Hydrogen production from electrolysis of water, AM0124 / V 1.1
ii. Methodology: “Feed switch in integrated Ammonia-urea manufacturing industry”. AM0050 V3.0
iii. Methodology: “Production of Ammonia through electrolysis of water, air separation and synthesis of hydrogen and nitrogen”. A6.4-PNM001
iv. TOOL28: Calculation of baseline, project and leakage emissions from the use of refrigerants (V1.0)
v. A6.4 –AMT 007: Emissions from electricity generation and consumption (V1.0)
vi. A6.4-AMT-006: Determination of the technical lifetime of equipment (V1.0)
vii. A6.4 -AMT 002: Investment analysis (V1.0)

5| ACTIVITY BOUNDARY AND GHGS SOURCES

5.1 | Activity boundary

5.1.1 | The activity boundary encompasses all anthropogenic sources of GHGs that are under the control of the activity developer, are related to the activity, or are significantly affected by the activity.

5.1.2 | The spatial extent of the activity boundary includes the physical infrastructure directly involved in the activity, as well as the upstream processes and market boundaries relevant for assessing the activity's baseline, activity, and leakage emissions.:

Table 3. Delineation of the Physical and Geographical Boundary

Component	Included?	Description/Justification
Physical Infrastructure and Sites		
Green hydrogen Production Facility Site(s)	Yes	The physical site containing the electrolysers, water purification units, hydrogen purification/drying systems, compressors, liquefaction units (if applicable), and storage tanks. Activity emissions occur within this boundary.
Renewable Energy Plant (REP)	Yes	The physical site(s) of the renewable energy facility (on-site or off-site) supplying electricity to the activity.
Electricity Grid	Yes	The electricity transmission and distribution system. Relevant for quantifying emissions from any permitted backup grid electricity consumption (capped at ≤10% annually).
Water Supply and Treatment Infrastructure	Yes	Included if the activity operates dedicated water treatment or desalination facilities. Energy consumption from these facilities shall be accounted for within total facility electricity consumption and shall be powered by renewable energy. Brine disposal infrastructure (where applicable) is included for VVB safeguard verification.
Processes and Activities		
Conventional Hydrogen Production (Baseline)	Yes	The operation of conventional fossil-fuel-based hydrogen production (e.g., SMR, coal gasification) that would have occurred in the absence of the activity to supply the eligible end-uses.
Hydrogen Transport	Yes	Downstream transportation of the final green hydrogen product to the verified eligible end-user.

5.2 | GHGs Sources

5.2.1 | **Baseline emissions:** The following table details the GHGs included in, or excluded from, the baseline scenario.

Table 4. Sources of Baseline Emissions

SOURCE	Description	GAS	INCLUDED	JUSTIFICATION
Hydrogen Production (Fuel Combustion & Reforming)	The thermal or chemical conversion of fossil fuels (e.g., SMR of natural gas, coal gasification) to produce hydrogen, including combustion for process heat in the baseline scenario.	CO_2	Yes	The primary source of baseline emissions resulting from fossil fuel combustion for process heat and chemical conversion.
Hydrogen Production (Upstream Fuel Supply)	Fugitive emissions associated with the extraction, processing, and transport of the baseline fossil fuels (e.g., natural gas, coal).	CH_4	No	Explicitly excluded. Upstream methane (CH_4) emissions associated with the extraction, processing, and transport of baseline fossil fuels are strictly excluded to ensure the baseline crediting benchmark remains highly conservative (yielding a mathematically lower baseline emission benchmark).
		N_2O	No	Insignificant; excluded for simplification and conservativeness.
Baseline Electricity Consumption	Electricity consumed in baseline hydrogen production (e.g., compressors, auxiliaries in SMR plants).	CO_2	Yes	Emissions associated with electricity consumption in the baseline. Accounted for in baseline emission factors.

Baseline Transportation	Transportation of hydrogen from baseline source to existing dedicated consumer(s).	CO_2	Yes	May be a significant emission source if baseline production is not co-located with the consumer.

5.3 | Activity emissions

5.3.1 | The following table details the direct and indirect GHGs included in, or excluded from, the activity scenario. Because hydrogen acts as an indirect climate forcer, physical leakage is strictly quantified.

Table 5. GHGs included in, or excluded from, the Activity Scenario

SOURCE	Description	GAS	INCLUDED	JUSTIFICATION
Grid Electricity Consumption	Electricity drawn from the grid (as backup/ supplementary power) to run the electrolysers, compressors, liquefaction units, or auxiliary systems.	CO_2	Yes	Emissions from non-renewable grid electricity utilised as supplementary or backup power (capped at ≤10% annually).
Fossil Fuel Combustion	Combustion of fossil fuels in on-site backup generators.	CO_2	Yes	Shall be accounted for if emergency backup systems are utilised (runtime capped at <0.1% annually).
		CH_4	No	Negligible for limited backup operations.
		N_2O	No	Negligible for limited backup operations.
Fugitive Hydrogen Leaks	Physical leaks of hydrogen gas from electrolysers, compressors, pipelines, and storage.	H_2	Yes	Hydrogen acts as an indirect climate forcer (extending the atmospheric lifetime of methane). Physical leaks shall be directly quantified as CO_2e using an explicitly referenced 100-year Global

				Warming Potential (GWP_{100}) of 14.4 (*Sand et al., 2023*).
HFC Emissions	Emissions from refrigeration and cooling equipment using hydrofluorocarbons (e.g., for hydrogen liquefaction or cooling systems).	HFCs		Included if the facility operates cryogenic liquefaction systems utilising high-GWP synthetic refrigerants.
Product Transportation	Downstream transportation of the hydrogen product to the existing dedicated consumer(s).	CO_2	Yes	Incremental emissions from downstream transportation (e.g., via truck, pipeline, or shipping) of the final product.

5.3.2 | **Leakage emissions:** The following table details the GHG emissions included in, or excluded from, the leakage emissions. In alignment with the *GS4GG Requirements for Addressing Leakage in Methodologies*, embodied emissions from the manufacturing of new infrastructure are classified as Leakage.

Table 6. Emissions included in, or excluded from, the leakage

SOURCE	Description	GAS	INCLUDED	JUSTIFICATION
Embodied Emissions (Infrastructure)	Cradle-to-gate emissions associated with the manufacturing, construction, and transport of the new activity infrastructure (e.g., solar panels, wind turbines, electrolysers, storage batteries).	CO_2e	Yes	Mandatory inclusion. Cradle-to-gate emissions associated with manufacturing new electrolysers, renewable energy plants, and battery storage shall be fully accounted for as Leakage and amortised over the first crediting period.

Transfer of Baseline Equipment	For brownfield retrofits: Re-use of decommissioned baseline equipment (e.g., SMR units) outside the activity boundary, continuing to emit GHGs.	CO_2e	Conditional	Applies exclusively to brownfield retrofits. Deemed zero if fossil-based equipment is verifiably destroyed. If transferred and reused outside the boundary, emissions shall be quantified and deducted.
Land Use Change (LUC)	Emissions resulting from the conversion of land (e.g., forest or grassland) to an industrial site for the hydrogen plant or its renewable energy facility.	CO_2e	Conditional	Changes in carbon stocks due to land clearing for the new industrial site or renewable energy plant. Included if material.

6| DEMONSTRATION OF ADDITIONALITY

6.1 | Requirements:

6.1.1 | The activity developer shall demonstrate that the activity—comprising the production of green hydrogen powered exclusively by renewable energy for eligible end-uses—would not have occurred in the absence of the incentives provided by carbon revenues.

6.1.2 | The demonstration of additionality shall be conducted in accordance with the latest version of the GS4GG Methodology Standard: Requirements for Additionality Demonstration.

6.1.3 | The additionality assessment shall follow the stepwise approach detailed below:

a. Step 1: Regulatory surplus analysis (Section 6.2 |)
b. Step 2: Lock-in risk analysis (Section 6.3 |)
c. Step 3: Financial viability analysis (Section 6.4 |)
d. Step 4: Common practice analysis (Section 6.5 |)
e. Step 5: Ongoing financial needs assessment (Section 6.6 |)

6.2 | Regulatory Surplus Analysis

6.2.1 | The activity developer shall demonstrate at the activity level that the emission reductions achieved are regulatory surplus—meaning they are not mandated by any existing laws, regulations, or legal requirements within the host country's jurisdiction at the time of the activity start date. The analysis shall be updated at each verification of emission reductions, or at the latest, at each renewal of the crediting period. If a legal mandate directly requiring the activity comes into force and is enforced during the crediting period, the activity shall cease to be eligible for crediting from the date the legal requirement takes effect.

6.2.2 | The activity developer shall provide verifiable evidence demonstrating that:

a. **Host Country Eligibility**: The green hydrogen activity type is not excluded or declared ineligible for carbon credit issuance by the host country (e.g., it is not on a national negative list).

b. **No Enforced Legal Mandate:** There is no legal obligation to produce hydrogen exclusively via water electrolysis, nor any enforced mandate banning conventional fossil-fuel-based hydrogen production without providing viable alternative pathways. The analysis shall verify that national, sub-national, or local laws do not:

    i. Directly mandate the implementation of water-electrolysis-based hydrogen production for the targeted end-use.

    ii. Indirectly mandate the activity by preventing alternative scenarios (e.g., an outright ban on the use of natural gas for Steam Methane Reforming [SMR] without providing viable alternative pathways).

    iii. Lead to the same amount of emission reductions without the activity due to laws requiring specific quantitative targets (e.g., a mandatory green hydrogen blending quota or an emissions trading system that caps the exact emission sources reduced by the activity, unless those allowances are verifiably cancelled).

c. **Green Hydrogen Definitions and Certification Schemes:** Where the host country has adopted an official green hydrogen definition, certification scheme, or minimum GHG-intensity threshold applicable to hydrogen production and/or end-use, the activity developer shall document for the additionality assessment: the applicable provisions; evidence of compliance for the production facility; and where relevant, any compliance obligations applicable to identified dedicated consumer(s).

d. **Confirmation of No Exclusion (Default):** In the absence of a published negative list, positive list, or specific regulatory exclusion, the activity developer shall provide a formal declaration confirming that no official communication or regulation has been issued by the host country identifying the specific technology as ineligible for carbon crediting.

6.3 | Lock In Risk Analysis

6.3.1 | The activity developer shall assess the risk that the activity may lead to a lock-in of GHG emissions, technologies, or carbon-intensive practices.

6.3.2 | This methodology explicitly mandates the use of water electrolysis and zero-emission renewable energy, inherently replacing a high-emission technology (fossil-based hydrogen) with a zero-emission alternative.[1] That analysis concludes that green hydrogen production, when compliant with all applicability conditions of Section 3, poses a low risk of technology, emissions, or carbon lock-in. This conclusion is supported by the following:

a. The core technology (water electrolysis) creates no dependency on fossil fuel feedstocks.
b. Electrolyser modularity allows for future technology upgrades and efficiency improvements.
c. The mandatory use of dedicated, additional renewable energy prevents diversion of existing clean energy resources.
d. The de-minimis limit on fossil backup (below 0.1% of energy on an energy basis), the capped and intensity-gated grid-electricity allowance, and the full accounting of any grid and backup emissions under Section 8 confine operational fossil use to a level that does not create fossil dependency.
e. The mandatory decommissioning of existing fossil-based hydrogen equipment for brownfield activities prevents the extension of high-emission infrastructure lifespans.

6.3.3 | The activity developer shall confirm in the PDD that the activity meets all applicability conditions of Section 3 and therefore qualifies for the methodology-level lock-in risk classification of 'Low Risk' as documented in the Supplementary Information.

6.3.4 | A specific lock-in risk analysis is not required at the activity level, provided the activity strictly adheres to all applicability conditions defined in Section 3.

6.4 | Financial Viability Analysis (Default Approach)

6.4.1 | To demonstrate that the eligible activity would not be implemented without carbon credit revenue, the financial viability analysis shall be the default approach. It is mandatory for all large-scale activities.

6.4.2 | The activity developer shall conduct an Investment Analysis in strict accordance with the UNFCCC *A6.4-AMT-002: Methodological tool: Investment analysis*.

a. **Selection of Financial Indicator:** The analysis shall use standard financial indicators (e.g., Net Present Value [NPV], Internal Rate of Return [IRR], or Levelized Cost of Hydrogen [LCOH]). The chosen

[1] A comprehensive methodology-level lock-in risk analysis has been conducted and is documented in the Supplementary Information.

indicator and the benchmark (hurdle rate) shall be clearly documented and justified in the PDD.

b. **Cost Modelling:** The analysis shall account for all relevant cash flows, including the high capital expenditure (CAPEX) for electrolysers, water purification systems, compression/liquefaction systems, and renewable energy infrastructure; operational expenditure (OPEX) for electricity and maintenance; and non-carbon revenues (e.g., green hydrogen sales, government subsidies, or production tax credits).

c. **Comparative Analysis:** The activity developer shall demonstrate that the activity without carbon revenues fails to meet the financial benchmark (e.g., Activity IRR < Hurdle Rate) or is financially less attractive than the continuation of conventional hydrogen production. It shall then be demonstrated that the inclusion of carbon revenues enables the activity to meet the financial benchmark.

d. **Sensitivity Analysis:** A sensitivity analysis shall be included to demonstrate that the conclusion remains robust under reasonable variations to critical parameters (e.g., ±10% in CAPEX, OPEX, electricity costs, and hydrogen sales revenues). Assumptions, data, and conclusions shall be transparently documented and supported by verifiable evidence.

6.5 | Common Practice Analysis:

6.5.1 | The activity developer shall conduct a common practice analysis to demonstrate that the activity is not widely adopted in the relevant sector and geographical region.

a. **Methodology-Level Exemption:** Based on comprehensive global market assessments utilising 2023–2025 data (detailed in the Supplementary Information), the total operational capacity of commercial-scale green hydrogen plants using renewable electrolysis represents less than 0.2% of total global hydrogen production. When evaluated against the total global hydrogen production capacity of approximately 100 million tonnes per annum, the current global market penetration rate of commercial green hydrogen is negligible. The technology is formally classified as nascent. The Levelized Cost of Hydrogen (LCOH) for green hydrogen (typically $4.00–$8.00/kg Western & $2.50–$5.00/kg China) remains 60–400% higher than conventional grey hydrogen ($1.50–$2.50/kg), vastly exceeding the 20% cost-difference threshold that classifies it as a "different technology" under the GS4GG Methodology Tool: Common Practice Analysis (MT400-06). In accordance with the GS4GG Additionality Standard, a methodology-level exemption is established.

b. **Deemed Status:** Any green hydrogen activity submitted for validation under this methodology within three (3) years of the publication date of this methodology version shall automatically be deemed to satisfy the

Common Practice Analysis requirement and is exempt from conducting an activity-level common practice calculation.

c. For activities submitted after this 3-year validity period expires, the developer shall conduct an activity-level assessment following the GS4GG Methodology Tool: Common Practice Analysis (MT400-06), demonstrating that the market penetration share of green hydrogen in the applicable geographical area remains below the strict threshold (i.e., F < 5%) defined by the prevailing GS4GG standard.

6.6 | Ongoing Financial Needs Assessment:

6.6.1 | At the time of crediting period renewal, the activity developer shall conduct an Ongoing Financial Need (OFN) assessment to demonstrate that the activity still requires carbon credit revenue to remain financially viable and continues to be additional over time.

6.6.2 | The OFN assessment shall confirm continuous compliance with Regulatory Surplus (Section 6.2) and reassess the Financial Viability Analysis (Section 6.4) utilised during the first crediting period.

a. **Treatment of CAPEX:** Green hydrogen production requires massive upfront capital expenditure. To ensure a fair and accurate OFN assessment at the time of renewal, the activity developer shall explicitly treat sunk CAPEX as follows:

   i. The original, actually incurred CAPEX from the start of the activity shall be retained in the updated cash flow model at its original value (in Year 0).

   ii. Ex-ante estimates for OPEX and revenues for the elapsed crediting period shall be replaced with actual historical operational data.

   iii. Forward-looking projections for the renewed crediting period shall be updated using revised market forecasts.

   iv. The developer shall demonstrate that the recalculated activity financial indicator (e.g., IRR) across the entire operational lifespan, inclusive of the CAPEX, still fails to meet the original financial benchmark without the continued inclusion of carbon revenues.

6.6.3 | The OFN assessment shall consider the prevailing technological costs, market conditions, policy context, and the remaining financial commitments at the time of renewal.

7| BASELINE SCENARIO

7.1 | Baseline Determination (Stepwise Approach)

7.1.1 | The crediting baseline emissions (BE_y), shall be determined following the stepwise approach mandated by the *GS4GG* Methodology Standard: Requirements for Baseline Determination (PAA MS400-04):

a. Step 1: Selection and Justification of the Baseline Approach. (Section 7.2 |)
b. Step 2: Application of the Selected Approach Prior to Downward Adjustment. (Section 7.3 |)
c. Step 3: Application of the Downward Adjustment for Uncertainty and Ambition. (Section 7.3.5 |)
d. Step 4: Identification and Calculation of the Conservative Business-as-Usual (BAU) Baseline. (Section 7.5 |)
e. Step 5: Comparison and Selection of the Final Crediting Baseline. (Section 7.6 |)

7.2 | Step 1: Selection and Justification of Baseline approach

7.2.1 | In accordance with Paragraph 36 of the Article 6.4 Rules, Modalities and Procedures (RMPs) and the GS4GG Baseline Standard, the activity developer shall select the baseline approach based on the activity type:

7.2.2 | **Scenario A: Greenfield Activities** (and Brownfield activities operating beyond the remaining technical lifetime of the replaced equipment).

a. **Selected Approach:** Approach 36(a) — Best Available Technology (BAT) that represents an economically feasible and environmentally sound course of action.
b. **Justification:** Green hydrogen production yields a highly homogeneous output (hydrogen gas) where emissions are primarily determined by the specific production technology deployed. The BAT approach ensures that the baseline represents the most efficient, modern conventional plants available globally or regionally, driving high ambition and preventing the crediting of outdated, high-emission technologies. For greenfield activities in host countries without existing domestic hydrogen production, the baseline scenario shall be deemed to be the importation of conventionally produced hydrogen, and the global BAT benchmark shall apply.

7.2.3 | **Scenario B: Brownfield Activities** (operating within the remaining technical lifetime of the replaced fossil-based equipment).

a. **Selected Approach:** Approach 36(c) – An approach based on existing actual or historical emissions, adjusted downwards, and strictly capped by the BAT approach.
b. **Justification:** For existing facilities, emissions per unit of output are highly site-specific. Using historical emissions ensures that emission reductions represent actual improvements at the specific facility being retrofitted. However, to prevent rewarding historical inefficiency, this approach is strictly capped at the BAT benchmark. (Note: Once the originally replaced equipment reaches the end of its remaining technical lifetime, the baseline shall automatically transition to Scenario A).

7.3 | Step 2: Application of the Selected Approach (Prior to Downward Adjustment)

7.3.1 | The activity developer shall calculate the unadjusted baseline emissions ($BE_{unadj,y}$) prior to any downward adjustment. To ensure maximum conservativeness, upstream methane (CH_4) emissions associated with the extraction, processing, and transport of baseline fossil fuels shall be explicitly excluded from all baseline emission calculations.

7.3.2 | **Determination of the Applicable BAT Emission Factor** (EF_{BAT}): The activity developer shall identify both the Global BAT benchmark and the relevant National BAT benchmark (where available and applicable to the host country). The applicable BAT emission factor (EF_{BAT}) shall strictly be the lowest (most conservative) value available.

$$EF_{BAT} = min(EF_{BAT,global}, EF_{BAT,national}) \qquad \text{(eq.1)}$$

Where

$EF_{BAT,global}$	The global conservative BAT default value representing top-tier conventional hydrogen production in year y. For natural gas SMR: 8.5 tCO_2/tH_2. For coal gasification: 18 tCO_2/tH_2. These values represent direct process and combustion emissions exclusively, with upstream CH_4 emissions explicitly excluded. The applicable global default shall correspond to the dominant baseline technology pathway in the host country.
$EF_{BAT,national}$	An officially established, peer-reviewed, or national BAT benchmark applicable to the host country.

Note: The BAT default values are sourced from the Supplementary Information (Section 4: Determination of Ambitious Benchmark), which establishes these benchmarks based on analysis of most efficient conventional plants globally, taken at the conservative lower bound of the reported range (see SI Section 4). Where no host country BAT exists, and the dominant baseline technology in the host country is not definitively established, the SMR BAT of 8.5 tCO_2/tH_2 shall apply as the conservative global default.

7.3.3 | **Unadjusted baseline for Scenario A (Greenfield):** The baseline emissions are calculated based on the metered quantity of green hydrogen produced, multiplied by the applicable BAT emission intensity.

$$BE_{unadj,y} = P_{H2y} \times EF_{BAT} \qquad \text{(eq.2)}$$

Where

$BE_{unadj,y}$	Unadjusted baseline emissions in year y (tCO_2e/yr).

$\boldsymbol{P_{H2,y}}$	Total monitored production of green hydrogen by the activity in year *y* (tH_2/yr).
$\boldsymbol{EF_{BAT}}$	Specific emissions intensity of the most conservative Best Available Technology (tCO_2e/tH_2), representing direct process and combustion emissions exclusively.

7.3.4 | **Unadjusted baseline for Scenario B (Brownfield):** For existing facilities retrofitting fossil-based hydrogen units with electrolysers, the historical emissions intensity (EF_{hist}) of the displaced equipment shall be calculated based on verified direct CO_2 emissions over the most recent 3-year period of continuous commercial operation prior to the activity start date. Upstream CH_4 emissions shall be excluded.

To guarantee absolute conservativeness and prevent the rewarding of historical inefficiency, the unadjusted baseline shall be determined using the lowest value between the historical emissions intensity and the applicable BAT:

$$EF_{baseline} = min(EF_{hist}, EF_{BAT}) \qquad \text{(eq.3)}$$

$$BE_{unadj,y} = P_{H2,y} \times EF_{baseline} \qquad \text{(eq.4)}$$

where

$\boldsymbol{EF_{hist}}$	Historical specific emissions intensity of the replaced equipment (tCO_2e/tH_2), explicitly excluding upstream CH_4 emissions. Calculated as the ratio of verified direct CO_2 emissions to verified hydrogen output, averaged over the most recent 3 years of continuous operation.
$\boldsymbol{EF_{baseline}}$	The final conservative baseline emission factor applied to the brownfield retrofit (tCO_2e/ tH_2).

7.3.5 | **Temporal Transition Safeguard (Post-RUL):** In accordance with Scenario B (Section 7.1) and A6.4-AMT-006, once the remaining technical lifetime (RUL) of the replaced baseline equipment has elapsed, the baseline emission factor $EF_{baseline}$ shall transition to the Scenario A (Greenfield) baseline (EF_{BAT})

7.4 | Step 3: Application of the Downward Adjustment & Uncertainty

7.4.1 | **Uncertainty Adjustment** ($BE_{adj,UNC,y}$)**:** The unadjusted baseline shall be adjusted for the statistical uncertainty of the parameters on which it depends, applying an Uncertainty Adjustment Factor (UAF) determined in accordance with the IPCC 2006 Guidelines (2019 refinement), Volume 1, Chapter 3, Approach 2 (Monte Carlo simulation). The uncertainty of the baseline and of activity emissions shall be assessed separately. The adjustment applies to parameters carrying genuine statistical uncertainty (the metered and measured parameters); fixed default parameters whose conservatism is already embedded in the value adopted — the baseline emission factor EF BAT, the hydrogen GWP, and the transmission-and-distribution loss default — are excluded from the aggregation, since applying a further uncertainty deduction to them would double-count conservatism already present. The derivation is set out in the Supplementary Information, Section 8. The Uncertainty Adjustment Factor shall be applied as follows:

$$BE_{adj,\mathrm{UNC},y} = BE_{unadj,y} \times UAF \qquad \text{(eq.5)}$$

where the UAF is determined as:

a. **Greenfield activities.** The baseline depends on a single monitored parameter (metered hydrogen production), the baseline emission factor being a fixed default. The UAF is fixed at 0.988, corresponding to the one-sided 90% lower bound of the metered production uncertainty (SI Section 8, Section 8.3).

b. **Brownfield activities.** The baseline depends on the metered production parameter and on the measured historical emission factor, combined through a MIN operator with the BAT cap. Because the result depends on the proximity of the measured historical intensity to the cap, the activity developer shall determine the UAF by IPCC Approach 2, running a Monte Carlo simulation (not fewer than 100,000 iterations, with a documented random seed) on the activity’s own historical-emission-factor distribution against the applicable EF_BAT cap, and taking the one-sided 90% lower bound of the resulting baseline distribution. The procedure and a worked example are given in SI Section 8. The value so determined shall be verified by the VVB.

The uncertainty adjustment is applied to the unadjusted baseline before the Ambition Adjustment (DAF) at eq.5. The measurement and parameter uncertainties detailed in Section 13 are the inputs to this uncertainty adjustment (the UAF). The adjustment is structurally distinct from, and applied prior to, the DAF at eq.5: it corrects for empirical and instrumental variance, whereas the DAF addresses macroeconomic policy ambition. The UAF derivation, by IPCC Approach 2 (Monte Carlo), is set out in SI Section 8

7.4.2 | **Ambition Adjustment (DAF):** The activity developer shall source the exact, country-specific DAF from the latest version of the GS4GG Tool: Downward Adjustment Factor (DAF) Determination, based directly on the host country's officially declared Net-Zero target year.

7.4.3 | **Calculation of the Downward-Adjusted Baseline ($\boldsymbol{BE_{adj,,y}}$):** The downward-adjusted baseline ($BE_{adj,y}$) shall be calculated as follows:

$$BE_{adj,y} = BE_{adj,\mathrm{UNC},y} \times \left(1 - DAF_y\right) \qquad \text{(eq.6)}$$

Where,

$\boldsymbol{BE_{adj,y}}$	Downward Adjusted Baseline Emissions in year y (tCO_2e/yr).

$\boldsymbol{DAF_y}$	The annual Downward Adjustment Factor for the host country, applicable to year y (fraction), sourced from the GS4GG DAF Tool.

7.5 | Step 4: Identification and Calculation of the Conservative BAU Scenario:

7.5.1 | The methodology shall identify the conservative Business-As-Usual (BAU) baseline to ensure the final crediting baseline remains demonstrably below BAU over time.

7.5.2 | **Define and Calculate the Unadjusted BAU (**BAU_y**):** The BAU scenario represents the emissions that would most likely occur in the host country in the absence of the activity. It shall explicitly incorporate any policies, legal requirements, and specific national targets that are active (e.g., legally enforced energy efficiency mandates)**.**

$$BAU_y = P_{H2,y} \times EF_{BAU} \times (1 - RA_{mandate}) \qquad \text{(eq.7)}$$

Where,

$\boldsymbol{BAU_y}$	Unadjusted, most likely net BAU emissions in year y (tCO_2e/yr).
$\boldsymbol{P_{H2,y}}$	Total monitored production of green hydrogen by the activity in year y, (tH_2/yr), adjusted to 100% chemical purity on a dry basis.
$\boldsymbol{EF_{BAU}}$	The prevailing average emission intensity of conventional hydrogen capacity in the host country (tCO_2e/tH_2).
$\boldsymbol{RA_{mandate}}$	Regulatory Adjustment Factor (fraction) representing any legally enforced efficiency improvements taking effect in year y. Calculated as the proportional reduction in BAU emission intensity attributable to legally enforced measures. If no legally enforced measures are in effect during the crediting period, $\boldsymbol{RA_{mandate}} = 0$. The developer shall provide legislative references and calculate the factor based on the specific requirements of the applicable regulation.

7.5.3 | **Calculation of Conservative BAU Baseline:** The activity developer shall calculate the DAF-adjusted conservative BAU baseline as follows:

$$BE_{BAU,y} = BAU_y \times (1 - DAF_y) \qquad \text{(eq.8)}$$

Where,

$\boldsymbol{BE_{BAU,y}}$	Conservative BAU baseline emissions in year y (tCO_2e/yr). (Note: As parameter-level conservativeness has been strictly applied, the separate aggregate uncertainty deduction is not required, and the Conservative BAU defaults to the DAF-adjusted BAU).)

DAF_y	The host country's annual Downward Adjustment Factor for year y (fraction), sourced from the GS4GG DAF Tool.

7.6 | Step 5: Comparison and Selection of the Crediting Baseline

7.6.1 | The final Crediting Baseline (BE_y) used to calculate the activity's net emission reductions shall be strictly determined ex-post for each calendar year. The activity developer shall compare the downward-adjusted baseline (Step 3) against the conservative BAU baseline (Step 4) and select the lower (most conservative) value of the two.

$$BE_y = MIN(BE_{adj,y}, BE_{BAU,y}) \qquad \text{(eq.9)}$$

Where,

BE_y	Final crediting baseline emissions for year y (tCO_2e/yr).

7.6.2 | **Quantification of the Difference between BAU and Crediting Baseline:** To ensure transparency regarding the climate ambition embedded in the methodology, the activity developer shall quantify and explicitly report the precise volume of emissions excluded from crediting due to the application of the DAF and uncertainty mechanisms. This value shall be reported in each monitoring report.

$$\Delta y = BAU_y - BE_y \qquad \text{(eq.10)}$$

Where,

Δy	Difference between unadjusted BAU and the final crediting baseline emissions in year.

7.6.3 | This calculated difference (Δy) shall be reported solely as a transparency metric in each monitoring report to demonstrate the uncredited ambition automatically accruing to the host country; it is not used in the final calculation of issuable emission reductions.

8| ACTIVITY EMISSIONS

8.1 | Identification of Activity Scenario

8.1.1 | The activity scenario is defined by the production of green hydrogen utilising water electrolysis powered exclusively or primarily by zero-emission renewable energy.

8.1.2 | Because the core chemical process is powered by zero-emission renewable energy, direct GHG emissions from the synthesis process itself are inherently near zero. Activity emissions (AE_y) shall solely encompass the anthropogenic emissions occurring within the activity boundary that are directly attributable to the operation of the facility.

8.1.3 | Activity emissions (AE_y) shall be limited to the following quantified sources:

a. Grid Electricity Consumption ($AE_{grid,y}$): Indirect emissions from the permitted consumption of grid electricity (capped at ≤ 10% annually) utilised as a supplementary or backup power source.
b. Fossil Fuel Consumption ($AE_{ff,y}$): Direct emissions from the permitted combustion of fossil fuels in on-site emergency backup generators.
c. Fugitive Emissions ($AE_{\text{fugitive},y}$): The climate impact of unintended physical leaks of hydrogen (H2) gas into the atmosphere.
d. Refrigerant Emissions ($AE_{\text{ref},y}$): Fugitive emissions of synthetic refrigerants (HFCs), applicable only if the activity operates cryogenic liquefaction or deep-cooling systems for hydrogen storage and transport.
e. Activity Transportation ($AE_{\text{trans},y}$): Incremental emissions associated with the downstream transportation of the final hydrogen product to the existing dedicated consumer(s).

8.2 | Calculation of Total Activity Emissions

8.2.1 | Total activity emissions in year y shall be calculated as the sum of the emissions from electricity consumption, fossil fuel combustion, and transportation:

$$AE_y = AE_{grid,y} + AE_{ff,y} + AE_{\text{fugitive,H2}y} + AE_{\text{ref},y} + AE_{\text{trans},y} \quad \text{(eq.11)}$$

Where,

$\boldsymbol{AE_y}$	Total activity emissions in year y (tCO_2e/yr).
$\boldsymbol{AE_{grid,y}}$	Activity emissions from the consumption of non-renewable grid electricity in year y (tCO_2e/yr).
$\boldsymbol{AE_{ff,y}}$	Activity emissions from the consumption of fossil fuels for auxiliary/backup purposes in year y (tCO_2e/yr).
$\boldsymbol{AE_{\text{fugitive},H2y}}$	Activity emissions from physical fugitive leaks of hydrogen in year y (tCO_2e/yr).
$\boldsymbol{AE_{\text{ref},y}}$	Activity emissions from physical fugitive leaks of HFC emissions in year y (tCO_2e/yr).
$\boldsymbol{AE_{\text{trans},y}}$	Activity emissions from the incremental transportation of the activity's hydrogen product in year y (tCO_2e/yr).

8.3 | Emissions from Grid Electricity Consumption ($AE_{grid,y}$)

8.3.1 | The grid electricity consumption shall be calculated strictly in accordance with the latest version of the UNFCCC Article 6.4 mechanism tool: A6.4-AMT-007: Methodological tool: Emissions from electricity generation and consumption.

8.3.2 | The activity developer shall apply the tool to determine the applicable grid emission factor ($EF_{grid,y}$) and calculate the emissions as follows:

$$AE_{grid,y} = EC_{grid,y} \times EF_{grid,y} \times \left(1 + TDL_y\right) \qquad \text{(eq.12)}$$

Where,

$\boldsymbol{EC_{grid,y}}$	Total metered quantity of electricity drawn from the grid by the activity facility in year y (MWh/yr).
$\boldsymbol{EF_{grid,y}}$	Grid emission factor determined in accordance with A6.4-AMT-007 (tCO_2e/MWh).
$\boldsymbol{TDL_y}$	Average technical transmission and distribution losses for the grid in year y (fraction). A conservative default of 0.10 (10%) shall be applied if official verifiable data is unavailable.

8.4 | Emissions from Fossil Fuel Combustion ($AE_{ff,y}$)

8.4.1 | The use of fossil fuels for the core hydrogen production process is strictly prohibited. Fossil fuel backup generators are strongly discouraged but may be utilised strictly for emergency safety shutdowns or critical auxiliary functions.

8.4.2 | If any fossil fuels are consumed during the monitoring period, the emissions shall be meticulously calculated based on actual metered fuel consumption using the latest version of GS4GG Tool 01: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (or equivalent TOOL03).

8.5 | Fugitive Emissions ($AE_{\mathrm{fugitive},H2y}$)

8.5.1 | Physical leaks of hydrogen from electrolysers, compressors, liquefaction plants, pipelines, and storage shall be continuously monitored via mass-balance and/or sensor networks.:

$$AE_{\mathrm{fugitive,H2}y} = Q_{\mathrm{leaks},H2,y} \times GWP_{\mathrm{H2}} \qquad \text{(eq.13)}$$

Where,

$\boldsymbol{Q_{\mathrm{leaks},H2,y}}$	Total monitored mass of uncombusted hydrogen physically leaked to the atmosphere in year y (tonnes H_2). Monitored via mass balance reconciliation or integrated gas leak detection sensors. For the first monitoring period, if mass-balance reconciliation yields an uncertainty exceeding ±20% of the calculated hydrogen losses, the developer shall apply a conservative default leakage rate of 2% of total hydrogen produced, based on industry benchmarks for comparable electrolyser systems. This default shall be used until sufficient operational data is available to validate the mass-balance approach. [Note: Hydrogen leakage rates from electrolysis production vary substantially depending on system boundaries, operating pressure, and whether intermittent operational losses (start-up venting, purging) are included. Estimates range from 0.2% for steady-state membrane crossover (Arrigoni & Bravo Diaz, 2022) to a literature-synthesis average of 1.72% when all operational

	losses are included (Trapani et al., 2025). A conservative default of 2% is consistent with the upper range for pressurised systems.].
GWP_{H2}	The 100-year Global Warming Potential (GWP_{100}) for hydrogen. The activity developer shall apply a value of **14.4** (*Sand et al., 2023).* This value is the upper bound of the 11.6 ± 2.8 estimate of Sand et al. (2023), adopted as a deliberate conservativeness measure; AR5 reports no GWP for hydrogen. The derivation is given in SI Sections 4 and 7.

8.6 | Refrigerant Emissions ($AE_{\mathrm{ref},y}$)

8.6.1 | If the activity operates cryogenic cooling or liquefaction systems utilising hydrofluorocarbons (HFCs), fugitive refrigerant emissions shall be calculated in accordance with the latest version of the CDM TOOL28: Calculation of baseline, project and leakage emissions from the use of refrigerants. If cryogenic systems are not employed, $AE_{\mathrm{ref},y}$ = 0.

8.7 | Emissions from Activity Transportation ($AE_{\mathrm{trans},y}$):

8.7.1 | If the average two-way transportation distance from the activity site to the eligible end-user is less than 200 km, transportation emissions may be deemed negligible and set to zero. For distances exceeding 200 km, emissions shall be calculated as follows:

$$AE_{\mathrm{trans},y} = \sum_m \left(Q_{\boldsymbol{H2},m,y} \times D_{proj,m} \times EF_{trans,m}\right) \quad \text{(eq.14)}$$

Where,

$AE_{\mathrm{trans},y}$	Incremental activity transportation emissions in year y (tCO_2e/yr).
$Q_{H2,m,y}$	Quantity of green hydrogen transported via transport mode m in year y (tonnes).
$D_{proj,m}$	Average two-way[2] distance from the activity site to the fertiliser manufacturing facility via mode m (km).
$EF_{trans,m}$	Emission factor for transport mode m (tCO_2e/tonne-km). Default values shall be sourced from recognised normative references (e.g., U.S. EPA Emission Factors Hub or national equivalents).

[2] The use of two-way distance multiplied by standard one-way emission factors deliberately introduces a conservative bias in activity emission accounting, equivalent to assuming all return trips are empty. This is an intentional conservativeness measure.

9| LEAKAGE EMISSIONS

9.1 | General Requirements

9.1.1 | In accordance with the GS4GG Methodology Standard: Requirements for Addressing Leakage in Methodologies, the activity developer shall apply a three-tiered approach to address leakage emissions:

a. Identify all potential sources of leakage;
b. Implement measures to avoid such leakage or, where avoidance is impracticable, to minimise any resultant negative leakage; and
c. Quantify and deduct any residual negative leakage in accordance with the specifications set forth below.

9.2 | Identification of Emission Sources

9.2.1 | The activity developer shall identify all potential sources of leakage associated with the green hydrogen production activity. These sources shall include, inter alia, the following:

a. **Baseline equipment transfer:** For brownfield activities, leakage shall be accounted for where equipment that was operational within the activity boundary prior to the implementation of the activity (e.g., fossil-based hydrogen production equipment such as SMR units) is displaced, retains operational functionality and residual economic value for third parties, and may be used outside the activity boundary in a manner that could displace processes with lower GHG intensity.
b. **Resource competition:** Leakage attributable to competition for renewable electricity is addressed in the Supplementary Information, Section 6; its exclusion rests on the applicability conditions (dedicated additional renewables, hourly matching, deliverability, and a grid-emission-factor charge on unmatched hours) that constrain the activity to a consequential-emissions outcome no worse than dedicated behind-the-meter supply and is bounded to that equivalence. Competition for local water is bounded by the potable-water cap of Section 3.
c. **Diversion of existing production processes or outputs:** Leakage attributable to the diversion of existing production processes or outputs shall be considered where the types of outputs or levels of service delivered under the activity scenario deviate from those established in the baseline scenario.
d. **Increases in environmental greenhouse-gas releases:** Leakage shall be assessed for any release of GHG emissions from natural reservoirs directly attributable to the implementation of the mitigation activity (e.g., land-use change due to the construction of new facilities).
e. **Changes in upstream and downstream processes (Embodied emissions):** Indirect GHG emissions (cradle-to-gate) associated with the production, processing, transport, and delivery of major equipment

and material inputs used by the mitigation activity (e.g., electrolysers, solar PV panels, wind turbines, and battery energy storage systems).

9.3 | Avoidance and Minimisation of Leakage

9.3.1 | The methodology incorporates strict applicability conditions and provisions to avoid or prevent, or where avoidance is not feasible, to minimise all identified sources of negative leakage:

a. **Avoidance of baseline equipment transfer:** To fully avoid leakage from baseline equipment transfer, the activity developer shall ensure that all displaced baseline equipment is verifiably decommissioned, destroyed, or otherwise irreversibly disposed of. Verifiable evidence (e.g., destruction certificates, photographic evidence, and independent audits by the VVB) shall be provided. If verified, leakage from equipment transfer is successfully avoided and deemed zero. In cases where the baseline equipment is dismantled and its components are repurposed in a disaggregated manner across different locations and for different functions, any associated leakage emissions may be neglected, as the equipment no longer functions in its original capacity. Proof of permanent decommissioning or scrapping shall be verified by the VVB.

b. **Minimisation of resource competition:** Leakage due to water resource competition is explicitly avoided via the applicability condition (Section 3) capping local drinking water consumption at 5%. Leakage attributable to competition for renewable electricity is addressed in the Supplementary Information, Section 6 (Renewable Electricity Attribution and Resource-Competition Leakage). As set out there, the exclusion of this leakage does not rest on the additionality of the renewable facility as such; it rests on the applicability conditions of Section 3 — dedicated additional renewable generation, hourly temporal matching, geographic deliverability, and the charging of any unmatched hour at the grid emission factor — which together constrain the activity to a consequential-emissions outcome no worse than generation supplied exclusively by dedicated behind-the-meter renewables. The VVB shall verify compliance with those conditions. The residual competition for renewable resource sites is bounded by that equivalence and is not further reducible by any accounting treatment; it is not separately deducted.

c. **Avoidance of diversion of existing production processes or outputs[3]:** The methodology restricts applicability to activities where the

[3] This methodology credits emission reductions on a per-unit basis (tCO_2e per tonne of green hydrogen produced for eligible end-use). It does not explicitly account for market-level substitution effects, whereby displaced conventional hydrogen production may continue serving other markets. This treatment is consistent with prevailing methodological practice for industrial decarbonization activities and is supported by the assumption that growing global hydrogen demand will progressively absorb green hydrogen as a substitute rather than purely as a displacement.

activity developer shall continue to produce the same type of output (hydrogen) and shall not result in a reduction of overall service levels or production capacity compared to the baseline. Therefore, leakage from the diversion of existing production outputs is avoided and deemed negligible.

d. **Minimisation of environmental releases:** Activity developers are encouraged to site new infrastructure on degraded, abandoned, or existing industrial lands to avoid disturbing natural carbon sinks and to minimise environmental GHG releases.

9.4 | Calculation and subtraction of leakage

9.4.1 | When negative leakage cannot be fully avoided through the measures outlined in Section 9.3, the methodology shall require the quantification of the remaining net leakage. If the calculation yields a net increase in emissions (negative leakage), the absolute amount of this leakage shall be deducted from the total quantified emission reductions.

9.4.2 | The total leakage emissions (LE_y) in year y shall be calculated as:

$$LE_y = LE_{equip,y} + LE_{LUC,y} + LE_{embodied,y} \quad \text{(eq.15)}$$

Where,

$\boldsymbol{LE_y}$	Total leakage emissions in year y (tCO_2e/yr).
$\boldsymbol{LE_{equip,y}}$	Leakage from transferred baseline equipment in year y (tCO_2e/yr).
$\boldsymbol{LE_{LUC,y}}$	Leakage from indirect land-use change in year y (tCO_2e/yr).
$\boldsymbol{LE_{embodied,y}}$	Leakage from amortised embodied infrastructure emissions in year y (tCO_2e/yr).

9.4.3 | **Leakage from Transferred Baseline Equipment** ($LE_{equip,y}$): If the transfer of baseline equipment cannot be avoided by its destruction, decommissioning, or disposal, the activity developer shall quantify the resulting negative leakage from its continued operation. The activity developer shall apply one of the following two approaches:

a. **Conservative default penalty:** The activity developer shall conservatively assume that the transferred equipment operates continuously at its historical maximum annual capacity.

$$LE_{equip,y} = Q_{\max\backslash Cap} \times EF_{hist} \quad \text{(eq.16)}$$

Where,

$\boldsymbol{Q_{\max Cap}}$	The historical maximum annual nameplate capacity of the transferred equipment (tH_2/yr).

EF_{hist}	The historical specific emissions intensity of the transferred equipment prior to the activity (tCO_2e/H_2), as determined in Section 7.

b. **Explicit tracking and metering:** The developer shall explicitly track the relocated equipment and directly meter its actual operational output ($Q_{\text{actual,y}}$) at its new location for the duration of its remaining technical lifetime. If access to the relocated equipment is denied or records are unverifiable, the developer shall default to the maximum capacity penalty.

9.4.4 | **Changes in upstream processes ($LE_{embodied,y}$):** The total cradle-to-gate lifecycle GHG emissions of the new renewable energy facility, electrolyser units, and energy storage shall be quantified using verified Environmental Product Declarations (EPDs compliant with ISO 14025/14040) or conservative IPCC/IEA median defaults. The total upfront embodied emissions shall be amortised linearly across the exact duration of the first crediting period (e.g., 5 years).

$$LE_{embodied,y} = \frac{E_{emboided,total}}{N} \qquad \text{(eq.17)}$$

Where,

$LE_{embodied,y}$	Annual amortised embodied emissions attributed to the activity in year y (tCO_2e/yr).
$E_{RE,total} + E_{electrolyser,total} + E_{storage,total}$	Total cradle-to-gate lifecycle GHG emissions of the newly installed activity infrastructure (tCO_2e).
N	N, the amortisation period in years, defined as the lesser of the technical lifetime of the installed infrastructure (determined under A6.4-AMT-006) and the aggregate crediting period, capped at 15 years, following the GS4GG G-RESET treatment. The annual embodied-emissions charge continues until the full upfront footprint has been recovered over N years; it is not confined to the first crediting period. Where N extends beyond the first crediting period, $LE_{embodied,y}$ continues into subsequent crediting periods until N is reached, per Section 17.

9.4.5 | **Land Use Change ($LE_{LUC,y}$):** If the greenfield construction of the hydrogen plant or its renewable energy facility results in the conversion of land from a natural state (e.g., forest, wetland, or grassland) to an industrial site or solar/wind farm, the resulting GHG emissions from the loss of carbon stocks shall be quantified as leakage. LUC emissions shall be deemed immaterial and set to zero if:

a. the activity is located on existing industrial, commercial, or degraded land with no significant above-ground biomass; AND
b. the total estimated leakage for land use change is below 5% of estimated annual emission reductions over the crediting period (i.e., 15 years).

In all other cases, a full LUC assessment per Equation 18 is required.

9.4.6 | The $LE_{LUC,y}$ shall be calculated as the difference between the carbon stocks of the land before conversion and after conversion across all five IPCC pools (Above-Ground Biomass, Below-Ground Biomass, Dead Wood, Litter, and Soil Organic Carbon). This shall be calculated using Tier 1 default values from the 2006 IPCC Guidelines for National GHG Inventories, unless higher-tier local data is verifiable.

9.4.7 | In accordance with IPCC good practice guidance, the total carbon stock loss shall be amortized over a fixed 20-year period.

$$LE_{LUC,y} = \max\left[0, \sum_i \left(C_{BSL,i} - C_{pro,i} \times A_i \times \frac{44}{12}\right)/20\right] \quad \text{(eq.18)}$$

Where,

$C_{BSL,y}$	Total carbon stock per unit area for the land use type of parcel i before conversion (tonnes C/ha).
$C_{pro,i}$	Total carbon stock per unit area for the land use type of parcel i after conversion (tonnes C/ha).
A_i	Area of land parcel *i* undergoing conversion (ha).
$\frac{44}{12}$	Conversion factor from tonnes of carbon (C) to tonnes of carbon dioxide (CO_2).
20	Amortization period for LUC emissions, fixed at 20 years as per IPCC good practice guidance. The 20-year amortization period for LUC emissions is fixed in accordance with IPCC good practice guidance to ensure the total climate impact is accounted for in a standardized manner, even if this period extends beyond the activity's 15-year crediting period

10| NET EMISSION REDUCTIONS

10.1 | Calculation of Gross GHG Emission Reductions

10.1.1 | The gross GHG emission reductions achieved by the activity during a given monitoring period ($ER_{gross,y}$) represent the climate benefit prior to the application of the end-use safeguard. The activity developer shall calculate the gross emission reductions by subtracting the total activity emissions (Section 8) and total leakage emissions (Section 9) from the final crediting baseline emissions (Section 7).

$$ER_{gross,y} = BE_{credit,y} - AE_y - LE_y \quad \text{(eq.19)}$$

Where,

$ER_{gross,y}$	Gross emission reductions during the monitoring period y (tCO_2e/yr)
$BE_{credit,y}$	Final crediting baseline emissions in the monitoring period y (tCO_2e/yr). This value inherently incorporates the DAF and conservative BAU checks as determined in Section 7.
AE_y	Total activity emissions in the monitoring period y (tCO_2e/yr).
LE_y	Total leakage emissions in the monitoring period y (tCO_2e/yr).

10.1.2 | If the calculation of $ER_{gross,y}$ yields a negative value, the gross emission reductions for that monitoring period shall be deemed zero. Negative emission reductions cannot be banked or carried forward to subsequent monitoring periods). Where the negative value is attributable in whole or in part to the amortised embodied-emissions charge ($LE_{embodied,y}$) exceeding the available reductions in that period, the unrecovered portion of that charge shall be carried forward as an embodied-emissions deficit and applied against reductions in subsequent monitoring periods until extinguished. This carry-forward applies to unrecovered embodied deductions only; it does not permit the banking or carry-forward of net reductions. This deficit-ledger treatment follows the GS4GG G-RESET methodology and ensures the full upfront embodied footprint is recovered before net reductions are claimed.

10.2 | Safeguard for verified end-use

10.2.1 | In accordance with the applicability condition established in Section 3, emission reductions shall only be credited for green hydrogen that is verifiably dispatched and utilised for eligible end-uses. Any volume of hydrogen sold, transferred, or utilised for non-eligible purposes (e.g., Enhanced Oil Recovery, unabated gas network blending) shall be strictly excluded from the crediting calculations.

10.2.2 | To robustly operationalise this safeguard without limiting future methodology revisions, the activity developer shall apply the Eligible End-Use Fraction ($F_{eligible,y}$).

10.2.3 | The activity developer shall rigorously reconcile the total volume of green hydrogen produced against audited sales receipts, dispatch logs, mass-balance tracking, or internal transfer records to the eligible consumer(s). *Note: If green hydrogen is produced in year y but retained in storage inventory and sold for an eligible use in year y+1, the activity developer may defer the crediting of that specific volume until the monitoring period in which the eligible end-use is officially verified.*

10.3 | Calculation of Final Net GHG Emission Reductions

10.3.1 | The final net emission reductions (ER_y) represent the actual, verifiable volume of GSVERs (Gold Standard Verified Emission Reductions) eligible for issuance.

To determine ER_y, the activity developer shall apply one of the following two approaches:

a. **Option A: The Fractional Multiplier Approach (Default):** The final net emission reductions are calculated by multiplying the gross emission reductions by the verified Eligible End-Use Fraction.

$$F_{eligible,y} = \frac{Q_{eligible,y}}{P_{H2,y}} \quad \text{(eq.20)}$$

$$ER_y = ER_{gross,y} \times F_{eligible,y} \quad \text{(eq.21)}$$

Where,

$\boldsymbol{ER_y}$	Final net emission reductions eligible for issuance during the monitoring period y (tCO_2e/yr).
$\boldsymbol{ER_{gross,y}}$	Gross emission reductions during the monitoring period y prior to end-use safeguard (tCO_2e/yr)
$\boldsymbol{F_{eligible,y}}$	The fraction of total low-carbon hydrogen produced in year y that is verifiably utilised for eligible end-uses (fraction).
$\boldsymbol{Q_{eligible,y}}$	Quantity of green hydrogen verifiably dispatched and sold for eligible end-uses in year y (tonnes).
$\boldsymbol{P_{H2,y}}$	Total monitored production of green hydrogen by the activity in year y (tonnes).

b. **Direct Baseline Allocation Approach (Alternative):** Alternatively, the activity developer may isolate the eligible production volume from the outset. In this approach, the baseline production parameter ($P_{H2,y}$ defined in Section 7) shall strictly equal only the exact metered volume of hydrogen verifiably delivered for eligible end-uses ($Q_{eligible,y}$). The remaining non-eligible volume is excluded from the baseline calculations entirely. To ensure absolute conservativeness under Option B, total activity emissions (AE_y) and total leakage emissions (LE_y) shall not be prorated downward; the full facility-level activity and leakage penalties shall be deducted from the eligible baseline:

$$ER_y = BE_{credit,y(eligible\ only)} - AE_{y(total)} - LE_{y(total)} \quad \text{(eq.22)}$$

c. Under either Option A or Option B, if the calculation of ER_y yields a negative value, the net emission reductions for that monitoring period shall be deemed zero. Negative emission reductions cannot be banked or carried forward.

11| METHODOLOGIES PRINCIPLES

11.1 | Encouraging ambition over time:

11.1.1 | This methodology ensures the continuous encouragement of climate ambition — moving beyond static emission reductions — through the following mandatory mechanisms:

a. **Downward Adjustment Factor (DAF):** The methodology operationalises ambition by mandating the application of the DAF (Section 7.4.2). The magnitude of the DAF is explicitly derived from the host country's declared Net-Zero target year, ensuring that the baseline trajectory mathematically mirrors the national long-term decarbonisation pathway.

b. **Conservative Baseline Setting:** By setting the unadjusted baseline against the performance of highly efficient, best in class modern conventional plants (Section 7.3.1), rather than a less ambitious fleet average or older, high-emission technologies, the methodology ensures only activities pushing the technological frontier generate carbon revenues.

11.2 | Equitable Sharing of Mitigation Benefits

11.2.1 | The methodology promotes the equitable sharing of mitigation benefits between participating Parties (the host country and the activity developer) by operating under the GS4GG framework and aligning with national development goals.:

a. **Long-Term Host Country Benefit:** Industrial hydrogen facilities possess operational lifetimes (e.g., 20–40 years) that significantly exceed the maximum 15-year crediting period allowed under this methodology. Consequently, the host country will continue to derive massive, uncredited emission reductions (well beyond Business-As-Usual [BAU]) for decades after carbon financing ends, directly contributing to the host country's Nationally Determined Contributions (NDCs).

b. **Uncredited Ambition:** Because the crediting baseline is forced below the actual, most likely BAU scenario via the DAF and uncertainty discounts, a significant volume of emission reductions physically occurs but is explicitly excluded from carbon crediting. These "uncredited" emission reductions automatically accrue to the host country.

c. **Safeguards and Local Co-Benefits:** Adherence to the GS4GG Safeguarding Principles and Requirements ensures that the rights and interests of local stakeholders are protected. Specifically, the strict 5% cap on local drinking water consumption for electrolysis (Section 3.2.8) guarantees that the activity's massive resource needs do not compromise local community access to essential water resources or agricultural livelihoods.

11.3 | Avoidance of Double Counting

11.3.1 | Given the complex, overlapping policy incentives emerging in the global hydrogen sector, the methodology includes strict safeguards to prevent double issuance, double use, and double claiming:

a. **Environmental Markets & Subsidies:** The activity developer shall demonstrate in each monitoring report that the emission reductions claimed under GS4GG are not simultaneously monetised or claimed under other environmental markets (e.g., Renewable Energy Certificates [RECs], Guarantees of Origin [GOs], Low-Carbon Fuel Standards, or green hydrogen certification schemes). As mandated in Section 3.2, any Power Purchase Agreement (PPA) utilised by the activity shall legally prevent the renewable energy generator from selling RECs or GOs to a third party for the power supplied to the hydrogen plant.

b. **Domestic Mitigation Schemes:** The Regulatory Surplus Analysis (Section 6.2) requires the developer to prove the emission reductions do not overlap with mandatory domestic compliance markets (e.g., an Emissions Trading System [ETS] that caps the exact emission sources reduced by the activity). If an overlap exists, the developer must prove that allowances equal to the GSVERs requested for issuance were verifiably cancelled.

c. **End-User Notification:** The activity developer shall explicitly assert ownership rights over the emission reductions via contractual agreements with the hydrogen off-taker(s) and legally notify the end-users that they cannot claim the emission reductions for their own Scope 3 decarbonisation targets unless the GS4GG credits are formally retired on their behalf.

11.4 | Aligning with the NDC and LT-LEDS

11.4.1 | The methodology ensures strict alignment with the host country's NDCs and Long-Term Low-Emission Development Strategies (LT-LEDS), as well as the temperature goals of the Paris Agreement:

a. **Lock-In Risk Avoidance:** The mandatory Lock-In Risk Analysis (Section 6.3) prevents the issuance of carbon credits to transitional fossil-fuel technologies (e.g., "blue" hydrogen equipped with CCS or SMR units). By strictly limiting eligibility to water electrolysis powered by zero-emission renewable energy, the methodology ensures the infrastructure built today is fully compatible with mid-century Net-Zero pathways.

b. **DAF Alignment:** The magnitude of the Downward Adjustment Factor (DAF) is explicitly derived from the host country's declared Net-Zero target year (Section 7.4.2), ensuring that the baseline trajectory mathematically mirrors the national long-term decarbonisation pathway.

11.5 | Encouraging broad participation

11.5.1 | The methodology encourages broad participation across diverse geographies through standardisation and flexibility:

a. **Global Applicability and Defaults:** The methodology is globally applicable to micro, small, and large-scale facilities. To reduce transaction costs and encourage participation in data-poor regions, it provides standardised, conservative global default values for the BAT baseline.

b. **Multiple Baseline Approaches:** The methodology accommodates diverse host-country contexts by providing for BAT baselines (where standardised benchmarks are available), historical baselines (for brownfield retrofits with verifiable operational data), and conservative BAU checks (reflecting national regulatory realities).

c. **Programmatic Approach:** The methodology is suitable for aggregation under Programmes of Activities (PoA), allowing for the scaled deployment of modular, decentralised green hydrogen production units under a single, streamlined certification umbrella.

11.6 | Including data sources, accounting for uncertainty and monitoring

11.6.1 | The methodology ensures robustness in data utilisation, uncertainty management, and monitoring integrity. Core monitored parameters (electricity consumption, hydrogen production volume, fugitive leaks) rely on continuous, industrial-grade metering with mandatory calibration. Non-measured parameters utilise conservative, peer-reviewed defaults or third-party verified Environmental Product Declarations. Uncertainty is addressed through parameter-level conservativeness (Section 13) and mandatory conservative adjustments for out-of-calibration equipment.

11.7 | Taking into account policies and measures and relevant circumstances

11.7.1 | The methodology accounts for relevant national policies and local circumstances:

a. **Regulatory Surplus:** The mandatory Regulatory Surplus Analysis (Section 6.2) ensures the activity is not legally mandated by current or anticipated national laws.

b. **Conservative BAU Integration:** The calculation of the Conservative Business-As-Usual (BAU) baseline (Section 7.5) explicitly incorporates any legally enforced efficiency improvements or emission caps taking effect during the crediting period, ensuring the crediting baseline reflects the true regulatory reality of the host country.

c. **National Hydrogen Definitions:** Where host countries have adopted official green hydrogen definitions or certification schemes, the methodology requires explicit documentation and alignment (Section 6.2).

12| REVERSALS

12.1 | Assessment of Reversal Risks

12.1.1 | This methodology addresses the avoidance of greenhouse gas emissions through the displacement of conventional, fossil-fuel-intensive hydrogen production with electrolysis-based hydrogen production powered by renewable energy.

12.1.2 | As an emission avoidance activity, there is no physical risk of captured or sequestered carbon re-entering the atmosphere, as the activity does not rely on carbon removal or storage technologies. Consequently, the concept of a "reversal" (the loss of stored carbon) is not applicable to this methodology.

12.1.3 | The only operational requirement for maintaining the integrity of emission reductions is demonstrating the continued, eligible operation of the zero-emission production facility. If the facility ceases operation or reverts to non-eligible production practices (e.g., using fossil-derived feedstocks or exceeding grid electricity thresholds), the activity shall immediately be disqualified from issuing further emission reductions.

13| UNCERTAINTY QUANTIFICATION

13.1 | Approach to Uncertainty Management

13.1.1 | This methodology establishes a structured framework to quantify and mitigate uncertainty, ensuring the calculated Net GHG Emission Reductions remain conservative. This approach combines methodological standardisation for non-measured (Fixed default) parameters with mandatory industrial metering accuracy and calibration for core empirical parameters. (and applies an Uncertainty Adjustment Factor (UAF) to the baseline at Section 7, Step 3. The UAF is determined by IPCC Approach 2 (Monte Carlo simulation): the baseline and activity uncertainties are assessed separately, and the fixed default parameters whose conservatism is already embedded are carved out of the aggregation. The full derivation is set out in SI Section 8. This uncertainty adjustment is structurally distinct from, and applied prior to, the DAF, which addresses macroeconomic policy ambition.

13.1.2 | **Standardisation and Defaults**: Uncertainty for non-measured parameters (e.g., Best Available Technology benchmark $[EF_{BAT}]$, embodied infrastructure emissions $[LE_{embodied,y}]$, Global Warming Potentials $[GWP_{100}]$, and chemical conversion factors) is managed using strictly conservative, methodology-approved defaults, peer-reviewed scientific consensus (e.g., Sand et al., 2023 for hydrogen), or third-party verified Environmental Product Declarations (EPDs).

13.1.3 | **Measurement Conservativeness (Industrial Metering):** The industrial green hydrogen production relies on continuous, direct measurement. Uncertainty for core empirical parameters (e.g., electricity consumption, hydrogen production, physical gas leaks) is managed through mandatory adherence to international calibration standards (e.g., ISO, IEC) for all metering equipment. If any measurement equipment falls out of calibration or precision targets are compromised, a mandatory conservative adjustment shall be mathematically applied to the dataset using the maximum observed error margin.

13.2 | Sources of Uncertainty and Mitigation

13.2.1 | Key uncertainty sources and their mandated mitigation measures are summarised in the following table. This matrix shall serve as the normative reference for VVBs when auditing uncertainty.

Table 7. Key uncertainty sources and mitigation measures

Source of Uncertainty	Affected Parameter(s)	Mandatory Mitigation Measure(s)
Measurement Uncertainty (Metering & Sensors) Sensor drift, flow meter inaccuracies, and electricity meter errors during continuous industrial operations.	$P_{H2,y}$ (Hydrogen Production) $Q_{eligible,y}$ (Eligible Hydrogen Sales) $EC_{grid,y}$ (Grid Electricity) $Q_{leak,H2,y}$ (Fugitive H_2)	1. **High-Precision Equipment:** Mandatory use of industrial-grade, continuous metering equipment complying with relevant national/international accuracy standards. 2. **Calibration:** Routine calibration of all meters against known reference standards (Section 14). 3. **Conservative Adjustment:** If a meter is discovered to be out of calibration during a post-test check, the maximum observed error margin shall be mathematically applied to the entire affected dataset in the most conservative direction (i.e., decreasing baseline production or increasing activity consumption/leaks).
Parameter Uncertainty (Defaults & LCA): Inherent uncertainty in lifecycle assessments, global warming potentials, and chemical conversion fractions.	GWP_{H2} (Hydrogen GWP) $LE_{embodied,y}$ (Embodied Emissions) $EF_{grid,y}$ (Grid Emission Factor)	1. **Standardisation:** Mandatory use of the specified, peer-reviewed GWP_{100} value for hydrogen 14.4 (11.6 ± 2.8). 2. **Verified LCAs:** Mandatory use of third-party verified, ISO 14025/14040 compliant EPDs for embodied emissions of new infrastructure, or conservative IPCC/IEA median defaults.

		3. **Approved Tools:** Adherence to A6.4-AMT-007 for grid emission factors.
Analytical Uncertainty (Baselines): Overestimating historical baseline emissions for brownfield retrofits or poorly selecting comparable regional BATs.	$EF_{baseline}$ (Final Crediting Baseline Emission Factor) EF_{hist} (Historical Emissions)	1. **Structural Conservativeness:** Mandatory application of the $min(EF_{hist}, EF_{BAT})$ logic for brownfield retrofits. 2. **BAT Selection:** Mandatory application of the $min(EF_{BAT,global}, EF_{BAT,national}$ logic. 3. **Boundary Exclusions:** Explicit exclusion of upstream baseline methane (CH_4) emissions to structurally guarantee a lower, highly conservative crediting benchmark.
Market and End-Use Uncertainty Hydrogen being diverted to non-eligible end-uses (e.g., Enhanced Oil Recovery, unabated gas blending) instead of the designated eligible end-uses, leading to unverified downstream impacts.	$F_{eligible,y}$ (Eligible End-Use Fraction) ER_y (Final Net Emission Reductions)	1. **End-Use Reconciliation:** Mandatory reconciliation of the total low-carbon hydrogen produced against audited sales receipts, dispatch logs, or internal mass-balance transfer records. 2. **Strict Exclusion:** Any volume of hydrogen lacking definitive proof of eligible end-use shall be strictly excluded from the baseline ($Q_{eligible,y}$), while full activity and leakage penalties shall remain fully deducted from the final crediting volume.
Hydrogen Leakage Quantification: Uncertainty in quantifying fugitive hydrogen emissions due to the difficulty of detecting small-molecule H_2 leaks and the nascent state of standardised H_2 leak measurement methodologies.	$Q_{leak,H2\,y}$ (Fugitive H_2); $AE_{fugitive,H2,y}$ (Fugitive Emissions)	**1. Dual Monitoring:** Mandatory use of both sensor-based leak detection AND mass-balance reconciliation, with the higher (more conservative) value applied. Default Leakage Rate: Conservative 2% default applied when mass-balance uncertainty exceeds ±20%. LDAR Programme: Mandatory Leak Detection and Repair programme with regular manual audits.

14| MONITORING METHODOLOGY

14.1 | General Requirements

14.1.1 | **Monitoring Plan:** The activity developer shall develop and implement a Monitoring Plan in the Project Design Document (PDD) or VPA-DD. The plan shall delineate the continuous industrial procedures for collecting, recording, analysing, and archiving all data required for the quantification of emission reductions, the tracking of eligible end-uses, and the verification of applicability and safeguard criteria (including water stress and extraction requirements).

14.1.2 | **Measurement Equipment and QA/QC Calibration:** All physical measurement equipment used for monitoring (e.g., electricity meters, mass flow meters for hydrogen, gas leak detection sensors, and weighbridges) shall be industrial-grade and comply with relevant national or international accuracy standards (e.g., ISO, IEC):

a. To prevent data invalidation due to calibration drift, all primary custody-transfer meters (for grid electricity import and final green hydrogen product output) shall undergo strict third-party calibration annually or in accordance with the manufacturer's specified calibration intervals, whichever is more stringent. Calibration logs shall be maintained and made available to the Validation and Verification Body (VVB).

b. If a primary meter is discovered to be out of calibration beyond its permissible error margin during a post-test check or routine maintenance, the maximum observed error margin shall be applied to the dataset in the most conservative mathematical direction (e.g., decreasing eligible baseline production or increasing activity electricity consumption and physical leaks).

14.1.3 | **Digital Monitoring (SCADA) and Reconciliation:** The utilisation of digital, continuous monitoring technologies—specifically Distributed Control Systems (DCS) and Supervisory Control and Data Acquisition (SCADA) systems—is mandatory for this industrial activity to ensure high-fidelity data capture of electricity consumption, gas flow rates, and physical leak detection. For fugitive emissions, continuous SCADA integration is mandatory for real-time alerting; however, mass-balance reconciliation across the production and compression/liquefaction loop may be utilised as a primary or fallback valid alternative to verify aggregate physical gas losses. Data shall be aggregated logically (e.g., hourly or daily) to facilitate robust VVB auditing.

14.1.4 | **Data Archiving:** All monitored data, including SCADA telemetry logs, mass-balance transfer records, dispatch/sales receipts for eligible end-use verification, and calibration certificates, shall be archived electronically. The data shall be securely backed up and retained for the duration of the crediting period plus an additional two (2) years after the final issuance of the corresponding vintage.

14.2 | Data and parameters not monitored

14.2.1 | The following parameters are determined ex-ante and remain fixed for the duration of the crediting period, unless otherwise noted.

Parameter ID	**GHM 1**
Data/parameter:	EF_{BAT}
Description	Best Available Technology (BAT) emission factor for conventional hydrogen production.
Data unit:	tCO_2e/tH_2
Purpose of data:	☒ Baseline emissions
Value(s) applied:	To be determined at the activity level. Global default for natural gas SMR: 8.5 tCO_2/tH_2. Global default for coal gasification: 18 tCO_2/tH_2 or Global default for Naphtha Reforming: 6.3 tCO_2/tH_2 The applicable global default shall correspond to the dominant baseline technology pathway in the host country.
Source of data:	☐ Measured ☒ Other source (Methodology Supplementary Information Section 4; or officially established, peer-reviewed national BAT benchmarks)
Choice of data or measurement methods and procedures:	The applicable BAT emission factor shall strictly be the lowest (most conservative) value available: $min(EF_{BAT,global}, EF_{BAT,national})$. Sourced from the methodology's Supplementary Information or officially established national BAT benchmarks applicable to the host country.
Treatment of uncertainty	Conservatively addressed by explicitly excluding upstream methane emissions from the benchmark value and applying the minimum between global and national BAT.
Comments:	Used to determine the unadjusted baseline emissions for Scenario A (eq.2) and as the strict cap for Scenario B (eq.3).

Parameter ID	**GHM 2**
Data/parameter:	EF_{hist}
Description	Historical specific emissions intensity of the replaced fossil-based equipment.
Data unit:	tCO_2e / tH_2
Purpose of data:	☒ Baseline emissions ☒ Leakage emissions
Value(s) applied:	To be determined at the activity level (applicable only to brownfield retrofits).
Source of data:	☐ Measured ☒ Other source

Choice of data or measurement methods and procedures:	Calculated based on verified direct CO_2 emissions from process heat and reforming over the most recent 3-year period of continuous commercial operation prior to the activity start date. Upstream CH_4 emissions shall be explicitly excluded.
Treatment of uncertainty	Conservatively managed by capping the historical baseline at the applicable BAT benchmark ($min(EF_{hist}, EF_{BAT})$) to prevent rewarding historical inefficiency.
Comments:	Also used to calculate Leakage if baseline equipment is transferred and reused ($LE_{equip,y}$).

Parameter ID	**GHM 3**
Data/parameter:	EF_{BAU}
Description	The prevailing average emission intensity of conventional hydrogen production capacity in the host country (Business-As-Usual). Derivation of EF_{BAU}.
Data unit:	tCO_2e / tH_2
Purpose of data:	☒ Baseline emissions
Value(s) applied:	To be determined at the activity level based on host country statistics or industry benchmarks.
Source of data:	☐ Measured ☒ Other source (Official national statistics, IEA reports, recognised industry associations)
Choice of data or measurement methods and procedures:	EF_{BAU} shall be sourced from the most recent published data on the emission intensity of conventional hydrogen production in the host country — in order of preference: (i) the host country's national greenhouse-gas inventory or officially reported industrial-process data; (ii) IEA hydrogen-production data for the host country; or (iii) where neither is available, a regional conventional-hydrogen intensity from a peer-reviewed or institutional source, applied conservatively. The source and vintage of the value shall be documented and verified by the VVB.
Treatment of uncertainty	Managed by applying the conservative BAU check (eq.7, eq.8) and selecting the lower of the adjusted baseline and the conservative BAU (eq.9).
Comments:	Used exclusively to calculate the unadjusted Conservative BAU Baseline (BAU_y) in Section 7.5.

Parameter ID	**GHM 4**
Data/parameter:	$RA_{mandate}$
Description	Regulatory Adjustment Factor representing legally enforced efficiency improvements.
Data unit:	Fraction (%)
Purpose of data:	☒ Baseline emissions
Value(s) applied:	To be determined at the activity level. Default = 0 if no legally enforced measures are in effect.
Source of data:	☐ Measured ☒ Other source (Legislative references, official government publications)
Choice of data or measurement methods and procedures:	Derived from existing policies, legal requirements, or specific national targets scheduled to take effect within the crediting period. The developer shall provide legislative references and calculate the factor based on the specific requirements of the applicable regulation.
Treatment of uncertainty	N/A
Comments:	Used to adjust the BAU scenario to ensure it accurately reflects the de facto regulatory environment (eq.7).

Parameter ID	**GHM 5**
Data/parameter:	GWP_{H2}
Description	100-year Global Warming Potential for hydrogen (H_2) to account for its indirect climate forcing effects.
Data unit:	tCO_2e / tH_2
Purpose of data:	☒ Activity emissions
Value(s) applied:	14.4.
Source of data:	☐ Measured ☒ Other source (Sand et al., 2023)
Choice of data or measurement methods and procedures:	Sourced from peer-reviewed scientific literature assessing the indirect climate forcing of hydrogen. The upper bound of estimate (considering climate-carbon feedbacks) from Sand et al. (2023) is adopted as it represents the latest scientific consensus.
Treatment of uncertainty	Managed via standardisation. This value remains fixed unless a superseding value is officially adopted by the IPCC or GS4GG. The uncertainty range reported by Sand et al. (2023) is 11.6 ± 2.8; the upper bound estimate is applied as the scientifically established consensus value.

Comments:	Used to calculate activity emissions from physical fugitive hydrogen leaks.

Parameter ID	**GHM 6**
Data/parameter:	$GWP_{ref,j}$
Description	100-year Global Warming Potential for refrigerant
Data unit:	tCO_2e / t refrigerant
Purpose of data:	☒ Activity emissions
Value(s) applied:	To be determined at the activity level based on the specific refrigerant gas used.
Source of data:	☐ Measured ☒ Other source
Choice of data or measurement methods and procedures:	Default values shall be sourced from the IPCC Assessment Report (AR5) or the latest defaults adopted by GS4GG.
Treatment of uncertainty	Default values shall be sourced from the latest IPCC Assessment Report (AR5) or the latest defaults adopted by GS4GG.
Comments:	Applicable only if the facility operates cryogenic systems for hydrogen storage or transport utilising synthetic refrigerants.

Parameter ID	**GHM 7**
Data/parameter:	$EF_{lCA,k}$
Description	Cradle-to-gate lifecycle GHG emission factor of newly installed activity infrastructure component k (e.g., electrolyser, renewable energy plant, battery storage).
Data unit:	tCO_2e/MWh (for RE facilities) or $tCO_2e/MWh_{capacity}$ (for storage)
Purpose of data:	☒ Leakage emissions
Value(s) applied:	To be determined at the activity level.
Source of data:	☐ Measured ☒ Other source (IPCC AR5 median harmonised LCA values; battery LCA literature)
Choice of data or measurement methods and procedures:	Shall be quantified using verified Environmental Product Declarations (EPDs compliant with ISO 14025/14040) specific to the manufactured equipment, or the conservative defaults from the sources listed above
Treatment of uncertainty	Managed by mandating ISO-compliant EPDs or conservative international defaults. An activity-specific LCA shall be made

	publicly available and verified by the VVB if a lower value is used.
Comments:	Used to calculate amortised embodied infrastructure leakage.

Parameter ID	**GHM 8**
Data/parameter:	$Q_{\max\_cap}$
Description	Historical maximum annual nameplate capacity of the transferred baseline equipment.
Data unit:	tH_2/yr
Purpose of data:	☐ Leakage emissions
Value(s) applied:	To be determined at the activity level.
Source of data:	☒ Measured ☒ Other source Original manufacturer specifications, plant commissioning documents, or historical operational records
Choice of data or measurement methods and procedures:	Sourced from original manufacturer specifications, plant commissioning documents, or historical operational records.
Treatment of uncertainty	Conservatively assumes the transferred equipment operates continuously at absolute maximum capacity if explicit metering at the new location is not conducted.
Comments:	Applicable only to brownfield retrofits where equipment is transferred rather than destroyed.

Parameter ID	**GHM 9**
Data/parameter:	$D_{proj,m}$
Description	Average two-way distance from the activity site to the end-user or dedicated consumer via transport mode m.
Data unit:	km
Purpose of data:	☒ Activity emissions
Value(s) applied:	To be determined at the activity level.
Source of data:	☒ Measured ☒ Other source Engineering estimates based on confirmed off-taker agreements, logistics contracts, mapped transport routes
Choice of data or measurement methods and procedures:	Sourced from confirmed off-taker agreements, logistics contracts, or mapped transport routes at validation Where multiple delivery points exist for a single transport mode m, the distance shall be calculated as a weighted average based on the contracted delivery volumes:

	$$D_{proj,m} = \frac{\sum(D_k \times V_k)}{\sum V_k}$$ Where Where D_k is the two-way distance to delivery point k, and V_k is the contracted volume to delivery point k.
Treatment of uncertainty	N/A.
Comments:	Used to calculate transportation activity emissions. If the distance is ≤ 200 km, emissions may be deemed negligible.

Parameter ID	**GHM 10**
Data/parameter:	$EF_{trans,m}$
Description	Emission factor for transport mode m.
Data unit:	tCO_2e/tonne-km
Purpose of data:	☒ Activity emissions
Value(s) applied:	Default values sourced from GS4GG Tool 02: Emissions from Freight Transportation, or recognised normative references (e.g., U.S. EPA Emission Factors Hub). Indicative defaults: Medium/Heavy-Duty Truck: 0.000115; Rail: 0.000015; Waterborne Craft: 0.000056; Air Freight: 0.000434.
Source of data:	☐ Measured ☒ Other source
Choice of data or measurement methods and procedures:	Default values shall be sourced from recognised normative references. Activity-specific data may be used if verifiable.
Treatment of uncertainty	N/A.
Comments:	Used in conjunction with $D_{proj,m}$ to calculate transportation emissions.

Parameter ID	**GHM 11**
Data/parameter:	TDL_y
Description	Average technical transmission and distribution losses for the grid.
Data unit:	Fraction (%)
Purpose of data:	☐ Baseline emissions ☒ Activity emissions☐ Leakage emissions
Value(s) applied:	0.10 (10%)
Source of data:	☐ Measured ☒ Other source

Choice of data or measurement methods and procedures:	Conservative methodology default.
Treatment of uncertainty	Applied as a static default to penalise grid electricity usage if verifiable official data is unavailable.
Comments:	Used to calculate activity emissions from backup grid consumption.

Parameter ID	**GHM 12**
Data/parameter:	ΔC_{LUC}
Description	Total loss of carbon stock due to land use conversion across the activity area.
Data unit:	tCO_2e
Purpose of data:	☒ Leakage emissions
Value(s) applied:	To be determined at the activity level.
Source of data:	☐ Measured ☒ Other source
Choice of data or measurement methods and procedures:	Calculated across all five IPCC pools using Tier 1 default values from the 2006 IPCC Guidelines for National GHG Inventories, unless higher-tier local data is verifiable.
Treatment of uncertainty	Addressed by applying conservative IPCC Tier 1 defaults and amortising over a strict 20-year period.
Comments:	Used to calculate leakage for greenfield activities that alter natural carbon stocks.

14.3 | Data and Parameters Monitored

14.3.1 | The following data and parameters shall be monitored continuously or periodically during the crediting period and recorded in the monitoring report.

Parameter ID	**GHM 13**
Data/parameter:	$P_{H2,y}$
Description:	Total monitored production of green hydrogen by the activity in year y.
Data unit:	tonnes ($tH2$)
Purpose of data:	☒ Baseline emissions ☒ Activity emissions
Measurement and updating frequency	Continuous, aggregated monthly and annually.

Measurement methods and procedures:	Direct continuous measurement using industrial mass flow meters or precision load cells on product dispatch pipelines or storage tanks. Data shall be logged continuously via the facility's SCADA or DCS. If flow is measured on a volume basis, it shall be converted to mass basis (Mass = Volume × Density) at standard reference conditions.	
Entity/person responsible for the measurement:	Activity developer / Plant Operator.	
Measuring instrument(s):	Type of instrument	Industrial mass flow meters (e.g., Coriolis) or load cells integrated with SCADA.
	Accuracy class	Industry standard for custody transfer (e.g., Class 0.5 or better)
	Calibration requirements	Strict annual third-party calibration against certified international/national standards, or per manufacturer specifications (whichever is more stringent).
	Location	Electrolyser output, hydrogen storage, or dispatch points.
QA/QC procedures:	Data shall be cross-checked against SCADA logs and external sales/dispatch records.	
Treatment of uncertainty	Managed through mandatory ISO/IEC calibration adherence. If meters are found out of calibration, the maximum observed error margin shall be applied mathematically to decrease the reported production volume for the uncalibrated period.	
Comments:	Forms the basis for the unadjusted baseline emission calculation (eq.2, eq.4) and the Eligible End-Use Fraction denominator.	

Parameter ID	**GHM 14**
Data/parameter:	$Q_{eligible,y}$
Description:	Quantity of green hydrogen verifiably dispatched and sold for eligible end-uses (e.g., fertiliser manufacturing) in year y.
Data unit:	tonnes ($tH2$)
Purpose of data:	☒ Baseline emissions
Measurement and updating frequency	Continuous tracking per dispatch, aggregated annually.
Measurement methods and procedures:	Audited supply chain reconciliation. Documented via formal sales receipts, commercial off-taker contracts, dispatch logs, or

	mass-balance transfer records explicitly proving delivery to eligible manufacturing facilities.	
Entity/person responsible for the measurement:	Activity developer / Commercial Management Team.	
Measuring instrument(s):	Type of instrument	N/A (Documentary evidence).
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	Commercial records / Dispatch logs.
QA/QC procedures:	VVB shall conduct rigorous audits of off-taker agreements, delivery receipts, and invoices to verify the exact volume delivered for eligible end-uses.	
Treatment of uncertainty	Zero tolerance for ambiguity. Any volume of hydrogen lacking definitive, auditable proof of eligible end-use shall be strictly excluded from baseline crediting ($Q_{eligible,y}$), while full activity/leakage penalties remain.	
Comments:	Used to calculate the Eligible End-Use Fraction ($F_{eligible,y}$) or directly allocate baseline volume to enforce applicability safeguards.	

Parameter ID	**GHM 15**	
Data/parameter:	$EC_{grid,y}$	
Description:	Total metered quantity of non-renewable electricity drawn from the grid by the activity facility in year y.	
Data unit:	MWh	
Purpose of data:	☒ Activity emissions	
Measurement and updating frequency	Continuous, aggregated monthly and annually.	
Measurement methods and procedures:	Direct measurement of all grid power imported into the facility boundary via the main utility connection point, logged automatically by the facility SCADA system.	
Entity/person responsible for the measurement:	Activity developer / Plant Operator.	
Measuring instrument(s):	Type of instrument	Utility-grade bi-directional electricity meters.

	Accuracy class	Custody-transfer grade (e.g., Class 0.2s or 0.5s).
	Calibration requirements	Calibrated in accordance with national utility regulations or international standards (IEC).
	Location	Main grid interconnection point(s).
QA/QC procedures:	SCADA logs shall be cross-checked against official utility invoices and grid operator statements. VVB shall verify that total annual grid consumption remains ≤10% of total facility electricity consumption to maintain eligibility.	
Treatment of uncertainty	If the meter under-reports due to calibration drift, the maximum error margin shall be applied to mathematically increase the recorded grid consumption.	
Comments:	Crucial for calculating activity emissions from backup grid consumption ($AE_{grid,y}$) and verifying the 10% applicability cap.	

Parameter ID	**GHM 16**	
Data/parameter:	$EF_{grid,y}$	
Description:	Grid emission factor for the host country/region grid in year y.	
Data unit:	tCO_2e/MWh	
Purpose of data:	☒ Activity emissions	
Measurement and updating frequency	Updated annually or fixed ex-ante for the crediting period, contingent upon the selected calculation option in the relevant tool.	
Measurement methods and procedures:	Calculated strictly in accordance with the latest version of A6.4-AMT-007: Methodological tool: Emissions from electricity generation and consumption.	
Entity/person responsible for the measurement:	Activity developer.	
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	The calculation and data sources shall be validated by the VVB according to the requirements in A6.4-AMT-007.	

Treatment of uncertainty	Managed via adherence to the rigorous standardisation of the A6.4 tool.
Comments:	Used to quantify emissions from permitted grid electricity consumption.

Parameter ID	**GHM 17**	
Data/parameter:	$FC_{ff,y}$	
Description:	Quantity of fossil fuel (e.g., diesel) combusted for backup generators in year y.	
Data unit:	Mass or volume units (e.g., tonnes, litres, m^3)	
Purpose of data:	☒ Activity emissions	
Measurement and updating frequency	Continuous (when operating) or per delivery, aggregated annually.	
Measurement methods and procedures:	Direct metering using fuel flow meters, or volumetric monitoring via calibrated tank dipsticks and purchase invoices.	
Entity/person responsible for the measurement:	Activity developer / Plant Operator.	
Measuring instrument(s):	Type of instrument	Fuel flow meters or calibrated storage tanks.
	Accuracy class	Industry standard.
	Calibration requirements	Annual calibration per manufacturer guidelines.
	Location	Backup generator inputs.
QA/QC procedures:	Metered consumption shall be cross-checked against fuel purchase receipts and inventory logs. Strict monitoring to ensure fossil fuels are used exclusively for emergency/auxiliary backup, not core synthesis.	
Treatment of uncertainty	Uncertainty is managed by assuming all purchased fossil fuel not remaining in inventory was combusted. Maximum error margins shall be applied upwards if meters are out of calibration.	
Comments:	Used to calculate activity emissions from backup fossil fuel combustion ($AE_{ff,y}$) using GS4GG Tool 01 / TOOL03.	

Parameter ID	**GHM 18**
Data/parameter:	$Q_{leak,H2,y}$

Description:	Total monitored mass of uncombusted hydrogen (H_2) physically leaked or purged to the atmosphere in year y.	
Data unit:	$tonnes\ (tH2)$	
Purpose of data:	☒ Activity emissions	
Measurement and updating frequency	Continuous monitoring via SCADA, aggregated annually.	
Measurement methods and procedures:	Quantified via real-time SCADA integration with ambient gas leak detection sensors AND overall system mass-balance reconciliation (comparing hydrogen generated at the electrolyser vs. hydrogen dispatched to consumers and inventory). The higher (more conservative) value between sensor-detected discrete leaks and unaccounted mass-balance losses shall be used. For the first monitoring period, if mass-balance reconciliation yields an uncertainty exceeding ±20%, the developer shall apply the conservative default leakage rate of 2% of total hydrogen produced.	
Entity/person responsible for the measurement:	Activity developer / Safety Team.	
Measuring instrument(s):	Type of instrument	Hydrogen gas leak detectors and mass flow meters.
	Accuracy class	Industrial safety grade (ppm precision for sensors, Class 1.0 or better for flow meters).
	Calibration requirements	Strict adherence to manufacturer and national safety calibration schedules.
	Location	Electrolysers, compressors, pipelines, and storage.
QA/QC procedures:	Continuous SCADA alerting for leaks. Regular manual leak detection and repair (LDAR) safety audits and mass-balance cross-checks by engineering staff.	
Treatment of uncertainty	Applying the higher value between discrete sensor-detected leaks and aggregate mass-balance losses ensures conservativeness.	
Comments:	Used to calculate fugitive hydrogen emissions ($AE_{fugitive,H2,y}$) using the GWP_{100} of 14.4.	

Parameter ID	**GHM 19**
Data/parameter:	$Q_{ref,leak,y}$
Description:	Quantity of synthetic refrigerant gas physically leaked from cryogenic liquefaction or deep-cooling systems in year y.

Data unit:	Tonnes of refrigerant	
Purpose of data:	☒ Activity emissions	
Measurement and updating frequency	Continuous (via mass balance/top-ups), aggregated annually.	
Measurement methods and procedures:	Monitored in accordance with CDM TOOL28 (Calculation of baseline, project and leakage emissions from the use of refrigerants). Typically determined by tracking the volume of refrigerant required to top up/recharge the cooling systems over the year.	
Entity/person responsible for the measurement:	Activity developer / Safety Team.	
Measuring instrument(s):	Type of instrument	Industrial weighing scales (for tracking refrigerant cylinder weights before and after recharge/top-up activities).
	Accuracy class	Commercial grade
	Calibration requirements	Annual calibration in accordance with national weights and measures standards.
	Location	E.g. Refrigerant storage facility or maintenance depot.
QA/QC procedures:	Maintenance and top-up logs shall be verified by the VVB.	
Treatment of uncertainty	Regulated under TOOL28 guidelines.	
Comments:	Applicable only if the facility operates cryogenic liquefaction systems for storage or transport utilising synthetic refrigerants.	

Parameter ID	**GHM 20**
Data/parameter:	$DAF_{NetZero,y}$
Description:	Downward Adjustment Factor for Ambition for the host country, applicable to year y.
Data unit:	Fraction (%)
Purpose of data:	☒ Baseline emissions (Ambition Adjustment)
Measurement and updating frequency	Annual (based on the calendar year of the monitoring period).
Measurement methods and procedures:	Sourced exclusively from the latest version of the GS4GG Methodology Tool 05: Downward Adjustment Factor (DAF)

	Determination, corresponding exactly to the host country and the monitoring year.	
Entity/person responsible for the measurement:	Activity developer.	
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	VVB verification that the precise DAF value has been applied based on the host country and the exact vintage of the emission reductions.	
Treatment of uncertainty	N/A	
Comments:	Mandatory adjustment to continuously lower the crediting baseline.	

Parameter ID	**GHM 21**	
Data/parameter:	$Q_{actual,y}$	
Description:	Actual operational output of transferred baseline equipment at its new location in year y.	
Data unit:	$Tonnes\ (tH2/yr)$	
Purpose of data:	☒ Leakage emissions	
Measurement and updating frequency	Continuous, aggregated annually for the duration of the equipment's remaining technical lifetime.	
Measurement methods and procedures:	Explicit tracking and direct mass-metering of the relocated equipment's output at its new operational site.	
Entity/person responsible for the measurement:	Activity developer (via contractual data-sharing agreements with the new owner).	
Measuring instrument(s):	Type of instrument	Industrial mass flow meters.
	Accuracy class	Industry standard for custody transfer.

	Calibration requirements	Proof of regular calibration required.
	Location	New operational site of the transferred equipment.
QA/QC procedures:	Third-party audits of the relocated plant's production records. If access is denied or records are unverifiable, the developer shall default to the maximum capacity penalty (Q_{max_cap})	
Treatment of uncertainty	If actual metered data is unreliable or tracking fails, the conservative maximum capacity default (Q_{max_cap}) shall be applied as a penalty.	
Comments:	Applicable exclusively to brownfield retrofits where equipment is transferred and actively metered.	

Parameter ID	**GHM 22**	
Data/parameter:	$Q_{H2,m,y}$	
Description:	Quantity of green hydrogen transported from the activity site via transport mode m in year y.	
Data unit:	tonnes (tH2).	
Purpose of data:	☒ Activity emissions	
Measurement and updating frequency	Per shipment, aggregated annually.	
Measurement methods and procedures:	Monitored based on product dispatch records, weighbridge tickets, and transport logistics logs.	
Entity/person responsible for the measurement:	Activity developer.	
Measuring instrument(s):	Type of instrument	Dispatch logs and weighbridges.
	Accuracy class	Industry standard
	Calibration requirements	Annual calibration per national standards.
	Location	Activity dispatch bay
QA/QC procedures:	Dispatch records shall be reconciled against total hydrogen sales and made available for VVB verification.	
Treatment of uncertainty	N/A	

Comments:	Sum of product transported across all modes should equal the total product dispatched off-site. Applicable if transport distance exceeds 200 km.

14.4 | QA/QC and Data Management

14.4.1 | **Data Validation:** The activity developer shall establish procedures for the validation of monitored data. This shall include the systematic cross-checking of automated telemetry (SCADA/DCS logs) against physical commercial records, such as utility electricity bills, off-taker sales receipts, and transport dispatch logs. Furthermore, an overall mass-balance reconciliation (comparing hydrogen gas generated at the electrolyser against hydrogen dispatched to consumers and stored inventory) shall be conducted at least monthly to verify system integrity and identify any unaccounted fugitive emissions. Arbitrary exclusion of data points or system warnings is strictly prohibited.

14.4.2 | **Staff Trainings:** All plant operators, commercial managers, and health and safety personnel responsible for data capture, mass-balance reconciliation, and meter maintenance shall undergo documented training on Standard Operating Procedures (SOPs), calibration protocols, and data security compliance. Training records shall be maintained for VVB review.

14.4.3 | **QA/QC**:

a. **Protocols:** All data collection and reconciliation processes shall adhere to standardised, internationally recognised industrial protocols.
b. **Calibration:** All measurement equipment (e.g., electricity meters, mass flow meters, load cells, and gas leak detection sensors) shall be calibrated according to the manufacturer's instructions or relevant national/international standards (e.g., ISO, IEC), whichever is more stringent. Primary custody-transfer meters (for grid electricity import and hydrogen product export) shall be checked frequently and calibrated by accredited third-party laboratories at least annually. Calibration records shall be maintained and made available for verification.
    i. If the calibration check reveals an error within the meter's permissible accuracy class margin, the data is accepted as is.
    ii. If the calibration check reveals an error beyond the permissible accuracy class margin, the recorded data is not discarded; instead, the measured values shall be mathematically corrected for the entire period since the last successful calibration by applying the maximum observed error percentage in the most conservative direction (e.g., decreasing eligible baseline production or increasing activity electricity consumption and leak volumes).
    iii. If the error indicates meter failure, all data collected since the last successful check shall be strictly excluded from the analysis, and the data gap rules below shall apply.

c. **Data Cross-Checks:** Procedures for cross-checking data entry and identifying anomalies shall be implemented. Outliers may only be excluded if there is a clear, documented reason (e.g., system calibration error, documented unusual plant trip event). All excluded data shall be retained in the database with a formal explanation.

14.4.4 | **Corrective Actions for Data Gaps ("Missing Data" Rule):** In the event of SCADA system failure, equipment breakdown, or irretrievable data loss, missing data shall be substituted using the most conservative mathematical approach to ensure emission reductions are not artificially inflated:

a. **For parameters contributing to Baseline Emissions (e.g., $P_{H2,y}$, $Q_{eligible,y}$):** A value of zero (0) shall be assumed for the entire duration of the missing data period.

b. **For parameters contributing to Activity or Leakage Emissions (e.g., $EC_{grid,y}$, $FC_{ff,y}$, $Q_{leak,H2,y}$)**: The maximum hourly or daily value historically recorded for that parameter during normal operations (or the absolute theoretical maximum capacity of the equipment) shall be applied continuously across the duration of the data gap, provided a verifiable valid justification is available for the data gap.

14.4.5 | Linear interpolation is permitted only for brief, documented data gaps of less than 24 hours, provided the facility was operating in a verifiable steady-state condition.

15| MONITORING REQUIREMENTS FOR ACTIVITIES WITH REVERSAL RISKS

15.1 | Scope and Applicability

15.1.1 | As established in Section 12 of this methodology, low-carbon hydrogen production generates mitigation outcomes strictly via the avoidance of greenhouse gas emissions (displacing the combustion and reforming of fossil fuels). The methodology does not generate credits for carbon removal or physical sequestration.

15.1.2 | Because there is no physical carbon reservoir to be depleted or reversed, the physical reversal of credited mitigation outcomes is structurally impossible. Consequently, the continuous monitoring requirements for activities with reversal risks, including the establishment of a reversal management plan and contributions to a Reversal Risk Buffer Pool, are not applicable to this methodology.

15.1.3 | The only ongoing operational safeguard required is the continuous metering of the facility's production and energy consumption (as detailed in Section 14) to prove the ongoing, eligible operation of the zero-emission infrastructure.

16| APPLICATION TO PROGRAMME OF ACTIVITIES

16.1 | General Requirements

16.1.1 | This methodology is fully applicable to a Programme of Activities (PoA). A PoA framework is particularly suitable for grouping multiple modular, decentralised green hydrogen production facilities (or the retrofitting of multiple existing facilities) under a single administrative structure.

16.1.2 | The implementation of the PoA shall comply with the latest version of the GS4GG Standard on Programme of Activities. The Coordinating/Managing Entity (CME) shall define clear, objective eligibility criteria for the inclusion of Voluntary Project Activities (VPAs) in the PoA Design Document (PoA-DD). These criteria shall ensure that every individual VPA explicitly meets all Applicability Conditions defined in Section 3 of this methodology.

16.2 | Additionality and Baselines at the VPA Level

16.2.1 | **Additionality:** Additionality shall be demonstrated independently for each VPA in accordance with Section 6. If a VPA is submitted during the active 3-year validity window of the methodology-level Common Practice exemption outlined in Section 6.5, the VPA shall be exempt from the activity-level common practice assessment. However, the Investment Analysis and Regulatory Surplus Analysis shall reflect the specific capital costs (CAPEX), operational costs (OPEX), revenues, and regulatory conditions relevant to the specific VPA. If a legal mandate requiring the mitigation activity comes into force in the host country of a specific VPA, that VPA shall cease crediting from the effective date of the mandate. Other VPAs within the same PoA that are located in different jurisdictions shall not be affected.

16.2.2 | **Baseline Scenarios:** The crediting baseline scenario shall be determined and justified individually for each VPA in accordance with Section 7. The CME shall explicitly evaluate whether each VPA qualifies as a Greenfield (Scenario A) or Brownfield (Scenario B) activity. If VPAs are located in different host countries or grid regions, parameters such as the regional Best Available Technology benchmark, the Grid Emission Factor, and the Downward Adjustment Factor shall be rigorously assigned based on the geographical location of each VPA.

16.3 | Monitoring and Cross-VPA Sampling

16.3.1 | The CME shall establish a uniform, comprehensive central monitoring system detailing data collection, SCADA/DCS integration, calibration schedules, and archiving across all VPAs.

16.3.2 | Proportionate monitoring for small-scale and aggregated activities. For micro- and small-scale Voluntary Project Activities, and for aggregated activities where continuous metering of every unit would be disproportionate, a proportionate monitoring approach may be applied, provided that the central monitoring system, calibration schedule, and data-integrity safeguards are maintained and the approach is justified and verified by the VVB. Continuous metering is retained for industrial-scale facilities where it is integrity-critical.

16.3.3 | **Prohibition of Cross-VPA Sampling:** Because this methodology governs an industrial chemical process requiring rigorous, continuous metering of mass flows and electricity for safety and commercial custody transfer, statistical cross-VPA sampling (e.g., measuring one unit to estimate the output of another) is strictly prohibited. The monitoring parameters and data inputs shall be metered and reconciled uniquely at each individual VPA site.

17| CHANGES REQUIRED FOR CREDITING PERIOD RENEWALS

17.1 | General Requirements

17.1.1 | The crediting period for activities applying this methodology is 5 years, renewable twice (up to a maximum total of 15 years). The renewal of the crediting period shall be conducted in accordance with the latest GS4GG requirements.

17.1.2 | At the time of renewal, the activity shall strictly comply with the latest approved version of this methodology available at the time of submission.

17.1.3 | To ensure the methodology actively encourages ambition over time, the activity developer shall conduct a comprehensive reassessment of the baseline scenario, additionality, and specific ex-ante parameters to ensure they reflect the prevailing technological, macroeconomic, and regulatory realities.

17.2 | Reassessment of the Baseline Scenario

17.2.1 | The baseline scenario shall be formally reassessed at each crediting period renewal to ensure that conventional, fossil-fuel-intensive hydrogen production remains the most plausible Business-As-Usual (BAU) scenario in the host country.

17.2.2 | For brownfield activities (Scenario B), the activity developer shall explicitly verify whether the replaced fossil-based equipment has reached the end of its remaining technical lifetime (as determined by A6.4-AMT-006). If the technical lifetime has expired during the preceding crediting period, the baseline shall strictly transition to Scenario A (Greenfield BAT) for the renewed crediting period; the historical emission factor shall no longer be used.

17.3 | Update of Fixed Ex-Ante Parameters

17.3.1 | To ensure the crediting baseline continuously tracks technological advancements, the following key parameters shall be updated at the renewal of the crediting period:

a. **Best Available Technology Benchmark:** The EF_{BAT} shall be formally re-established. The activity developer shall identify the latest Global BAT benchmark and the latest National BAT benchmark prevailing at the time of renewal. The lowest (most conservative) of these updated values shall be applied for the renewed crediting period.

b. **Downward Adjustment Factor:** The applicable DAF value shall be updated based on the latest version of the GS4GG Tool 05: Downward

Adjustment Factor (DAF) Determination corresponding to the host country and the new crediting period's vintage years.

c. **Grid Emission Factor:** If fixed ex-ante during the first crediting period, the grid emission factor shall be recalculated using the latest available data and the most recent version of A6.4-AMT-007.

d. **Embodied Emissions:** Embodied emissions continue to be amortised under Section 9.4 until the full upfront footprint has been recovered over N years (N ≤ 15). Where the amortisation period N extends beyond the first crediting period, the annual charge continues into subsequent crediting periods until N is reached; it is not set to zero at renewal. Where significant new capacity or infrastructure is installed at renewal, its embodied emissions are quantified afresh and amortised over their own N.

e. Major component replacement, including but not limited to electrolyser stack replacement at end-of-life, shall be treated as new infrastructure for the purposes of embodied emissions accounting. The embodied emissions of replacement stacks shall be calculated and amortized over the remaining crediting period at the time of replacement.

f. The parameters relating to the historical maximum capacity of retrofitted brownfield facilities (Q_{max_cap}) shall remain fixed for the duration of the equipment's remaining technical lifetime and do not require updating.

17.4 | Reassessment of Additionality

17.4.1 | **Regulatory Surplus:** The Regulatory Surplus Analysis (Section 6.2) shall be updated. If new, fully enforced, and funded legal mandates have come into force that legally require the activity to produce hydrogen exclusively via electrolysis (or explicitly ban the baseline alternative without carbon finance), the crediting period shall not be renewed.

17.4.2 | **Ongoing Financial Need (OFN):** The activity developer shall demonstrate OFN in accordance with Section 6.6. This requires re-running the original Investment Analysis to demonstrate the continued financial need for carbon revenues. The activity developer shall explicitly apply the Sunk CAPEX rules (retaining the historically incurred CAPEX at its Year 0 value, replacing historical ex-ante OPEX/revenue estimates with actual operational data, and updating forward-looking market projections) to prove that the activity's financial indicator still fails to meet the benchmark without carbon revenues.

17.4.3 | **Positive List Transition:** Activities initially deemed additional via the Positive List shall conduct a full Investment or Barrier analysis at the first renewal if the host country/region no longer meets the Positive List criteria at the time of renewal.

17.4.4 | The crediting period shall only be renewed if the OFN assessment mathematically confirms the continued additionality of the activity.

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ANNEX -1: Methodology-Level Determinations and Default Factors

1. Objective and Scope

This normative annex establishes the binding default factors and methodology-level determinations for additionality and baseline setting. Activity developers shall apply these values to standardise quantification, ensure ultimate conservativeness, and reduce transaction costs, without requiring bespoke activity-level modelling for these specific macroeconomic or historical parameters.

2. Methodology-Level Common Practice Determination

- **Rationale and Empirical Basis:** In accordance with the *GS4GG Methodology Standard: Requirements for Additionality Demonstration* and *GS4GG MT400-06 (Common Practice Analysis)*, a methodology-level common practice analysis has been conducted for green hydrogen (electrolysis-based) production. Based on comprehensive global market assessments (utilising 2024–2025 data detailed in the Supplementary Information), total global hydrogen demand is approximately 97 million tonnes per annum (Mtpa). However, the operational commercial capacity of green hydrogen stands at a mere 0.2 Mtpa. This equates to a global market penetration rate of **<0.1%**. Furthermore, while announced project pipelines are large, the Furthermore, while announced activity pipelines are large, the Final Investment Decision (FID) rate for green hydrogen is critically low at just 4%.
- **Economic Barrier (Different Technology):** The Levelized Cost of Hydrogen (LCOH) for green hydrogen currently ranges between $3.50 and $12.00/kg, compared to $0.98 to $2.93/kg for conventional grey hydrogen. Because this persistent cost premium vastly exceeds the 20% economic variance threshold established in standard common practice frameworks, green hydrogen is unequivocally classified as a "different technology" that cannot compete commercially without significant policy and carbon market intervention.
- **Deemed Status and Exemption:** Because the global market penetration is statistically negligible and the cost premium is prohibitive, green hydrogen production via water electrolysis is formally classified as a nascent, non-common practice technology. Consequently, any activity submitted for Design Certification under this methodology shall be automatically deemed to satisfy the Common Practice Analysis requirement. The activity developer is explicitly exempt from conducting a bespoke activity-level common practice calculation.
- **Validity Period (Sunset Clause):** This methodology-level exemption shall have a strict validity period of three (3) years from the publication date of Version 1.0 of this methodology. Following this period, the global penetration rate and LCOH metrics shall be reviewed by the GS4GG Secretariat to ensure continued empirical relevance, or the activity developer shall be required to conduct an activity-specific assessment.

3. Global Best Available Technology (BAT) Benchmarks

- **Rationale and Empirical Basis:** To ensure that baseline emissions are strictly capped at an ambitious level (for both Scenario A and Scenario B), this methodology establishes Global BAT benchmarks. The benchmark represents the direct emissions performance of the most efficient conventional hydrogen plants globally operating without Carbon Capture and Storage (CCS).
- **Boundary Conservativeness:** To ensure maximum environmental integrity, these benchmarks represent direct process and combustion emissions exclusively. Upstream methane (CH_4) emissions from the fossil fuel supply chain are explicitly excluded from these benchmarks to mathematically force a stricter (lower) crediting baseline, preventing the activity from being over-credited for the high upstream leakage rates of the displaced fossil fuels.
- **Normative Default Values:** The conservative Global BAT default values shall be applied as follows based on the dominant baseline technology in the host region:

Baseline Technology Pathway	Global Default EF_{BAT} (tCO_2e/tH_2)	Justification / Source
Natural Gas - Steam Methane Reforming (SMR)	**8.5**	Represents the highest efficiency, most efficient operational facilities SMR plants operating globally without CCS. Excludes upstream CH_4 emissions to ensure maximum baseline conservativeness. Applicable globally (ex-China) where natural gas is the dominant feedstock.
Coal Gasification	**18**	Represents the best-available-technology performance for coal-to-hydrogen synthesis. Applicable primarily in regions where coal is the overwhelmingly dominant feedstock (e.g., China).
Naphtha Reforming	**6.3**	Represents BAT for hydrogen production sourced as a primary product via naphtha reforming, typically within captive refinery complexes.

- **Application Rule:** As mandated in Section 7.3, the activity developer shall use the applicable global default value from the table above unless an officially established, peer-reviewed regional/national BAT benchmark exists that is mathematically lower (stricter) than the global default. The highest level of conservativeness shall always prevail.

  Naphtha reforming baseline — eligibility. An activity may apply the naphtha reforming benchmark only where it demonstrates, by metered records covering the three years preceding the activity start date, that the hydrogen it displaces was produced in a dedicated naphtha steam reformer. Hydrogen arising as a co-product of refinery naphtha catalytic reforming is not eligible under this methodology, as its output is determined by gasoline demand rather than hydrogen demand and its displacement does not reduce production. This condition and its basis are set out in SI Section 4.

ANNEX -2: References

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