Gold Standard for the Global Goals

Climate Security & Sustainable Development

METHODOLOGY

GS4GG PAA M400-13

SDG 13

POWERING UNIVERSAL LIGHTING VIA SOLAR ENERGY (PULSE)

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SUMMARY

This methodology is applicable to activities that introduce solar-powered light emitting diode (LED) lighting technologies to reduce or avoid greenhouse gas (GHG) emissions by replacing fossil fuel-based lighting devices (e.g., kerosene wick lamps, hurricane lanterns, pressurized mantle lamps, diesel-powered lighting), candles, and/or inefficient dry-cell battery torches. The methodology applies to end-users in households, communities, and small commercial premises (e.g., shops, kiosks) located in areas with no grid connection or unreliable grid supply. However, the baseline service levels and emission caps for all non-residential installations are strictly limited to the residential household equivalent.

The methodology quantifies emission reductions based on the displaced fossil fuel consumption relative to the lighting service provided. It incorporates Suppressed Demand provisions, allowing for the calculation of emission reductions based on a Minimum Service Level (MSL) equivalent to Tier 1 of the Multi-Tier Framework (1,000 lumen-hours/day or 22 kWh per year), provided the activity technology meets specific performance and quality criteria.

This methodology updates and replaces the approaches of AMS-III.AR to align with the Gold Standard for the Global Goals (GS4GG) Paris Agreement Alignment (PAA) requirements. It includes standardized, rigorous approaches for:

- **Baseline Setting:** Utilising historical emissions adjusted downwards to ensure conservativeness and incorporating dynamic reassessments for grid expansion and baseline consistency.
- **Ambition:** The mandatory application of a Downward Adjustment Factor (DAF) to align the crediting baseline with the host country's Net Zero trajectory or Ambition Floor.
- **Leakage:** The mandatory accounting of leakage emissions, including the embodied emissions associated with the manufacturing of activity devices (e.g., batteries and solar PV panels).
- **Monitoring & Integrity:** A 100% Asset Census mandate and digital-first MRV to eliminate population uncertainty and prevent double-counting across registries.
- **Safeguards:** Strict requirements for battery and PV panels waste management to prevent environmental harm and ensure compliance with "Do No Significant Harm" principles.

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1| KEY INFORMATION

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

Table 1. Key information

Term	Description
Activity summary	The activity involves the distribution and installation of solar-powered LED lighting systems (e.g., portable solar lanterns, pico-solar systems, or Solar Home Systems) that replace fossil fuel-based lighting devices (e.g., kerosene wick lamps, hurricane lanterns, pressurized mantle lamps, diesel-powered lighting), candles, and/or inefficient dry-cell battery torches in households, communities, and small commercial premises. The systems utilize photovoltaic (PV) charging to provide clean, reliable lighting services that meet or exceed the Tier 1 Energy Access threshold.
Mitigation 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 tCO2e per year)
Sectoral Scope	**Sector 3:** Energy demand
Activity Requirement	Community Services Activity Requirements
Activity start date	The start date is the date of implementation (distribution or installation) of the first unit under the mitigation activity.
Crediting Period start date	The start date of the Crediting Period is the date of the start of use of the first device distributed/installed or a maximum of two years prior to the date of Design Certification, whichever occurs later.
Crediting period length	The maximum crediting period is five years, renewable twice (total of 15 years). The crediting period for any specific unit shall not exceed its rated technical life (specifically the battery life) unless a verified battery replacement event is logged in the activity database in accordance with the objective criteria defined in Section 3.2.10 |. For phased distribution, the crediting period start date is the start of use of the first distributed/installed unit within the activity boundary. Subsequent units generate emission reductions from their respective operations start dates within the defined crediting

	period.
Geographical applicability	Global
Limitations	The methodology is limited to activities where: 1. The activity technology is charged by solar photovoltaic (PV) systems (grid-charging and any standalone fossil-fuel based generation system is excluded). 2. The target area has no grid access, or grid availability is unreliable (defined as providing less than Tier 3 service levels or <12 hours availability/day). 3. A robust waste management plan for used/discarded batteries and PV panels is implemented. 4. While communities and small commercial premises are eligible, their crediting baselines and service caps shall strictly not exceed the defined residential household equivalent.

2| DEFINITIONS

2.1.1 | The definitions outlined in the Glossary of Gold Standard for the Global Goals and the Activity Requirements shall apply, in addition to those outlined below:

Table 2. Terms and definitions

TERM	DEFINITION
Activity Device	The solar-powered LED lighting system (SLS) introduced by the activity. This refers to Solar Portable Lights (Pico-Solar) or Solar Home Systems (SHS) that are charged exclusively by photovoltaic (PV) panels.
Activity Lamp	When the solar-powered LED lighting system has more than one LED lamp connected to a single rechargeable battery system, serving one household/premise, each LED lamp capable of providing lighting service shall be considered as one activity lamp.
Baseline Lighting System	The fossil fuel-based lighting device (e.g., kerosene wick lamp, hurricane lantern, pressurized mantle lamp, diesel-powered lighting), candle, and/or inefficient dry-cell battery torch that provides lighting services in the absence of the activity and is replaced by the Activity Lamp.
Crediting Baseline	The baseline GHG emissions profile used for the calculation of emission reductions. It is determined as the lower value between the Conservative Business-As-Usual (BAU) scenario and the Downward Adjusted Baseline scenario (which applies the DAF).
Light Output	Activities opting for standard replacement shall meet the luminous

	flux of 25 lumens or illuminance of 50 lux over an area ≥0.1 m^2 when suspended at a vertical distance of 0.75 meters or self-supported. Activities opting for suppressed demand shall meet Minimum Service Level (MSL) equivalent to Tier 1 of the Multi-Tier Framework (1,000 lumen-hours/day or 22 kWh per year)
Lumen-Hour	A unit of measurement for the total quantity of light energy delivered over time. It is calculated as the Luminous Flux (lumens) multiplied by the duration of operation (hours). This is the primary metric for establishing Service Level Equivalence in suppressed demand calculations.
Minimum Service Level (MSL)	The minimum threshold of lighting service required to satisfy basic human needs and alleviate suppressed demand. In this methodology, MSL is defined in alignment with Tier 1 of the World Bank Multi-Tier Framework (MTF) for energy access: • 1,000 lumen-hours per day (per household); or • 22 kWh per year (implied energy equivalent).
Rated Average Life	The period certified by the manufacturer over which the activity lamp's initial light output will decline by no more than 15% (L85) after 2,000 hours of continuous operation, or 30% (L70) over the full rated life. This must be verified by third-party testing (e.g., VeraSol / IEC 62257-9-5).
Solar Run Time (SRT)	The operational time of the activity device resulting from one day of solar charging under Standard Solar Day conditions (defined as 5 kWh/m² of incident solar radiation). This defines the maximum daily lighting service capability of the system. • **For standard replacement:** operation time in a mode that is bright enough to satisfy the light output (defined above) for at least 4 hours per day • **For suppressed demand:** operation time in a mode that is bright enough to satisfy light output (defined above) to meet Minimum Service Level (MSL) requirements
Rated Technical Life	The average time for which the activity device operates effectively before requiring major component replacement. For solar devices, this is strictly determined by the cycle life of the battery, unless a verified battery replacement event is logged in accordance with the objective criteria defined in Section 3.2.10 |.
Unreliable Grid	A grid connection status where electricity supply is insufficient to meet basic lighting needs. Defined in this methodology as a connection providing less than Tier 3 reliability (e.g., less than 12 hours of availability per day or subject to frequent evening blackouts resulting in less than 2 hours of grid access in the evening).

3| SCOPE, APPLICABILITY, AND ENTRY INTO FORCE

3.1 | Scope

3.1.1 | This methodology applies to activities that introduce solar-powered LED lighting technologies to reduce or avoid greenhouse gas (GHG) emissions from lighting.

3.1.2 | The methodology is applicable to end-users in households, communities, and/or small commercial premises (e.g., shops, kiosks). However, where the technology is installed in community or commercial premises, the baseline service claims and emission caps are strictly limited to the residential household equivalent.

3.1.3 | The methodology applies to activities that replace:

a. Fossil fuel-based lighting devices (e.g., kerosene wick lamps, hurricane lanterns, pressurized mantle lamps, diesel-powered lighting);

b. Candles; and/or

c. Inefficient dry-cell battery torches (flashlights/handheld torches).

3.1.4 | The scope is strictly limited to activity technologies charged by Solar Photovoltaic (PV) systems. Technologies charged by the national grid or fossil fuel generators are excluded.

3.2 | Applicability

The activity shall demonstrate compliance with the following conditions.

3.2.1 | Technology Specifications and Performance: The activity shall choose a technology design that is proven to be efficient and durable under field conditions. The activity device shall meet the following criteria:

a. **Light Output:** The activity device shall meet the following criteria:

i. **Standard Replacement:** luminous flux of 25 lumens or illuminance of 50 lux over an area ≥0.1 m^2 when suspended at a vertical distance of 0.75 meters or self-supported.

ii. **Suppressed Demand:** Meet Minimum Service Level (MSL) equivalent to Tier 1 of the Multi-Tier Framework (1,000 lumen-hours/day or 22 kWh per year)

b. **Charging Source:** The activity device shall be charged by a renewable energy system (PV) included as an integral part of the lamp or a standalone system.

c. **Rated Average Life:** The activity device (specifically the LED unit) shall be certified by the manufacturer to have a rated average operational life of greater than 5,000 hours.

d. **Rated Lumen Maintenance:** The light output over a 2,000-hour lumen maintenance test shall not decline by more than 15%.

e. **Rated Luminous Efficacy:** The luminous efficacy of the activity lamp shall be no less than 70 lumens per Watt. A transitional grandfathering clause applies to design certified activity: legacy devices commissioned prior to the publication date of this methodology may utilise a minimum efficacy floor of 50 lumens per Watt. All new devices procured and commissioned post 31/12/2027 shall strictly meet the 70 lumens per Watt requirement.

f. **Solar Run Time (SRT):**

   i. **Standard Replacement:** The activity device shall be capable of providing a bright enough light output for at least 4 hours per day under Standard Solar Day conditions (5 kWh/m²)

   ii. **Suppressed Demand:** The activity device shall be capable of providing a bright enough light output to meet minimum service requirements under Standard Solar Day conditions (5 kWh/m²).

g. **Warranty:** The activity device shall carry a minimum manufacturer's warranty of one year from the time of end-user receipt.

3.2.2 | **Minimum Service Level (For Suppressed Demand):** To apply the Suppressed Demand baseline approach (Tier 1 equivalence), the activity developer shall demonstrate that the Activity Device meets or exceeds Tier 1 of the World Bank Multi-Tier Framework (MTF) for energy access. The suppressed demand approach is only applicable for households:

3.2.3 | **Requirement:** The activity device shall provide a minimum of 1,000 lumen-hours per day of lighting service (e.g., 250 lumens for 4 hours) per premise or a minimum of 22 kWh per year per premise. Interpolation or proportional crediting for systems delivering below this threshold is not allowed; such systems shall default to the standard historical replacement baseline (historical emissions).

a. **Performance Verification:** This performance shall be verified by third-party testing results (e.g., VeraSol / IEC 62257-9-5).

3.2.4 | **Target Area and Grid Status:** The activity applies to technologies installed at premises that:

3.2.5 | **Off-Grid**: Have no connection to a national or regional electricity grid; OR

3.2.6 | **Unreliable Grid**: Have a connection to a grid that is deemed "unreliable." Unreliable is defined as providing less than Tier 3 service levels (i.e., less than 12 hours of availability per day; or subject to frequent evening blackouts resulting in less than 2 hours of grid access in the evening). For activities located in Least Developed Countries (LDCs) and Small Island Developing States (SIDS), the unreliability of the grid in rural areas may be demonstrated using official government statistics or reports from credible international agencies (e.g., World Bank), without the need for activity-specific reliability surveys.

3.2.7 | **Implementation Structure and Scale:** The activity is implemented by a developer and can include additional activity participants.

a. **Activity Scale:** Measures are limited to those that result in emission reductions of less than or equal to 60,000 tCO_2e annually.

b. **Premise Limit:** The number of activity lamps distributed or sold to each household is restricted to a maximum six (6) units to prevent over-crediting beyond realistic lighting needs. Exceptions to this cap may only be invoked for institutional, commercial, or demonstrably large premises by submitting robust, verifiable justification via a site-specific survey validated by the VVB.

3.2.8 | **Monitoring Systems and Data Management:** This methodology requires 100% Unique Identification Marker tracking:

3.2.9 | **Requirement:** The activity developer shall implement a monitoring system capable of tracking 100% of the activity devices. Every activity device shall be identified with a unique serial number or identifier affixed to the device.

a. **Data Management:** The activity developer shall maintain a comprehensive database tracking the distribution date, location, model type, and end-user details for every unit. Sampling for the purpose of determining the number of units distributed is not permitted.

3.2.10 | **Technical Life and Replacement:** The crediting period for a specific unit shall not exceed the Technical Life of the activity device, which is strictly defined by the battery cycle life. A fixed crediting extension for specific unit is granted per verified battery replacement event. This is triggered and permitted only when:

a. A new battery UID is logged in the project database against the original unit UID or similar marker;

b. The physical replacement is corroborated by field-agent records or PAYG transactional data; and

c. The replacement battery meets the original safety and quality standards.

If these verified provisions for battery replacement are not in place, no emission reductions can be claimed for the technology after its rated technical life has ended.

3.3 | Entry into force

3.3.1 | The date of entry into force after 90 days of the publication date of this methodology.

3.4 | Mandatory Compliance and Safeguards

3.4.1 | The activity shall adhere to the GS4GG Principles and Requirements, Safeguarding Principles and Requirements, and the Community Services Activity Requirements.

3.4.2 | **Regulatory Compliance:** The activity shall not undermine or be in conflict with any national, sub-national, or local regulations regarding rural electrification or waste management. The activity shall document the relevant regulatory framework within the activity boundary.

3.4.3 | **Double Counting:** To avoid double-counting or double claiming, the activity developer shall:

a. Explain the proposed method for distribution of the activity device in the PDD/VPA-DD;

b. Ensure activity device is tracked in the activity database via its unique identifier;

c. Clearly communicate its ownership rights and intention of claiming the emission reductions by contract or clear written assertions (e.g., warranty cards, receipts) to all other activity participants – end users, device manufacturers, and retailers;

d. Inform and notify the other activity participants, at the time of device distribution or installation, that they cannot claim emission reductions from the activity. Evidence of transfer shall clearly and unambiguously demonstrate informed consent. Transactional records (whether paper or digital) shall contain a specific assertion, accessible in the local language, explicitly demonstrating that the end-user was informed of the carbon title waiver prior to the execution of the transfer; and

e. Exclude from the activity any devices included in any other voluntary market or compliance mechanism activity.

3.4.4 | Indoor Air Pollution and Safety (Battery Waste)

a. **Safety:** The activity developer shall demonstrate that the Activity Device meets relevant safety standards (e.g., IEC 62257-9-5) regarding battery safety, wiring, and protection against water ingress.

b. **Environmental Safeguard (Battery and Electronic Waste):** The activity developer shall document a Waste Management Plan for the collection, recycling, or safe disposal of used batteries and PV panels, at a minimum. This plan shall comply with relevant national regulations or international best practices.

4| NORMATIVE REFERENCES

4.1.1 | The following standards, methodologies, tools, and guidelines are normative references for the application of this methodology. Activity developers shall apply their latest valid version.

4.1.2 | 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) which will become effective thereafter.

4.1.3 | GS4GG Standards and Requirements

a. Principles and Requirements
b. Safeguarding Principles and Requirements
c. Community Services Activity Requirements

4.1.4 | GS4GG Methodologies, Standards, and Tools

a. Methodology Standard: Requirements for Additionality Demonstration (V1.0)
b. Methodology Standard: Requirements for Baseline Setting (GS4GG A6 MS400-04) (V1.0)
c. Methodology Standard: Requirements for Addressing Leakage in Methodologies (GS4GG PAA MS400-05) (V1.0)
d. Methodology Standard: Requirements for Suppressed Demand Accounting in Methodologies (GS4GG A6 MS400-05) [final version is to be published]
e. Tool 01: Emissions from Fossil Fuel Combustion (V1.0)
f. Tool 02: Emissions from Freight Transportation (V1.0)
g. Tool 05: Downward Adjustment Factor (DAF) Determination (GS4GG A6 MT400-05) (V1.0)
h. Tool 06: Common Practice Analysis (V1.0)
i. Tool - Analysis of lock-in risk [Latest Approved Version]
j. Tool - Technical lifetime [Latest Approved Version]

4.1.5 | UNFCCC/A6.4 Tools and Standards:

a. CDM TOOL33: Default values for common parameters (or subsequent A6.4 tools).
b. CDM Standard: Sampling and surveys for CDM project activities and programme of activities
c. CDM Guideline: Sampling and surveys for CDM project activities and programme of activities
d. A6.4 –AMT 007: Emissions from electricity generation and consumption (V1.0)
e. A6.4-AMT-006: Determination of the technical lifetime of equipment. (V1.0)
f. A6.4 -AMT 002: Investment analysis (V1.0)

4.1.6 | Other Sources:

a. IEC/TS 62257-9-5: Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-5: Integrated systems – Laboratory evaluation of stand-alone renewable energy products for rural electrification.
b. VeraSol Quality Standards.

5| ACTIVITY BOUNDARY AND GHG SOURCES/SINKS

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 activity developer shall clearly identify the activity boundary following the definitions below:

5.1.3 | **Physical and Geographical Boundary:** The spatial extent of the activity boundary is the physical, geographical site(s) where the Activity Devices are distributed, installed, and operated (e.g., households, communities, commercial premises) and the associated charging systems (PV panels and batteries).

5.1.4 | **Upstream Emissions (Manufacturing):** The boundary includes the upstream (cradle-to-gate) emissions associated with the manufacturing of the Activity Device components, specifically the batteries and solar PV modules. These shall be accounted for as Leakage Emissions (See Section 9|).

a. **Fuel Production/Supply Systems (Baseline):** Where the baseline fuel is a fossil fuel (e.g., kerosene, diesel), the boundary implicitly accounts for the emissions avoided from the combustion of this fuel. However, to ensure absolute conservativeness and strict alignment with jurisdictional boundaries, upstream emissions associated with the extraction, refining, and transport of baseline fossil fuels are explicitly excluded from the activity boundary.

5.2 | GHG Sources and sinks

5.2.1 | Emissions can occur during fuel production, device manufacturing, transportation, and consumption. The following sections identify the relevant GHG sources for the baseline scenario, the activity scenario, and the leakage.

5.2.2 | Materiality and Simplification Rules:

a. **Baseline Simplification:** Baseline emissions of CH_4 and N_2O from fossil fuel combustion may be omitted for simplification, provided this results in a conservative estimate of emission reductions.

b. **Activity Emission Completeness:** As the Activity Devices are charged exclusively by Solar PV, activity emissions from energy generation are considered zero.

c. **Device Manufacturing (Embodied Emissions):** Indirect GHG emissions associated with the production of the Activity Devices (Leakage) shall be accounted for.

d. **Transportation Emissions:** Activity emissions from the transportation of activity devices shall be accounted for if the total transportation distance exceeds 200 km; otherwise, they can be neglected.

5.2.3 | Baseline Emissions: The following table details the GHGs included in, or excluded from, the baseline scenario(s).

Table 3. GHGs included in, or excluded from, the baseline

SOURCE	DESCRIPTION	GAS	INCLUDED?	JUSTIFICATION
Delivery of lighting services	Combustion of fossil fuel (e.g., Kerosene, Diesel) or wax (Candles) in the baseline lighting devices.	CO_2e	Yes	Major source of emissions.
		CH_4	No	Excluded for simplification. Omission is conservative and is quantitatively demonstrated as immaterial in the methodology's Supplementary Information.
		N_2O	No	
Production of fuel	Emissions associated with the extraction, refining, and transport of baseline fossil fuels (upstream emissions).	CO_2e	No	Excluded to ensure absolute conservativeness, mitigate macro-economic fuel rebound risks, and maintain strict alignment with host country National GHG Inventory (NDC) boundaries under Article 6.

5.2.4 | Activity emissions: The following table details the GHGs included in, or excluded from, the activity scenario(s).

Table 4. Sources of Activity Emissions

SOURCE	DESCRIPTION	GAS	INCLUDED?	JUSTIFICATION
Operation of Activity Device	Generation of electricity by the Solar PV system to power the LED lamp.	CO_2e	No	Zero Emissions. The technology is strictly limited to Solar PV charging (See Applicability 3.2 |).
		CH_4	No	Zero Emissions.
		N_2O	No	Zero Emissions.
Transport of Activity Devices	Emissions associated with the transportation of the Activity Devices to the distribution site.	CO_2e	Yes	Included if the total transportation distance exceeds 200 km (See Materiality Rules).

5.2.5 | **Leakage emissions:** Leakage is the net change of GHG emissions occurring outside the activity boundary, attributable to the activity. The following table details the potential sources of leakage emissions that shall be assessed.

Table 5: Sources of Leakage Emissions

SOURCE	DESCRIPTION	GAS	INCLUDED?	JUSTIFICATION
Embodied Emissions (Upstream)	Cradle-to-gate emissions associated with the manufacturing of the Activity Device (specifically Battery and PV Panel).	CO_2e	Yes	Mandatory Inclusion. Significant source of emissions for hardware-based activities. Shall be accounted for using conservative defaults or specific product data (See Section 9.3 |).
Reuse of Baseline Equipment	The displaced baseline lighting systems are reused outside the activity boundary or within the household (Rebound/Stacking).	CO_2e	Yes	Potential source of leakage. Assessed via monitoring or application of a discount factor (See Section 9.4 |).
Market Effects	Increased demand for lighting, leading to secondary fossil fuel use.	CO_2e	No	Excluded. The methodology internalizes this by defining strict Baseline Service Levels (Section 7|).

6| DEMONSTRATION OF ADDITIONALITY

6.1 | Requirements

6.1.1 | The activity developer shall demonstrate that the activity would not have occurred in the absence of the incentives provided by the carbon revenues. The demonstration of additionality shall be conducted in accordance with the latest version of the *GS4GG Standard:* Requirements for Additionality Demonstration.

6.2 | Additionality Approach Selection

6.2.1 | The activity developer shall demonstrate additionality by conforming to the requirements of one of the options below:

a. **Positive List (Deemed Additionality):** The activity is deemed additional if it meets the criteria of a GS4GG-approved positive list applicable to the technology type and geographical area (See Section 6.3 |).

b. **Activity-Specific Assessment:** If the activity does not qualify for a Positive List, additionality shall be demonstrated through a detailed assessment (Investment Analysis or Barrier Analysis).

6.2.2 | All activities, regardless of the compliance approach selected, shall successfully complete the following mandatory analyses:

a. Regulatory Surplus Analysis

b. Lock-In Risk Analysis

c. Common Practice Analysis

d. Ongoing Financial Need (at Crediting Period Renewal)

6.3 | Positive List Criteria

6.3.1 | Activities utilizing activity devices are deemed automatically additional (regarding financial/barrier additionality) if they meet one of the following criteria:

a. **LDC/SIDS Criteria:** The activity is implemented in a Least Developed Country (LDC), Small Island Developing State (SIDS), or a Landlocked Developing Country (LLDC). Activities implemented in LLDCs are eligible for positive list only where the country is also classified as low-income or lower-middle-income by the World Bank.

b. **Penetration Criteria:** The activity developer demonstrates that the market penetration of the specific activity device (e.g., Pico-Solar or SHS) in the Applicable Geographical Area (AGA) is less than 5% (based on annual stock data) or less than 2.5% (based on annual sales data).

6.4 | Regulatory Surplus Analysis

6.4.1 | The activity developer shall demonstrate that the emission reductions achieved by the activity are regulatory surplus. This means the activity and its resulting emission reductions are not required by any existing laws, commitments, regulations, or mandates (legal requirements) within the host country.

6.4.2 | The assessment shall be conducted at the start of the 1st crediting period and reassessed at each renewal of the crediting period.

6.4.3 | The analysis shall verify that legal requirements do not:

a. Directly mandate the use of solar lighting technologies in the target end-user;

b. Directly ban the use of the baseline fossil fuel-based lighting technologies (e.g., kerosene, candles) in the target area; or

c. Establish a support scheme (e.g., a government funded distribution program) designed to achieve the same target that would likely result in the same amount of emission reductions if the activity were not implemented.

6.4.4 | **Host Country Eligibility (Positive/Negative List):** The activity developer shall confirm that the mitigation activity type is not excluded from any publicly available Positive/Negative List or regulatory exclusion declared by the Host Country for Article 6.2 or 6.4 participation.

6.4.5 | Compliance with this requirement shall be demonstrated through one of the following, as applicable, at the time of Validation and Crediting Period Renewal:

a. **Official policy document:** A policy document or a legal framework of the country prohibiting generation of carbon credits from proposed activity type.
b. **Official List Review:** A citation of the Host Country's most recent official Article 6 policy framework, decrees, or public eligibility lists (e.g., a "Negative List" or "Ineligible Activity List") published by the Designated National Authority (DNA) or Article 6 Focal Point, confirming the activity is not excluded.
c. **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.

6.5 | Lock-In Risk Analysis (Mandatory for All Tracks)

6.5.1 | The activity developer shall assess the risk whether activity may lead to a lock-in of GHG emissions, technologies, or carbon-intensive practices inconsistent with the achievement of the host country's NDC or the long-term goals of the Paris Agreement.

6.5.2 | **Methodology-Level Determination (Zero-Emission Technologies):** Activity devices charged by Solar Photovoltaic (PV) systems are classified as Zero-Emission Technologies and are considered fully compatible with long-term decarbonization pathways.

6.5.3 | Activities exclusively utilising these Solar PV zero-emission technologies are formally exempt from conducting Lock-In Risk Analysis.

6.6 | Investment Analysis

6.6.1 | If the activity-specific assessment pathway is used, an Investment Analysis and/or Barrier Analysis shall be conducted.

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

6.6.3 | Step 1: Selection of Method

a. **Benchmark Analysis:** Compare the activity IRR (without carbon) to a recognized Sectoral Benchmark (e.g., commercial lending rates in the Host Country).

b. **Investment Comparison:** Compare the activity NPV/IRR to the Baseline Scenario (continuation of current practice).

6.6.4 | **Step 2: Input Parameters:** The analysis shall account for all relevant cash flows, including:

a. **Costs (CAPEX/OPEX):** Investment cost for SLS manufacturing, procurement, or distribution operational and maintenance costs.

b. **Revenues:** Activity revenue from sale, or service-based provision (e.g., PAYG models) of SLS.

c. **Exclusion:** Carbon revenues shall be excluded from the initial calculation to determine the activity's financial viability.

6.6.5 | **Step 3: Outcome**: The analysis shall demonstrate that the Activity is financially unattractive (IRR < Benchmark) or less attractive than the Baseline without carbon revenue.

6.6.6 | **Step 4: Sensitivity Analysis:** As per A6.4-AMT-002, a sensitivity analysis shall be conducted varying key parameters (e.g., CAPEX, OPEX) by ±10% to confirm the robustness of the conclusion.

6.7 | Barrier Analysis:

6.7.1 | For Micro-scale and Small-scale activities not utilising the Positive List or Investment Analysis, a Barrier Analysis may be used to demonstrate that significant barriers prevent the implementation of the activity in the absence of carbon finance.

6.7.2 | The activity developer shall identify and substantiate barriers such as:

6.7.3 | **Financial Barrier:** The high initial retail cost of the Activity Device (Solar Home System or Pico-Solar) compared to the low daily cost of baseline fuels (kerosene/candles/torches) prevents adoption by low-income households (Tier 0/1). Lack of access to credit for end-users or distributors to finance the inventory/purchase.

6.7.4 | **Technological/Infrastructure Barrier:** Lack of maintenance infrastructure, spare parts, or technical capacity in remote, off-grid areas.

a. **Institutional/Market Barrier:** Low market awareness, weak institutional framework for quality assurance.

6.7.5 | Barriers shall be substantiated by independent evidence (e.g., extensive surveys, academic studies specific to the region) and not anecdotal claims.

6.8 | Common Practice Analysis (Mandatory for All Tracks):

6.8.1 | All activities shall evaluate common practice by assessing the market penetration of equivalent technologies in the applicable geographic area (AGA).

6.8.2 | Activities previously registered under the GS4GG, Article 6.4 mechanism, Clean Development Mechanism (CDM) or similar voluntary carbon market

programme, as well as activities substantially supported by international climate finance or Official Development Assistance (ODA) dedicated to climate mitigation, shall be excluded from the calculation of the penetration of Similar Activities (P_{sim}) to ensure the analysis reflects autonomous market adoption. Activity developers shall apply the following definitions:

a. **Applicable Geographical Area (AGA):** The Host Country (Sub-national permissible if justified, e.g., off-grid provinces).

b. Indicator ($\boldsymbol{P}$): Count-based.

c. **Metric:** The number of End Users utilizing the technology.

d. Assessment Approach: Stock-Based.

6.8.3 | The Common Practice Factor (F) is calculated as:

$$F = \frac{P_{sim}}{P_{all}}$$

6.8.4 | **Common Practice Factor (F)** shall be compared with the Common Practice Threshold (F_{max}) specified below. If $F \geq F_{max}$, the proposed activity shall be considered common practice and is therefore not additional.

6.8.5 | Group Parameters for Solar Lighting:

a. **Target Market Size (P_{all}):** Total number of households/premises within the AGA that lack access to reliable grid electricity (Off-grid + Unreliable Grid).

6.8.6 | Similar Activities (P_{sim}) Attribute Matrix: Table 6.

Table 6: Attribute Matrix for Solar Lighting

Attribute	Description	Required for Similarity (Yes/No)
Primary Energy Source	Solar Photovoltaic (PV).	Yes
Service Level	Meets Minimum Service Level (Tier 1 / >1000 lm-hr).	Yes
Application	Primary source of lighting for the premise.	Yes
Exclusion of Carbon Finance	Technologies distributed, subsidised, or maintained via voluntary or compliance carbon market mechanisms shall be explicitly excluded from the count when calculating the common practice penetration rate.	Yes
Financing Model	Technology requires similar financing (e.g., upfront cash vs. PAYG).	No (All financing models considered similar).

6.8.7 | Common Practice Threshold (F_{max}):

6.8.8 | Technology Maturity Categories (TMC) Classification: TMC-3 (Early Majority). **Justification:** The technology is matured however adoption is hindered by high upfront costs, access to formal financing, and lack of last-mile delivery and service networks. F_{max} (Stock-Based): 25%.

6.9 | Ongoing Financial need (OFN)

6.9.1 | At the renewal of the crediting period, the additionality of the activity shall be reassessed. The Activity Developer shall demonstrate Ongoing Financial Need in accordance with *Section 7* of the *GS4GG Additionality Standard*.

6.9.2 | At the time of renewal of crediting period, the activity developer shall conduct an Ongoing Financial Need (OFN) assessment to demonstrate continued compliance with a. Regulatory surplus (mandatory), AND b. Investment analysis or Barrier analysis.

6.9.3 | This involves providing evidence (e.g., an updated financial analysis, funding assessment, or barrier identification) that the activity still requires income from carbon credit to remain operational and sustainable in the renewed period.

6.9.4 | Positive List Exemption: Activities that qualified for and remain eligible under a recognized GS4GG Positive List (Deemed Additionality) are exempt from the Investment analysis or Barrier analysis demonstration at crediting period 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 (Uncertainty and Ambition) (Section 7.3.4 |).

d. Step 4: Identification of a conservative Business-as-Usual (BAU) baseline considering regulatory constraints (Section 7.5 |).

e. Step 5: Comparison and selection of the final Crediting Baseline (Section 7.6 |).

7.2 | Selection of and Justification of the Baseline Approach

7.2.1 | Selection of Baseline Approach: In accordance with *Paragraph 36(c)* of Article 6.4 Rules, Modalities and Procedures (RMPs) and *Section 8.4* of the *GS4GG*

Standard: Requirements for Baseline Determination, this methodology utilizes: Approach (c): An approach based on existing actual or historical emissions, adjusted downwards.

7.2.2 | Justification for the Baseline Approach: The selection of approach (c) is justified as follows:

a. **Data Constraints:** Reliable, granular data on historical fuel consumption in remote, off-grid areas is often sparse or non-homogeneous, making benchmark approaches technically infeasible.

b. **Suppressed Demand:** The target population typically suffers from suppressed demand (Tier 0 access). This approach allows for the estimation of baseline emissions based on the Minimum Service Level (Tier 1) provided by the activity, to address the historical lack of access due to poverty.

c. **Conservativeness:** The approach incorporates mandatory downward adjustments (DAF) to ensure the baseline remains ambitious and aligned with the Paris Agreement goals over time.

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

7.3.1 | **Identification of the Baseline Scenario:** The activity developer shall identify the applicable baseline scenario (b) based on the target population's characteristics.

a. **Scenario 1 (Off-Grid / Fossil Fuel):** For premises with no grid connection. The baseline is the use of fossil fuel-based lighting devices as per Section 3.1 |.

b. **Scenario 2 (Diesel/Generator):** For premises relying on standalone or shared diesel generators for lighting (typically commercial, community or larger households).

c. **Scenario 3 (Unreliable Grid):** For premises with a grid connection defined as "Unreliable", relying on fossil fuels (Scenario 1 or 2) during outages.

7.3.2 | **Consistency Check (Retrospective Baseline):** To ensure the identified baseline scenario is representative of the actual activity participants, the activity developer shall conduct a Consistency Check.

7.3.3 | Retrospective questions shall be included in the first monitoring survey/interaction regarding the lighting source used immediately prior to acquiring the activity device

7.3.4 | A material discrepancy occurs if the actual field population presents a lower-emitting profile than the ex-ante assumptions (e.g., reported baseline lighting source is cleaner than the identified scenario) as reported in the survey.

a. If <20% of users report a baseline lower than the selected scenario (e.g., they used battery torches instead of kerosene), a conservative weighted downward correction shall be applied to the baseline calculation proportionally reflecting the lower-emission technology for those users.

b. If >20% of users report a baseline lower than the selected scenario (e.g., they used battery torches instead of kerosene), this constitutes a fundamental divergence from the target demographic. The activity developer shall formally redefine the baseline scenario via a new Baseline Scenario Survey.

c. Activity developers shall not arbitrarily exclude non-conforming, lower-emitting households from the monitoring sample solely to maintain compliance with the original baseline.

7.3.5 | Grid Transition: Premises that transition from an Unreliable Grid status (Tier <3) to a Reliable Grid status (Tier ≥3) during a monitoring period shall be subject to a baseline scenario re-assessment. If a premise achieves a connection providing service levels at or above Tier 3 (≥12 hours of daily availability or ≥2 hours of peak evening access), the baseline emissions ($BE_{i,y}$) for that specific premise shall be adjusted to reflect the National/Regional Grid Emission Factor for the remainder of the crediting period.

7.3.6 | **Calculation of Unadjusted Baseline Emissions (BE_{unadj}):** The activity developer shall select one of the following options to calculate the unadjusted baseline emissions.

7.3.7 | **Option A: Standard Replacement (Historical Emissions)** Applicable to activities that only replace the use of kerosene lamps and/or candles with solar-powered LED lighting in areas with no grid or unreliable grid, where Suppressed Demand is not claimed. This applies to all types of eligible premises (household, community, and commercial). However, baseline claims for community and commercial premises are strictly capped at the residential household equivalent.

$$BE_{unadj,i,y} = N_{lamps,i} \times DV \times Days_y \qquad \text{(eq.1)}$$

Where

$BE_{unadj,i,y}$	Unadjusted baseline emissions in year y (tCO_2e/premise)
$N_{lamps,i}$	Number of activity lamps in premise i
DV	Daily Emissions per kerosene lamp (tCO_2e/lamp/day). Calculation: $\frac{0.03\ L/h\ \ (Fuel\ Rate) \times 3.5\ h/day\ (Utilization) \times 2.4\ kgCO2e/L\ (EF)}{1000} = 0.000252\ tCO2e/day.$
$Days_y$	Annual utilization of activity device (days)

7.3.8 | **Option B: Suppressed Demand (Service Level Equivalence):** Applicable only to Households where the activity device meets the Minimum Service Level (Tier 1 / 1,000 lumen-hours/day) or activities with legacy devices. This option calculates the number of baseline kerosene lamps that would be required to provide the equivalent lighting service delivered by activity device, subject to a conservative cap**.**

a. Scenario 1 (Off Grid/Fossil Fuel/Torches) and Scenario 3 (Unreliable Grid)

$$BE_{unadj,i,y} = MIN\left(SLR_{cap}, \frac{L_{activity}}{L_{baseline}}\right) \times DV \times Days_y \qquad \text{(eq.2)}$$

Where

$BE_{unadj,i,y}$	Unadjusted baseline emissions in year y (tCO_2e/premise)
$L_{activity,i}$	Service Level of all activity lamps (Lumen-Hours/Day) in premise i.
$L_{baseline,i}$	Service Level of a typical Baseline Kerosene Lamp. Fixed Default: 200 Lumen-Hours/Day in premise i. Calculation: $0.21\ lm/watt\ (lumen\ efficacy)\ x\ 43.1\ TJ/Gg\ (NCV)\ x\ 0.81\ (density)\ x\ 0.03\ L/h\ (Fuel\ Rate)\ x\ 3.5\ h/day\ (Utilization)\ x\ 1000\ \div\ 3.6\ \approx\ 200\ lumen-hours/day$
$SLR_{cap,i}$	**Service Level Ratio Cap**. To ensure conservativeness and prevent over-crediting, the ratio ($\frac{L_{project}}{L_{baseline}}$) shall not exceed 5.0 in premise i (representing a maximum realistic expenditure on 5 kerosene lamps per household).
DV	Daily Emissions per kerosene lamp (tCO_2e/lamp/day). Calculation: $0.03\ L/h\ (Fuel\ Rate)\ \times\ 3.5\ h/day\ (Utilization)\ \times\ 2.4\ kgCO2e/L\ (EF)\ \div\ 1000\ =\ 0.000252\ tCO2e/day.$
$Days_y$	Annual utilization of activity device (days)

7.3.9 | Scenario 2 (Diesel / Generator) and Scenario 3 (Unreliable Grid)

$$BE_{unadj,i,y} = EG_{i,y} \times EF_y\ \times\ Days_y \qquad \text{(eq.3)}$$

Where

$BE_{unadj,i,y}$	Unadjusted baseline emissions in year y (tCO_2e/premise)
$EG_{i,y}$	Energy generated/supplied by all activity devices (MWh/day) in premise i. Capped at 22KWh/Year (0.022 MWh/year) per premise to align with the residential household limit, regardless of whether the premise is domestic, commercial, or community.
EF_y	CO_2 equivalent emission factor of diesel (tCO_2e/MWh).
$Days_y$	Annual utilisation of activity device (days)

7.3.10 | **Operational Constraints:** Regardless of the option selected, emission reductions can only be claimed for devices within their Rated Technical Life, which is strictly defined by the battery cycle life. Devices exceeding this technical life (e.g., typically 2–5 years depending on chemistry) shall be excluded from the BE_{unadj}calculation unless a verified battery replacement is logged in accordance with Section 3.2.10 |.

7.4 | Application of the Downward Adjustment & Uncertainty

7.4.1 | Suppressed Demand Uncertainty Adjustment: In line with *GS4GG Requirements for Baseline Determination*, an initial downward adjustment shall be applied where the suppressed demand baseline is used to address uncertainty in the "Actual vs Historical" assumption. This addresses uncertainty associated with estimating baseline emissions from historical or default service level assumptions and operates independently of the macroeconomic policy ambition represented by the Downward Adjustment Factor (DAF).

$$BE_{adj,UNC,i,y} = BE_{unadj,i,y} \times (1 - UNC_{act/hist,}) \qquad \text{(eq.4)}$$

Where

$BE_{adj,UNC,i,y}$	Uncertainty-adjusted baseline emissions in year y (tCO_2e/premise)
$BE_{unadj,i,y}$	Unadjusted baseline emissions in year y (tCO_2e/premise)
$UNC_{act/hist}$	Uncertainty adjustment factor. Default value: 0.05 (5%) unless a lower value is justified via activity-specific uncertainty analysis.

7.4.2 | **Adjustment for Ambition (DAF):** The applicable Downward Adjustment Factor (DAF) shall be applied to the baseline emissions to encourage ambition over time. This factor shall be sourced directly from the published default tables within the GS4GG Methodology Tool: Downward Adjustment Factor (DAF) Determination (A6 MT400-05), which provides pre-approved, country-specific adjustment rates.

7.4.3 | Calculation of Downward Adjusted Baseline Emissions ($\boldsymbol{BE_{adj,y}}$):

$$BE_{adj,i,y} = BE_{adj,UNC,i,y} \times \left(1 - DAF_y\right) \qquad \text{(eq.5)}$$

Where

DAF_y	Downward Adjustment Factor for year $\boldsymbol{y}$ (fraction).
$BE_{adj,i,y}$	DAF adjusted baseline emissions in year y (tCO_2e/premise)
$BE_{adj,UNC,i,y}$	Use the value from Eq. 4.

7.5 | Identification and Calculation of the Conservative BAU Scenario

7.5.1 | The Conservative Business-as-Usual (BAU) scenario represents the emissions that would occur in the absence of the Activity, accounting for uncertainty but excluding the DAF (Ambition).

$$BE_{BAU,i,y} = BE_{adj,UNC,i,y} \quad \text{(eq.6)}$$

Where

$BE_{BAU,i,y}$	Conservative Business-as-Usual baseline emissions in year y (tCO_2e/premise).
$BE_{adj,UNC,i,y}$	Use the value from Eq. 4.

7.6 | Selection of the Crediting Baseline

7.6.1 | The final Crediting Baseline ($BE_{i,y}$) is the lower of the Downward-Adjusted Baseline (Step 3) or the Conservative BAU Baseline (Step 4).

$$BE_{i,y} = MIN(BE_{adj,i,y}, BE_{BAU,i,y}) \quad \text{(eq.7)}$$

Where

$BE_{i,y}$	Crediting baseline emissions in year y (tCO_2e/premise).
$BE_{adj,i,y}$	Use the value from Eq.5
$BE_{BAU,i,y}$	Use the value from Eq.6

7.7 | Quantification of the Difference between BAU and Crediting Baseline

7.7.1 | As required by the Methodology Standard: Requirements for Baseline Setting, the difference between the Conservative BAU emissions ($BAU_{,y}$) and the final Crediting Baseline Emissions ($BE_{i,y}$) shall be quantified and reported transparently in the Monitoring Report.

$$\Delta_{i,y} = BE_{BAU,i,y} - BE_{i,y} \quad \text{(eq.8)}$$

Where

$\Delta_{i,y}$	Emissions excluded from the crediting baseline due to ambition adjustment (DAF) in year y
$BE_{BAU,i,y}$	Conservative Business-as-Usual emissions in year y
$BE_{i,y}$	Crediting Baseline Emissions in year y

7.7.2 | This difference represents the emissions excluded from crediting due to the application of the Ambition/DAF mechanism. For transparency and VVB auditing, the emission reduction calculation sheets shall explicitly display the step-by-step mathematical flow: Unadjusted Emissions, Uncertainty-Adjusted Emissions, and the final Crediting Baseline.

8| ACTIVITY EMISSIONS

8.1 | Identification of Activity Scenario

8.1.1 | The activity scenario is defined by the installation and operation of activity devices (Solar PV-charged LED lighting systems) by end-users in the target population to replace baseline fossil fuel, candle and/or handheld torch-based lighting.

8.1.2 | Under this methodology, the activity technology is strictly limited to systems charged by Solar Photovoltaic (PV) sources (as per Section 3.2 |). Therefore, direct operational emissions from energy generation during the activity are considered zero.

8.2 | Operational Emissions

8.2.1 | **Scenario A - Dedicated Solar Charging (Default)**: For activity device charged exclusively by solar PV systems (verified by the absence of grid-compatible charging ports or provision of proprietary connectors), the emissions from energy consumption are zero.

$$AE_{operation,i,y} = 0 \qquad \text{(eq.9)}$$

8.2.2 | **Scenario B: Hybrid Charging Safeguard (Unreliable Grid Areas):** If the activity device is technically capable of being charged by the grid (e.g., possesses a standard USB charging port or AC adapter) **AND** the activity is located in an area with an Unreliable Grid (Scenario 3), there is a risk that end-users may supplement solar charging with grid electricity.

8.2.3 | To address this risk the activity developer shall apply one of the following approaches:

a. **Technical Prevention:** Demonstrate that the device is supplied without a grid adapter and the charging connector is proprietary/non-standard. ($AE_{operation,i,y}$ = 0). Acceptable evidence includes manufacturer technical specifications, datasheets, product photographs of the charging port/connector, and a formal supplier declaration. Physical dismantling or removal of the connector by the developer is explicitly not required.

b. Conservative Deduction: Apply a flat 5% deduction to the calculated Emission Reductions (ER_y) to account for potential non-renewable charging. Activities applying conservative deductions shall refer to equation 14 in section 10.1.1.

8.3 | Transport Emissions

8.3.1 | Emissions associated with the transportation of new activity devices distributed during the monitoring period, from the port of entry or manufacturing site to the distribution hubs shall be accounted for.

a. **Materiality Threshold:** If the total weighted average transportation distance is less than 200 km, transport emissions may be considered negligible and set to zero ($AE_{transport,5y} = 0$).

b. If the distance exceeds 200 km, emissions shall be calculated utilising the latest version of Tool 02: Emissions from Freight Transportation or a conservative default calculation based on total weight and distance transported.

c. The activity developer shall calculate and deduct emissions from transportation only once for all new devices distributed during the monitoring period.

9| LEAKAGE EMISSIONS

9.1 | Requirement

9.1.1 | In accordance with the *GS4GG Methodology Standard: Requirements for Addressing Leakage (PAA MS400-05)*, the activity developer shall apply a three-tiered approach:

a. **Identify** all potential sources of leakage;

b. **Avoid** or minimize leakage where feasible; and

c. **Quantify** and deduct any residual negative leakage.

9.2 | Identification of Leakage Emission Sources

9.2.1 | The following table details the potential sources of leakage emissions that shall be assessed for this activity type. Refer to Table 5 in Section 5.2.5 | for the Leakage Source Identification Matrix

9.3 | Embodied Emissions ($LE_{Embodied,y}$)

9.3.1 | In compliance with cradle-to-gate assessment requirements, embodied emissions associated with the manufacturing and transport of the activity devices shall be accounted for leakage.

9.3.2 | Calculation and Embodied Emissions: To simplify the assessment and ensure conservativeness, a standardized default deduction shall be applied. A mandatory deduction as provided in Table 7 shall be applied to account for the cradle-to-gate embodied emissions.

9.3.3 | **Default Factors:** The activity developer shall apply the following defaults derived from lifecycle assessment (LCA) literature, unless specific verified Environmental Product Declarations (EPDs) (ISO 14025 compliant) are provided.

Table 7: Default Embodied Emission Factors

Device Category	Specification	Default $EF_{emboided,y}$	Justification

Pico-Solar / Portable	Integrated PV < 10 Wp or Separate PV < 10 Wp	0.005 tCO_2e/unit (5 kg)	Conservative estimate for Li-ion battery, small PV cell, and casing.
Solar Home System (SHS)	Separate PV ≥ 10 Wp and ≤30Wp	0.020 tCO_2e/unit (20 kg)	Accounts for larger Lead-acid/LFP battery and aluminium framed PV panel.
Solar Home System (SHS)	Separate PV > 30 Wp	0.020 tCO_2e + [0.0015 tCO_2e × (System Wp - 30 Wp)]	Accounts for larger Lead-acid/LFP battery and aluminium framed PV panel.

9.3.4 | The activity developer shall apply one of two pathways for the deduction of embodied emissions, contingent upon the verifiable rated technical lifetime of the activity device (as established via manufacturer specifications, standardized testing, or commercial guarantees):

9.3.5 | **Short-Lived Technologies (Rated Technical Lifetime < 5 years)**: For devices where the battery cycle life is rated for less than 5 years, the total embodied emissions shall be deducted entirely upfront from the emission reductions calculated during the first monitoring period for that specific unit. The activity developer shall calculate embodied emissions for all distributed devices distributed during the monitoring period.

$$LE_{Embodied,y} = \sum_j \left(N_{dist,j,y} \times EF_{emboided,j,y}\right) \qquad \text{(eq.11)}$$

Where

$LE_{Embodied,y}$	Leakage due to embodied emissions in year y (tCO_2e/year) derived from Table 7
$\sum_j$	Sum over all devices j
$N_{dist,i,y}$	Total number of activity devices distributed and eligible for crediting (unit)
$EF_{embodied,y}$	Embodied Emissions Factor for device type j (tCO_2e/unit).

a. **Durable Technologies (Rated Technical Lifetime ≥ 5 years):** To preserve project financial viability for high-quality, durable systems, the total embodied emissions may be annualized (distributed evenly) over the duration of the First Crediting Period (5 years). This annual deduction shall be applied to the cumulative cohort of disseminated devices for exactly five full years from their respective dates of commissioning, regardless of whether individual units break or drop out of the active operational fleet. The annual deduction per operational unit is

$$LE_{Embodied,y} = \sum_j \left(N_{dist,j,y} \times \frac{EF_{embodied,j,y}}{5}\right) \qquad \text{(eq.12)}$$

9.3.6 | **Mandatory True-Up Provision**: If a project utilising approach 2 ceases verification or permanently terminates prior to the completion of the 5-year

First Crediting Period, the activity developer shall conduct a true-up calculation at the final issuance event. Any remaining unamortized embodied emissions for the distributed device fleet shall be deducted in full, from the final issuance request to prevent unpaid carbon debt.

9.4 | Market and Behavioural Leakage ($LE_{Market,y}$):

9.4.1 | This category addresses the risk of Baseline Equipment Transfer (MS400-05 Section 6.2.2), where old kerosene lamps and/or generators continue to be used.

9.4.2 | **Avoidance Strategy (Scrapping):** The activity developer shall prioritize avoidance. Leakage from equipment transfer is deemed Zero if a verifiable Scrapping Mechanism is implemented:

a. **Requirement:** Identify displaced baseline system at the time of distribution; Collect the system; and Destroy/Render them permanently inoperative (e.g., punching holes in fuel tanks) with no new deployment or sale of the baseline type devices.

b. **Verification:** Photographic evidence or recycling certificates for a representative sample. The sample shall meet a minimum 90/10 confidence/precision requirement, with an absolute minimum sample size of 50 units (90/10, minimum n ≥ 50 per stratum).

9.4.3 | **Quantification (Default Deduction):** If a scrapping mechanism cannot be verifiably implemented (e.g., open market sales), the activity developer shall apply a conservative Default Leakage Deduction to the Crediting Baseline Emissions.

$$LE_{Market,i,y} = BE_{i,y} \times 0.05 \quad \text{(eq.13)}$$

Parameter	Description
$LE_{Market,i,y}$	Leakage from market effects and behavioural changes outside the Activity boundary in year y (tCO_2e/premise).
$BE_{i,y}$	The Crediting Baseline Emissions in year y (tCO_2e/premise).
0.05	Default leakage deduction factor (5%) to account for the continued use or transfer of baseline devices.

10| NET GHG EMISSION REDUCTIONS/REMOVALS

10.1 | Calculation of Net GHG Emission Reductions

10.1.1 | The Net Emission Reductions (ER_y) are the final result of the quantification process, calculated by subtracting Activity Emissions and Leakage from the Crediting Baseline, adjusted for the number of operational devices.

a. For activity where devices are charged exclusively by solar PV systems:

$$ER_y = \left(\sum_i \left[\left((BE_{i,y} - AE_{i,y}) \times OF_{i,y} - LE_{market,i,y}\right)\right]\right) - LE_{embodied,y} \quad \text{(eq.14)}$$

Where

ER_y	Net emission reductions during the monitoring period y (tCO_2e/yr).
$\sum_i$	Sum over all premises i
$BE_{i,y}$	Crediting Baseline Emissions per premise i in year y (tCO_2e/premise) (derived from Section 7.6 |).
$AE_{i,y}$	Activity Emissions per premise i in year y (tCO_2e/premise) (Section 8.2 |). Considering $AE_{operation,y}$= 0, $AE_{i,y} = AE_{transport,y}$
$LE_{market,i,y}$	Market Leakage per premise i in year y (tCO_2e/premise) (Section 9.4 |).
$OF_{i,y}$	**Operational Fraction**: The percentage of Activity lamps distributed to end users that are operating and in service in premise i in year y (percentage). Value shall be considered 1 in case of remote/digital monitoring[1].
$LE_{embodied,y}$	Total Embodied Emissions for *new* devices distributed in year y (tCO_2e) (Section 9.3 |). *(Note: This is deducted as a lump sum based on distribution or annualized over 5 years, depending on the applicable pathway in Section 9.2.3).*

10.1.2 | For activity where devices have hybrid Charging:

$$ER_y = \{(\sum_i[(BE_{i,y} - AE_{i,y}) \times OF_{i,y} - LE_{market,i,y})] \times 0.95) - LE_{embodied,y}\} \quad \text{(eq.15)}$$

Where

Parameter	Description
$AE_{i,y}$	Activity Emissions per premise i in year y (tCO_2e/premise) (Section 8.2 |). In this case, $AE_{i,y}$= $AE_{transport,i,y}$
95%	Flat 5% deduction to the calculated Emission Reductions (ER_y) to account for potential non-renewable charging

10.2 | Safeguard for Technical Life

10.2.1 | Emission reductions can only be claimed for activity devices that have valid Technical Life (as defined in Section 3.2 |).

10.2.2 | The Activity Developer shall track the age of each device in the Activity database relative to its distribution date.

[1] The OF_y is considered 1 because number of days of operation of activity device has been considered in Equation 1.

a. Devices exceeding their Technical Life (e.g., >3 years for specific battery types without verified replacement logged in the database in accordance with Section 3.2.10 |) shall be deemed non-operational and excluded from the calculation of ER_y.

11| UNCERTAINTY QUANTIFICATION

11.1 | Approach for Uncertainty Management

11.1.1 | The methodology quantifies and manages uncertainty to ensure that the reported Net GHG Emission Reductions are conservative. Uncertainty is addressed through a tiered approach based on the nature of the monitoring data:

a. **Census Data (Database Integrity):** For parameters tracked via 100% Census (specifically the Number of Distributed Units, N_{dist}), uncertainty is minimised through QA/QC, unique identification, and duplicate analysis. Sampling is prohibited for determining the population size.

b. **Sampled Data (Statistical Conservativeness):** For parameters derived from representative sampling (specifically the Operational Fraction, OF_y), uncertainty is managed by applying the "90/10 Rule" (90% confidence interval with 10% relative precision). If precision targets are not met, a mandatory statistical deduction is applied.

c. **Digital Data (Gap Management):** For Activities utilising remote monitoring (GSM/PAYG), uncertainty regarding connectivity gaps is managed through conservative rules, including:

i. **Non-Operational Default:** If digital logs are used and a data transmission gap is identified, the device is automatically deemed "Non-Operational" (status = 0) for the entire duration of the gap, subject to the Connectivity Gap Allowance detailed below.

ii. **"Dead Logic" Protocol:** Under the digital "heartbeat" protocol, if a device goes silent and no signal is received, the monitoring system assumes the device is either broken or not operational.

iii. Connectivity Gap Allowance: Recognising that rural telecommunications infrastructure may be unreliable, a bounded exception is permitted. Signal gaps of up to 30 consecutive days shall be treated as "presumed operational" provided that: (a) the activity area is documented as having poor GSM connectivity (verified via national connectivity maps or International Telecommunication Union (ITU) data), and (b) the last recorded signal prior to the gap indicated normal operation. Gaps exceeding 30 consecutive days shall immediately revert to

the "Dead Logic" non-operational default for the entirety of the gap.

iv. **Verification Requirement for Gap Recovery:** The only way to reverse this non-operational status for a gap period is if the developer can provide raw device logs retrieved via secondary pathways (e.g., Bluetooth batch uploads, physical port reading) that verify the device was indeed functioning during the time the signal was missing. Offline "store-and-forward" architectures are explicitly authorised to override the non-operational default upon successful synchronisation.

v. **Cumulative Operational Threshold:** For a unit to be considered "Operational" for a monitoring period under Option A (Remote Monitoring), it must transmit a "Power On," "Charging," or valid "Payment Token" signal for at least 180 cumulative days during the year. If data gaps prevent the verification of this threshold, the unit is excluded unless specific proof for the gap periods is retrieved.

11.1.2 | The VVB shall validate the automated gap-management algorithm to ensure non-operational defaults are applied correctly.

11.1.3 | **Sources of Uncertainty and Mitigation:** The following table summarizes the key sources of uncertainty and the mandatory mitigation measures required by this methodology.

Table 8. Key uncertainty sources and mitigation measures

Source of Uncertainty	Parameter(s) Affected	Mitigation Measure(s)
Population Count Error	$N_{dist,y}$ (Number of distributed units/devices)	**100% Census Tracking:** Mandatory tracking of unique serial numbers in a central database. Sampling to estimate population size is prohibited. **Mitigation:** Automated duplicate ID checks and "Existence Verification" audits (Section 13.3).
Sampling Error	OF_y (Operational Fraction)	**Statistical Rigor:** Mandatory application of the 90/10 Rule. **Adjustment:** If precision targets are missed, the Lower Bound of the 90% Confidence Interval is applied to prevent over-crediting (Section 13.6 |).
Digital Data Gaps	$Days_y$ (PAYG Data)	**Conservative Approach:** If digital logs are used, any device with data transmission gaps is deemed "Non-Operational" for the gap period unless verified through supporting evidence.

Recall/Survivor Bias	OF_y (Survey Data)	**Physical Verification:** Surveys shall verify device status physically (e.g., photo evidence of light turning on) rather than relying solely on verbal respondent claims.
Baseline Assumptions	BE_y (Baseline Emissions)	**Downward Adjustment:** Application of the Initial Uncertainty Deduction (Year 1) and the DAF (Subsequent Years) explicitly acts as a buffer for baseline scenario uncertainty (Section 7|).
Leakage Estimation	$LE_{embodied,y}$	**Standardisation:** Use of conservative default factors based on high-bound LCA literature to ensure embodied emissions are not underestimated.

11.2 | Management of Sampling Uncertainty (90/10 Rule)

11.2.1 | This requirement applies specifically to the determination of the Operational Fraction (OF_y) when using the Survey Method (Option B). Additionally, in the event that an ad-hoc baseline reassessment survey is triggered (e.g., at crediting period renewal or due to a material demographic divergence), the same statistical minimums shall apply.

11.2.2 | **Precision Requirement:** The activity developer shall design the monitoring survey (or any required baseline reassessment survey) with a sample size sufficient to achieve a minimum 90% Confidence Interval (CI) with a 10% Relative Precision (Margin of Error).

11.2.3 | **Calculation of Precision:** After conducting the survey, the actual Relative Precision (RP) of the estimate shall be calculated as:

$$RP = \frac{t_{value} \times SE}{Mean} \times 100 \qquad \text{(eq. 16)}$$

Where

t_{value}	Two-sided t-value for 90% confidence level with $n-1$ degrees of freedom.
SE	Standard Error of the sample mean.
$Mean$	The calculated Operational Fraction (OF_y).

11.2.4 | **Adjustment for Non-Compliance:** The value of OF_y applied in the emission reduction calculation (Equation in Section 10.1 |) shall be determined as follows:

a. **Precision Target Met ($RP \leq 10\%$):** The sampling requirement is satisfied. The **Mean** value from the survey shall be used.

b. **Precision Target Not Met ($RP > 10\%$):** The sampling requirement is not satisfied. To ensure conservativeness, the Lower Bound of the one-sided 90% Confidence Interval shall be used.

$$OF_{applied} = Mean \times \left(1 - \frac{RP}{100}\right) \qquad \text{(eq. 17)}$$

11.3 | Management of Census & Digital Uncertainty

11.3.1 | **Census Data QA/QC (Existence Check):** To address uncertainty in the distribution database (e.g., data entry errors, phantom beneficiaries) where sampling is not applied to the count:

a. **Requirement**: The VVB shall perform a randomised Existence Check on a sample of the distribution records (e.g., calling end-users or checking contracts).

b. **Adjustment:** If material discrepancies (>5% error rate) are found in the Existence Check (e.g., users do not exist or never received the device), the total population (N_{dist}) shall be adjusted downwards by the observed error rate for the entire population.

11.3.2 | **Digital Data Gap Rules:** For Activities using Digital/PAYG monitoring to determine the Annual Utilization of Activity Devices: If data is missing for any period of time, the device shall be conservatively deemed Non-Operational for the entire duration of the gap, unless (a) the gap is strictly 30 consecutive days or fewer and occurs in a verified poor-connectivity region in accordance with the Connectivity Gap Allowance, or (b) retrospective on-device logs can be retrieved (e.g., via offline store-and-forward batch uploads) or verified through supporting documents to prove operation..

12| REVERSALS

12.1 | Assessment of Reversal Risks

12.1.1 | A reversal occurs when previously credited GHG emission reductions or removals are subsequently released into the atmosphere.

a. **Nature of Mitigation:** This methodology applies exclusively to emission reduction (avoidance) activities. The mitigation outcomes are achieved by avoiding the combustion of fossil fuels (kerosene/diesel) that would have otherwise occurred in the baseline scenario.

b. **Permanence:** Once fossil fuel combustion is avoided during a specific monitoring period, the corresponding emission reduction is permanent. The CO_2 that was *not* emitted cannot be "re-emitted" later.

12.1.2 | **Conclusion:** Therefore, the mitigation outcomes generated under this methodology are not at risk of reversal.

12.2 | Mitigation and Management of Reversal Risks

12.2.1 | As the risk of reversal is Not Applicable, specific reversal mitigation mechanisms (e.g., contributions to the GS Compliance Buffer) are not required.

12.2.2 | Management of Performance Risks (Non-Permanence of Activity): While the *credited reductions* cannot be reversed, there is a risk that the *activity itself* stops generating benefits (e.g., if the Activity Device breaks or the battery fails). This is defined as a Performance Risk, not a Reversal Risk. This risk is rigorously managed through the Monitoring Methodology (Section 14|).

12.3 | Addressing Reversals

12.3.1 | Procedures for addressing reversals (e.g., compensation mechanisms, reversal event reporting) are Not Applicable to this methodology.

13| MEETING METHODOLOGICAL PRINCIPLES

13.1 | Encouraging ambition over time

13.1.1 | This methodology ensures the encouragement of ambition over time through the following mandatory mechanisms:

a. **Downward Adjustment Factor (DAF):** The methodology mandates the application of the DAF (Section 7.4.3 |), sourced from the GS4GG Methodology Tool: Downward Adjustment Factor (DAF) Determination. This factor ensures that the crediting baseline (BE_y) is systematically lowered annually, aligning the activity with the host country's long-term Net-Zero trajectory or the established Ambition Floor.

b. **Net Atmospheric Benefit (Embodied Emissions):** By requiring the deduction of Embodied Emissions (Scope 3) associated with the manufacturing of the Activity hardware (Section 9.3 |), the methodology sets a higher standard of environmental integrity. This ensures that the "carbon debt" of manufacturing batteries and panels is repaid before net emission reductions are claimed.

c. **Technical Life Restrictions:** By strictly linking the crediting period to the Battery Cycle Life (Section 3.2.10 |), the methodology prevents the passive crediting of ageing or non-functional technology, encouraging the continuous deployment of active, high-performance assets.

d. **Minimum Service Levels:** For activities claiming Suppressed Demand, the methodology enforces a Tier 1 Service Level (1,000 lumen-hours/day or 22kWh/year) threshold. This ensures that carbon finance supports technologies that deliver meaningful development impacts, rather than merely displacing fuel with substandard lighting.

13.2 | Equitable sharing of mitigation benefits

13.2.1 | The methodology promotes the equitable sharing of benefits by operating under the GS4GG Community Services Activity (CSA) Requirements.

13.2.2 | Targeting the Energy-Poor: The methodology is specifically designed to support Suppressed Demand accounting, enabling carbon finance to reach Tier 0 (off-grid) populations who historically consume very little fuel due to

poverty. This directs investment toward the most vulnerable communities for providing the essential lighting services.

13.2.3 | **Co-Benefits:** The activity provides direct co-benefits to households, which are monitored and reported, but not limited to:

a. Health (SDG 3): Elimination of Indoor Air Pollution (PM2.5, Black Carbon) from kerosene lamps.

b. Education (SDG 4): Extended study hours for children via high-quality lighting.

c. Poverty Alleviation (SDG 1): Reduction in household energy expenditure (kerosene/batteries).

13.2.4 | **Safeguards**: Adherence to the GS4GG Safeguarding Principles ensures that the rights of local stakeholders are protected, specifically regarding the safe management of hazardous battery waste and PV panels, at a minimum (Do No Significant Harm).

13.3 | Avoidance of double counting

13.3.1 | The methodology includes explicit requirements (Section 3.4.3 |) to mitigate the risk of double counting (double issuance, double use, and double claiming):

a. **Unique Identification (Census Tracking):** This methodology mandates 100% Census Tracking. Every activity device shall be identified by a unique serial number tracked in a central database (Section 14) to prevent the same physical unit from being claimed in multiple projects.

b. **Ownership Rights:** The activity developer is required to clearly assert ownership rights over the emission reductions via contractual agreements with other participants (e.g., warranty cards or sales receipts) and explicitly notify end-users/manufacturers/retailers that they cannot claim the emission reductions.

c. **Registry Cross-Checks:** The activity developer must verify that the specific device serial numbers are not included in any other voluntary market, Article 6 mechanism, or domestic subsidy scheme that claims carbon rights.

13.4 | Aligning with NDC and LT-LEDS

13.4.1 | The methodology ensures alignment with the host country's Nationally Determined Contributions (NDCs) and Long-Term Low-Emission Development Strategies (LT-LEDS):

a. **Strategic Alignment:** Decentralized solar lighting is a key strategy in the NDCs of most LDCs and developing countries for achieving Universal Energy Access (SDG 7) and rural electrification.

b. **Ambition Alignment:** The DAF mechanism ensures the Activity's baseline evolves in step with national decarbonization goals (e.g., as the grid expands, the DAF tightens the baseline).

c. **Lock-In Avoidance:** The Lock-In Risk Analysis (Section 6.5 |) confirms that the technology is zero-emission. Zero-emission solar PV systems qualifying under the positive list are formally exempt from narrative Lock-In Risk assessments, confirming their absolute compatibility with global decarbonisation goals. Furthermore, the mandatory Waste Management Plan prevents environmental lock-in (toxic waste accumulation), ensuring alignment with broader sustainable development goals.

13.5 | Encouraging Broad Participation

13.5.1 | The methodology encourages broad participation through flexibility and scalability:

a. **Scalability:** It is applicable to Micro and Small-scale activities and utilizes a Programme of Activities (PoA) approach (Section 16|) to aggregate distributed units across wide regions, lowering barriers for local developers.

b. **LDC Differentiation:** Specific provisions (e.g., Positive List additionality, Simplified Grid Reliability evidence) reduce transaction costs for Least Developed Countries (LDCs) and Small Island Developing States (SIDS), encouraging participation in under-represented regions.

13.6 | Including Data Sources, Accounting for Uncertainty, and Monitoring

13.6.1 | The methodology ensures robustness in data use and uncertainty management:

a. **Data Sources:** It relies on actual monitoring data (100% distribution census) rather than sampling for the population size.

b. **Accounting for Uncertainty:** Uncertainty in the Operational Fraction (OF_y) is managed through rigorous statistical sampling (90/10 confidence/precision) or the use of conservative bounds (Lower Bound of Confidence Interval) as detailed in Section 11|.

13.7 | Taking into Account Policies, Measures, and Relevant Circumstances

a. **Regulatory Surplus:** The mandatory Regulatory Surplus Analysis (Section 6.4) ensures the activity is not legally mandated.

b. **Relevant Circumstances:** The "Unreliable Grid" applicability condition allows the methodology to remain relevant in regions where

infrastructure exists physically but fails to deliver service, accurately reflecting the circumstances of the end-users.

14| MONITORING METHODOLOGY

14.1 | Requirements

14.1.1 | The activity developer shall develop and implement a Monitoring Plan detailing the procedures for data collection, management, and quality control. The monitoring system shall be designed to ensure the continuous, accurate, and transparent quantification of Net GHG Emission Reductions.

14.1.2 | **Core Monitoring Principles**:

a. **Asset Census (No Sampling):** The number of distributed devices (N_{dist}) shall be determined via a 100% Census of the Activity Database. Sampling is prohibited for estimating the total population size.
b. **Operational Verification:** The Operational continuity shall be determined annually via digital tracking or representative sampling.
c. **Technical Life Enforcement:** The monitoring system shall automatically exclude units that have exceeded their rated Technical Life (Battery Cycle Life) from the crediting calculation unless a verified battery replacement event is recorded.

14.1.3 | **Activity Database:** The activity developer shall maintain a secure, centralized electronic database acting as the "Single Source of Truth" for credit issuance. This database shall include, at a minimum, the following attributes for every single device:

- **Unique Identifier (UID):** Serial number physically affixed to the Activity Device.
- **Commissioning Date:** The date of handover to the end-user (Start of Crediting Life).
- **Model Type:** To link the specific unit to the ex-ante parameters (Service Level, number of lamps, Embodied Emissions).
- **End-User Type and Location:** Households/Commercial. To comply with international data privacy standards (e.g., GDPR), precise GPS coordinates are preferred but optional; at a minimum, location shall be logged at the lowest permissible administrative unit (e.g., village/ward/district).
- **Baseline device:** Baseline device used by the end user prior to activity.
- **Status Flag:** A dynamic field indicating the current eligibility of the activity device and the applicability of the baseline scenario (e.g., Active, Expired, Transitioned to Reliable Grid, Defective, or Scrapped). This is updated continuously if utilising remote digital telemetry, or annually if utilizing a representative sample survey.

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	**PULSE 1**
Data/parameter:	DV
Description	Daily Emissions per kerosene lamp
Data unit:	tCO_2e/lamp/day
Purpose of data:	☒ Baseline Emissions
Value(s) applied:	0.000252
Source of data:	☐ Measured ☒ Other Sources Methodology provides a default annual baseline emission factor which is calculated as $0.03\ L/h\ (Fuel\ Rate) \times 3.5\ h/day\ (Utilization) \times 2.4\ kgCO2e/L\ (EF) \div 1000 = 0.000252\ tCO2e/day.$
Choice of data or measurement methods and procedures:	N/A
Treatment of uncertainty	Conservativeness is assured by parameter selection rather than statistical sampling: the 0.03 L/h fuel rate sits at the lower-to-mid of the empirical hurricane-lamp range (0.02–0.045 L/h) and the 3.5 h/day utilisation is a lower-bound median of observed lighting use, so DV is a deliberate under-estimate of true baseline emissions. The downstream uncertainty deduction (PULSE 18) and the DAF (PULSE 17) provide further buffers against baseline over-statement. See the Supplementary Information for the materiality assessment.
Comments:	N/A

Parameter ID	**PULSE 2**
Data/parameter:	$L_{baseline,i}$
Description	Service Level of a typical Baseline Kerosene Lamp. Fixed Default: 200 Lumen-Hours/Day in premise i
Data unit:	Lumen-hours/day
Purpose of data:	☒ Baseline Emissions
Value(s) applied:	200
Source of data:	☐ Measured ☒ Other Sources Methodology provides a value based on the calculation as *0.21 lm/watt (lumen efficacy) x 43.1 TJ/Gg (NCV) x 0.81 (density) x 0.03 L/h (Fuel Rate) x 3.5 h/day (Utilization) x 1000 ÷ 3.6 ≈ 200 lumen-hours/day*

Choice of data or measurement methods and procedures:	N/A
Treatment of uncertainty	The value is conservative by construction: actual photometric output of wick and hurricane lamps (35–140 lm-hr/day) is well below the 200 lm-hr/day denominator, which mathematically shrinks the service-equivalence ratio and therefore under-states baseline crediting. The value is held fixed (not sampled), removing measurement variance. Distinct from the 1,000 lm-hr/day Tier 1 MSL eligibility threshold (PULSE 3 / Definitions).
Comments:	N/A

Parameter ID	**PULSE 3**
Data/parameter:	$L_{activity,i}$
Description	Service Level of all activity lamps (Lumen-Hours/Day) in premise i.
Data unit:	Lumen-hours/day
Purpose of data:	☒ Baseline Emissions
Value(s) applied:	To be determined for each Activity device
Source of data:	☒ Measured ☒ Other Sources
Choice of data or measurement methods and procedures:	Any of the following sources shall be used: • Manufacturer specification • Third-party testing certificate
Treatment of uncertainty	Uncertainty is controlled by requiring accredited third-party test data (VeraSol / IEC 62257-9-5) in preference to manufacturer self-declaration, and by applying the SLR_{cap} of 5.0 (PULSE 5) which caps the service-equivalence ratio regardless of any over-statement in $L_{activity}$. Where only manufacturer data are available, the VVB shall apply added scrutiny and may require derating.
Comments:	Fixed per model for the crediting period; re-tested if the model hardware changes.

Parameter ID	**PULSE 4**
Data/parameter:	EF_y
Description	CO_2 equivalent emission factor of diesel
Data unit:	tCO_2e/MWh
Purpose of data:	☒ Baseline Emissions
Value(s) applied:	To be determined at the activity level, determined at validation.

Source of data:	☐ Measured ☒ Other Sources
Choice of data or measurement methods and procedures:	CDM Tool 33 (or A6.4 equivalent). To ensure conservativeness, the selected emission factor shall strictly reflect combustion emissions only; upstream emissions associated with extraction, refining, and transport shall be explicitly excluded.
Treatment of uncertainty	N/A
Comments:	Applicable only where the Scenario 2 baseline is used; updated to the latest tool version at renewal.

Parameter ID	**PULSE 5**
Data/parameter:	SLR_{cap}
Description	Service Level Ratio Cap
Data unit:	-
Purpose of data:	☒ Baseline Emissions
Value(s) applied:	To ensure conservativeness the ratio ($\frac{L_{activity}}{L_{baseline}}$) shall not exceed **5.0** (representing a maximum realistic expenditure on 5 kerosene lamps per residential household). Where installed in community or commercial premises, the cap shall strictly not exceed this residential equivalent of 5.0.
Source of data:	☐ Measured ☒ Other Sources
Choice of data or measurement methods and procedures:	N/A
Treatment of uncertainty	The cap is itself the principal uncertainty-control on suppressed-demand inflation: it removes the risk of unbounded service ratios for high-capacity systems by hard-limiting the credited baseline to 5 lamp-equivalents. The value is fixed, not sampled, and is re-evaluated for continued conservativeness at renewal (Section 17.3 |).
Comments:	Re-evaluated at crediting-period renewal.

14.3 | Data and parameters monitored

Parameter ID	**PULSE 6**
Data/parameter:	$Days_y$
Description	Annual utilisation of Activity device
Data unit:	Days
Purpose of data:	☒ Baseline Emissions

Measurement and updating frequency:	Annual
Measurement methods and procedures:	For ex-ante: Assume 365 days of operation. For ex-post, calculated based on the following approaches: a. **Remote Monitoring (Option A):** The value shall be calculated based on digital logs. i. **Method:** $Days_y$ is calculated based on the complete dataset of digital logs (100% Census). ii. **Operational Criteria:** A unit is considered "Operational" for the monitoring period if it transmits a "Power On," "Charging," or valid "Payment Token" signal for at least 180 days (cumulative) during the year. iii. **Data Gaps:** If data gap is identified, the unit is deemed Non-Operational for that period unless (a) the gap is ≤30 consecutive days and qualifies under the Connectivity Gap Allowance for poor-infrastructure regions, or (b) proof of operationality can be provided for the gap period (e.g., via offline store-and-forward batch data synchronisation). b. **Monitoring survey (Option B) and Warranty Proxy (Option C):** The value shall be calculated as the number of days from the date of commissioning of the activity device to the end of the monitoring period, or where commissioning occurs prior to the start of the monitoring period, from the start to the end of the monitoring period. The calculation shall exclude activity devices that have completed their technical life (if not replaced/retrofitted).
Measuring instrument(s):	Data Loggers (for Option A)
QA/QC procedures:	The activity developer shall internally validate the automated gap-management algorithm and the Connectivity Gap Allowance trigger logic, and cross-check a sample of logs against the computed $Days_y$ prior to verification. VVB validates the automated gap-management algorithm and the Connectivity Gap Allowance trigger logic; cross-checks a sample of logs against the computed $Days_y$.
Treatment of uncertainty	Digital-gap uncertainty is managed conservatively by the Dead-Logic protocol (any unproven gap = non-operational), bounded by the Connectivity Gap Allowance (≤30 days) so that functioning devices in poor-GSM areas are not unfairly excluded while open-ended gaps remain excluded. The ≥180-day operational threshold prevents partial-year signals from being credited as full operation.

	For Options B/C, day-counting uncertainty is subsumed into the Operational Fraction sampling treatment (PULSE 9).
Comments:	N/A

Parameter ID	**PULSE 7**
Data/parameter:	EG_y
Description	Energy generated/supplied by all Activity devices in premise i
Data unit:	MWh/day
Purpose of data:	☒ Baseline Emissions
Measurement and updating frequency:	Once at the time of distribution
Measurement methods and procedures:	Any of the following sources shall be used: • Manufacturer specification (Battery Pack, Solar run time etc.) • Third-party testing certificate
Measuring instrument(s):	N/A
QA/QC procedures:	Value capped at 22 kWh/year per premise (0.022 MWh/year) to align with the residential household limit, regardless of whether the premise is domestic, commercial, or a community service. VVB shall verify the assessment and data.
Treatment of uncertainty	Bounded by a hard cap of 22 kWh/yr per premise (0.022 MWh/yr) applied regardless of premise type (domestic, commercial, community), which limits the effect of any over-statement in the rated energy figure. Preference for third-party test data over self-declaration further controls source uncertainty.
Comments:	-

Parameter ID	**PULSE 8**
Data/parameter:	N_{dist}
Description	Total number of activity devices distributed and eligible for crediting
Data unit:	Number
Purpose of data:	☒ Emission Reductions
Measurement and updating frequency:	Continuous (logged at handover; aggregated per monitoring period).
Measurement methods and procedures:	100% census of the Activity Database by UID, accounting for commissioning dates and excluding units that have completed technical life (unless a verified replacement is logged per Section

	3.2.10 |). Sampling to estimate the population size is strictly prohibited.
Measuring instrument(s):	Centralised Activity Database (electronic).
QA/QC procedures:	The activity developer shall maintain a secure, centralized electronic database acting as the "Single Source of Truth" for credit issuance. This database shall include, at a minimum, the following attributes for every single unit: • **Unique Identifier (UID):** Serial number physically affixed to the Activity Devices. • **Commissioning Date:** The date of handover to the end-user (Start of Crediting Life). • **Model Type:** To link the specific unit to the ex-ante parameters (Service Level, Embodied Emissions). • **End-User Type and Location:** Households/Commercial. GPS coordinates (preferred) or Village/District/State level location. • **Baseline device:** Baseline device used by the end user prior to activity • **Status Flag:** A dynamic field indicating the current eligibility of the Activity Device and the applicability of the baseline scenario (e.g., Active, Expired, Transitioned to Reliable Grid, Defective, or Scrapped). The VVB shall: • **Validate** (at initial review) the activity developer's proposed system for collecting, managing, and backing up the sales and distribution record. • **Verify** (at each verification) that the record is complete, accurate, and maintained as required by Inspecting the sales and distribution record for completeness and compliance with all data points listed in above. Sampling to determine or estimate the total number of distributed units is strictly prohibited.
Treatment of uncertainty	Managed by census integrity rather than statistics: automated duplicate-UID checks, and a VVB Existence Check on a random sample of distribution records. Where the Existence Check finds a material error rate (>5%), $Ndist$ for the whole population is reduced by the observed error rate (Section 14.4.5 |) – a conservative downward adjustment that substitutes for a sampling-uncertainty deduction on a censused parameter.
Comments:	-

Parameter ID	**PULSE 9**
Data/parameter:	$OF_{i,y}$
Description	The percentage of activity lamps distributed to end users that are operating and in service in premise i in year y
Data unit:	Fraction (%)
Purpose of data:	☒ Emission Reductions
Measurement and updating frequency:	Annual
Measurement methods and procedures:	Determined via Option B (Monitoring survey) or Option C (Proxy). For the purpose of this methodology: a. **Remote Monitoring (Option A):** Assumed as 1. Note: Subject to Data Gap rules b. **Monitoring Survey (Option B)** • **Method:** The activity developer shall conduct an annual Monitoring Survey on a representative sample of distributed Activity devices. • **Stratification:** The sample shall be stratified by Vintage (Year of Distribution) to accurately capture the decline in battery performance over time. Applying a single average OF_y across all vintages is prohibited. • **Survivor Bias:** The sample frame shall include all distributed Activity devices (including those likely to be broken/lost), not just active customers. Non-respondents or "device not found" cases shall be conservatively treated as Non-Operational $OF = 0$ • **Verification Rigour:** The survey shall verify physical functionality (e.g., the enumerator must observe the light turning on). Relying solely on verbal self-reporting is not permitted for High Rigour activities • **Calculation:** i. **For Option A: Standard Replacement (not suppressed demand** Where a premise is equipped with multiple Activity Lamps (e.g., a solar home system with three lamps), and that premise is selected for survey, the Activity Developer shall record the number of non-operational lamps at the premise. The operational fraction of the premise shall be determined as Number of Operational Lamps within the premise/Total Number of Lamps within the premise. For the avoidance of doubt: the operational fraction is determined at the premise level based on total operational lamps

	ii. For Option B: Suppressed Demand Where a premise is equipped with multiple Activity Lamps (e.g., a solar home system with three lamps), and that premise is selected for survey, the Activity Developer shall record the number of non-operational lamps at the premise. The operational status of the premise shall be determined as follows: **(a)** The premise shall be classified as operational if, after excluding any non-operational lamps, the remaining operational lamps collectively deliver a minimum of 1,000 lumen-hours per day (the "Minimum Service Level"). **(b)** The premise shall be classified as non-operational if the remaining operational lamps fail to deliver the Minimum Service Level of 1,000 lumen-hours per day — regardless of how many individual lamps remain functional. Simple average OF_y for each vintage shall be calculated and accordingly applied for calculation of emission reduction. For the avoidance of doubt: the operational status is determined at the premise level based on total service delivery, not at the individual lamp level. **(c) Warranty Proxy (Option C):** Applicable only to activities in LDCs/SIDS/LLDCs and only during Years 1 & 2 of the device life. The OF_y may be deemed based on warranty data if a robust service network exists. Calculation: $OF_y = 100\% - (Warranty\ Return\ Rate_y + 5\%)$. (A 5% deduction is applied to account for unreported failures). From Year 3 onwards, the developer shall transition to Option B (Survey).
Measuring instrument(s):	Survey instruments / enumerator records (Option B); warranty management system (Option C).
QA/QC procedures:	Option B is governed by the 90/10 rule (90% confidence, 10% relative precision; minimum n ≥ 50 per vintage stratum). If the precision target is not met, the lower bound of the one-sided 90% confidence interval is applied ($OF_{applied} = Mean \times (1 - RP/100)$), per Section 11.2 | and Eq. 16–17. Vintage stratification prevents averaging across degradation curves; survivor-bias and non-response rules bias the estimate downward. Option C carries an explicit additional 5% deduction for unreported failures. Option A treats unproven data gaps as non-operational.
Treatment of	Recognised survey protocols, enumerator training and supervision, VVB validation of sampling design, strata and

uncertainty	precision calculation.
Comments:	Detailed sampling requirements at Section 14.4.5 | and Annex 5.

Parameter ID	**PULSE 10**
Data/parameter:	Number of Warranty Claims (Option C only)
Description	Total warranty claims received in year y; numerator of the warranty return rate used in the Option C proxy for OF_y.
Data unit:	Number
Purpose of data:	☒ Emission Reductions
Measurement and updating frequency:	Continuous. Only for Years 1 & 2 of the device life where Option C is used
Measurement methods and procedures:	Logbook, service request forms and/or digital database
Measuring instrument(s):	Warranty management system / service records
QA/QC procedures:	Only applicable when "Warranty Proxy" method is opted for monitoring of OF_y VVB cross-checks claim records against the distribution database; applicable only when the Warranty Proxy is used.
Treatment of uncertainty	Under-reporting of failures (claims understate true breakage, which would over-state OF) is countered by a mandatory additional 5% deduction applied within the Option C formula. Reliance on Option C is time-limited to Years 1–2 and to LDC/SIDS/LLDC contexts, after which the higher-rigour survey (Option B) with full statistical treatment applies.
Comments:	-

Parameter ID	**PULSE 11**
Data/parameter:	Total distributed devices within warranty in year y (Option C only)
Description	Number of distributed devices that are still under warranty in year y; denominator of the warranty return rate (Option C).
Data unit:	Number
Purpose of data:	☒ Emission Reductions
Measurement and updating frequency:	Continuous. Only for Years 1 & 2 of the device life where Option C is used
Measurement methods and	Derived from the sales and distribution database (commissioning date + warranty term).

procedures:	
Measuring instrument(s):	Activity Database.
QA/QC procedures:	The activity developer shall cross-check the warranty-term logic and consistency with the distribution database prior to verification. Applicable only when the Warranty Proxy is used. VVB shall verify warranty-term logic and consistency with the distribution database; applicable only when the Warranty Proxy is used.
Treatment of uncertainty	Drawn from the 100% distribution census, so population-count uncertainty is controlled by the same database-integrity and Existence-Check mechanisms as N_{dist} (PULSE 8). The 5% unreported-failure deduction in the Option C formula provides the conservative buffer on the resulting ratio.
Comments:	-

Parameter ID	**PULSE 12**
Data/parameter:	Date of commissioning
Description	Actual date of commissioning of the activity device i.e., date of handover/activation to the end-user; starts the technical-life clock and the crediting life of the unit.
Data unit:	Date
Purpose of data:	☒ Emission Reductions
Measurement and updating frequency:	Continuous (logged once per unit at handover).
Measurement methods and procedures:	Sales/distribution database entry at point of handover, linked to the device UID.
Measuring instrument(s):	Activity Database.
QA/QC procedures:	The activity developer shall internally cross-check that the record is complete, accurate, and corroborated by source documents for a sample of units prior to verification. VVB shall verify record is complete, accurate, and corroborated by source documents for a sample of units.
Treatment of uncertainty	Date integrity is assured through the UID-linked database and source documents (sales receipts, PAYG activation records, warranty cards). For units credited under the retrospective crediting-start window, the commissioning date is admissible only where UID-level operational evidence exists for the back-dated

	period; absent such evidence the unit is credited only from the period for which evidence exists.
Comments:	N/A

Parameter ID	**PULSE 13**
Data/parameter:	Age
Description	Elapsed time since commissioning; used to enforce the technical-life limit on crediting.
Data unit:	Years
Purpose of data:	☒ Emission Reductions
Measurement and updating frequency:	Continuous (computed relative to commissioning date).
Measurement methods and procedures:	Automated database calculation: $Age = current\ date - commissioning\ date.$
Measuring instrument(s):	Activity Database (automated query).
QA/QC procedures:	The activity developer shall internally cross-check that the automated expiry flag operates correctly and that expired units are successfully excluded from ER_y prior to verification. VVB shall verify the automated expiry flag operates correctly and that expired units are excluded from ER_y.
Treatment of uncertainty	A deterministic, computed field rather than a measured quantity, so statistical uncertainty does not arise; integrity depends only on the commissioning-date record (PULSE 12). The automated expiry rule (Age > rated battery life $\rightarrow OF = 0$ unless a verified replacement is logged) removes discretion and prevents passive crediting of expired units.
Comments:	N/A

Parameter ID	**PULSE 14**
Data/parameter:	$AE_{operation,y}$
Description	Emissions from energy used to charge the activity device.
Data unit:	tCO_2e/yr
Purpose of data:	☒ Activity Emissions
Measurement and updating frequency:	Annual

Measurement methods and procedures:	Per Section 8.2 |. Scenario A (dedicated solar): $AE_{operation,y}$ = 0 where the device is demonstrably supplied without a grid adapter and uses a proprietary/non-standard connector. Scenario B (hybrid-capable in unreliable-grid areas): in lieu of measurement, a flat 5% deduction is applied to ER_y (Eq. 15).
Measuring instrument(s):	Not applicable (technical demonstration / conservative deduction).
QA/QC procedures:	The activity developer shall cross-check the distributed device models against manufacturer technical specifications and/or physical inventory samples to ensure the correct charging scenario is accurately recorded prior to verification. VVB shall verify the connector/adapter demonstration (Scenario A) or the correct application of the 5% deduction (Scenario B) against device technical specifications.
Treatment of uncertainty	The risk that some charging draws on high-carbon grid electricity is addressed without metering by either eliminating the pathway (Scenario A, technical prevention) or applying a conservative flat 5% ER deduction (Scenario B). The 5% factor is a deliberately conservative proxy for the uncertain non-renewable charging fraction; the device-design demonstration is verified rather than estimated.
Comments:	Scenario B applies only to hybrid-capable devices in unreliable-grid (Scenario 3) areas.

Parameter ID	**PULSE 15**
Data/parameter:	$AE_{transport,y}$
Description	Emissions from the transportation of activity devices from port/manufacturing to distribution hubs.
Data unit:	tCO_2e/yr
Purpose of data:	☒ Activity Emissions
Measurement and updating frequency:	Annual
Measurement methods and procedures:	If the weighted-average transport distance ≤200 km, set to zero (materiality threshold). If >200 km, calculate using Tool 02: Emissions from Freight Transportation (or a conservative default based on total weight and distance).
Measuring instrument(s):	Freight records (weight, distance, mode) Tool 02: Emissions from Freight Transportation data requirements
QA/QC procedures:	The activity developer shall cross-check the distance determination, the materiality decision, and the calculation

	against Tool 02: Emissions from Freight Transportation. VVB shall verify distance determination, the materiality decision, and the Tool 02 calculation.
Treatment of uncertainty	Below the 200 km materiality threshold the term is conservatively set to zero only because it is immaterial relative to the baseline; above it, Tool 02: Emissions from Freight Transportation applies its own conservative default factors and data-quality provisions.
Comments:	N/A

Parameter ID	**PULSE 16**
Data/parameter:	$LE_{market,i,y}$
Description	Leakage from continued use or transfer of displaced baseline lighting devices outside the activity boundary
Data unit:	tCO_2e/yr or % of BE_y
Purpose of data:	☒ Leakage Emissions
Measurement and updating frequency:	Annual
Measurement methods and procedures:	• Option 1 (Scrapping): leakage deemed zero where a verifiable take-back-and-destroy mechanism is implemented (Section 9.4.2 |), evidenced by photographic records / recycling certificates for a sample meeting 90/10 confidence-precision, minimum n ≥ 50 per stratum • Option 2 (Default): Application of the 5% default deduction (0.05 x BE_y)
Measuring instrument(s):	Scrapping evidence (photos, recycling certificates) for Option 1; not applicable for Option 2.
QA/QC procedures:	The activity developer shall ensure availability and accuracy of the supporting evidence in case of Option 1 or ensure the correct application of the 5% factor in case of Option 2 prior to verification. VVB shall verify supporting evidence in case of Option 1 or the correct application of the 5% factor (Option 2).
Treatment of uncertainty	For Option 1, sampling uncertainty on the scrapping evidence is controlled by the 90/10 rule with minimum n ≥ 50 per stratum. For Option 2, the uncertain residual-transfer effect is addressed by a deliberately conservative flat 5% deduction which removes the need to monitor a diffuse, low-value behavioural effect.
Comments:	N/A

Parameter ID	**PULSE 17**
Data/parameter:	DAF_y
Description	Downward Adjustment Factor for year y. Country- and year-specific ambition adjustment applied to the baseline (Eq. 5).
Data unit:	Fraction (%)
Purpose of data:	☒ Baseline Emissions
Measurement and updating frequency:	Annual (based on the calendar year of the monitoring period)
Measurement methods and procedures:	Sourced from the latest version of the GS4GG Methodology Tool: Downward Adjustment Factor (DAF) Determination, corresponding to the host country and the monitoring year
Measuring instrument(s):	Not applicable (published tool value).
QA/QC procedures:	The activity developer shall apply the correct DAF based on the host country and monitoring period year prior to verification. VVB verification that the correct DAF value has been applied based on the host country and monitoring period year
Treatment of uncertainty	Not a statistically uncertain quantity: the value is a centrally maintained, pre-approved tool output, so no estimation uncertainty arises at the activity level. Conservativeness is built into the tool itself (the DAF systematically lowers the baseline toward the national net-zero trajectory). The only control needed is correct look-up.
Comments:	Updated to the latest tool version at each verification and at renewal.

Parameter ID	**PULSE 18**
Data/parameter:	$UNC_{act/hist}$
Description	Uncertainty adjustment factor. Default value: 0.05 (5%) unless a lower value is justified via activity-specific uncertainty analysis. (Eq. 4).
Data unit:	Fraction (0–1)
Purpose of data:	☒ Baseline Emissions
Measurement and updating frequency:	Once, in the start year of the first crediting period - fixed thereafter
Measurement methods and procedures:	Default 0.05 (5%). A lower value may be applied only where justified by an activity-specific uncertainty analysis approved by the VVB.

Measuring instrument(s):	Not applicable (default, or activity-specific analysis).
QA/QC procedures:	The activity developer shall internally cross-check that the default is applied, or that any lower value is supported by a documented activity-specific analysis prior to verification. VVB verifies the default is applied, or that any lower value is supported by an approved activity-specific analysis
Treatment of uncertainty	This parameter is itself the methodology's explicit treatment of baseline data-variance uncertainty: the 5% default is a conservative buffer for the difference between assumed and actual historical emissions, applied independently of the DAF. Any reduction below 5% must be evidenced by a documented uncertainty analysis, ensuring the buffer is never relaxed without statistical support.
Comments:	-

14.4 | QA/QC and Data Management

14.4.1 | **Unique Identification & Duplicate Check:** To prevent double-counting:

a. **Internal Check:** The database management systems shall include automated validity checks to prevent the registration of duplicate Serial Numbers.

b. **External Check:** Prior to verification, the activity developer shall screen the current batch of Serial IDs against previous vintages and, where data is available, against other carbon finance or subsidy programs in the region to ensure no double claiming.

14.4.2 | **Technical Life Safeguard (Automated Expiry):** To ensure compliance with the Technical Life limitations (Section 3.2.10 |):

a. **Requirement:** The monitoring system shall track the "Age" of each activity device relative to its Commissioning Date.

b. **Procedure:** The database shall automatically flag any activity Device where (Current Date - Commissioning Date) > Rated Battery Life as "Expired".

c. **Effect:** Expired activity Device shall be automatically assigned an Operational Fraction of Zero for the current monitoring period, unless a verified battery replacement event is logged in the database for that specific UID in strict accordance with the objective criteria defined in Section 3.2.10 |.

14.4.3 | **Waste Management Audit:** To verify compliance with the Lock-In Risk / Environmental Safeguard (Section 3.4.4 | b):

a. The activity developer shall maintain records of the Battery and PV panels E-Waste collected, recycled/disposed of and/or safely stored during the monitoring period.

b. **Verification:** The VVB shall audit agreements with recycling partners, collection logs, disposal certificates or proof of safe storage to confirm the Waste Management Plan is active.

14.4.4 | **Data Retention**

a. All distribution records (e.g., digital logs, sales receipts, warranty cards) shall be backed up electronically.

b. Records shall be retained for a minimum of two years after the end of the crediting period.

14.4.5 | **Sampling & Operational Status Requirements:** This section defines the requirements for determining the Operational Fraction (OF_y). The activity developer shall select one of the following options for each device type/vintage.

a. Option A: Digital / PAYG Monitoring (Census): Applicable to smart-enabled devices (e.g., Solar Home Systems) with remote monitoring capabilities.

i. **Method:** $Days_y$ is calculated based on the complete dataset of digital logs (100% Census).

ii. **Operational Criteria:** A unit is considered "Operational" for the monitoring period if it transmits a "Power On," "Charging," or valid "Payment Token" signal for at least 180 days (cumulative) during the year.

iii. **Data Gaps:** If data gap is identified, the unit is deemed Non-Operational for that period unless (a) the gap is ≤30 consecutive days and occurs in a verified poor-connectivity region (Connectivity Gap Allowance), (b) proof of operationality is recovered via offline "store-and-forward" synchronisation, or (c) other robust supporting evidence can be provided for the gap period.

b. Option B: Annual Monitoring Survey (Sampling): Applicable to non-connected devices or cash sales.

i. **Method:** The activity developer shall conduct an annual Monitoring Survey on a representative sample of distributed units.

ii. **Stratification:** The sample shall be stratified by Vintage (Year of Distribution) to accurately capture the decline in battery performance over time. Applying a single average OF_y across all vintages is prohibited.

iii. **Survivor Bias:** The sample frame must include all distributed devices (including those likely to be broken/lost), not just active customers. Non-respondents or "device not found" cases must be conservatively treated as Non-Operational $OF = 0$

iv. **Verification Rigor:** The survey shall verify physical functionality (e.g., the enumerator must observe the light turning on). Relying solely on verbal self-reporting is not permitted for High Rigor activities.

14.4.6 | Calculation:

a. For Option A: Standard Replacement (not suppressed demand:
Where a premise is equipped with multiple activity lamps (e.g., a solar home system with three lamps), and that premise is selected for survey, the activity developer shall record the number of non-operational lamps at the premise. The operational fraction of the premise shall be determined as Number of Operational Lamps within the premise/Total Number of Lamps within the premise. For the avoidance of doubt: the operational fraction is determined at the premise level based on total operational lamps within the premise

b. For Option B: Suppressed Demand
Where a premise is equipped with multiple activity Lamps (e.g., a solar home system with three lamps), and that premise is selected for survey, the Activity Developer shall record the number of non-operational lamps at the premise.
The operational status of the premise shall be determined as follows:

i. The premise shall be classified as **operational** if, after excluding any non-operational lamps, the remaining operational lamps collectively deliver a minimum of 1,000 lumen-hours per day (the "Minimum Service Level").
ii. The premise shall be classified as **non-operational** if the remaining operational lamps fail to deliver the Minimum Service Level of 1,000 lumen-hours per day — regardless of how many individual lamps remain functional.

Simple average OF_y for each vintage shall be calculated and accordingly applied for calculation of emission reduction.
For the avoidance of doubt: the operational status is determined at the **premise level based on total service delivery**, not at the individual lamp level.

c. Option C: Warranty Proxy

Applicable only to activities in LDCs/SIDS/LLDCs and only during Years 1 & 2 of the device life.

a. To reduce monitoring costs in vulnerable regions, the OF_y may be deemed based on warranty data if a robust service network exists.
b. Calculation: $OF_y = 100\% - (Warranty\ Return\ Rate_y + 5\%)$. (A 5% deduction is applied to account for unreported failures).

$$Warranty\ Return\ Rate_y = \frac{Number\ of\ warranty\ claims\ in\ year\ y}{Total\ distributed\ devices\ within\ warranty\ in\ year\ y} \times 100$$

Limit: From Year 3 onwards, the developer shall transition to Option B (Survey).

14.4.7 | **Sample Size Calculation**

14.4.7.1 | For Option B (Monitoring Survey), the sample size shall meet a minimum 90/10 confidence/precision requirement, with an absolute minimum sample size of 50 units (90/10, minimum n ≥ 50 per stratum) for the estimated parameter (OF_y).

a. If the precision target is not met, the Lower Bound of the 90% confidence interval shall be applied to the emission reduction calculation.

15| MONITORING REQUIREMENTS FOR ACTIVITIES WITH REVERSAL RISKS

15.1 | Scope and Applicability

15.1.1 | As detailed in Section 12|, the mitigation outcomes generated under this methodology are not at risk of reversal. As the risk of reversal is Not Applicable, specific reversal mitigation mechanisms (e.g., contributions to the GS Compliance Buffer) are not required. The methodology does not require monitoring of reversals risks.

16| APPLICATION TO PROGRAMME OF ACTIVITIES

16.1 | General Requirements

16.1.1 | The PoA shall comply with the latest version of the GS4GG Programme of Activities Requirements.

a. **Role of CME:** The Coordinating/Managing Entity (CME) shall be responsible for the implementation of the Monitoring Plan, the management of the Centralized Activity Database (Census) across all VPAs, and the enforcement of the Waste Management Plan (Annex 4).

b. **Real Case VPA:** The first VPA submitted shall be a "Real Case" activity with actual verified distribution data.

c. **Homogeneity:** The CME shall define clear eligibility criteria for the inclusion of VPAs, ensuring that the technologies (e.g., Pico-Solar vs. SHS) and baseline conditions (e.g., Off-Grid vs. Unreliable Grid) within specific VPAs or clusters are homogeneous.

16.2 | Baseline and Additionality Demonstration

16.2.1 | **Additionality:** Additionality shall be demonstrated at the PoA level or VPA level depending on the approach:

a. **Positive List:** If the PoA utilizes the Positive List (Section 6.3 |), the CME must demonstrate that each VPA meets the specific eligibility criteria (e.g., located in an LDC or <5% penetration).

b. **LDC Differentiation:** VPAs located in LDCs/SIDS (eligible for automatic additionality) shall be distinct from VPAs in non-LDCs (which may require Barrier Analysis). Mixing these geographical scopes within a single VPA is prohibited to ensure regulatory clarity.

16.2.2 | **Baseline Determination:** The CME may define distinct baseline scenarios applicable to different geographical regions or user groups within the PoA boundary.

a. **Standardised Baselines:** A Baseline Emission Factor (BE_y) and associated parameters (e.g., Service Level Caps), once determined for a specific target group (e.g., "Off-grid households in Region X using Kerosene"), may be applied to subsequent VPAs included in the PoA that share the exact same characteristics.

b. **Validity:** The standardised baseline is valid for the duration of the crediting period. **Two distinct validity periods apply (and shall not be conflated):** (a) once a VPA is included, its standardised baseline is fixed for that VPA's crediting period; but (b) the underlying baseline survey data may be used to admit new VPAs for a maximum of three years from the date of the survey, after which a fresh baseline survey is required for further inclusions.

16.3 | Monitoring and Sampling (Pooled Approach)

16.3.1 | **Census Tracking**: The requirement for 100% Census Tracking of distributed devices (Section 14.1 |) applies to every VPA. The CME shall maintain a master database of Unique Serial Numbers to ensure that a device registered in one VPA cannot be double-counted in another VPA.

16.3.2 | **Cross-VPA Sampling (Pooled Sampling):** For the determination of the Operational Fraction (OF_y) via the Survey Method (Option B), the CME may implement a Pooled Sampling Strategy to reduce monitoring costs, subject to the following:

a. **Homogeneity:** VPAs can only be pooled if they distribute the same Technology Level and operate in similar socio-economic conditions.

b. **Vintage Stratification:** The pooled sample shall be strictly stratified by Vintage (Year of Distribution) across the entire PoA to accurately capture battery degradation curves (Annex 5).

c. **Precision Requirement:** The pooled sample must achieve a 90/10 confidence/precision level with a minimum of n ≥ 50 per vintage stratum (Annex 5). If the precision target is missed, the uncertainty deduction (Lower Bound) of the 90% confidence interval is applied to the entire pool.

17| RENEWAL OF CREDITING PERIOD

17.1 | Crediting Period Renewal Requirements

17.1.1 | The activity developer may apply for the renewal of the crediting period (maximum two renewals, totalling 15 years) by complying with the GS4GG Validation and Verification Body (VVB) Requirements valid at the time of the request.

17.1.2 | **Technical Life Constraint:** Renewal of the crediting period applies to the Activity (the infrastructure/program), not the individual Assets.

a. Individual Activity Devices are strictly limited to their Rated Technical Life (Battery Cycle Life).

b. Renewal allows the activity to continue crediting new devices distributed in later years, or existing devices that have undergone verifiable Battery Replacement/Refurbishment and have operational quality of a new device.

c. A device distributed in Year 1 of the first crediting period cannot generate credits in the second crediting period if its rated life is 5 years, unless a replacement event is logged.

17.2 | Reassessment of the Baseline Scenario

17.2.1 | At the time of renewal, the activity developer shall conduct a comprehensive reassessment of the baseline scenario to ensure it remains a credible representation of the "Business-as-Usual" conditions.

17.2.2 | **Grid Extension Check (Mandatory):** The developer shall provide updated evidence regarding the grid status of Applicable Geographical Area (AGA).

a. If the national grid has extended to the activity area and provides reliable service (Tier 3+), the baseline must be updated to "Grid Electricity" (which generally yields zero reductions for solar lighting), or the affected area must be excluded.

b. If the area remains Off-Grid or the grid is Unreliable, updated statistics or surveys shall be provided.

17.2.3 | **Fuel Mix Update:** The developer must verify if the baseline fuel mix has naturally evolved (e.g., if end-users have shifted from kerosene to diesel independent of the activity).

17.3 | Update of Baseline Parameters

17.3.1 | All parameters used to calculate the Crediting Baseline shall be updated using the latest data and methodological versions available at the time of renewal.

17.3.2 | **Emission Factors:** Update default Emission Factors (e.g., for Kerosene or Embodied Emissions) based on the latest IPCC guidelines or LCA literature.

17.3.3 | **Service Level Caps:** Re-evaluate the Service Level Ratio Cap (Section 7.3.3) to ensure it still reflects a conservative estimate of suppressed demand limits.

17.3.4 | **Leakage and uncertainty factors:** re-evaluate the market-leakage default (5%, Annex A2.4) and the Year-1 uncertainty factor for continued conservativeness in light of updated displacement evidence.

17.4 | Reassessment of Additionality

17.4.1 | The activity developer shall conduct an Ongoing Financial Need (OFN) assessment and update the Regulatory Surplus analysis, as required by Section 6.8 and 6.4 respectively.

17.4.2 | **Ongoing Financial Need (Mandatory):** provide evidence (updated financial analysis or operating budget) that the activity still requires carbon-credit income to remain operational. For solar lighting, the analysis should focus on the funding gap for operations and maintenance — in particular the Waste Management Plan (battery and PV-panel recycling) and warranty servicing — which are often not covered by hardware-sales margins.

17.4.3 | Positive List exemption: activities that qualified for and remain eligible under a recognised GS4GG Positive List are exempt from the Investment/Barrier Analysis demonstration at renewal, but shall still demonstrate Regulatory Surplus.

17.4.4 | **Regulatory Surplus:** Confirmation that no new laws have been passed mandating solar lighting or banning kerosene or other fossil fuels or lighting.

17.5 | Safeguard Audit (Do No Significant Harm)

17.5.1 | **Mandatory Condition for Renewal:** The VVB shall perform a retrospective audit of the activity's adherence to the Waste Management Plan (Annex 4) during the previous crediting period. If the activity failed to implement the required collection/recycling of hazardous battery or PV panels waste, the renewal request shall be denied under the "Do No Significant Harm" principle.

ANNEX -1| MONITORING SCHEDULE AND REQUIREMENTS

A 1.1| Normative References and Applicability:

A 1.1.1| This Annex defines the mandatory timeline and frequency for data collection approach defined in Section 14|.

Table A1.1: Monitoring Schedule

Activity	Description / Key Parameters	Frequency and Timing	Applicability
EX-ANTE (BASELINE & ELIGIBILITY)			
Technology Performance Testing	Verification of Lumen output, Solar Run Time, and Battery Cycle Life via third-party lab (IEC 62257-9-5/VeraSol) for each device model/type deployed under the activity. Key Parameter: $L_{activity}$ (Lumen-Hours), Rated Technical Life.	Once. Ex-ante (prior to Design Certification). Fixed per model type.	All Activities
Grid Status Assessment	Verification of "No Grid" or "Unreliable Grid" status in the AGA. Key Parameter: Baseline Scenario, BE_y (Baseline Emissions).	Once. Ex-ante. Validated via government stats or survey.	All Activities
Embodied Emissions Assessment	Selection of Default Factor (Annex 2) or submission of ISP 14025 EPD for the specific device model. Key Parameter: $EF_{embodied}$	Once. Fixed per Device Model for the crediting period.	All Activities
CONTINUOUS MONITORING (CENSUS)			
Distribution Tracking (Census)	Recording of Unique Identifiers (UIDs), Commissioning Date, and End-User details for 100% of devices. Key Parameter: $N_{dist,y}$	Continuous. Logged at the point of handover. Aggregated per monitoring period.	All Activities
Warranty Claim Tracking (if	Recording warranty claims Key Parameter: *Number of Warranty Claims*	Continuous; Years 1–2 only, where	All Activities

applicable)		the Warranty Proxy (Option C) is used.	
Technical Life Management	Automated database query to flag and exclude units exceeding their Rated Battery Life. Key Parameter: *Age (vs rated technical life)*	Continuous. Algorithm runs prior to every issuance request.	All Activities
Waste Management Audit	Tracking of battery and PV panels collection volumes and recycling certificates. Key Parameter: *E-Waste Volume (kg)*	Continuous. Records maintained throughout the monitoring period.	All Activities
PERIODIC MONITORING (OPERATIONALITY)			
Operational Fraction (OF_y)	Census (digital), survey (Option B) or warranty proxy (Option C) to determine the operational share. to determine the percentage of devices within a premise still functioning. Key Parameter: OF_y	Annual. Conducted on a representative sample (Survey) or proxy approach.	All Activities
Annual Utilization ($Days_y$)	Digital loggers to determine operational days of activity device Key Parameter: $Days_y$	Annual Full dataset (digital)	All Activities
Existence Check (QA/QC)	Random VVB audit of the distribution database to detect phantom users. if the error rate exceeds 5%, N_{dist} is reduced for the whole population by the observed rate (Section 14.4.5 |).	Annual. Conducted by VVB prior to verification.	All Activities
RENEWAL OF CREDITING PERIOD			
Baseline Reassessment	Check for grid extension into the activity area. Update DAF parameters.	Every 5 Years. At renewal of the crediting period.	All Activities
Safeguard Retro-Audit	Verification that Waste Management Plan was executed during the previous period.	Every 5 Years.	All Activities

ANNEX -2| CONSERVATIVE STANDARDISATION FACTORS

A 2.1| Normative References and Applicability:

A 2.1.1| This Annex provides the standardised default factors required to operationalise the Baseline (Section 7|) and Leakage (Section 9|) calculations without site-specific laboratory measurement.

A 2.1.2| Applicability: Mandatory. Activity Developers shall use these Conservative Defaults unless they provide ISO 14025 Environmental Product Declarations (EPD) or rigorous local Baseline Surveys approved by the VVB.

A 2.2| Baseline Emission Parameters

A 2.2.1| Parameter: DV (Daily Emissions). Use: Section 7| (Baseline Calculation). Source: Derived from AMS-III.AR default parameters ($Fuel\ Rate \times Utilization \times EF$).

Table A2.1: Baseline Defaults

Parameter	Value	Unit	Justification
Fuel Use Rate	0.03	Liters/hour	Within the empirical hurricane-lamp range (0.02–0.045 L/h); consistent with UNFCCC AMS-III.AR (2012).
Utilization Rate	3.5	Hours/day	Conservative average daily lighting need.
Emission Factor (Kerosene)	2.4	kg CO_2e/Liter	IPCC default for Kerosene combustion.
Daily Emissions (DV)	0.000252	tCO_2e/lamp/day	Calculated ($0.03 \times 3.5 \times 2.4 / 1000$).

A 2.3| Service Level Defaults (Suppressed Demand)

A 2.3.1| Parameter: $L_{baseline}$, SLR_{cap}.Use: Section 7| (Suppressed Demand Calculation). Source: World Bank Multi-Tier Framework (MTF) & Lighting Global.

Table A2.2: Service Level Ratios

Parameter	Value	Justification
Baseline Service Level ($L_{baseline}$)	200 Lumen-Hours/Day	Conservative denominator; actual wick/hurricane output (35–140 lm-hr/day) is lower, under-stating crediting.
Minimum Service Level (MSL)	1,000 Lumen-Hours/Day	Tier 1 Threshold. Minimum requirement to claim Suppressed

		Demand.
Service Level Ratio Cap (SLR_{cap})	5.0	Maximum Crediting Cap. The affordability ceiling on baseline fuel expenditure (≤5 lamp-equivalents per household).

A 2.4| Leakage & Embodied Emission Factors

A 2.4.1| Parameter: $EF_{embodied}$, LE_{market}. Use: Section 9|(Leakage). Source: Lifecycle Assessment (LCA) literature (e.g., Alstone et al., 2014; Antonanzas-Torres et al., 2021; Peters et al., 2017).

Table A2.3: Embodied Emissions

Device Category	Definition	Default $EF_{embodied}$	Justification
Pico-Solar / Portable	Integrated PV < 10 Wp and separate PV < 10 Wp	$0.005\ tCO_2e\ (5\ kg)$	Conservative upper bound for a Li-ion battery, small PV cell and casing (verified range 2.6–4.8 kg).
Solar Home System (SHS)	Separate PV ≥ 10 Wp and ≤30 Wp	$0.020\ tCO_2e\ (20\ kg)$	Conservative for the lead-acid/LFP battery, cabling and aluminium-framed PV panel (verified range 12.4–23.1 kg).
Solar Home System (SHS)	Separate PV > 30 Wp	$0.020\ tCO2e + [0.0015\ tCO2e \times (System\ Wp - 30\ Wp)]$	Capacity-based build-up for larger battery and PV mass above 30 Wp; or submit a model-specific EPD.

Table A2.4: Market Leakage Factors

Factor	Value	Condition
Scrapping Deduction	0%	Applied only if a verifiable "Take-Back & Destroy" scheme is in place.
Default Deduction	5%	Applied where displaced baseline lamps are left with the household (standard practice). Consistent with Equation 13 and PULSE 16.

ANNEX -3| DIGITAL MONITORING & UNIQUE ID PROTOCOL

A 3.1| Normative References and Applicability

A 3.1.1| This Annex defines the mandatory technical specifications for the Census Monitoring System. It establishes the "Single Source of Truth" requirements to prevent double counting and ensure auditability.

A 3.1.2| Applicability: Mandatory. All Activities shall utilize a digital database meeting these specifications.

A3.1 | Unique Identifier (UID) Rule

A 3.1.3| Every activity device shall be assigned a UID that is permanently associated with the physical hardware.

a. **Format:** Alphanumeric Serial Number (physically printed/etched on the device).
b. **Granularity:** UID shall be unique to the Individual Activity Device, not just the Batch or Model.
c. **Traceability:** UID shall be recorded at the point of import/manufacturing and traced through to the end-user handover.

A 3.2| Activity Database Structure

A 3.2.1| The activity developer shall maintain a secure database containing the following fields for every UID:

Table A3.1: Minimum Database Fields

Field Name	Data Type	Description
UID_Serial	String	Unique Serial Number (Primary Key).
Model_ID	String	Links to Ex-Ante Tech Specs (Annex 2).
Commissioning_Date	Date	Date of handover/activation. Starts the "Technical Life" clock.
End_User_Pre	Enum	Household/Commercial/ community
End_User_Loc	GPS / String	Coordinates or Village/District/Region. (minimum)
Baseline_Device	Enum	Kerosene/Diesel/Torch/Grid
Battery_Status	Enum	Active / Expired / Replaced.
Status_flag	Enum	Active / expired / transitioned to reliable grid / defective / scrapped.
Last_Verified_Date	Date	Date of last digital signal or physical survey check.

A 3.3| Digital "Heartbeat" Protocol (PAYG/GSM)

A 3.3.1| For devices utilizing Option A (Digital Monitoring) in Section 14.4.5 |, the following logic applies:

a. **Heartbeat Signal:** The device shall transmit a state-of-health or payment token log.

b. **Active Logic:** Status = 1 IF (Signal_Received)

c. **Dead Logic:** Status = 0 IF (No_Signal_Received). If the device goes silent, it is assumed that activity device is either broken/not operational until proof of operation of activity device can be provided for gap period.

d. **Connectivity Gap Allowance:** a silent period of ≤30 consecutive days is treated as operational where (a) the area's connectivity falls below a defined threshold (ITU or national data) and (b) the last signal before the gap indicated normal operation. Beyond 30 consecutive days, dead logic applies in full.

ANNEX -4| WASTE MANAGEMENT & SAFETY PROTOCOL

A 4.1| Normative References and Applicability

A 4.1.1| This Annex defines the mandatory Environmental Safeguards required to meet the Lock-In Risk assessment (Do No Significant Harm).

A 4.1.2| Objective: To prevent the accumulation of hazardous electronic waste (specifically Lead, Cadmium, and Lithium toxicity) in off-grid communities.

A 4.1.3| Applicability: Mandatory for all activities. Failure to comply renders the activity ineligible.

A 4.2| Prohibited Chemistries (Negative List)

A 4.2.1| To prevent environmental toxicity in regions with poor waste infrastructure, the following battery chemistries are Strictly Prohibited in Activity Devices:

a. Nickel-Cadmium (NiCd): Due to Cadmium toxicity.

A 4.3| Permitted Chemistries (Positive List)

a. Lead-Acid (Flooded/Wet): Due to spill risk (Sealed Lead Acid / AGM is permitted but discouraged).

b. Lithium-Ion (LCO, NMC), Lithium Iron Phosphate (LFP), Nickel-Metal Hydride (NiMH).

A 4.4| Waste Management Plan (WMP)

A 4.4.1| The activity developer shall document and execute a WMP containing three pillars:

a. **Collection (Reverse Logistics):** A mechanism for end-users to return end-of-life batteries and PV panels. *Example:* Drop-off points at distribution centres or "Discount on Replacement" incentives.

b. **Storage:** Safe storage protocols to prevent fire risk (e.g., sand buckets, non-flammable containers) at aggregation hubs.

c. **End-of-Life (EoL) Solution:**

   a. *Preferred:* Handover to a certified formal e-waste recycler.

   b. *Acceptable (LDC Context):* If no certified recycler exists in-country, encasement in concrete (stabilization) or export to a neighbouring country with facilities (Basel Convention compliant). Landfilling of loose Li-ion batteries is prohibited.

A 4.5| Audit Trail

A 4.5.1| Evidence: The developer shall produce transfer certificates or destruction Certificates or verifiable evidence of safe storage in absence of recycling infrastructure from the end-of-life partner or other verifiable evidence.

ANNEX -5| SAMPLING GUIDELINES (OPERATIONAL FRACTION)

A 5.1| Normative References and Applicability

A 5.1.1| This Annex defines the criteria for determining the Operational Fraction (OF_y) via Option B (Survey). Proper stratification is essential to account for the non-linear degradation of batteries over time.

A 5.1.2| Stratification Hierarchy

a. The activity developer shall stratify the total population of distributed activity devices (N_{dist}) by Vintage (Year of Commissioning).

b. **Justification:** A device distributed in Year 1 has a significantly higher probability of battery failure than a device distributed in Year 4. averaging across vintages introduces bias thus not allowed.

A 5.1.3| **Sampling Frame:** Activity developer shall draw samples at device level and not lamp level. The frame shall include all registered UIDs for the vintage, including users who have moved or discarded the device. Oversampling is strongly encouraged to compensate for non-response and outliers.

A 5.1.4| Sample Size Calculation (90/10 Rule)

a. For each Stratum, the sample size (n) shall be calculated to achieve **90% Confidence** with **10% Precision**.

$$n = \frac{1.645^2 \times p \times (1-p)}{0.10^2}$$

- 1.645: Z-score for 90% Confidence.
- p: Expected Operational Fraction (Default: 0.5 for maximum conservativeness).
- 0.10: Precision (Margin of Error).
- **Worked value:**

n = $(1.645^2 \times 0.5 \times 0.5) / 0.10^2 = (2.706 \times 0.25) / 0.01 \approx 68\ units\ per\ stratum$.

- An absolute minimum of n ≥ 50 per stratum applies in all cases. Where the achieved precision exceeds 10% (RP > 10%), the lower bound of the one-sided 90% confidence interval shall be applied to OF_y) (Section 11.2, Eq. 17).

A 5.1.5| The sample frame shall include all registered UIDs for that vintage, including those who may have moved or discarded the device.

- Oversampling is strongly encouraged to compensate for any outliers or non-response.
- If the user says "I threw it away" or "Given away": Record as Non-Operational ($OF = 0$).
- If the lamp lights up during the visit: Record as Operational ($OF = 1$)

ANNEX -6| METHODOLOGY-LEVEL ADDITIONALITY AND BARRIER ANALYSIS

A 6.1| Objective and Scope of Exemption

A comprehensive, methodology-level barrier and additionality analysis has been conducted to evaluate the baseline penetration and autonomous adoption of quality-verified off-grid solar lighting technologies (pico-solar devices and solar home systems). The analysis demonstrates that, for decentralised solar lighting activities operating in highly vulnerable, energy-poor contexts, autonomous market-based adoption at the required quality and service level is not a credible business-as-usual (BAU) scenario in the absence of carbon finance. On this empirical basis, project activities that meet all the criteria specified in Section A6.6 of this Annex are deemed automatically additional and are exempt from the requirement to conduct a separate, activity-specific investment or barrier analysis.

This Annex sets out the theoretical framework, the peer-reviewed and institutional evidence base, and the resulting Positive List criteria, so that the basis of the Positive List is transparent and publicly verifiable.

A 6.2| Theoretical framework for decentralised additionality

Traditional additionality tools were designed for large, centralised infrastructure, where additionality hinges on a singular, upfront investment decision by a single project owner. Decentralised household-lighting activities are fundamentally different: they rely on the aggregate procurement behaviour of thousands of individual low-income households, each making a small purchase decision. Additionality for these activities shall therefore be evaluated on the likelihood of autonomous, household-level procurement of a quality-verified solar device — at the service level the methodology credits — in the absence of carbon-financed subsidisation and last-mile distribution networks.

This methodology-level analysis evaluates the prevailing financial, market and behavioural barriers to autonomous adoption in order to establish a standardised Positive List. The relevant counterfactual is not whether a household values lighting (it does), but whether, absent carbon finance, it would autonomously purchase and continue to pay for a quality-verified device that meets the Tier 1 Minimum Service Level.

A 6.3| Empirical evidence on autonomous adoption and willingness to pay (2015–2024)

A consistent and geographically diverse body of randomised, quasi-experimental and revealed-preference field evidence isolates the rate at which off-grid households autonomously acquire quality solar lighting, and the price they will pay for it, when not subsidised. The studies span the principal off-grid regions — East Africa (Rwanda, Ethiopia, Kenya, Uganda), West Africa and South Asia (India) — and use complementary methods: incentive-compatible Becker–DeGroot–Marschak (BDM)

auctions, contingent valuation, randomised controlled trials (RCTs) and panel tracking of purchasers. The central and replicated finding across every method and geography is that revealed willingness to pay (WTP) among the target population sits well below cost-covering retail prices, so that unsubsidised, market-based adoption at the required quality and service level is structurally low.

Study pool

- **Rwanda — Grimm, Lenz, Peters & Sievert (2020), *Journal of the Association of Environmental and Resource Economists*:** revealed-preference auctions for several solar technologies in rural Rwanda found households willing to dedicate substantial parts of their budget to electricity but not enough to reach cost-covering prices, with WTP equivalent to roughly 30–40% of market prices. Randomly extended payment periods (relaxing liquidity constraints) did not change the result, indicating an affordability-and-value gap, not merely a cash-flow-timing problem.
- **Rural Ethiopia — Bensch & Peters (2020), World Bank Policy Research Working Paper 9595:** a BDM randomised field experiment found WTP low enough that most households would purchase a solar lantern only if subsidised, and that raising the subsidy level directly raised the adoption rate — direct evidence that subsidisation, not autonomous demand, drives uptake. Grid-connected households showed lower WTP and lower adoption likelihood.
- **Rural India — Wong, Blankenship, Harish & Urpelainen (2022), *Energy Economics*:** a randomised controlled trial among 500 households in Bahraich, Uttar Pradesh, using BDM elicitation across voucher, cash-transfer and microfinance arms, found that even households receiving a purchase voucher were willing to pay only about 34% more than the control group (436 INR vs a 326 INR control mean), and still below the retail price of the lantern — confirming that, absent intervention, baseline WTP falls materially short of the unsubsidised price.
- **Rural India — Mahajan, Harish & Urpelainen (2020), *Energy for Sustainable Development*:** a randomised controlled trial distributing solar lanterns confirmed strong household valuation of basic lighting access, while corroborating that uptake at the prevailing market price depended on the intervention rather than autonomous purchase.
- **Rural India — Aklin, Bayer, Harish & Urpelainen (2017), *Science Advances*:** a field experiment with off-grid solar across rural villages confirmed strong service value but documented that adoption depended on the intervention rather than autonomous market purchase at the prevailing price.
- **Rural Kenya — Zuch (2025), *Energy Policy*:** a national contingent-valuation study estimated mean WTP for an off-grid solar-home-system solution of about USD 43 — roughly half the WTP for a grid connection (~USD 78) — and well below cost-covering levels for a quality system, with prior solar experience increasing (not removing) the gap.
- **Uganda & Kenya — Stojanovski, Thurber & Wolak (2017), *Energy for Sustainable Development*:** panel tracking of roughly 500 new solar-home-

system purchasers found large reductions in kerosene use post-adoption (kerosene-using households fell by 58% in Uganda and 36% in Kenya), confirming both strong substitution and that adoption clustered around assisted/financed sales channels rather than spontaneous cash purchase.

- **Sub-Saharan Africa (regional) — ESMAP/GOGLA Market Trends Reports (2020, 2022, 2024):** the flagship institutional series shows off-grid solar delivering the majority of new access in SSA while the bulk of the unelectrified population remains unable to afford a Tier 1 service on commercial terms (Section A6.4).

Evidence summary

Study (geography, method)	Finding relevant to autonomous adoption / additionality
Grimm et al. 2020 — Rwanda (auction/RP)	WTP ≈ 30–40% of market price; extended payment periods do not close the gap.
Bensch & Peters 2020 — Ethiopia (BDM RCT, World Bank WP 9595)	Most would buy only if subsidised; adoption rises with subsidy; grid access lowers WTP.
Wong et al. 2022 — India (RCT/BDM)	Voucher households pay only ~34% more than control, still below retail price.
Mahajan et al. 2020 — India (RCT)	Strong valuation of basic lighting; uptake at market price depends on intervention.
Aklin et al. 2017 — India (field experiment, Science Advances)	Adoption contingent on intervention, not autonomous purchase at market price.
Zuch 2025 — Kenya (contingent valuation, Energy Policy)	Mean WTP for SHS ≈ USD 43 vs ≈ USD 78 for grid; below cost-covering price.
Stojanovski et al. 2017 — Uganda/Kenya (purchaser panel)	Strong kerosene substitution post-adoption; sales clustered in financed channels.

Synthesis. Across six countries and four independent methods, the experimental and revealed-preference literature converges on the same conclusion: autonomous WTP for quality-verified solar lighting in rural off-grid LDC/lower-income contexts is consistently and substantially below cost-covering prices (of the order of 30–40% of market price), adoption rises with subsidy rather than occurring spontaneously, and reliable-grid access further depresses demand. Unsubsidised, market-based adoption at the methodology's required service level is therefore not a credible business-as-usual scenario for the target population. The consistency of this finding across heterogeneous geographies and methods is itself strong evidence of a structural — not context-specific — affordability barrier.

A 6.4| Financial, market and infrastructural barriers

The flagship Off-Grid Solar Market Trends Report 2024, published by the World Bank's Energy Sector Management Assistance Programme (ESMAP) and GOGLA, quantifies

the affordability barrier directly: only around 22% of households lacking electricity can afford the monthly payment for a Tier 1 solar kit even under Pay-As-You-Go (PAYG) financing — the financing model specifically designed to overcome the upfront-cost barrier. In other words, roughly four in five unelectrified households cannot afford a Tier 1 solar service on the most favourable commercial terms available. In conflict-affected areas, where an estimated 64% of people lacking access live, the cost of offering PAYG is approximately 57% higher, deepening the gap precisely where need is greatest.

Beyond household affordability, the same institutional evidence shows that the sector cannot reach the remaining unelectrified population on commercial terms alone. ESMAP/GOGLA estimate that a six-fold increase over current investment levels — on the order of USD 21 billion — is required to extend off-grid solar to the roughly 400 million people for whom it is the most cost-effective solution. Establishing last-mile distribution, after-sales service and battery-replacement networks in remote, low-density rural areas requires substantial upfront capital that commercial markets will not provide without guaranteed long-term revenue. Carbon finance is a principal mechanism for buying down device capital expenditure and underwriting this distribution and servicing infrastructure.

For a subsistence household, the baseline lighting source (kerosene, candles, dry-cell torches) is purchased in small, deferrable increments, while a quality solar device requires a comparatively large outlay or a multi-year payment commitment. Because the health, safety and climate externalities of fuel-based lighting are not priced into the household's decision, and because revealed WTP is well below cost-covering prices, the unsubsidised payback proposition is insufficient to drive autonomous adoption at scale. Carbon finance is, for the target population, frequently the decisive — and often the only — mechanism that makes quality-verified service affordable and the distribution model viable.

A 6.5| Affordability gap and the suppressed-demand baseline

The same evidence that establishes additionality also substantiates the methodology's suppressed-demand baseline, because both rest on a single underlying fact: the target population's observed energy consumption is artificially depressed below its basic-needs level by an affordability constraint, not by a lack of need.

Energy-poverty scholarship and the World Bank Multi-Tier Framework (MTF) define energy poverty precisely as the inability to meet basic energy-service needs: energy-poor households are forced onto unreliable, unhealthy, costly sources (kerosene, candles, dry-cell torches) and cannot consume the lighting service they require (IEA et al., 2023). Baseline household lighting in Tier 0 contexts is therefore not a revealed optimum but a constrained minimum: multi-country rural Sub-Saharan baseline surveys consistently find the overwhelming majority of off-grid households relying on kerosene for lighting, each lamp delivering only tens of lumen-hours per day — far below the Tier 1 service level the same households would consume if they could afford it.

The World Bank MTF explicitly introduces fractional measurement between Tier 0 and Tier 1 to capture the benefit of pico-solar and small-scale devices that improve lighting but may not yet reach Tier 1, and sets 1,000 lm-hr/day as the Tier 1 threshold for basic household lighting needs. The suppressed-demand baseline operationalises exactly this logic: it credits the lighting service the household is enabled to consume up to the recognised basic-needs level (the Minimum Service Level), rather than the deprived quantity it was observed to consume under the affordability constraint. This is the orthodox, institutionally grounded application of suppressed demand, not an inflation of the baseline.

The WTP evidence (Section A6.3) shows households value lighting yet cannot pay cost-covering prices — the definition of suppressed demand. The intervention relieves that suppression. The methodology nonetheless constrains the credited uplift through independent conservative safeguards — the conservative 200 lm-hr/day baseline-lamp denominator, the Service Level Ratio Cap ($SLR_{cap} = 5.0$), the 1,000 lm-hr/day Minimum Service Level eligibility threshold, and the Downward Adjustment Factor — so that the credited service is capped at the basic-needs level and cannot exceed it. The suppressed-demand baseline therefore rests on the same peer-reviewed and institutional evidence as the Positive List, and is bounded so as to remain conservative.

A 6.6| Rural/off-grid versus urban/grid dichotomy

The literature also delineates where additionality risk is elevated, which defines the boundaries of the Positive List:

- **Reliable-grid and urban contexts:** where households have grid access or higher, cash-based incomes, WTP is higher and commercial solar markets can occasionally achieve viability without carbon finance. The observed reduction in solar WTP among grid-connected households supports excluding reliable-grid (Tier 3+) areas from deemed additionality.
- **Active government subsidy programmes:** where a host government operates a comprehensively funded electrification or solar-distribution programme targeting the same population, baseline adoption may occur through policy rather than carbon finance. Such contexts must be screened out via the Regulatory Surplus analysis to avoid crediting reductions that would have occurred under government policy.
- **Large-scale, well-capitalised operations:** large commercial deployments with access to conventional debt and equity face materially lower capital-access barriers and shall be subject to activity-specific scrutiny rather than deemed additionality.

A 6.7| Conclusion and justification for the Positive List

The synthesis of the peer-reviewed and institutional evidence establishes a clear, empirically validated dichotomy. In rural and energy-poor areas of LDCs, SIDS and lower-income economies that lack reliable grid access and comprehensive government subsidies, compounding affordability and last-mile-distribution barriers suppress

autonomous, market-based adoption of quality-verified solar lighting to levels well below what is required for universal access: revealed WTP is consistently 30–40% of cost-covering prices, and only around one in five unelectrified households can afford a Tier 1 service even on PAYG. In these contexts, carbon finance is not a supplementary revenue stream but a prerequisite for activity viability, and autonomous implementation at the credited service level is not a credible business-as-usual scenario.

It is therefore methodologically rigorous and conservative to grant deemed additionality (a Positive List) to micro- and small-scale solar lighting activities in these vulnerable contexts, while requiring activities in reliable-grid or urban middle-income settings, large-scale commercial deployments, or areas with active government subsidies to undertake strict, activity-specific barrier or investment analysis.

A 6.8| Positive List criteria for deemed additionality

An activity is deemed additional and exempt from conducting an activity-specific Investment Analysis or Barrier Analysis if it simultaneously meets all the criteria specified in Table A6.1 below.

Table A6.1: Positive List criteria for deemed additionality

Criterion	Requirement	Scientific & methodological justification
Geographic location & socio-economic context	The activity shall be physically located in a country or region that, at the time of first submission for listing, meets one of the following: (a) is classified as a Least Developed Country (LDC) or Small Island Developing State (SIDS); OR (b) is classified as a low-income or lower-middle-income economy (most recent World Bank classification) AND the activity targets exclusively rural or officially recognised underserved/off-grid areas.	Aligns with experimental evidence (Grimm et al., 2020; Bensch & Peters, 2020) showing revealed WTP at 30–40% of cost-covering prices in rural off-grid contexts, and with ESMAP/GOGLA (2024) data showing only ~22% of unelectrified households can afford a Tier 1 service on PAYG. Excludes higher-income urban contexts where commercial markets may drive baseline adoption.
Grid status	The target premises shall be off-grid or served only by an unreliable grid (below Tier 3 reliability) at the time of listing. Premises with reliable	Grid-connected households exhibit lower WTP for solar lighting and lower adoption likelihood (Bensch & Peters, 2020), indicating higher non-additionality risk where

	grid access (Tier 3+) are ineligible for deemed additionality.	reliable grid service exists. Restricting the Positive List to off-grid/unreliable-grid premises targets the population for which autonomous adoption is least credible.
Activity scale	The activity shall be classified as micro-scale (≤10,000 tCO_2e/year) or small-scale (≤60,000 tCO_2e/year).	Reserves deemed additionality for activities facing acute capital-access barriers. Large, well-capitalised commercial operations have access to conventional debt and equity markets and shall be subject to activity-specific financial scrutiny, consistent with the elevated viability of commercial models at scale.
Regulatory & subsidy absence	Via the Regulatory Surplus Analysis (Section 6.4 |), the developer shall demonstrate that the target population is not the recipient of an active, comprehensively funded government programme (e.g. full capital-cost subsidy or free distribution) providing equivalent solar lighting or electrification addressing the same baseline.	Ensures the activity does not claim reductions that would have occurred under host-country policy. Where government fully funds equivalent access, baseline adoption may be policy-driven rather than carbon-driven, removing additionality; such contexts are therefore screened out.
Technology quality	The activity device shall be a quality-verified product meeting the eligibility and service criteria of Section 3.2 | (including third-party performance verification and the Minimum Service Level).	The WTP evidence concerns quality-verified devices delivering durable Tier 1 service; the affordability gap is specific to this quality tier. Tying deemed additionality to the same quality standard ensures the empirical basis matches the credited product and prevents non-additional crediting of low-quality or non-compliant devices.

A 6.9| Validity period and review

This Positive List for deemed additionality shall have a validity period of three (3) years from the date of publication of this version of the methodology. At the end of

this period — and at each crediting-period renewal in the interim — the criteria and the underlying scientific and institutional evidence shall be reviewed by the Secretariat to confirm continued empirical relevance against evolving market penetration, affordability and grid-extension conditions. Where the evidence base materially changes (for example, if unsubsidised market adoption in a given context rises above the threshold supporting deemed additionality), the criteria shall be updated accordingly.

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