CLEAN DEVELOPMENT MECHANISM

CDM-SSCWG48-A01

Draft Small-scale Methodology

AMS-III.XXX: Integrated methodology for electrification of rural communities

Version 01.0

Sectoral scope(s): 01 and 02

United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. The recommended new methodology “AMS-III.XXX: Integrated methodology for electrification of rural communities” is based on:

   (a) The request for new methodology[1] “SSC-NM099: Consolidated methodology for electrification of rural communities”; and

   (b) The elements of the work to develop a top-down new methodology on "Integrated methodology for rural electrification combining grid connected and captive generation including grid extension to users" under CDM MAP (2015), Project 244[2] “Top down development of Methodologies/Standardized baselines and tools”.

2. Purpose

2. The proposed new methodology aims to:

   (a) Broaden the coverage of small-scale methodologies for electrification based on a gap analysis for example coverage of multiple technologies for electrification including hybrid energy system that would potentially accommodate all technologies/measures that target increased electricity access (grid, off-grid, etc.);

   (b) Provide simplified and flexible monitoring procedures to reduce transaction costs without compromising environmental integrity;

   (c) Integrate provisions from approved methodologies namely: AMS-I.F- “Renewable electricity generation for captive use and mini-grid”, AMS-I.L: “Electrification of rural communities using renewable energy”, AMS-III.BB: “Electrification of communities through grid extension or construction of new mini-grids”;

   (d) Integrate the deliverables under CDM MAP (2015), project 244 pertaining to the product "Integrated Rural Electrification Methodology” such as, simplification for determining project emissions for projects involving grid extension and provisions to accommodate project households/consumers that switch from off-grid to grid based solutions during the crediting period.

3. Key issues and proposed solutions

3. Electrification is pursued in many countries by agencies in the public and/or private sector, with the aim of increasing energy access, reducing emissions and achieving

[1] See Section 7 (c) of the cover note

[2] See Section 7 (a) and (b) of the cover note

sustainable development. These efforts focus on electrification of an entire identified region, and do not usually resort to segregating grid connected electrification from off-grid solutions in a geographic location. The relative cost of grid extension at times, determines the choice of off grid solutions such as solar home systems or power packs over extending the grid[3]. Furthermore in many instances grid connection represents progress over off-grid solutions which may have inherently included some elements of suppressed demand. However, CDM methodologies (e.g., AMS-I.A/I.L/I.F, AMS-III.AW/III.BB) for electrification distinguish technology/measures for grid connected, captive and off grid electrification, i.e. separate methodologies are provided for grid connection and off-grid generation.

4. The submission SSC-NM099 informed that many rural electrification programme applying CDM methodologies include several different technologies under the same overall governance structure and implementation framework. Because the applicability conditions for the relevant methodologies were created in isolation, there are often gaps such as technology/baseline combinations that may not be covered under approved small –scale methodologies i.e., Type I methodology covers only renewable based electrification and Type-III covers hybrid mini-grid or grid based electrification which may result result in;

   (a) A PoA for a rural energy program that may need to use multiple methodologies leading to more complicated project development and monitoring; and

   (b) Significant duplication in PoA-DD and CPA-DD leading to increase in transaction cost.

5. The proposed new methodology aims to broaden the coverage of CDM methodologies to include cases not covered by current approved methodologies, and to reduce the complexity and transaction costs for typical rural electrification programmes, which include multiple technology types.

4. Impacts

6. The proposed methodology will facilitate the implementation of CDM project activities and component project activities (CPAs), supplying electricity to consumers who, prior to project implementation, were not connected to a national/regional grid and relied on high-carbon-intensive mini-grids or stand-alone power generators. The project activities and CPAs covered under this methodology are highly relevant for the least developed countries (LDCs) and other regions that are underrepresented in the CDM.

5. Subsequent work and timelines

7. The draft methodology is recommended by the SSC WG for consideration by the Board at its eighty-fifth meeting. No further work is envisaged.

6. Recommendations to the Board

8. The SSC WG recommends that the Board adopt this final draft methodology, to be made effective at the time of the Board's approval.

[3] The grid becomes prohibitively expensive to extend to small communities after certain distance (Africa Energy Outlook, IEA, 2014)

7. References

9. Reference documents:

(a) EB82 Annex 11 (Paragraph 35) - Concept note: Development of new methodologies to broaden the applicability of CDM available at http://cdm.unfccc.int/Meetings/MeetingInfo/DB/C1REFM4G0ZT6K8P/view

(b) Annex 2, EB82 (Page 32) "Work-plan of panels and working groups for 2015 (version 01.0) available at http://cdm.unfccc.int/EB/index.html

(c) Consolidated methodology for rural electrification (SSC-NM099) available at http://cdm.unfccc.int/methodologies/SSCmethodologies/pnm/pending

(d) AMS-I.A: Electricity generation by the user

(e) AMS-I.F: Renewable electricity generation for captive use and mini-grid

(f) AMS-I.L: Electrification of rural communities using renewable energy

(g) AMS-III.AW: Electrification of rural communities by grid extension

(h) AMS-III.BB: Electrification of communities through grid extension or construction of new mini-grids

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1. Introduction

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

Table 1. Methodology key elements

Typical project(s)	Rural communities are supplied with electricity from renewable and/or hybrid energy systems (e.g., wind-diesel) or grid. The project activity supplies electricity to consumers who, prior to project implementation, were not connected to a national/regional grid.
Type of GHG emissions mitigation action	Displacement of fossil fuel use. Low-carbon-intensive grid/mini-grid electricity displaces high-carbon-intensive electricity or lighting services.

2. Scope, applicability, and entry into force

2.1. Scope

2. Project activities involve displacement of fossil fuel use such as in fossil fuel-based lighting systems, stand-alone diesel generators and diesel-based mini-grids.

2.2. Applicability

3. This methodology is applicable in situations where consumers that were not connected to a national/regional grid, prior to project implementation are supplied with electricity generated from the project activity. It is also applicable in situations where a fraction of consumers that were supplied with electricity from a fossil based individual energy system or fossil fuel based mini-grid prior to the implementation of the project, are supplied with electricity from the project activity (e.g. moving from carbon intensive mini-grid to less carbon intensive grid or mini grid).

4. Electricity consumers may include households, commercial facilities such as shops, public services/buildings and small, medium and micro enterprises (SMMEs). Applications may include lighting, household electrical appliances (e.g. refrigerators, TV, radio), public lighting and water pumps. At least 75 per cent (by number) of the consumers connected by the project activity shall be households.

5. This methodology is applicable to electrification of a community of consumers which is achieved through one or more of the following technologies/measures:

   (a) New construction of individual energy systems (renewable or hybrid) such as roof-top solar photovoltaic systems or hybrid energy systems;

   (b) Rehabilitation (or refurbishment) of individual energy systems, mini-grid or hybrid energy system may be undertaken, if it can be demonstrated that the existing system(s) i) are not part of another CDM activity; ii) are non-operational and iii) require a substantial investment for them to be rehabilitated to or above the original electricity generation capacity. To demonstrate compliance with this condition, the project participants shall provide documentation that:

(i) The existing system has not generated electricity, or that alternative fuels (e.g. kerosene) have been used, for at least six months prior to PDD or SSC-CPA-DD submittal; and

(ii) Substantial investments are required to rehabilitate the existing systems (e.g. investments greater than half of the cost to install a new power generation system with the same electricity generation capacity);

(c) Installation or extension of a mini-grid that distributes electricity generated from renewable energy systems or hybrid energy systems;

(d) Hybridization of existing fossil fuel powered mini-grids using renewable energy systems;

(e) Extension of a grid (national or regional) to supply new consumers as well as consumers currently connected to mini-grid.

6. Project equipment shall comply with applicable international standards or comparable national, regional or local standards/guidelines and, when relevant, the Project Design Document (PDD) shall indicate the standard(s) applied for main project equipment.

7. For projects involving the installation of hydro power plants with reservoirs the requirements prescribed under AMS-I.D shall be followed.

8. Measures are limited to those that result in emission reductions of less than or equal to 60 kt CO2 equivalent annually.

2.3. Entry into force

9. The date of entry into force is the date of the publication of the EB 85 meeting report on the 24 July 2015.

3. Normative references

10. This methodology is based on the proposed small-scale methodology "SSC-NM099: Consolidated methodology for rural electrification" submitted by The World Bank Group.

11. Project participants shall apply the "General guidelines for SSC CDM methodologies"[4] and the tools[5] for "Demonstration of additionality of small-scale project activities" and/or "Demonstration of additionality of microscale project activities" mutatis mutandis.

12. This methodology also refers to the latest approved versions of the following tools and methodologies mutatis mutandis:

(a) "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion";

(b) "Tool to calculate the emission factor for an electricity system"

(c) AM0045 "Grid connection of isolated electricity systems";

[4] https://cdm.unfccc.int/Reference/Guidclarif/index.html

[5] https://cdm.unfccc.int/methodologies/SSCmethodologies/approved

(d) AM0104 “Interconnection of electricity grids in countries with economic merit order dispatch”;

(e) AMS-I.D “Grid connected renewable electricity generation”;

(f) “Standard on sampling and surveys for CDM project activities and PoAs”.

4. Definitions

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

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

(a) **Off-grid systems:**

(i) **Individual renewable energy (RE) system** – electricity generation system that supplies electricity to a single consumer (e.g. a home or school) and that is not connected with other facilities or generation systems (i.e. stand-alone systems);

(ii) **Mini-grid system** – An integrated energy system consisting of interconnected loads and one or more energy resources with a total capacity not exceeding 15 MW (i.e. the sum of installed capacities of all electricity generating units connected to the mini-grid is equal to or less than 15 MW). The system is not connected to a national or a regional grid;

(iii) **Hybrid energy system** – combines at least two different kinds of electricity generation technologies including at least one renewable energy technologies with a total installed capacity not exceeding 15 MW. It includes hybrid “mini-grid” and hybrid “individual energy system” such as wind-diesel, PV-Diesel, wind-PV-Diesel energy system.

(b) **Rehabilitation (or refurbishment**) – Investment to restore existing individual, renewable electricity generation systems or renewable energy systems that are not generating electricity in their current condition which excludes investments in non-operational fossil fuel units. The investment may involve repairs, renovations or replacement of broken, missing or worn out equipment, but specifically excludes actions only involving on-going or deferred maintenance. The primary objective of rehabilitation or refurbishment is to restore the performance of the system. Rehabilitation may also lead to increased efficiency performance of individual renewable electricity generation systems or renewable energy systems serving a mini-grid ultimately increasing electricity generation;

(c) **Grid (National/regional Grid):** Grid is an electricity network, including transmission and distribution lines and power plants. The spatial extent of the grid includes the power plants that are physically connected through transmission and distribution lines to the project activity (e.g., extension of a grid for the purpose of electrification of communities) and that can be dispatched without significant transmission constraints.

(d) **Consumer(s)** - are end-user(s)/facility(ies) that may include households; public buildings; and/or small, medium and micro enterprises (SMMEs);

(e) **Consumer sub-group** – within a given consumer type, a group of consumers with a similar connection size (e.g. size of renewable energy system, load limit on connection, or other connection limitation) and likely to have a similar consumption level. Sub-group is used as strata for stratified random sampling.

(f) **New connection or new consumer –** consumers that, prior to the project activity, had no connection to an operational source of electricity.

(g) **Existing supply:** In all cases, existing supply source refers to an operational system. If a consumer is physically connected to an energy source (e.g., individual RE system or mini-grid system) that has not been operational in six months, it is not considered an operational connection. For example, if a household is connected to a mini-grid, but it has not been operational in six months, they are not considered as "existing mini-grid consumer". Instead, they are considered to be a consumer with no electricity supply.

5. Baseline methodology

5.1. Project boundary

15. For project activities involving national or regional grids, the spatial extent of the project boundary includes all power plants within the host country physically connected through transmission and distribution lines to the national or regional grid[6] which is being extended through the project activity.

16. For project activities involving mini-grids, the spatial extent of the project boundary includes all power plants connected through transmission and/or distribution lines to the mini-grid that is being built or extended through the project activity.

17. For all project types, the spatial extent of the project boundary also includes the physical sites of the end-use consumers served by the project activity.

18. For projects involving multiple technologies (e.g. grid extension and standalone system), the project boundary shall cover relevant locations per the paragraphs 15 to 17 above.

5.2. Baseline

19. The baseline emissions are calculated using the three steps as prescribed below.

5.2.1. Step 1. Classification of consumers

20. The baseline scenario is determined by the *type* of consumer. Appendix (Table 1, Table 2, and Table 3) provides classification of consumer types I, II and III and are summarised below:

(a) Type I – consumers who were not connected to a national/regional grid or a mini-grid prior to the project implementation and who consume less than 500 kWh per year;

[6] Refer to the most recent version of the "Tool to calculate the emission factor for an electricity system" for the definition of electricity system.

(b) Type II – includes two separate consumer groups (i) consumers that were previously supplied by a stand-alone fossil fuel power system such as diesel generators who consume less than 500 kWh[7], and (ii) consumers who use more than 500 kWh per year and had no supply prior to the project or were previously supplied by a stand-alone fossil fuel power system such as diesel generators;

(c) Type III – consumers who were connected to a mini-grid system prior to the project activity;

21. Type IV consumer category includes water pumping and public lighting consumers, regardless of their previous supply of electricity.

22. The baseline scenario for each type of consumers is defined as follows

Table 2. Type of consumers and baseline scenario

Type of consumer	Baseline Scenario
Type I	A combination of fuel based lighting and stand-alone fossil fuel generators. This is reflected in the tiered baseline emission factors in the following section 5.2.3.
Type II	Stand-alone fossil fuel generators
Type III	Generation from existing mini-grid[8]
Type IV	Stand-alone fossil fuel generation

23. Project participants shall provide an ex-ante estimate of the number of consumers that will fall into each group or type, based on business plans or other similar project documents. The estimates of consumers belonging to each group or type shall be transparently documented. During project implementation, the exact number of consumers by type and project technology/measure shall be recorded as part of the monitoring plan during the first monitoring period. The designation of consumer type shall be done only once, at start date of the project or at the first verification of the project. Table 3 below shows an example for reporting the consumer numbers. During the project crediting period, consumers may move from one technology/measure to another for example from individual system to mini-grid over time, but not from type I to type II (i.e., one column to the next but not from one row to the another with reference to the table below).

[7] For consumers whose baseline technology can be identified as the operation of fossil fuel generator and can be documented.

[8] Type III consumers are only served by mini-grids or grid extension measures, while Type I and II consumers could be served by individual energy systems, mini-grids or grid extension

Table 3. Reporting of consumer numbers by type and project technology/measure

	Project technology/measure		
Type	**Individual System**	**Mini-Grid**	**Grid Extension**
I			
II			
III	N/A		
IV			

5.2.2. Step 2. Determine consumption of each consumer type and sub-group

24. Consumption levels for each type of consumer are determined ex post using one of the following options (A, B, C or D) prescribed below, depending on the technology/measure being implemented at that consumer site. The flow charts in Figure 1 and Figure 2 specify the applicability of each of the four options.

Figure 1. Flow chart showing options for determining consumption for Type I, II and III consumer

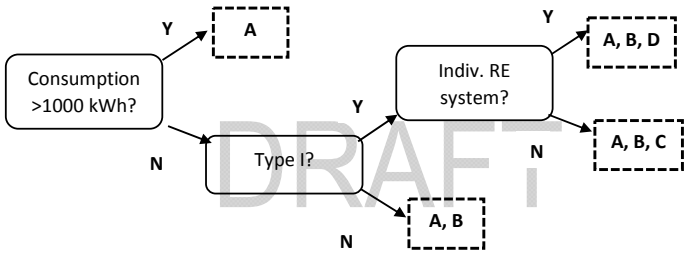
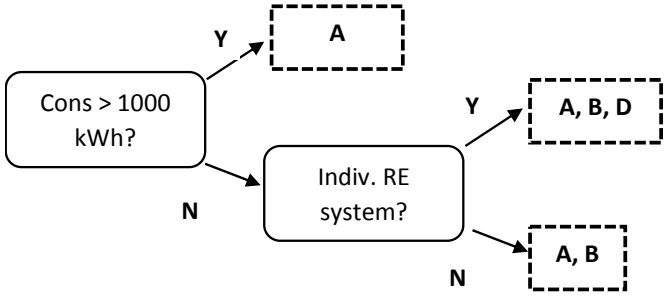


Figure 2. Flow chart showing options for determining consumption for Type IV consumers



(a) **Option A**. Metering (standard electrical meter or pre-payment meter) – All consumer types may use metering. However, for any consumer with annual consumption greater than 1000 kWh, then Option A is mandatory.

Where pre-payment meters are used, consumption shall be determined from the billing records. The total electricity consumed for each consumer is the summation of the pre-paid electricity purchased during the monitoring period, which excludes the last purchase during the monitoring period and includes the last purchase of the previous monitoring period.

(b) **Option B. Sample survey (stratified random sampling)** – All consumer types with expected annual consumption less than 1000 kWh may undertake a sample survey to determine the average consumption for specific consumer sub-groups (e.g. service levels, load limits, or other connection controls or sizes). The sample survey should follow the "Standard on sampling and surveys for CDM project activities and PoAs".

(c) **Option C. Distribution metering and consumer numbers** – Only Type I consumers served by a mini-grid or grid connection may choose to estimate consumption levels from the total metered consumption of a community/consumer group, less the sum of consumption by other consumer types, divided by the number of operational connections, taking into account distribution losses (see paragraph 26).

Example: In a mini-grid with 100 households, where 10 households have meters and consume 1200 kWh/year per household, total mini-grid net output of 18000 kWh/year, and default distribution losses of 10%, the average consumption of the households without meters would be ((18000 x (1 – 0.1)) – (10 x 1200))/(100-10) = 47 kWh/yr.

(d) **Option D. Deemed consumption** – as a special case, Type I, II and Type IV consumers that are served by an individual renewable energy systems may determine consumption based on the installed system capacity and an availability factor (see paragraph 54).

25. Where Option B is used, annual average consumption of a single sub-group (i.e., parameter such as "$EC_{T1,x,y}$" ,"$EC_{T2,z,y}$" ,$EC_{T3,w,y}$" or $EC_{T4,i,y}$" specified in equations 3 to 6 below) are determined using sampling strata, which may be based on load limits or other characteristics that restrict consumption, rather than metering the consumption of an individual consumer. For example, the average annual electricity consumption of each sub-group of Type I consumers used as a strata in the sample survey, as opposed to consumption of a single Type I consumer measured using Option A.

26. If Option C is used to determine annual average electricity consumption of Type I consumers (which are not metered) in a project area, it is calculated from:

(a) Total electricity supply to the project area monitored at the nearest sub-station or by monitoring electricity outputs of plants feeding a mini-grid and

(b) The total electricity consumption from other consumer groups (metered)

27. The annual average electricity consumption of Type-I consumers is then calculated using the equation below:

$$EC_{T1,x,y} = \frac{\left(ES_{tot} \times \left(1 - TL_p\right)\right) - \sum EC_{T2,z,y} - \sum EC_{T3,w,y} - \sum EC_{T4,i,y}}{N_y} \quad \text{Equation (1)}$$

Where

$EC_{T1,x,y}$	=	Annual electricity consumption of Type I consumer *x* in year *y* (MWh)
$ES_{tot,y}$	=	Total electricity supply to all consumers (MWh)
TL_p	=	Transmission and distribution losses within the project area (%), with 10 per cent as a default value
$EC_{T2,z,y}$	=	Annual electricity consumption of Type II consumer *z* in year *y* (MWh)
$EC_{T3,w,y}$	=	Annual electricity consumption of Type III consumer *w* in year *y* (MWh)
$EC_{T4,i,y}$	=	Annual electricity consumption of Type IV consumer *i* in year *y* (MWh)
N_y	=	Number of Type I consumers in year y

28. In the above example, if some Type I consumers use Option A and some use Option C, then the amount of electricity consumption of Type I consumers determined using option A is subtracted in the equation above (i.e. the numerator would include subtracting the sum of Type I consumption using Option A).

29. As indicated in paragraph 23, project participants shall provide an ex-ante estimate of the consumption levels (i.e. less than 500 kWh per year, between 500 kWh and 1000 kWh per year and greater than 1000 kWh per year) of each consumer type or sub-group within that type (e.g. different load limit groups within Type I or Type II), based on business plans or other similar project documents. However, during project implementation, consumption shall be determined according to the monitoring procedure presented in section 6 below.

5.2.3. Step 3. Determine baseline emissions of each consumer type and sub-group

30. The parameters are determined differently for different project technologies and consumer groups, as outlined below. Total baseline emissions are the sum of all the individual consumer groups.

$$BE_y = BE_{T1,y} + BE_{T2,y} + BE_{T3,y} + BE_{T4,y} \quad \text{Equation (2)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2)
$BE_{T1,y}$	=	Baseline emission from Type I consumers in year *y* (tCO_2)
$BE_{T2,y}$	=	Baseline emission from Type II consumers in year *y* (tCO_2)
$BE_{T3,y}$	=	Baseline emission from Type III consumers in year *y* (tCO_2)
$BE_{T4,y}$	=	Baseline emission from Type IV consumers in year *y* (tCO_2)

31. For Type I consumers, baseline emissions are calculated as follows:

$$BE_{T1,y} = \sum_{x=1}^{N} \left(EC_{T1,x,y} \times EF_{CO2,T1} \right)$$ Equation (3)

Where:

$BE_{T1,y}$ = Baseline emission from Type I consumers in year *y* (tCO_2)

$EC_{T1,x,y}$ = Annual electricity consumption of Type I consumer *x* in year *y* (MWh)

$EF_{CO2,T1}$ =
- If $EC_{T1,x,y}$ is equal to or less than 0.055 MWh, then use a default value of 6.8 (tCO_2/MWh);
- If $EC_{T1,x,y}$ is less than or equal to 0.250 MWh but greater than 0.055 MWh, then:
  - For the portion up to and including 0.055 MWh, use a default value of 6.8 (tCO_2/MWh);
  - For the portion greater than 0.055 MWh, use a default value of 1.3 (tCO_2/MWh);
- If $EC_{T1,x,y}$ is greater than 0.250 MWh but less than or equal to 0.500 MWh, then:
  - For the portion up to and including 0.055 MWh use a default value of 6.8 (tCO_2/MWh);
  - For the portion greater than 0.055 MWh and less than 0.25 MWh/y use a default value of 1.3 (tCO_2/MWh); and
  - For the portion greater than 0.250 MWh use a default value of 1.0 (tCO_2/MWh);
- If $EC_{T1M,j,y}$ is greater than 0.500 MWh then use a default value of 1.0 (tCO_2/MWh) for the entire portion (i.e. default values of 1.3 (tCO_2/MWh) or 6.8 (tCO_2/MWh) are not eligible for any of the portions)[9]

N_y = Number of Type I consumers in year *y*

x = Type I consumer (x = 1, 2, 3, …)

32. For Type II consumers, baseline emissions are calculated as follows:

$$BE_{T2,y} = \sum_{z=1}^{M} \left(EC_{T2,z,y} \times EF_{CO2,T2} \right)$$ Equation (4)

Where:

$BE_{T2,y}$ = Baseline emission from Type II consumers in year *y* (tCO_2)

[9] Type I consumers are defined as having less than 500 kWh/year consumption at the start of the project activity. In the event that average electricity consumption of Type-I consumers monitored during the crediting period exceeds 500 kWh/year, they should be reclassified as Type II consumers at the renewable of the crediting period.

$EC_{T2,z,y}$ = Annual electricity consumption of Type II consumer *z* in year *y* (MWh)

$EF_{CO2,T2}$ = Baseline emissions factor for Type II consumers (1.0 tCO_2/MWh)

M_y = Number of Type II consumers in year *y*

z = Type II consumer (z = 1, 2, 3, …)

33. For Type III consumers, baseline emissions are calculated as follows:

$$BE_{T3,y} = \sum_{w=1}^{P} \left(EC_{T3,w,y} \times EF_{CO2,T3} \right) \quad \text{Equation (5)}$$

Where:

$BE_{T3,y}$ = Baseline emission from Type III consumers in year *y* (tCO_2)

$EC_{T3,w,y}$ = Annual electricity consumption of Type III consumer *w* in year *y* (MWh)

$EF_{CO2,T3}$ = Baseline emissions factor for Type III consumers (tCO_2/MWh) For a mini-grid system where all generators use exclusively fuel oil and/or diesel fuel, emission factor can be determined using the emissions factors given in Table 4 below. For all other mini-grids it shall be calculated as the weighted average emissions for the current generation mix following the procedure provided in "AMS-I.D: Grid connected renewable electricity generation"

P_y = Number of Type III consumers in year *y*

w = Type III consumer (w = 1, 2, 3, …)

Table 4. Default emission factors for diesel generator systems (in kg CO_2e/kWh[(a)]) for three different levels of load factors[(b)]

Cases	Mini-grid with 24 hour service	i. Mini-grid with temporary service (4-6 hr/day); ii. Productive applications; iii. Water pumps	Mini-grid with storage
Load factors [%]	**25%**	**50%**	**100%**
<15 kW	2.4	1.4	1.2
>=15 <35 kW	1.9	1.3	1.1
>=35 <135 kW	1.3	1.0	1.0
>=135<200 kW	0.9	0.8	0.8
> 200 kW	0.8	0.8	0.8

(a) A conversion factor of 3.2 kg CO_2 per kg of diesel has been used (following revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories);

(b) Values derived from figures reported in RETScreen International's PV 2000 model retrieved from: <http://retscreen.net/>;

34. For Type IV consumers, baseline emissions are calculated as follows:

$$BE_{T4,y} = \sum_{i=1}^{Q} \left(EC_{T4,i,y} \times EF_{CO2,T4} \right)$$ Equation (6)

Where:

$BE_{T4,y}$ = Baseline emission from Type IV consumers in year *y* (tCO_2)

$EC_{T4,i,y}$ = Annual electricity consumption of Type IV consumer *i* in year *y* (MWh)

$EF_{CO2,T4}$ = Baseline emissions factor for Type IV consumers (1.0 tCO_2/MWh).

Q_y = Number of Type IV consumers in year *y*

5.3. Leakage

35. Leakage on account of construction of new transmission/distribution lines (e.g. carbon stock loss due to deforestation) shall be calculated using the method indicated in baseline and monitoring methodology AM0045 “Grid connection of isolated electricity systems” or AM0104 “Interconnection of electricity grids in countries with economic merit order dispatch”. If the estimated leakage is within 5% of the estimated emission reductions of the project, then this leakage source may be neglected, otherwise the leakage shall be deducted from the emissions reductions.

36. If any energy generating equipment is transferred from another activity, leakage is to be considered.

5.4. Project emissions

37. The table below shows a summary of the approaches for project emissions:

Table 5. Approaches to determine project emissions based on technology type

Project technology	Project emissions approach
New or rehabilitation of individual renewable or hybrid energy systems	If only renewables, no project emission If hybrid system, emissions from diesel generator fuel use
Renewable or hybrid mini-grids	Emissions factors based on default emissions factors for fossil fuel plants or weighted average following AMS I.D
Grid-extension	Emissions factor based on: top 10 per cent high emission intensive plants in the grid or default emission factor based on the highest carbon intensive fuel in the grid for projects implemented in LDCs/SIDs/Underrepresented countries Project emissions is zero if: Grid extension is directly associated with the renewable energy plant Fuel mix in grid is greater than 95% renewable and projects are located in LDCs/SIDs/Underrepresented countries

38. Total project emissions are the sum of all the individual technologies.

$$PE_y = PE_{IS,y} + PE_{G,y}$$ Equation (7)

Where:

PE_y = Project emissions in year *y* (tCO_2)

$PE_{IS,y}$ = Project emission from new or rehabilitated individual renewable or hybrid energy systems in year *y* (tCO_2)

$PE_{G,y}$ = Project emissions from renewable and hybrid mini-grids (new and rehabilitated) and grid extension in year *y* (tCO_2)

5.4.1. Project emissions for new or rehabilitation of individual renewable or hybrid energy systems

39. For systems with only renewable energy generation, project emissions are considered zero (i.e. $PE_{IS,y}$ =0) except in the cases of geothermal plants or hydro power plants with reservoirs, where the most recent version of "AMS-I.D: Grid connected renewable electricity generation" is applied to calculate project emissions.

40. For hybrid individual systems, project emissions are calculated from the generation contribution of the diesel part of the system.

$$PE_{IS,y} = EG_{diesel,y} \times EF_{CO2,diesel}$$ Equation (8)

Where:

$PE_{IS,y}$ = Project emissions from new or rehabilitated individual renewable or hybrid energy systems in year *y* (tCO_2)

$EG_{diesel,y}$ = Generation at individual systems from diesel in year *y* (MWh).

$EF_{CO2,diesel}$ = Emissions factor for diesel generation, based on Table 4 (tCO_2/MWh)

41. Total project emissions for this technology would then be the sum of the emissions from all of the individual systems.

5.4.2. Project emissions from renewable or hybrid mini-grids (new and rehabilitated) or grid extension

42. Project emissions are emissions associated with the generation of electricity supplied to the project activity end use facilities.

$$PE_{G,y} = \frac{\left(ES_{tot,y} \times EF_{grid,CO2,y}\right)}{\left(1 - TL_{grid}\right)}$$ Equation (9)

Where:

$PE_{G,y}$ = Project emissions from renewable and hybrid mini-grids (new or rehabilitated) and grid extension in year *y* (tCO_2)

$ES_{tot,y}$ = Total electricity supply to all consumers (MWh)

$EF_{grid,CO2}$	=	Emission factor for the project electricity system in year *y* (tCO_2/MWh) If the project activity involves connection to an existing mini-grid, rehabilitated mini-grid or construction of new mini-grid, the emissions factor is determined as either: (a) for a mini-grid system where all generators use exclusively fuel oil and/or diesel fuel using the emissions factors in Table 4; or (b) for all other mini-grids per the weighted average emissions for the current generation mix following the procedure provided in AMS-I.D. If the project activity involves connection to an existing national or regional grid, the emissions factor is determined using one of the options prescribed under paragraph 46 below.
TL_{grid}	=	Transmission losses in the project electricity system, where the project activity is grid extension, with a 10% default value. This does not apply to a mini-grid, because local distribution losses are already captured as TLp in equation 10 below (i.e. TL_{grid} = 0 for mini-grid)

43. $ES_{tot,y}$ is either determined by the measurement at an electricity meter at the point of supply to community, or as the sum of electricity consumption of all consumers. Note that, if Option C is used for calculating consumption by any consumer groups, then $ES_{tot,y}$ shall be measured directly.

44. If the sum of consumption from all consumers is used, $ES_{tot,y}$ is calculated using the following equation:

$$ES_{tot,y} = \frac{\sum_{x=1}^{N_y} EC_{T1,x,y} + \sum_{z=1}^{M_y} EC_{T2,z,y} + \sum_{w=1}^{P_y} EC_{T3,w,y} + \sum_{i=1}^{Q_y} EC_{T4,i,y}}{(1 - TL_p)} \quad \text{Equation (10)}$$

Where

$ES_{tot,y}$	=	Total electricity supply to all consumers (MWh)
$EC_{T1,x,y}$	=	Annual electricity consumption of Type I consumer *x* in year *y* (MWh)
$EC_{T2,z,y}$	=	Annual electricity consumption of Type II consumer z in year *y* (MWh)
$EC_{T3,w,y}$	=	Annual electricity consumption of Type III consumer *w* in year *y* (MWh)
$EC_{T4,i,y}$	=	Annual electricity consumption of Type IV consumer *i* in year *y* (MWh)
N_y	=	Number of Type I consumers in year *y*
M_y	=	Number of Type II consumers in year *y*
P_y	=	Number of Type III consumers in year *y*
Q_y	=	Number of Type IV consumers in year *y*
DL_p	=	Local distribution losses within the project area (%), with 10 per cent as a default value

45. If multiple mini-grids are involved, total project emissions shall be calculated as the sum of the emissions from all of the mini-grids.

5.4.2.1. Determination of grid emission factor for calculating project emissions

46. The following options are available for determining grid emission factor for the purpose of determining project emissions due to electrification through grid extension:

    (a) **Option 1:** Emission factor is determined by ranking all the power units in the national or regional grid in decreasing order of GHG intensity. The emissions factor is the weighted average emission factor of the top 10% most GHG intensive plants in the grid.[10] The emissions factors of the plants shall be calculated based on default plant efficiency provided in the "Tool to calculate the emission factor for an electricity system";

    (b) **Option 2:** If the project activity involves electrification of a community due to the construction of a new grid connected renewable power plant, the emission factor of zero can be applied if the following conditions are met:

        (i) The main feeder supplying electricity to a community is a dedicated line "energized/ charged" from the newly constructed renewable power plant;

        (ii) The feeder is not "energized/ charged" by a grid or other fossil fuel sources when the plant is not in operation. If this is not the case, project emissions shall be calculated for the proportion of electricity that is supplied by a grid or other sources, for the period of time when the plant is not in operation, using the other optioned mentioned in this section.

    (c) **Option 3:** If the projects are implemented in Least Developed Countries (LDCs) or Small Island developing States (SIDs) or in countries that had 10 or fewer registered CDM project activities as of 31 December 2010 (namely, underrepresented countries (URCs)), the following alternatives are available:

        (i) The emission factor of zero can be applied if the share of renewable energy mix is greater than 95% based on immediate three years average historical data

        (ii) The emissions factor is determined by the most GHG intensive fuel used in the national or regional grid and the default technology efficiency (lower range) as provided in the "Tool to calculate the emission factor for an electricity system". The default emission factors prescribed in the Table 6 below should be used.

            Example for using default emission factor:

            a. If a grid has a fuel mix of natural gas, oil and hydro, take the default emission factor of oil;

            b. if a grid has a fuel mix of several oil and several coal fired power plants, take the default emission factor of coal

[10] If the grid, associated with the project, is the net importer of electricity from other countries the emission factor shall be the higher among the following two: (i) the weighted average emissions factor of the top 10% most GHG intensive plants in the grid of the host country; and (ii) the weighted average emissions factor of the top 10% most GHG intensive plants in the exporting grid.

Table 6. Default emission factors for determining project emissions

Fuel	Fuel EF from IPCC (kg/TJ)	Efficiency (%)	Default grid EF (tCO_2/MWh)
Coal	101 000	36.5	1.0
Natural gas	58 300	30	0.7
Oil	74 800	30	0.9

6. Monitoring methodology

47. The monitoring of all the relevant parameters shall be as per the procedures detailed below. The applicable requirements (e.g. calibration) for the monitoring plan as specified in the "General guidelines for SSC CDM methodologies" are an integral part of the monitoring guidelines specified below and therefore shall be referred to by the project participant.

48. For project activities covering Type I, Type II and Type IV consumer, it is possible for a phased implementation. That is, if during the crediting period, a consumer changes from electricity being supplied under the project by an individual energy system (in an earlier phase) to being supplied by a mini-grid or grid extension (in a later phase) the consumer will thereafter be considered a mini-grid or grid consumer for purposes of baseline and project emissions (i.e. they no longer will qualify to use Option D for monitoring). In such a case, the information regarding the potential phased implementation shall be provided in the applicable project documentation (e.g., PDD or PoA-DD/CPA-DD).

49. The key parameters monitored are the consumption of each type of consumer, as well as the total electricity supplied by the project activity, where applicable. above illustrates the applicability requirements for each monitoring option.

    (a) **Option A**. Metering;

    (b) **Option B.** Sample survey;

    (c) **Option C.** Distribution metering and consumer numbers;

    (d) **Option D.** Deemed consumption.

50. Project participants shall document how many consumers of each type will apply which option for monitoring. The template presented below (Table 7) may be used.

Table 7. Number of consumers by type and monitoring option

	Monitoring Option			
Type	**A**	**B**	**C**	**D**
I				
II				
III				N/A*
IV				

* Option D only apply to individual renewable energy systems, which would not be used to replace a fossil fuel mini-grid

6.1. Option A. Metering

51. All consumer types may use metering. However, any consumers with annual consumption greater than 1000 kWh are required to use metering. Where pre-payment meters are used, consumption will be determined from the billing records. The total electricity consumed for each consumer is the summation of the pre-paid electricity purchased during the monitoring period, excluding the last purchase during the monitoring period but including the last purchase of the previous monitoring period. Pre-payment purchases shall be substantiated by billing records from the supplier or similar documentation.

6.2. Option B. Sample survey

52. A sample survey may be undertaken for all consumer types with consumption less than 1000kWh to determine their average consumption. Where there are sub-groups within this consumer type that are likely to have different consumption levels (e.g. due to specified service levels, load limits, or other connection controls or sizes), the sampling should be stratified for each sub-groups. The sample survey should follow the "Standard on sampling and surveys for CDM project activities and PoAs". The share of connections that are operational are determined using the same approach as outlined in paragraph 55 for individual renewable energy systems.

6.3. Option C. Distribution metering and consumer numbers

53. Type I consumers that are served by a mini-grid or grid connection (may choose to estimate consumption levels from the total metered consumption of a community/consumer group, less the sum of consumption by other consumer types, divided by the number of operational connections, taking into consideration distribution losses. The calculation for this is shown in paragraph 26 and the relevant monitoring parameters are included below.[11] The share of connections that are operational are determined using the same approach as outlined in paragraph 55 for individual renewable energy systems.

6.4. Option D. Deemed consumption

54. This option may only be used by Type I, II and Type IV consumers who, under the project activity, are served by individual energy systems that use only renewable energy. The consumption is calculated as the installed capacity of the project renewable energy generation systems multiplied by an annual average value for availability/capacity factor.[12] For solar photovoltaic electricity systems, the annual average value for availability can be obtained through following options[13]:

[11] For example, in a mini-grid with 100 households, where 10 households have meters and consume 200 kWh/year, total mini-grid output of 8000 kWh/year, and default distribution losses of 10%, the average consumption of the households without meters would be ((8000 x (1 – 0.1)) – (10 x 200))/(100-10) = 57 kWh/yr.

[12] This assumes that all of the renewable energy that is produced will be consumed by the facility.

[13] Availability factors for other renewable energy systems may be proposed following the procedures for request for revision of small-scale CDM methodologies.

(a) **Option D1**: Assume a conservative default value of twelve per cent (12 per cent) for the annual average value for availability;[14]

(b) **Option D2:** Calculate the annual average value for availability based on local site conditions and system characteristics. "RETScreen® International Photovoltaic Project Model" included in the "RETScreen Clean Energy Project Analysis Software"[15] may be used as below:

(i) Complete the "Energy Model and Solar Resource & System Load" worksheet;

(ii) For the cells where "user inputs" are required and where online databases are provided (e.g. weather database), the latter may be used as sources for the input to the cells.

(iii) If the annual solar radiation[16] (MWh/m^2/year) in the sites of the project activity or the component project activity vary significantly (i.e. greater than +/-10% variation) then:

a. Perform the calculation for the site receiving the least amount of annual solar radiation; or

b. Perform the calculation for a representative selection of sites and take the weighted average value;

(iv) If there is more than one type of project electricity generation system i.e. the system characteristics of the project systems differ, then perform the calculations separately for each type of system and take the weighted average value. The following parameters may be considered for defining the system characteristics:

a. The system is an off-grid or water pumping system;

b. System is with or without battery backup;

c. System includes or excludes inverters;

d. Type of solar panel when more than one type of solar panel is used (e.g. monocrystalline silicon, polycrystalline silicon and thin films);

e. Type of tracking device when more than one type of solar tracking devices are used (i.e. fixed, one-axis, two-axis, azimuth);

f. Type of control method, orientation and slope (i.e. maximum power point tracker vs clamped degrees above horizontal for the slope, azimuth of solar panel in degrees from due South);

[14] For example a 15 Wp Solar Home System would deliver 15.77 kWh annually (0.015 x 8760 x 0.12).

[15] Publicly available at http://www.retscreen.net/ang/home.php. Other similar software may be proposed for inclusion following the procedures for a revision of a methodology.

[16] If the solar radiation values are available for each month it may be annualized by taking the average for 12 months.

g. Assume a value of 10% loss for the miscellaneous losses;

(c) **Option D3**: Source the annual average value for availability from the project feasibility report (e.g. provided by the manufacturer/supplier of the system) when it includes the calculations for estimating the output from the system (i.e. weather data used, system characteristics and losses assumed are described).

55. The number of operating renewable electricity generation systems is determined on a sample basis either annually choosing 90/10 confidence/precision or biennially choosing 95/10 confidence/precision for the sample size estimation following the requirements under "Standard on sampling and surveys for CDM project activities and PoAs". This monitored value determines N/M/P/Q (number of consumers) in equations (1), (3), (4), (5) and (6). Renewable electricity generation systems can be counted as operating only if they can be shown to be able to produce electricity by means of one of the following:

(a) The manufacturer's warranty; or

(b) Regular maintenance arrangement (e.g. with suppliers/distributors/ implementers); or

(c) Showing that the systems are procured following the standards/guidelines (local/national/international) to ensure that the systems are of adequate quality and provide the required performance; or

(d) By direct monitoring of systems, if necessary on sample basis

56. In the absence of this demonstration, the system capacity shall be de-rated following manufacturers guidelines or as per relevant international standards/guidelines.

6.5. Data parameters that are monitored

Data / Parameter table 1.

Data / Parameter:	**$EC_{T1,x,y}$, $EC_{T2,z,y}$, $EC_{T3,w,y}$, $EC_{T4,i,y}$**
Data unit:	MWh
Description:	Electricity consumption at each Type I, II, III or IV consumer
Source of data:	-
Measurement procedures (if any):	Option A- electricity meters or pre-payment meters. For electricity meters, the difference between the meter reading at the end of the monitoring period and the start of the period. Option B - sample survey, as per paragraph 52. Option D – recording of capacity at installation, based on manufacturer's specifications. Deemed consumption will be estimated as described in paragraphs 54, 55, and 56. Annual/biennial checks that individual systems are still working, done with a statistically significant sample of consumers. Use 90/10 and 95/10 precision for annual and biennial checks, respectively

Monitoring frequency:	Option A – continuous, with annual reporting Option B – sample survey to be conducted in first year after installation, and repeated at least every 24 months Option D – once at installation (proportion of operational systems would still need to be monitored as per data /parameter table 2 below)
QA/QC procedures:	-
Any comment:	Only used for monitoring option A, option B and option D. Options C is not included because it is calculated from other parameters.

Data / Parameter table 2.

Data / Parameter:	**Proportion of operational systems and connections**
Data unit:	No units
Description:	Check for continued operation or access to the grid or mini-grid
Source of data:	-
Measurement procedures (if any):	Annual/biennial checks that individual systems and connections to the grid or mini-grid are still working, by taking a statistically significant sample of consumers. Use 90/10 and 95/10 precision for annual and biennial checks, respectively When a consumer has a meter, these readings may be used in place of on-site checks.
Monitoring frequency:	Annual/biennial
QA/QC procedures:	-
Any comment:	Only used for individual energy systems applying monitoring Option D and mini-grid and grid connections applying Options B or C.

Data / Parameter table 3.

Data / Parameter:	**$EG_{diesel,y}$**
Data unit:	MWh
Description:	Generation at individual systems from diesel
Source of data:	-
Measurement procedures (if any):	For units larger than 750 kW, electricity meters are required. For units below 750 kW, generation may be estimated from the design specific fuel consumption and the quantity of diesel consumed.
Monitoring frequency:	Continuous, with monthly recording and annual reporting or using fuel purchase/invoices
QA/QC procedures:	Calibration according to manufacturer's specifications if system capacities are larger than 750 kW or following local regulatory requirements
Any comment:	Refer to the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" Used for project emissions from hybrid energy systems

Data / Parameter table 4.

Data / Parameter:	**$ES_{tot,y}$**
Data unit:	MWh
Description:	Total electricity supply to all consumers
Source of data:	-
Measurement procedures (if any):	Measured using an electricity meter at the main point of supply (e.g. sub-station serving a community)
Monitoring frequency:	Continuous, with monthly recording and annual reporting
QA/QC procedures:	Calibration according to manufacturer's specifications or following local regulatory requirements
Any comment:	Only used when Option C for monitoring mini-grid and grid consumers is applied

6.6. Project activity under a programme of activities

57. The methodology is applicable to a programme of activities; no additional leakage estimations are necessary other than that indicated under leakage section above.

58. The applicable requirements specified in the "Standard on sampling and surveys for CDM project activities and PoAs" are also an integral part of the monitoring guidelines and therefore shall be referred to by the project participant in the case of PoAs.

Appendix 1. Detailed classification of consumers

Table 1. Alternative technology and baseline combinations for stand-alone, facility scale power systems

Size	Existing supply	Project supply technology	Baseline	Consumer Type	Project emissions
<=500 kWh/yr	None	New RE system	Tiered	I	Diesel generation in hybrid system; no RE emissions unless hydro under conditions in AMS-I.D or geothermal
		New hybrid system	Tiered	I	
	Non-operational RE	Rehabilitate RE system	Tiered	I	
	Fossil system	Replace with RE system	Diesel generator	II	
		Supplement/expand with RE system (hybridise)	Diesel generator	II	
> 500 kWh/yr	None	New RE system	Diesel generator	II	
		New hybrid system	Diesel generator	II	
	Non-operational RE	Rehabilitate RE system	Diesel generator	II	
	Fossil system	Replace with RE system	Diesel generator	II	
		Hybridise	Diesel generator	II	

Note: RE= renewable energy; Non-operational RE includes both individual systems and plants serving a mini-grid

Table 2. Alternative technology and baseline combinations for mini-grid projects

Hybrid Mini-grid ?	Existing Supply	Project supply technology	Connections/ consumers	Baseline	Consumer type	Project emissions
Yes	None	New hybrid mini-grid	All new	Tiered/ Diesel generator*	I/II*	Diesel generation in hybrid MG; no RE emissions unless hydro under conditions in AMS-I.D or geothermal
	Non-operational hybrid mini-grid	Rehabilitate RE plant of the mini-grid	Existing	Tiered/ Diesel generator*	I/II*	
			New	Tiered/ Diesel generator*	I/II*	
	Operational fossil mini-grid	New RE plant displace some fossil in the mini-grid	Existing	Fossil mini-grid	III	
			New	Tiered/ Diesel generator*	I/II*	
	Individual fossil or hybrid energy systems	New hybrid mini-grid	Existing	Diesel generator	II	
No	None	New RE mini-grid	All new	Tiered/ Diesel generator*	I/II*	
	Non-operational RE mini-grid	Rehabilitate RE plant of the mini-grid	Existing	Tiered/ Diesel generator*	I/II*	
			New	Tiered/ Diesel generator*	I/II*	
	Operational fossil mini-grid	New RE plant displace all fossil in the mini-grid	Existing	Fossil mini-grid	III	
			New	Tiered	I/II*	
	Individual fossil or hybrid energy systems	New RE mini-grid	Existing	Diesel generator	II	

Note: RE = renewable energy, MG= Mini Grid

* In the case of table 2, the threshold for determining whether consumers are Type I consumer or Type II consumer, designated at the start of the project or at the start of the first verification of the project, is whether their consumption is > 500 kWh per year. No tiered baseline is applicable for Type-II consumers.

Table 3. Alternative technology and baseline combinations for grid extension projects

Existing supply	Project supply technology	Connections/ consumers	Baseline	Consumer type	Project emissions
None	Grid	All new	Tiered/ Diesel generator*	I/II*	National/ regional grid EF
Operational fossil MG	Grid	Existing	Fossil MG EF	III	
		New	Tiered/ Diesel generator*	I/II*	
Operational hybrid MG	Grid	Existing	Hybrid MG EF	III	
		New	Tiered/ Diesel generator*	I/II*	
Individual fossil or hybrid energy systems	Grid	Existing	Diesel generator	II	

* In the case of table 3, the threshold for determining whether consumers are Type I consumer or Type II consumer, designated at the start of the project at the start of the first verification of the project, is whether their consumption is > 500 kWh per year. No tiered baseline is applicable for Type-II consumers.

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