# Simplified Approval Process

# Annex 22 : Greenhouse gases emissions calculation

**SAP: Upscaling "Naatanguee" integrated family and village farms for a resilient agriculture in Senegal**

Senegal | Centre de Suivi Ecologique

December 2023

## Annex 22: GHG Methodology

## GHG Emissions Reductions Methodology

GHG emissions reductions for the project primarily stem from the conversion of diesel and grid-tied (two farms – Mont Rolland and Diacksao are grid-tied) irrigation pumps on village/consolidated farms to solar irrigation pumps. The solar irrigation systems are assumed to displace all of the pumping needs for 7 h

ours each day, but any remaining pumping would still be met with the baseline energy systems. In total annual emissions reductions are estimated at 921,907 tC02eq (% of baseline emissions) and emissions reductions over the 20-year lifetime of the solar modules is 18314,16 TC02eq. Estimates are based on the UNFCCC CDM Guidelines AMS-I. A Version 19.0, " Electricity generation by the user "[1] with the following input parameters and assumptions:

- Lifespan of Solar Systems[2] – 20 years
- Diesel Emissions Factor (kg/GJ) – 74,1[3]
- Diesel Density (kg/liter) – 0.8439
- Grid emission factor for West African Power Pool[4] - 0.573
- Length of Growing Season[5] – 180 days
- Solar Production Window[6] – 7 hours

Per the methodology guidelines, baseline emissions are calculated based on kilograms of diesel burned and/or the established baseline emissions factors for grid electricity in Senegal using the equation outlined below:

**Emission reductions**

$ERy = BEy - PEy - LEy$

Where:

- $ERy$ = Emission reductions in year y (t CO2)
- $BEy$ = Baseline emissions in year y (t CO2)
- $PEy$ = Project emissions in year y (t CO2)
- $LEy$ = Leakage emissions in year y (t CO2)[7]

[1] UNFCCC CDM Guidelines AMS-I.A Version 19.0 " Electricity generation by the user "; Available at: CDM: Electricity generation by the user --- Version 19.0 (unfccc.int)
[2] Standard Solar Panel Warranty
[3] IPCC 2006
[4]Grid emission factor for West African Power Pool available at: CDM: Standardized baselines (unfccc.int)
[5] ANIDA estimate
[6] ANIDA estimate
[7] leakage is assumed to be 0.

## 1.1. Baseline

1. The baseline emissions are calculated based on the fuel consumption of the technology in use or that would have been used to generate the equivalent quantity of energy[8] in the absence of the project activity, using one of the following two options:

### 1.1.1. Option 1: based on the electricity consumption of the households/user

2. Baseline emissions are calculated as follows:

$$BE_y = E_{BL,y} \times EF_{CO2,y} \quad \text{Equation (1)}$$

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Baseline emissions in year *y* (t $CO_2$) |
| $E_{BL,y}$ | = | Energy baseline in year *y* (kWh) |
| $EF_{CO2,y}$ | = | Emission factor (t $CO_2$/kWh) |

3. The energy baseline is the total annual electricity consumption of the households/users *c* that are supplied with electricity generated by units *i*:

$$E_{BL,y} = \sum_i \sum_c \left(n_{c,i} \times EC_{c,i,y}\right)/(1 - TDL) \quad \text{Equation (2)}$$

Where:

| | | |
|---|---|---|
| $E_{BL,y}$ | = | Energy baseline in year *y* (kWh) |
| $c$ | = | Type of consumer (e.g., households, rural health centres, rural schools, grain milling, water pumping, irrigation, etc.) covered by the project activity |
| $i$ | = | Type of renewable electricity generation unit(s) implemented by the project activity |
| $n_{c,i}$ | = | Number of consumers type *c* supplied with renewable electricity generation unit(s) type *i* |
| $EC_{c,i,y}$ | = | Electricity consumption by user type *c* supplied with unit type *I* in year *y* (kWh) |
| $TDL$ | = | Average technical transmission and distribution losses that would have been observed in diesel powered mini-grids installed by public programmes or distribution companies in isolated areas, expressed as a fraction |

[8] Renewable energy lighting applications shall consider the equivalent level of lighting service instead of energy (See annex 1 of EB 08).

| n | EC | TDL | Baseline electricity consumption / year kWh | Grid Emissions Factor (kC02/KWh ) | Baseline emissions electricity consumption kCO2/ year | Project emissions |
|---|---|---|---|---|---|---|
| 2 | 18900 | 0,2 | 47250 | 0,573 | 27074,25 | 0 |

| year(n) | Emissions reduction with solar energy per year | cumulated emissions |
|---|---|---|
| 1 | 27074,25 | 27074,25 |
| 2 | 27074,25 | 54148,5 |
| 3 | 27074,25 | 81222,75 |
| 4 | 27074,25 | 108297 |
| 5 | 27074,25 | 135371,25 |
| 6 | 27074,25 | 162445,5 |
| 7 | 27074,25 | 189519,75 |
| 8 | 27074,25 | 216594 |
| 9 | 27074,25 | 243668,25 |
| 10 | 27074,25 | 270742,5 |
| 11 | 27074,25 | 297816,75 |
| 12 | 27074,25 | 324891 |
| 13 | 27074,25 | 351965,25 |
| 14 | 27074,25 | 379039,5 |
| 15 | 27074,25 | 406113,75 |
| 16 | 27074,25 | 433188 |
| 17 | 27074,25 | 460262,25 |
| 18 | 27074,25 | 487336,5 |
| 19 | 27074,25 | 514410,75 |
| 20 | 27074,25 | 541485 |

### 1.1.2. Option 2: based on a trend-adjusted projection of historical fuel consumption

4. In the case of replacement of existing fossil fuel-based technologies, the baseline emissions in year *y* are calculated based on a trend-adjusted projection of historical fuel consumption as follows:

$$BE_y = \sum_j FC_{j,y} \times NCV_j \times EF_{CO2,j} \qquad \text{Equation (3)}$$

Where:

$BE_y$ = Baseline emissions in year *y* (t $CO_2$)

$FC_{j,y}$ = Projected fuel consumption of fuel type *j* in year *y* (mass or volume unit)

$NCV_j$ = Net calorific value of fuel type *j* (GJ per mass or volume unit)

$EF_{CO2,j}$ = $CO_2$ emission factor of fuel type *j* (t $CO_2$/GJ)

$j$ = Fuel type used for combustion

| FC (Tonnes) | NCV(TJ/Gg) | FC (TJ) | EF | Baseline emissions fuel consumption (Diesel) kCO2/ year | Project emissions |
|---|---|---|---|---|---|
| 278,9 | 43 | 11992,4 | 74,1 | 888633,8 | 0 |

| year(n) | Emissions reduction with solar energy per year | cumulated emissions |
|---|---|---|
| 1 | 888633,8 | 888633,809 |
| 2 | 888633,809 | 1777267,618 |
| 3 | 888633,809 | 2665901,427 |
| 4 | 888633,809 | 3554535,236 |
| 5 | 888633,809 | 4443169,045 |
| 6 | 888633,809 | 5331802,854 |
| 7 | 888633,809 | 6220436,663 |
| 8 | 888633,809 | 7109070,472 |
| 9 | 888633,809 | 7997704,281 |
| 10 | 888633,809 | 8886338,09 |
| 11 | 888633,809 | 9774971,899 |
| 12 | 888633,809 | 10663605,71 |
| 13 | 888633,809 | 11552239,52 |
| 14 | 888633,809 | 12440873,33 |

| | | |
|---|---|---|
| 15 | 888633,809 | 13329507,14 |
| 16 | 888633,809 | 14218140,94 |
| 17 | 888633,809 | 15106774,75 |
| 18 | 888633,809 | 15995408,56 |
| 19 | 888633,809 | 16884042,37 |
| 20 | 888633,809 | 17772676,18 |

**Total emissions reduction with solar energy**

| year(n) | Total emissions reduction with solar energy per year | cumulated emissions reduction | |
|---|---|---|---|
| 1 | 915708,1 | 915708,1 | |
| 2 | 915708,1 | 1831416 | |
| 3 | 915708,1 | 2747124 | |
| 4 | 915708,1 | 3662832 | |
| 5 | 915708,1 | 4578540 | |
| 6 | 915708,1 | 5494248 | |
| 7 | 915708,1 | 6409956 | |
| 8 | 915708,1 | 7325664 | |
| 9 | 915708,1 | 8241373 | |
| 10 | 915708,1 | 9157081 | |
| 11 | 915708,1 | 10072789 | |
| 12 | 915708,1 | 10988497 | |
| 13 | 915708,1 | 11904205 | |
| 14 | 915708,1 | 12819913 | |
| 15 | 915708,1 | 13735621 | |
| 16 | 915708,1 | 14651329 | |
| 17 | 915708,1 | 15567037 | |
| 18 | 915708,1 | 16482745 | |
| 19 | 915708,1 | 17398453 | |
| 20 | 915708,1 | 18314161 | |
| | | 18314,16 | tC02 |

| year(n) | Total emissions reduction with solar energy per year | cumulated emissions reduction | |
|---|---|---|---|
| 1 | 915708,1 | 915708,1 | |
| 2 | 915708,1 | 1831416 | |
| 3 | 915708,1 | 2747124 | |
| 4 | 915708,1 | 3662832 | |
| 5 | 915708,1 | 4578540 | |
| 6 | 915708,1 | 5494248 | |
| 7 | 915708,1 | 6409956 | |
| 8 | 915708,1 | 7325664 | |
| 9 | 915708,1 | 8241373 | |
| 10 | 915708,1 | 9157081 | |
| 11 | 915708,1 | 10072789 | |
| 12 | 915708,1 | 10988497 | |
| 13 | 915708,1 | 11904205 | |
| 14 | 915708,1 | 12819913 | |
| 15 | 915708,1 | 13735621 | |
| 16 | 915708,1 | 14651329 | |
| 17 | 915708,1 | 15567037 | |
| 18 | 915708,1 | 16482745 | |
| 19 | 915708,1 | 17398453 | |
| 20 | 915708,1 | 18314161 | |
| | | 18314,16 | tC02 |

# 2. Monitoring methodology

5. For project activities that determine baseline emissions based on section 5.2.3 (Option 3), above the corresponding monitoring procedures prescribed in AMS-I.L. shall apply.

6. For project activities that determine baseline emissions based on the other options provided by the methodology, the relevant parameters shall be monitored as indicated in the tables below.

## 2.1. Data and parameters monitored

*Data / Parameter table 1.*

| **Data / Parameter:** | ***Continuous operation of the project unit(s)*** |
|---|---|
| Data unit: | - |
| Description: | Continuous operation of the project unit(s) |
| Source of data | Records maintained by PP/CME |

| | |
|---|---|
| Measurement procedures (if any): | Record annually the number of units operating (evidence of continuing operation, such as on-going rental/lease payments could be a substitute).<br>Where necessary refer to the "Standard: Sampling and surveys for CDM project activities and programme of activities" |
| Monitoring frequency: | Annual |
| QA/QC procedure | Check of all appliances or a representative sample thereof to ensure that they are still operating or are replaced by an equivalent in service appliance |
| Any comment: | - |

*Data / Parameter table 2.*

| **Data / Parameter:** | ***Grid availability*** |
|---|---|
| Data unit: | - |
| Description: | Availability of grid electricity |
| Source of data | Records maintained by PP/CME |
| Measurement procedures (if any): | Record the availability of grid electricity supply to households and users and the number of hours during which the grid was not available in the given calendar month.<br>Grid coverage statistics from reputable sources may be used |
| Monitoring frequency: | Continuously |
| QA/QC procedure | - |
| Any comment: | If the project activity applies paragraph **Error! Reference source not found.**, the availability of grid electricity to the households or other users shall be determined with continuous monitoring in order to determine the grid availability for any given calendar month.<br>If during a specific month the power supply from the grid to the households and users is for less than 36 hours, emission reductions can be calculated for that specific month |

*Data / Parameter table 3.*

| **Data / Parameter:** | $EF_{CO2,y}$ |
|---|---|
| Data unit: | t $CO_2$e/kWh |
| Description: | Emission factor in year *y* |
| Source of data | - |
| Measurement procedures (if any): | For Options 1 and 2, a default value from Table 1 of TOOL33 shall be applied. The project participants shall appropriately justify the choice in the PDD.<br>For option 3, $EF_{CO2}$ shall be determined as per the TOOL05 |
| Monitoring frequency: | Annual |
| QA/QC procedure | - |
| Any comment: | - |

*Data / Parameter table 4.*

| **Data / Parameter:** | $EG_{i,y}$ |
|---|---|
| Data unit: | kWh |
| Description: | Electricity generation by the project activity unit(s) type *i* in year *y* |
| Source of data | Plant records |
| Measurement procedures (if any): | Measured using calibrated meters |

| | |
|---|---|
| Monitoring frequency: | Continuous monitoring, integrated hourly and at least monthly recording |
| QA/QC procedure | - |
| Any comment: | If the project activity applies paragraph **Error! Reference source not found.**, $EG_{i,y}$ corresponds to the electricity generation in specific calendar months during which grid electricity is available to the households or other users for less than 36 hours. For any hour in which electricity is available from the grid, $EG_{i,y}$ = 0 |

*Data / Parameter table 5.*

| **Data / Parameter:** | $\boldsymbol{EC_{c,i,y}}$ |
|---|---|
| Data unit: | kWh |
| Description: | Electricity consumption by user type *c* supplied with unit type *i* in year *y* |
| Source of data | Plant records |
| Measurement procedures (if any): | The average individual electricity consumption shall be determined as either:<br>i) Average annual individual energy consumption observed in the closest grid electricity systems among grid connected consumers belonging to the same type *c;*<br>ii) Monitored electricity consumption by individual users type *c* supplied with unit type *i* |
| Monitoring frequency: | Continuous monitoring, integrated hourly and at least monthly recording |
| QA/QC procedure | - |
| Any comment: | |

*Data / Parameter table 6.*

*Data / Parameter table 7.*

| **Data / Parameter:** | $\boldsymbol{NCV_{i,y}}$ |
|---|---|
| Data unit: | GJ/mass or volume unit |
| Description: | Net calorific value of fossil fuel type *i* |
| Source of data | As per the TOOL05 |
| Measurement procedures (if any): | As per the TOOL05 |
| Monitoring frequency: | As per the TOOL05 |
| QA/QC procedure | As per the TOOL05 |
| Any comment: | - |

*Data / Parameter table 8.*

*Data / Parameter table 9.*

| **Data / Parameter:** | ***TDL*** |
|---|---|
| Data unit: | - |
| Description: | Average technical transmission and distribution losses |
| Source of data | - |
| Measurement procedures (if any): | A reasonable default value for distribution losses on low voltage rural distribution grid could be 0.2. Project proponents shall demonstrate that in the absence of the project activity electricity supply would have entailed distribution losses, e.g. users are in distributed locations, else a value of TDL = 0 shall be used |

| | |
|---|---|
| Monitoring frequency: | Determine once in the first year of the crediting period |
| QA/QC procedure | If the measurement results differ significantly from previous measurements or other relevant data sources, conduct additional measurements |
| Any comment: | - |

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**Table 1: Estimated Baseline Emissions and Emissions Reductions for Selected Village Farms.** Highlighted farms have grid tied electric pumps as a baseline instead of diesel irrigation pumps.

| Farms | Size (ha) | Generator Rating (kW) | Consumption /Hour (Liters) or (kWh) | Pump Rating (kW) | Watering Time/ha/ day (hours) | Total Watering Time/ day | Total watering time/ day with solar power | Consumption Liters/Day or KWh/Day | Diesel Consumption Growing Season (liters) | Diesel Consumption (kg) | Electricity Consumption Growing Season (kWh) | Emissions (MT) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keur Gallo | 15 | 40 | 6 | 60 | 1,00 | 15,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Mont Rolland | 5 | SENELEC | 15 | 0 | 0,00 | 15,00 | 7,00 | 105 | 0 | 0 | 18900 | |
| Djilakh | 50 | 100 | 15 | 100 | 0,67 | 33,33 | 7,00 | 105 | 18900 | 15949,71 | | |
| Guolby | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Diossong | 10 | 35 | 5,25 | 40 | 1,50 | 15,00 | 7,00 | 36,75 | 6615 | 5582,3985 | | |
| Gapakh | 5 | 20 | 3 | 30 | 2,00 | 10,00 | 7,00 | 21 | 3780 | 3189,942 | | |
| Taiba Niasséne | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Ndramé scale | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Passy Mbelbouck | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Sagna | 5 | 35 | 5,25 | 40 | 1,50 | 7,50 | 7,00 | 36,75 | 6615 | 5582,3985 | | |
| Keur Serigne Diabel | 5 | 30 | 4,5 | 30 | 2,00 | 10,00 | 7,00 | 31,5 | 5670 | 4784,913 | | |
| Kaffat | 10 | 50 | 7,5 | 60 | 1,00 | 10,00 | 7,00 | 52,5 | 9450 | 7974,855 | | |
| Makayope | 10 | 35 | 5,25 | 40 | 1,50 | 15,00 | 7,00 | 36,75 | 6615 | 5582,3985 | | |
| Malène Niani | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Goudiry | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Véliguara Tall | 5 | 35 | 5,25 | 40 | 1,50 | 7,50 | 7,00 | 36,75 | 6615 | 5582,3985 | | |
| Ndiogué Fall | 10 | 40 | 6 | 50 | 1,33 | 13,33 | 7,00 | 42 | 7560 | 6379,884 | | |
| Kafess | 50 | 100 | 15 | 100 | 0,67 | 33,33 | 7,00 | 105 | 18900 | 15949,71 | | |
| Djiocomol | 10 | 35 | 5,25 | 40 | 1,50 | 15,00 | 7,00 | 36,75 | 6615 | 5582,3985 | | |
| Soulabaly | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Marsassoum | 10 | 30 | 4,5 | 30 | 2,00 | 20,00 | 7,00 | 31,5 | 5670 | 4784,913 | | |
| Diaba | 10 | 45 | 6,75 | 60 | 1,00 | 10,00 | 7,00 | 47,25 | 8505 | 7177,3695 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sinthiang Koumembouré | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Kandio kamako | 50 | 150 | 22,5 | 250 | 0,25 | 12,50 | 7,00 | 157,5 | 28350 | 23924,565 | | |
| Thieppe | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Ouarkhokh | 10 | 50 | 7,5 | 60 | 1,00 | 10,00 | 7,00 | 52,5 | 9450 | 7974,855 | | |
| Bandègne_Gueoul | 5 | 40 | 6 | 60 | 1,00 | 5,00 | 5,00 | 30 | 5400 | 4557,06 | | |
| Diouldé Diabé | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Bamba Thialene | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Yadjine | 5 | 30 | 4,5 | 30 | 2,00 | 10,00 | 7,00 | 31,5 | 5670 | 4784,913 | | |
| Nguékhokh | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Ndioudiouf | 5 | 30 | 4,5 | 30 | 2,00 | 10,00 | 7,00 | 31,5 | 5670 | 4784,913 | | |
| Ndieguene | 10 | 100 | 15 | 70 | 0,75 | 7,50 | 7,00 | 105 | 18900 | 15949,71 | | |
| Ndiangue Dakhar | 10 | 40 | 6 | 30 | 2,00 | 20,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Mbodiene | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| Diacksao | 5 | SENELEC | 15 | 0 | 0,00 | 15,00 | 7,00 | 105 | 0 | 0 | 18900 | |
| Aga Babou | 35 | 40 | 6 | 40 | 1,50 | 52,50 | 7,00 | 42 | 7560 | 6379,884 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mandouar | 5 | 30 | 4,5 | 30 | 2,00 | 10,00 | 7,00 | 31,5 | 5670 | 4784,913 | | |
| Djinaki | 10 | 60 | 9 | 60 | 1,00 | 10,00 | 7,00 | 63 | 11340 | 9569,826 | | |
| SEFA | 10 | 40 | 6 | 60 | 1,00 | 10,00 | 7,00 | 42 | 7560 | 6379,884 | | |
| | | | | | | | total Consumption Litres/year or kWh/year | | | 278892,072 | 37800 | |

## Annex 14b: GHG Excel Sheet

Please refer to the Excel sheet in annex 22a.