Gold Standard
for the Global Goals

TEMPLATE

MONITORING REPORT

PUBLICATION DATE **14.10.2020**
VERSION **v. 1.1**
RELATED SUPPORT – **TEMPLATE GUIDE Monitoring Report v. 1.1**

This document contains the following Sections

KEY PROJECT INFORMATION

Key Project Information

GS ID (s) of Project (s)	GS 751
Title of the project (s) covered by monitoring report	National Biodigester Programme, Cambodia
Version number of the PDD/VPA-DD (s) applicable to this monitoring report	2.2
Version number of the monitoring report	3.0
Completion date of the monitoring report	08/08/2023
Date of project design certification	24/05/2011 (retroactive, 24/5/2009)
Date of Last Annual Report	N/A
Monitoring period number	4th
Duration of this monitoring period	01/01/2022 – 31/12/2022, both dates inclusive
Project Representative	National Biodigester Programme, Cambodia
Host Country	Cambodia
Activity Requirements applied	☒ Community Services Activities ☐ Renewable Energy Activities ☐ Land Use and Forestry Activities/Risks & Capacities ☐ N/A
Methodology (ies) applied and version number	TPDDTEC 3.1
Product Requirements applied	☒ GHG Emissions Reduction & Sequestration ☐ Renewable Energy Label ☐ N/A

Table 1 - Sustainable Development Contributions Achieved

Sustainable Development Goals Targeted	SDG Impact	Amount Achieved	Units/ Products
SDG 13 Climate action	Emission reductions	61,764	GSVERs
SDG 2: Zero Hunger	Area on which bio-slurry is applied	11,882	Hectare
SDG 7 - Affordable and clean energy.	Number of people benefitting from biogas	77,296	Number of people

Table 2 – Product Vintages

		Amount Achieved
Start Dates	**End Dates**	**VERs**
01/01/2022	31/12/2022	61,764

SECTION A. DESCRIPTION OF PROJECT

A.1. General description of project

The National Biodigester Programme
In January 2006, the Ministry of Agriculture, Forestry and Fisheries (MAFF) and SNV[1] agreed on the joint development of a National Biodigester Programme (NBP) as a way to create an indigenous, sustainable energy source in Cambodia and to utilize the potential of biogas in the country.

The scenario existing prior to the project activity
Before the onset of the project activities, most households with the technical potential for a biodigester rely primarily on wood for cooking both causing substantial exposure to hazardous household air pollution (with related health hazards) and contribution to deforestation.

A substantial part of the fuel wood is collected, which is both drudgery and significant time expenditure for especially women. Purchased wood on the other hand is a burden on the limited household's revenues.

In addition, unhygienic animal waste management practices with different storage system[2] such as the slurry, lagoon, dry lots, daily spread, solid storage and other; and the lack of access to basic sanitation result in pollution, foul odour, methane emissions and a relatively high prevalence of hygiene related diseases, such as diarrhoea.

The purpose of the National Biodigester Programme
The overall objective of the National Biodigester Programme is the dissemination of domestic biodigesters as an indigenous, sustainable energy source through the development of a

[1] *Please note, SNV is no longer involved in the project*

[2] See the definition of animal waste management system in Table 10.18 (Updated), IPCC 2019 carbon inventory, Volume 4 AFOLU, Chap 10.

commercial, market oriented, biodigester sector in eight selected provinces of Cambodia with the potential to expand to other provinces. The project activities aim to resolve the issues sketched of the baseline scenario above, by hygienically treating animal and human waste in a biodigester to produce a clean renewable cooking fuel, biogas, whereas the treated waste is to be used as a potent and safe organic fertilizer. The specific objectives of the National Biodigester Programme contributing to its overall objective are:

1. To increase the number of family sized, quality biodigesters with the total 8,600 biodigesters in the period 2019-2025 in selected provinces[3]
2. To ensure the continued operation of all biodigesters installed under the biodigester programme;
3. To maximise the benefits of the operated biodigesters, in particular the optimum use of digester effluent;
4. Technical and promotional capacity development of the stakeholders within the NBP for further wide scale deployment of biodigester technology in Cambodia. This objective will particularly focus on the development of a capable and viable private sector responsible for marketing, construction and after-sales service of biodigesters;

Technology implemented

NBP installs, through franchised Biodigester Company Agencies (BCA), biodigesters. The main type of digester that NBP installs is the Farmer's Friend digester and a scaled down version of this model, the S1 in the size of 2 to 15 m^3 with possibility to construct up to 50 m^3. Both technologies have an expected lifespan of over 25 years. The programme is otherwise biodigester technology agnostic, provided that technologies meet the following requirements:

1. Durability: Biodigesters are expected to last for over 10 years
2. Gas storage: The digester should be able to store at least 50% of daily gas production
3. Warrantee: A minimum warranty of 1 year shall be offered

The list of facilities, system and equipment that will be installed include:

- Inlet (for mixing the manure with water)
- Biodigester and integrated gasholder
- Compensation tank
- Slurry pit (to store overflown slurry temporarily before it is scooped to the compost hut)
- Compost hut (optional but strongly encouraged)
- Toilet (optional)
- Gas piping and water trap (water trap is necessarily to remove condense water from the biogas)
- A biogas stove (stoves disseminated via NBP are recommended but not mandatory)
- Pressure gauge (gas pressure in the plant is a proxy for gas availability)
- Biogas lamp / biogas rice cooker (both optional)

[3] This is the overall NBP's planning from 2019 to 2025 but due to the necessity to include the medium and large biodigester size for the animal farm, NBP has decided to close its implementation of phase III by end of June 2021 and start the new phase (phase IV) from 1 July 2021 onward.

The project installs continuously digesters since the start of this project on 13/03/2006 based on the demand of farmers. Dates likes construction and commissioning for each unit are captured in the project database and unique for each installation.

A.2. Location of project

>>
NBP office: General Directorate of Animal Health and Production, 371 Solar, Phnom Penh 12350
Host country: Cambodia

Table 2: GPS coordinates of the provincial capital in the current NBP provinces

#	Province	Latitude (xx° xx' xx" N)	Longitude (xx° xx' xx" E
1	Kampong Cham	11° 59' 00" N	105° 27' 00" E
2	Kandal	11° 78' 30" N	104° 81' 70" E
3	Svay Reang	11° 05' 00" N	105° 48' 00" E
4	Takeo	10° 59' 00" N	104° 47' 00" E
5	Kampong Speu	11° 27' 00" N	104° 30' 00" E
6	Kampong Chhnang	12° 00' 00" N	104° 30' 00" E
7	Kampot	10° 36' 00" N	104° 10' 00" E
8	Kampong Som	10°38’00” N	103°30’00” E
9	Kep	10°29’00” N	104°18’00” E
10	Prey Veng	11°29' 00" N	105°19' 00" E
11	Siem Reap	13°21’44” N	103°51’35”E
12	Pursat	12°32’00” N	103°55’00” E
13	Battambang	13°06’00” N	103°12’00” E
14	Kampong Thom	12°42’00” N	104°53’00” E
15	Tbong khmum	11°54’34”N	105°38’49”E
16	Phnom Penh	11°33’43” N	104°53’18” E
17	Banteay Meanchey	13°45’00” N	103°00’00”E

NBP has the long-term aim to meet the biogas potential in the whole country depending on the budget available to enlarge the geographical scope of the Program.

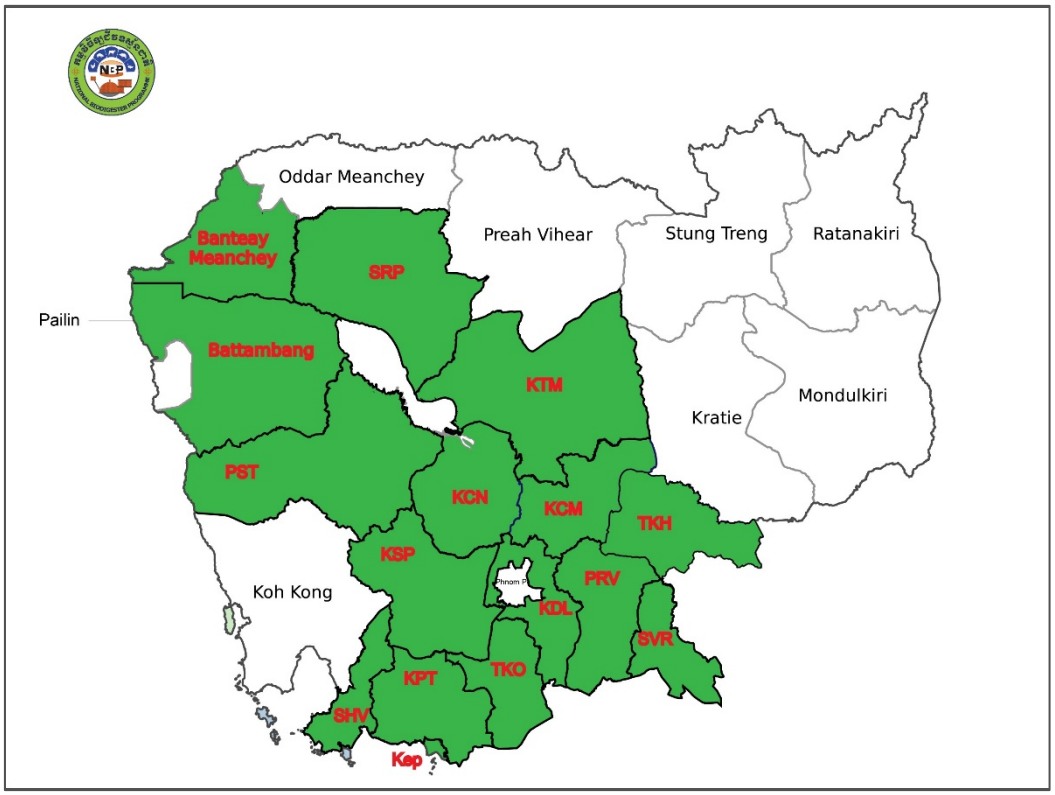

Figure 1: Provinces in which the program is active

A.3. Reference of applied methodology

>>
The methodology applied is Technologies and Practices to Displace Decentralized Thermal Energy Consumption: version 3.1.

A.4. Crediting period of project

>>
01/01/2019 – 31/12/2025 (both dates inclusive) for crediting period 3 (CPIII).

Length of crediting period: 7 years

SECTION B. IMPLEMENTATION OF PROJECT

B.1. Description of implemented project

>>
There have been no changes from the project design that was envisaged at the Design Certified PDD.

The next table tabulates the number of digesters installed since the operation of the first digester on 31/03/2006. In the project database construction dates and commissioning dates can be found.

Table 3: Total Number of units installed by year and cumulative[4]

year	Installation/year	Cumulative installations
2006	294	294
2007	1,150	1,444
2008	2,340	3,784
2009	2,616	6,400
2010	3,744	10,144
2011	4,826	14,970
2012	4,201	19,171
2013	1,115	20,286
2014	1,831	22,117
2015	2,042	24,159
2016	1,383	25,542
2017	1,043	26,585
2018	646	27,231
2019	749	27,980
2020	703	28,683
2021	292	28,975

In this monitoring period, there is no biodigester constructed under this existing carbon project GS751. Digesters installed from 01/07/2021 belong to a new project that NBP is developing, GS11138. Therefore, the number of units installed in this project has reached its maximum with 28,975 units.

The installation and commissioning dates of the digesters installed in this MP are too many to include in this MR. Instead, these dates are included in the excel file belonging to this report.

[4]ER spreadsheet sheet Gen_analysis cell B18:F:34

NBP has installed 9 different digester sizes:

Table 4: Digesters installed by size[5]

Size (m^3)	units	share (%)
2	56	0.2%
3	754	2.6%
4	16,911	58.4%
6	9,896	34.2%
7	83	0.3%
8	884	3.1%
9	25	0.1%
10	251	0.9%
15	115	0.4%
Total	28,975	100%

The most proliferated digester has a volume of 4 m^3, followed by the 6 m^3. Other digester sizes are built to a much smaller extent. The average digester size built has a volume of 4.88 m^3, the smallest average of all the years so far. This indicates that the technology is becoming more popular with smaller farmers and at the same time indicates that NBP is increasingly reaching poorer farmers.

Table 5: Units installed by digester type[6].

Model	Type	units	share (%)
Farmer's Friend	Fixed dome made from brick and concrete with biodigester plant's size of $4m^3$, $6m^3$, $8m^3$, $10m^3$ and $15m^3$.	27,319	94.3%
NBP S1	Fixed dome made from brick and concrete with biodigester plant's size of $2m^3$ and $3m^3$.	786	2.7%
Composite	Pre-fabricated digester made from fiberglasse with biodigester plant's size of $4m^3$, $7m^3$ and $9m^3$.	846	2.9%

[5] ER spreadsheet sheet Gen_analysis cell B4:D14
[6] ER spreadsheet sheet Gen_analysis cell F5:H10

Polyethylene (PE)	Pre-fabricated digester made from PE with biodigester size of 3m^3	24	0.1%
sum		28,975	100%

The main digester installed is the Farmer's friend digester followed by two models which are rapidly becoming more popular, the composite digester and the NBP S1.

Operation and maintenance and basic repairs of the digester are carried out by the end-user and for this purpose training is provided. In 2022, 54 user training courses were conducted with total 717 participants (347 women) on maintenance and operation; and 27 courses of filed demonstration were conducted to show on the effectiveness of bio-slurry usage with 540 (265 women)[7].

As stated above, NBP has installed 28,975 by 30 June 2021 and each biodigester was provided with two years of warranty. To close the warranty, an end warranty visit should be conducted by BCA. Cumulatively by end of 2021, end warranty of 26,313 plants were completed and during this monitoring period, end warranty of 715 biodigesters were completed, while the remaining 1,946 biodigesters are under end-warranty process which will be continue to be completed in the following years. It should be noted that if there are repairs necessary within the warranty period (2 years), NBP is involved as funds are disbursed to support the repairs.

In 2022, 25 biodigester plants were repaired through the request from Provincial Biodigester Programme (PBP) in which 22 are out of warranty period. Although most of the repaired plants were out of warranty and the expenses for this reparation should be paid by the biodigester owner, PBP paid for all the reparation as part of their strategic and marketing plan to reactivate the biodigester market in those villages. In addition, 40 biodigester were repaired through after sale service provided by Biodigester Construction Agent (BCA)[8]. After the warranty period, the repairs are a commercial transaction between the end-user and the BCA. NBP is only involved when there are reported issues, these are recorded in the grievance sheet, if any. See annex G.

[7] NBP 2022 annual report Executive summary
[8] See file Plant Repair In 2022 Final, tab Summary.

It should be noted that while NBP is a managing and supporting body of the programme at national level, PBP playing similar role at provincial level with the technical and financial support from NBP. BCA is a private entity that receive technical training from NBP and PBP and work as biodigester constructor in each target province as illustrated in Figure **2** and Figure **3**.

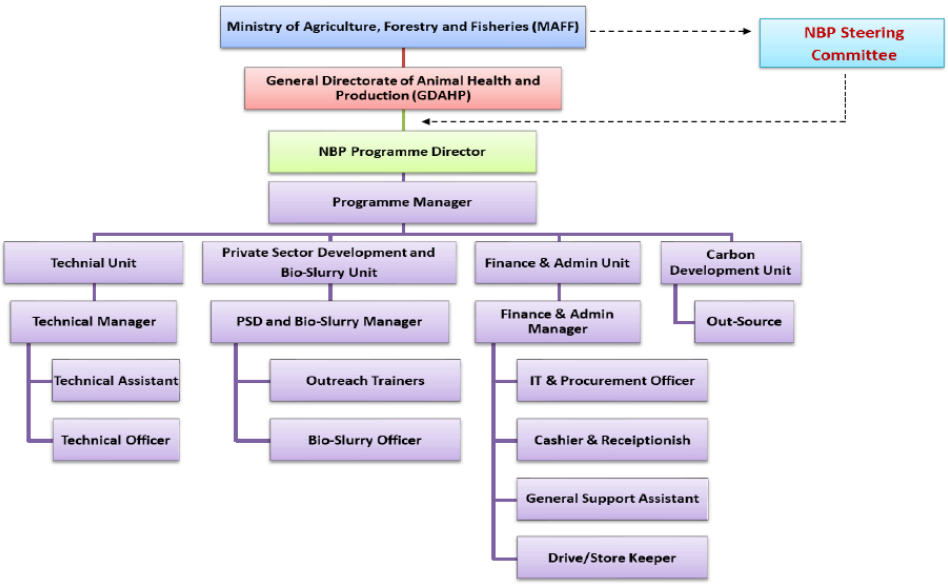

Figure 2. NBP's organizational chart

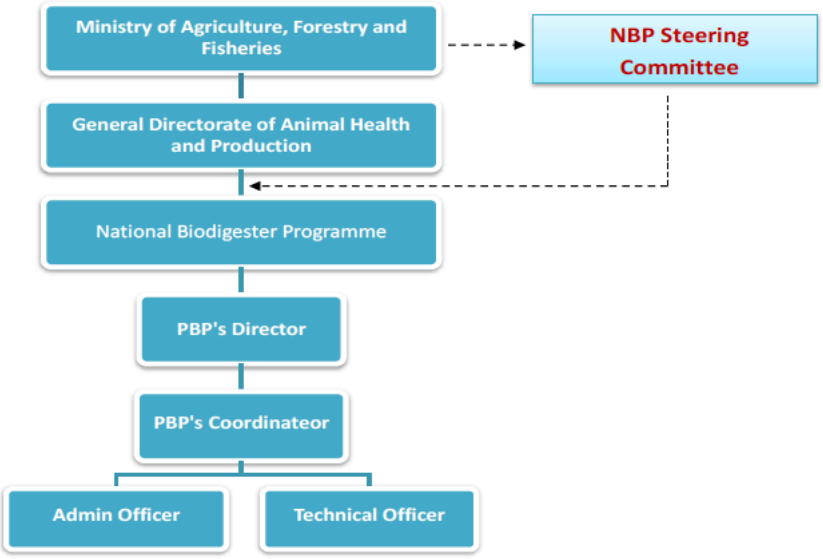

Figure 3. PBP's organizational chart

B.1.1. Forward Action Requests

N/A

B.2. Post-Design Certification changes

>>

B.2.1. Temporary deviations from the approved Monitoring & Reporting Plan, methodology or standardized baseline

>>
N/A

B.2.2. Corrections

N/A

B.2.3. Changes to start date of crediting period

>>
N/A

B.2.4. Permanent changes from the Design Certified monitoring plan, applied methodology or applied standardized baseline.

>>
N/A

B.2.5. Changes to project design of approved project

>>
N/A

SECTION C. DESCRIPTION OF MONITORING SYSTEM APPLIED BY THE PROJECT

>>
The monitoring plan in the PDD is the same as section D in this MR template. In this section the surveys are described that have been used to gather data conform registered monitoring plan. The sampling is included in section D4.

The objective of the monitoring effort conducted under this project was to meet the monitoring requirements set forth in the methodology 'Technologies and Practices to Displace Decentralized Thermal Energy Consumption' (Version 3.1), as per the PDD.

As per registered PDD a number of monitoring activities were undertaken for this monitoring period:

Survey	Description of survey	Comment
Usage survey	This survey establishes the usage rate of the technology amongst a random sample of households with the technology in each age-group. In this survey household members were interviewed during physical visits. The survey took place in Feb- March 2023	For more details on the sampling, execution, results, see section D.2 and D.4
Carbon monitoring survey (CMS)	This survey amongst technology users assesses manure management systems and baseline fuel ratio's amongst a number of other related parameters. In this survey household members were interviewed during physical visits. The survey took place concurrently with Usage survey in Feb- March 2023	
PFT	For this monitoring period, no PFT was conducted. PD uses the result of PFT in the last MP and it is in line with the registered methodology.	

The person in charge of all these monitoring activities and this report is Meng Chanvibol, the selected consultant by NBP. The surveys and the entities involved are shown in the next figure:

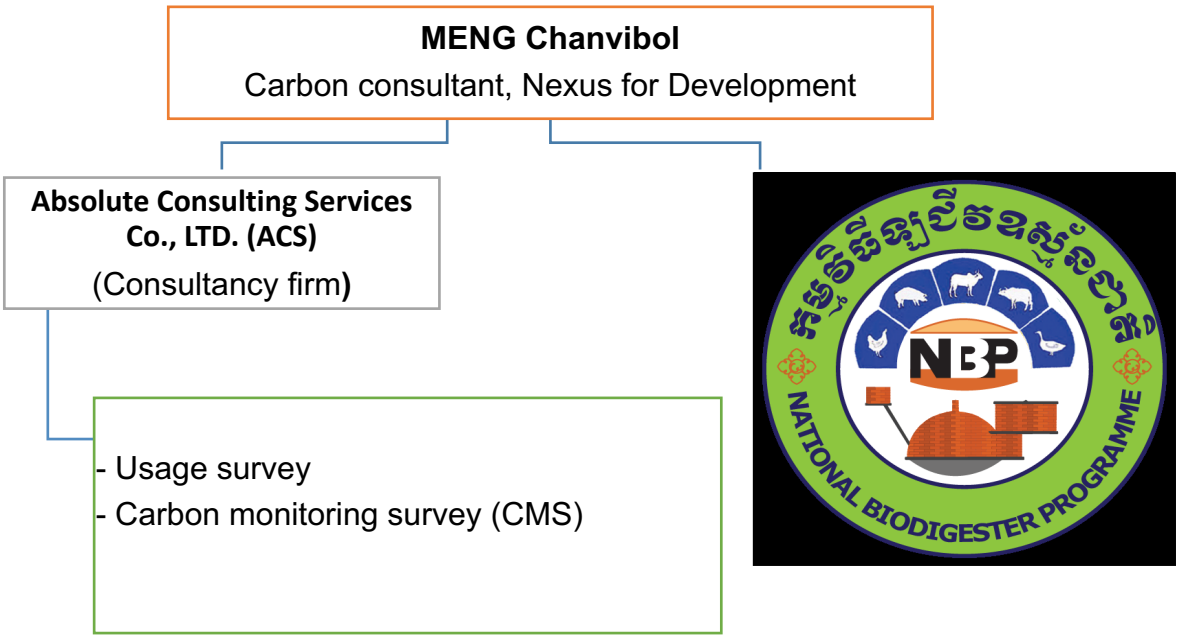

Figure 4: Surveys executed in this MP and entities involved

Meng Chanvibol: The key responsible person for the carbon monitoring is Meng Chanvibol, technical services manager of Nexus for development (https://nexusfordevelopment.org/). Vibol has been working for Nexus over 7 years and involved in many carbon projects including water filter, improved cookstove and biodigester technology. Vibol oversees all the activities, from ensuring proper data collection by the contracted parties to reporting and VVB assistance in the field.

ACS: is a consultancy firm that have experience in conducting survey and project evaluation. ACS has worked with a similar carbon project in conducting monitoring survey, recently. ACS was selected for this task by Vibol and NBP.

NBP Cambodia: NBP Cambodia is the project owner who assist in field coordination and share necessary project data for this survey.

Quality Assurance and Quality control

The project proponent is responsible for accurate and transparent record keeping, monitoring and evaluation. All supporting documentation and records for the project are easily accessible for spot checking and cross referencing by a third party.
The contact information in the project database will allow a project auditor to easily contact and visit end users. Auditors are able to cross-check pertinent project documentation, which will include archives such as sale records, completion report, financial accounts and other relevant documents per request from a third party.

Quality control on monitoring survey and test are strictly monitored, either the survey or test done by a third party or by Project Proponent, a carbon consultant is hired to guide, advise and

check the work quality. The survey or field test must follow its sampling protocol/testing protocol as detail in section D2 and D4.

Double counting

As there are other biodigesters being sold in Cambodia, there is a risk of potential double counting or including biodigesters from other organizations into this carbon project.

There are three major actions that will ensure that there is no double counting of biodigesters:

1 - Each of biodigester constructed under NBP program has a unique plant code and recorded in a plant completion report (Form No9) which is entered into project database system maintained at NBP office and can be crossed check any time.

2 - The NBP biodigester look physically different from the other biodigester in the market, making it easy to recognize them.

3 - NPB will only account for the biodigester constructed under NBP and have plant completion report recorded in project database, thus removing the risk that other biodigesters may be double counted.

SECTION D. DATA AND PARAMETERS

D.1. Data and parameters fixed ex ante or at renewal of crediting period

>>

13.2.1 "Number of countries that have communicated the establishment or operationalisation of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production.

Data / Parameter:	$EF_{,CO2}$
Unit	$kgCO_2/TJ$ fuel
Description:	CO_2 emission factor arising from use of fuels in the baseline scenario and continued use of baseline fuels in the project scenario
Source of data	2006 IPCC Guidelines defaults, see chapter 2 Stationary Combustion: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html and
Value(s) applied	Fuel *b* / $EF_{,CO2}$ ($kgCO_2/TJ$) LPG / 63,100 Charcoal in wood eq / 112,000 Firewood / 112,000
Choice of data or Measurement methods and procedures	N/A
Purpose of data	Calculation of baseline and project emissions
Additional comment	CO2 and non-CO_2 emissions factors for charcoal is the same as that of firewood as a wood to charcoal production ratio (IPCC 1996 revised guidelines, Chapter 1, page 45: http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref3.pdf) is used.

Data / Parameter:	EF_{CH4}
Unit	$kgCH_4/TJ$ fuel
Description:	CH_4 emission factor arising from use of fuels in the baseline scenario and continued use of baseline fuels in the project scenario
Source of data	2006 IPCC Guidelines defaults see chapter 2 Stationary Combustion: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html, table 2.9
Value(s) applied	Fuel *i* / $EF_{CH4,}$ (kg/TJ) LPG / 11.95 Charcoal in wood equivalent / 1,224 Firewood / 1,224
Choice of data or Measurement methods and procedures	IPCC default value

Purpose of data	Calculation of baseline and project emissions
Additional comment	CH4 emissions factors for charcoal is the same as that of firewood as a wood to charcoal production ratio (IPCC 1996 revised guidelines, Chapter 1, page 45: http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref3.pdf) is used. Some of the EF values in table 2.9 are ranges; in that case the average value is taken. The wood stove value taken is the value that has reference number 7. This stove is assumed more closely resembling the stoves in Cambodia as it is a value obtained from neighbouring countries.

Data / Parameter:	$EF_{i,N2O}$
Unit	kgN_2O/TJ fuel
Description:	N_2O emission factor arising from use of fuels in the baseline scenario
Source of data	2006 IPCC Guidelines defaults, see chapter 2 Stationary Combustion, table 2.9 http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
Value(s) applied	
Choice of data or Measurement methods and procedures	IPCC default value
Purpose of data	Calculation of baseline and project emissions
Additional comment	N_2O emissions factors for charcoal is the same as that of firewood as a wood to charcoal production ratio (IPCC 1996 revised guidelines, Chapter 1, page 45: http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref3.pdf) is used. Some of the EF values in table 2.9 are ranges; in that case the average value is taken. The wood stove value taken is the value that has reference number 7. This stove is assumed more closely resembling the stoves in Cambodia as it is a value obtained from neighbouring countries.

Fuel *i*	$EF_{i,N20}$ (kg/TJ)
LPG	2.1
Charcoal in wood equivalent	11.25
Firewood	11.25

Data / Parameter:	NCV_i
Unit	TJ/Gg
Description:	Net calorific value of the fuel i used in the baseline
Source of data	2006 IPCC Guidelines defaults, see chapter 1 Energy table 1.2 http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
Value(s) applied	

	<table><tr><th>Fuel *i*</th><th>NCV_i (TJ/Gg)</th></tr><tr><td>LPG</td><td>47.3</td></tr><tr><td>Charcoal in wood equivalent</td><td>15.6</td></tr><tr><td>Firewood</td><td>15.6</td></tr></table>
Choice of data or measurement methods and procedures	IPCC default value
Purpose of data	Calculation of baseline and project emissions
Additional comment	Charcoal is expressed in wood equivalents, and the NCV of firewood is applied

Data / Parameter:	Charcoal to wood ratio
Unit	[_]
Description:	Charcoal to wood conversion ratio
Source of data	SAR IPCC
Value (s) Applied	1:6
Choice of data or Measurement methods and procedures	N/A
Purpose of data	Calculation of baseline and project emissions
Any comment:	From IPCC 1996 revised guidelines, Chapter 1, page 45: http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref3.pdf

Data/Parameter	$B_{b1,wood}$
Unit	Tonnes/year
Description	Amount of woody biomass used in the baseline scenario b1
Source of data	BFT study MPI – file CPIII MPIV spreadsheet tab ER_FUEL D21
Value(s) applied	1.145815
Choice of data or measurement methods and procedures	Baseline fuel consumption will be determined with a Kitchen Performance Test as per the requirements of the TPDDTEC methodology.
Purpose of data	Calculation of baseline emissions
Additional comment	Fixed for CPIII. The test achieved a level of precision/confidence of 90/8 and thereby meeting the requirements. See in the same file sheet Gen_analysis Next to woody biomass, households also used 13.04897 kg LPG on average per year, this is included in the scenario B1 as emission source.

Data/Parameter	$B_{b2,charcoal}$
Unit	Tonnes/year
Description	Amount of charcoal (in fuel-wood equivalents) used in the baseline scenario b2
Source of data	BFT study MPI – file CPIII MPIV spreadsheet sheet ER_Fuel cell D27
Value(s) applied	3.6685 (expressed in wood equivalents)
Choice of data or measurement methods and procedures	Households have been asked how much charcoal they use for cooking and undergo a Kitchen Performance Test as per the requirements of the TPDDTEC methodology.
Purpose of data	Calculation of baseline emissions
Additional comment	The test achieved a level of precision/confidence of 90/12 and thereby meeting the requirements. See in the same file sheet Gen_analysis. Next to charcoal, households also used 29.701 kg LPG and 24.277 kg wood on average per year, this is included in the scenario B2 as emission source.

Data / Parameter:	GWP_{CH4}
Unit	tCO_2e per tCH4
Description:	Global Warming Potential (GWP) of methane
Source of data	AR5 IPCC
Value (s) applied	28
Choice of data or Measurement methods and procedures	N/A
Purpose of data	Calculation of baseline and project emissions
Additional comment:	Updated as per GS ruling

Data / Parameter:	GWP_{N2O}
Unit	tCO_2e per tN_2O
Description:	Global Warming Potential (GWP) of nitrous oxide
Source of data	AR5 IPCC
Value (s) applied	265
Choice of data or Measurement methods and procedures	N/A
Purpose of data	Calculation of baseline and project emissions
Additional comment:	Updated as per GS ruling

Data / Parameter:	$VS_{(T)}$
Unit	kg dry matter per animal per day

Description:	Daily volatile solid excreted for livestock category T
Source of data	Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, chapter 10 (online: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html)
Value (s) applied	Animal: kgVS/day Pig: 0.3 Buffalo: 3.9 Cow: 2.3
Choice of data or Measurement methods and procedures	IPCC default value
Purpose of data	Calculation of baseline and project emissions
Additional comment:	Any comment: 365 = basis for calculating annual VS production, days per year, region Asia and for animal weights of 319 kg for cow, 380 kg for buffalo and 28 kg for market and breeding swine. The VS value will be proportionally adjusted when credible animal weight data is available as per equation 3 of AMS-III.D v21 and see section B.6.2 of PDD.

Data / Parameter:	$Bo_{(T)}$
Unit	m^3 CH_4 per kg of VS excreted
Description:	Maximum methane production capacity for manure produced by livestock category T
Source of data	Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, chapter 10 (online: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html)
Value (s) applied	Animal T: $Bo_{(T)}$ m^3CH_4/kgVS Pig: 0.29 Buffalo: 0.10 Cow: 0.10
Choice of data or Measurement methods and procedures	IPCC default value
Purpose of data	Calculation of baseline and project emissions
Additional comment:	N/A

Data / Parameter	MCF(k)
Unit	%
Description	Methane conversion factors for each manure management system by climate zone, Cambodia located in Warm Tropical Wet for 10 months and in Warm Tropical Dry for 2

<table>
<tr><td></td><td>months based on the average monthly temperature defined in IPCC, 2019 refinement[9].</td></tr>
<tr><td>Source of data</td><td>IPCC default values from Tables 10.17, Chapter 10, Volume 4 of the 2019 refinement to the IPCC 2006 Guidelines and ER spreadsheet, Tab MS_AWMS, B15:J15.</td></tr>
<tr><td>Value(s) applied</td><td><table>
<tr><th>Anaerobic lagoon</th><th>Slurry</th><th>Dry lot</th><th>Daily spread</th><th>Solid storage</th><th>Other</th><th>Pasture</th></tr>
<tr><td>80%</td><td>74.22%</td><td>2%</td><td>1.0%</td><td>5%</td><td>1%</td><td>2%</td></tr>
</table></td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>As per requirement of the methodology and sourced from Tables 10.17, Chapter 10, Volume 4 of the 2019 refinement to the IPCC 2006 Guidelines

The IPCC is a standard, credible source of emissions factors.</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline and project emissions</td></tr>
<tr><td>Additional comment</td><td>IPCC (2019); May be updated according to any future changes by the IPCC

Category other includes manure that is sold, or not collected and the lowest MCF is adopted (of daily spread) which is conservative</td></tr>
</table>

Data / Parameter:	$LE_{p,y}$
Unit	tCO_2e/year
Description:	Leakage in project scenario during year y
Source of data	N/A
Value (s) applied	0
Choice of data or Measurement methods and procedures	N/A
Purpose of data	Calculation of leakage emissions

[9] Based on the World Bank data (https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-historical), the monthly average for January and December were 25.73 °C and 25.63°C respectively which fall under the Warm Tropical Dry (25.6 °C) and the other months fall under the Warm Tropical Wet having average monthly temperature greater than 25.9 °C refer to the IPCC, 2019 refinement, Table 10.17 (Updated).

Additional comment:	According to the methodology applied "leakage risks deemed very low can be ignored as long as the case for their insignificance is substantiated" (p.16). Section *B.6.2 table 6* of the PDD provides an overview of potential sources of leakage, including their applicability and justification for excluding the sources of leakage. The assessment deemed the leakage source negligible and are therefore not monitored. As also stated, leakage due to continuation of baseline fuels and AWMS emission from manure not fed in the biodigester and physical leakage are included in the project emission and monitored on an annual interval.

Data / Parameter:	$EF_{awms,T}$
Unit	$kgCH_4$ per animal per year for livestock type T in the project
Description:	Animal waste methane emission factor by both average temperature and region.
Source of data	ER spreadsheet, tab ER_AWMS, column H22:H24
Value (s) applied	Animal T: Value Cow: 4.249 Pig: 22.786 Buffalo: 13.808
Choice of data or Measurement methods and procedures	Calculated as per requirement of the methodology and sourced from Tables 10.A-4 through A-9., Chapter 10, Volume 4 of the 2006 IPCC Guidelines and the IPCC 2019 Based on the formula (equation 10) where VS_T, Bo_T are default value from IPCC 2006 where Asia region are used and MCF are default value from IPCC 2019 where temperature is used to define climate zone and the MS is from the baseline survey $EF_{awms(T)} = (VS_T \times 365) \times \left[Bo_T \times \frac{0.67kg}{m^3} \times \sum_k^1 \frac{MCF_{T,k}}{100} \times MS_{(T,k)}\right]$ (10) $VS_{LT,y} = \left(\frac{W_{site}}{W_{default}}\right) \times VS_{default} \times nd_y$ (11)
Purpose of data	Calculation of baseline emissions
Additional comment:	IPCC (2006, 2019) are used and may be updated according to any future changes by the IPCC.

Data / Parameter:	$\eta_{biogasstove}$
Unit	[-]%
Description:	Combustion efficiency of the biogas stove

Source of data	Centre for Energy Studies, Institute of Engineering for the Nepal Biogas Support Programme (BSP)[10]
Value (s) applied	99.4%
Choice of data or Measurement methods and procedures	N/A
Purpose of data	Calculation of project emissions
Additional comment:	BSP is the mother programme of NBP. The combustion efficiency is according to the study 99.4%. That figure is assumed reasonable and conservative

Data/Parameter	**$B_{b3,LPG}$**
Unit	Tonnes/year
Description	Amount of LPG used in the baseline scenario b3
Source of data	-Excel file CPIII MPIV spreadsheet tab ER_FUEL D33 -Excel file CPIII MPII ER spreadsheet tab BFT_LPG E71
Value(s) applied	0.078849
Choice of data or measurement methods and procedures	It is not practical to establish LPG consumption using the KPT for reasons of safety. Instead, households were be asked how often they buy a bottle and the bottle size will be recorded. Annual consumption was be calculated as: $$Annual\ LPG\ consumption\ (\frac{kg}{year}) = \frac{Bottle\ size\ (kg)}{Usage\ period\ (days)} \times 365$$
Purpose of data	Calculation of baseline emissions
Additional comment	Fixed for CPIII A level of confidence/precision of 90/14% was achieved and thereby meeting the minimum requirements stipulated by the methodology. Next to LPG, households use 314.386 kg wood per year (cell F71) of Excel file CPIII MPII ER spreadsheet tab BFT_LPG.

[10] https://www.researchgate.net/profile/Asheesh_Kumar4/post/what_are_all_the_methods_that_we_can_employ_to_increase_the_combustion_efficiency_when_LPG_is_used_as_the_fuel/attachment/59d6207e79197b807797ef48/AS%3A273821083340822%401442295441788/download/efficiency_measurement_of_biogas_kerosene_and_lpg_stoves_nepal_2001.pdf

	Please note that $B_{b3,\ LPG}$ should be in D.1 (Data and parameters fixed ex ante). However, due to the limitation of the previous BFTLPG, that BFT only assessed LPG usage and hot fuel stacking. In order to capture the full range of fuels usage for cooking, a new BFT was organized for fuel scenario-user that mainly use LPG as cooking fuel during CPIII-MPII and this value of $B_{b3,\ LPGP}$ is used as fixed parameter from CPIII-MPII onward for the whole CPIII.

D.2. Data and parameters monitored

>>
SDG 13

Data / Parameter:	**$f_{NRB,y}$**
Unit	Fraction of Non-Renewable Biomass
Description:	Non-renewability status of woody biomass fuel in scenario i during year y
Measured/calculated /default	Calculated
Source of data	fNRB assessment NBP report
Value(s) of monitored parameter	95.01%
Monitoring equipment	N/A
Measuring/reading/recording frequency:	Fixed by baseline study for a given crediting period, updated if necessary, as specified in section 3.1 of the applied methodology
Calculation method (if applicable):	N/A
QA/QC procedures:	Transparent data analysis and reporting
Purpose of data	Calculation of baseline and project emissions
Additional comment	

Data/parameter:	**$B_{p,y}$**
Unit	kg/ project household-year
Description	Quantity of biomass fuel that is consumed in the project scenario in year y
Measured/calculated/default	Measured
Source of data	-Excel file CPIII MPIV spreadsheet tab ER_FUEL cell K31:32 -Excel file CPIII MPIII spreadsheet tab ER_FUEL cell K31:32

Value(s) of monitored parameter	<table><tr><th>Fuel</th><th>Average per household (kg/year)</th></tr><tr><td>Charcoal in wood eq</td><td>63.112</td></tr><tr><td>Firewood</td><td>142.286</td></tr></table>
Monitoring equipment	Determined using survey methods, newton scale. Newton scales were checked and calibrated with the standard weight before using in the PFT between Feb and Mar 2022 (see MR of CPIII-MPIII, page 41 and 42)
Measuring/reading/recording frequency:	Biennial, starting from MPI
Calculation method (if applicable):	N/A
QA/QC procedures:	Transparent data analysis and reporting The PFT test was conducted during CP3-MPIII between Feb and March 2022 achieved a level of precision/confidence of 90/27 and thereby meeting the requirements. Per registered methodologies TPDDTEC 3.1, these values are valid for two years, thus applying this value in this MPIV is in line with the registered methodology. See in the ER file for CP3-MPIII, sheet Gen_analysis
Purpose of data:	Calculation of project emissions
Additional comments:	N/A

Data/parameter:	**$B_{p,LPG}$**
Unit	kg/ project household-year
Description	Amount of LPG used in the project scenario
Measured/calculated/default	Determined using survey methods: CMS survey
Source of data	-Excel file CPIII MPIV spreadsheet tab ER_FUEL K30 -Excel file CPIII MPIII spreadsheet tab ER_FUEL K30
Value(s) of monitored parameter	19.102
Monitoring equipment	Determined using survey methods, newton scale Newton scales were checked and calibrated with the standard weight before using in the PFT between Feb and Mar 2022 (see MR of CPIII-MPIII, page 41 and 42)
Measuring/reading/recording frequency:	Biennial, starting from MPI

Calculation method (if applicable):	It is not practical to establish LPG consumption using the KPT for reasons of safety. Instead, households were be asked how often they buy a bottle and the bottle size will be recorded. Annual consumption was be calculated as: $$Annual\ LPG\ consumption\ (\frac{kg}{year}) = \frac{Bottle\ size\ (kg)}{Usage\ period\ (days)} \times 365$$
QA/QC procedures:	N/A
Purpose of data:	Calculation of project emissions
Additional comments:	See $B_{p,y}$ for the achieved confidence/precision interval

Data/parameter:	**$B_{b,ratio}$**
Unit	%
Description	Baseline scenario ratios
Measured/calculated/default	Measured
Source of data	Excel file CPIII MPIV spreadsheet tab ER_FUEL and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis
Value(s) of monitored parameter	
Monitoring equipment	Determined using survey methods: CMS survey
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	Households will be asked which baseline scenario they fell into before receiving a biogas digester. The four baseline scenarios are defined by asking the households "what is your primary fuel source for cooking purposes?". The purpose of this question is to allocate a household to a baseline scenario, whereby 'primary' fuel consumption is defined as that fuel meeting more than 50% of their fuel needs for cooking purposes. The households that respond "firewood", for example, are subsequently allocated to the baseline scenario b1. This means that households in, for example, baseline scenario b1 may also use small amounts of fossil fuels (i.e. secondary and tertiary fuels) for cooking, which will be included in the baseline emissions.
QA/QC procedures:	Transparent data analysis and reporting

Baseline scenario	**% of users**	
Households with main fuel wood	Bb1,ratio	91.4%
Households with main fuel charcoal	Bb2,ratio	3.4%
Household with main fuel LPG	Bb3,ratio	5.2%
Households using other fuels	n/a	0.0%

Purpose of data:	Calculation of baseline emissions
Additional comments:	N/A

Data/parameter:	**$MS_{(T,S,k)}$**
Unit	[-] %
Description	Fraction of livestock category T's manure fed into the bio-digester, S in climate region k
Measured/calculated/default	Measured and calculated
Source of data	Excel file CPIII MPIV spreadsheet, tab MS_AWMS, cell C12:C14 and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis.
Value(s) of monitored parameter	**Livestock** / **% fed into Biodigester**: cow 55.86%; Pig 61.16%; Buffalo 46.88%
Monitoring equipment	Determined using survey methods: CMS survey
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	First the manure management system of the stabled animal were collected from the CMS survey in percentage together with number of hours animal staying in the stable or nearby where the manure can be collected as shown in A. Second, B is calculated B: A * Hours stabled/24 hours; as shown in B.
QA/QC procedures:	Transparent data analysis and reporting
Purpose of data:	Calculation of contribution to SDG13
Additional comments:	There is only one climate region k in Cambodia

A

Livestock	**% fed into Biodigester**	**Hours stabled**
cow	74.60%	17.97
Pig	61.67%	23.80
Buffalo	65.69%	17.13

B

Livestock	**% fed into Biodigester in 24h**
cow	55.86%
Pig	61.16%
Buffalo	46.88%

Data/parameter:	**$MS_{(P,S,K)}$**

Unit	[-]
Description	Fraction of livestock category T's manure not fed in the biodigester S in climate region k
Measured/calculated/default	Measured and calculated
Source of data	Excel file CPIII MPIV spreadsheet tab MS_AWMS cell D12:J14 and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis
Value(s) of monitored parameter	The MS of all the AWMS systems is shown below. The share not fed, is the sum of the non-biodigester AWMS systems:
Monitoring equipment	Determined using survey methods: CMS survey.
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	N/A
QA/QC procedures:	Transparent data analysis and reporting
Purpose of data:	Calculation of contribution to SDG13
Additional comments:	The sum of the MS in the table in values applied is MS_{notfed}. The PP applies IPCC Tier 2 approach and will monitor the AWMS of the MS not fed into the digester. There is only one climate region k in Cambodia. Assumed is that manure excretion is on constant during the day and night on average and that the ratio of time not stabled is MS pasture. Thus if 8 hours are spent not stabled, the MS pasture is 8/24/100 = 30%

Livestock	slurry	An lagoon	Dry lot	Daily sprea	Solid storag	Other	Pasture
cow	0.40%	0.22%	0.58%	3.89%	12.96%	0.87%	25.12%
Pig	0.00%	8.75%	0.00%	8.33%	18.03%	2.91%	0.82%
Buffalo	0.00%	0.00%	1.47%	8.47%	14.46%	0.09%	28.63%

Data/parameter:	**$N_{(T)}$**
Unit	[-]
Description	Number of animals of livestock category T per household
Measured/calculated/default	Measured
Source of data	Excel file CPIII MPIV spreadsheet, tab ER_AWMS, cell D31:D33 and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis
Value(s) of monitored parameter	
Monitoring equipment	Determined using survey methods: CMS survey
Measuring/reading/recording frequency:	Annual

Animal (T)	$N_{(T)}$
Cow	6.19
Pig	1.48
Buffalo	0.88

Calculation method (if applicable):	NA
QA/QC procedures:	Transparent data analysis and reporting
Purpose of data:	Calculation of contribution to SDG13
Additional comments:	N/A

Data/parameter:	**PL**
Unit	%
Description	Physical leakage of the biodigester
Measured/calculated/default	Measured
Source of data	Excel file CPIII MPIV spreadsheet, tab ER_AWMS, cell F51 and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis.
Value(s) of monitored parameter	0.5%
Monitoring equipment	Determined using survey methods: CMS survey
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	The PP may opt to calculate the percentage of leakage as per section A6.3 of the applied methodology. On page 68 of section A.6.3 it is stated: *Where project participants use lower values or percentage of physical leakage, they should provide measurements proving that this lower value is appropriate for the project activity.* The measurement is as follows: In case households report that their digester leak, in case there is an obvious biogas smell, or when there is visible leakage, i.e. bubbling, it is assumed that the biodigester leaks. PL is therefore calculated as: PL = 10% * %BDleak where %BDleak = the share of households with a leaking biodigester and 10% is the IPCC default value for physical leakage. In case the PP does not measure the leakage, %BDleak is 100% meaning that all plants are assumed to leak as per IPCC estimate.
QA/QC procedures:	Transparent data analysis and reporting
Purpose of data:	Calculation of project emissions

Additional comments:	Physical leakage of the bio-digester

Data/parameter:	**$W_{(site)}$**
Unit	(kg)
Description	Average pig weight at the project site (kg)
Measured/calculated/default	Measured and calculated
Source of data	Excel file CPIII MPIV spreadsheet, tab ER_AWMS, cell E14 and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis, cell D9.
Value(s) of monitored parameter	87.04
Monitoring equipment	Determined using survey methods: CMS survey
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	The weight of fattening pigs and piglets is the average between the weight entering the farm and leaving the farms. Pigs that stay for a long time at the farm, which are sows and boars, will be determined using credible methods from the literature as described in section E. In section E it is described how based on the girth and the length of the pig the weight can be determined reliably[11].
QA/QC procedures:	At least 25% of all sows shall be measured. Boars are relatively rare and in case less than 5 boars can be measured the average sow weight will be adopted as boar weight. This is conservative as male pigs attain higher weights than female pigs. For this MP, more than 25% of all sows were measure and 7 boars were measured (See US and CMS data).
Purpose of data:	Calculation of VS excretion
Additional comments:	N/A

This parameter also applies to SDG 7 and 2

Data/parameter:	**$U_{p,y}$**
Unit	Percentage

[11] As per the method described on this website http://www.thepigsite.com/articles/541/weighing-a-pig-without-a-scale/

Description	Percentage of bio-digesters in use in monitoring period y
Measured/calculated/default	Measured and calculated
Source of data	Usage and CMS survey data: Combined_Data_NBP_CP3_MP4_20230423(final), Tab, Usage_Analysis, cell L30
Value(s) of monitored parameter	50.58%
Monitoring equipment	Determined using survey methods: usage survey.
Measuring/reading/recording frequency:	Annual

<table>
<tr><td>Calculation method
(if applicable):</td><td>An assessment of the drop-off rate of usage requires that digesters of different age groups are assessed. Monitoring shall be carried out on a random sample of digesters of different ages. The minimum total sample size is 100, with at least 30 samples for biogas digesters of each age bracket (measured in annual increments) being surveyed.

The usage rate of thermal applications will be monitored annually using survey methods to satisfy the requirements put forth by the methodology 'Technologies and practices to displace decentralized thermal energy consumption' V3.1

Up will be calculated as follows:

$$U_p = U_{us} \times UP_{us} \times C_y$$

Where
<table><tr><td>Up</td><td>=</td><td>Percentage of biodigesters in use</td></tr><tr><td>Uus</td><td>=</td><td>Percentage of biodigesters in use during the usage survey</td></tr><tr><td>UPus</td><td>=</td><td>Fraction of the year that digesters were temporarily out of use due to repairs or sale of animals on average in the MP</td></tr><tr><td>Cy</td><td>=</td><td>Correction factor of the number of days out of operation biodigesters were in operation during monitoring year y. Calculated as

$C_y = 1 - \frac{OUT_y}{TOT_y}$

Where,
OUTy = cumulative plant years in operation of plants that went out of operation during in year y ((Total number of plants out of operation in the respective monitoring period* days in operation) / 365)
TOTy= Plant-year of all plants in operation in year y (plants in operation x years in monitoring period, e.g. times 1 year during annual monitoring)</td></tr></table></td></tr>
<tr><td>QA/QC procedures:</td><td>Transparent data analysis and reporting</td></tr>
<tr><td>Purpose of data:</td><td>Calculation of share of units in use</td></tr>
</table>

Additional comments:	To account for void responses and lack of availability of some households on the day of the survey, additional households within each age group should be questioned. To ensure conservativeness, participants in a usage survey with technologies in the first year of use (age 0-1) must have technologies that have been in use on average longer than 0.5 years. For technologies in the second year of use (age 1-2), the usage survey must be conducted with technologies that have been in use on average at least 1.5 years, and so on. Usage rate guideline 2.0 specifies that biogas projects can claim up to 90%. In age-group 2,3 and 4, the calculated percentage in operation is above 90%, this has been caped to 90%. All other years have a usage rate lower than 90% and no adjustments were necessary. In the data source provided, see cell J11:13 for the original value and cell K11:13 for the capped value.

This parameter also applies to SDG 7 and 2

Data/parameter:	**$N_{b,y}$**
Unit	units
Description	Number of biogas plants commissioned
Measured/calculated/default	Measured
Source of data	CPIII MPIV ER spreadsheet tab 'GEN_analysis cell D34 and the tab "DB".
Value(s) of monitored parameter	28,975
Monitoring equipment	N/A
Measuring/reading/recording frequency:	Continuous
Calculation method (if applicable):	N/A

QA/QC procedures:	100% of all plants are checked after completion of the construction by the PBP technician or by the BCAs. The main goal of NBP is to develop a market-based biogas programme and will gradually allow experienced BCAs to take over the commission check. The results of the commissioning check are recorded in Form 9, this is currently a physical document but in the coming years this may transit to using tablets. Only when Form 9 (plant completion report) is approved by NBP, data is entered into the central database.
Purpose of data:	Calculation of emission reductions
Additional comments:	$N_{b,y}$ will be determined on a monthly basis. The applied value in the calculations, however, will be the value of the previous month to allow for a 1 month period for starting up the biodigester. This is conservative because in most cases within 2 weeks biogas is being produced

SDG 2 **Indicator 2.4.1 "Proportion of agricultural area under productive and sustainable agriculture**

Data/parameter:	**$\%BS_y$**
Unit	percentage
Description	Share of households that uses bio-slurry for crop production in year y
Measured/calculated/default	Measured using survey methods: CMS survey
Source of data	Excel file CPIII MPIV spreadsheet tab SDG2&7 calculation cell F8 and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis, cell D38.
Value(s) of monitored parameter	95.70%
Monitoring equipment	Determined using survey methods: CMS survey
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	N/A
QA/QC procedures:	Transparent data analysis and reporting
Purpose of data:	Calculation of SDG contribution
Additional comments:	This question cannot be answered by farmers that have recently installed their digester outside the cropping season. They are often storing bio-slurry in their compost hut awaiting the cropping season. If these farmers are committed to apply bio-slurry during that season, they will be counted towards contributing this SDG.

Data/parameter:	Abs,h
Unit	hectare
Description	Average area per household on which bio-slurry is applied.
Measured/calculated/default	Measured
Source of data	Excel file CPIII MPIV spreadsheet tab SDG2&7 calculation cell F9 and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis, cell C43.
Value(s) of monitored parameter	0.847
Monitoring equipment	Determined using survey methods: CMS survey
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	N/A
QA/QC procedures:	Transparent data analysis and reporting
Purpose of data:	Calculation of SDG contribution
Additional comments:	Question No 41 and 41.1 are asked to each surveyed household[12]:

+Use of Bio-slurry			
41.	Do you use bio-slurry as fertilizer for your crops?	No (Skip to Q42) Yes	
41.1.	How many square meters of land (total) do you apply the bio-slurry?	m2	

SDG7 **SDG 7.2.1: Proportion of population with primary reliance on clean fuels and technology**

Data / Parameter	**$B_{daily,y}$**
Unit	percentage
Description	Share of biogas users that uses biogas at least once per day for cooking in year y
Measured/calculated /default	Measured using survey methods: CMS survey
Source of data	Excel file CPIII MPIV spreadsheet tab SDG2&7 calculation, cell F17 and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis, cell D48.
Value(s) of monitored parameter	99.713%

[12] See the CMS survey questionnaire.

Monitoring equipment	Questionnaire
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	N/A
QA/QC procedures:	Transparent data analysis and reporting
Measuring/reading/recording frequency:	Annual
Purpose of data	Calculation of SDG contribution
Additional comment	In the CMS survey question No48: Which types of biogas stove do you have now? Then, Q50&Q51; Q52&Q53; Q54&Q55, Q56&Q57 asking about number of difference type of biogas stove and their frequency of use as shown in CMS questionnaire.

Data/parameter:	**$H_{s,y}$**
Unit	Household size
Description	Number of family members permanent residing in the household in year y
Measured/calculated/default	Measured using survey methods: CMS survey
Source of data	Excel file CPIII MPIV spreadsheet tab SDG2&7 calculation cell F18 and Combined_Data_NBP_CP3_MP4_20230423(final), Tab: CMS_Analysis, cell C53.
Value(s) of monitored parameter	5.29
Monitoring equipment	Determined using survey methods
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	N/A
QA/QC procedures:	Transparent data analysis and reporting
Purpose of data:	Calculation of SDG contribution
Additional comments:	N/A

D.3. Comparison of monitored parameters with last monitoring period

Data/parameter	Value obtained in this monitoring period	Value obtained in last monitoring period
$f_{NRB,y}$	95.01%	95.01%
$B_{b3,LPG}$	Fuel: LPG; ton/year/hh: 0.078849	Fuel: LPG; ton/year/hh: 0.078849

	Charcoal	0	Charcoal	0
	Wood	0.314386	Wood	0.314386
Bdaily,y	99.71%		97%	
$H_{s,y}$	5.29		4.74	
$\%BS_y$	95.70%		97%	
Abs,h	0.847		0.69	

$B_{p,y}$

Bb,y	Average per household (kg/year)
Charcoal in wood eq	63.112
Firewood	142.286

Bb,y	Average per household (kg/year)
Charcoal in wood eq	63.112
Firewood	142.286

$B_{p,LPG}$	19.102	19.102

$B_{b,ratio}$

Fractions	Scenario	% hh
Wood	Bb1,ratio	91.4%
Charcoal	Bb2,ratio	3.4%
LPG	Bb3,ratio	5.2%
Dried manure	n/a	0.0%

Fractions	Scenario	% hh
Wood	Bb1,ratio	93.9%
Charcoal	Bb2,ratio	2.4%
LPG	Bb3,ratio	3.0%
Dried manure	n/a	0.6%

$U_{p,y}$	50.58%	38.851%
$N_{b,y}$	28,975	28,975

$MS_{(T,S,k)}$

Livestock	Biodigester
cow	55.86%
Pig	61.16%
Buffalo	46.88%

Livestock	Biodigester
cow	49.59%
Pig	27.64%
Buffalo	46.47%

$MS_{(P,S,K)}$

Livestock	slurry	An lagoon	Dry lot	Daily spread	Solid storage	Other	Pasture
cow	0.40%	0.22%	0.58%	3.89%	12.96%	0.87%	25.12%
Pig	0.00%	8.75%	0.00%	8.33%	18.03%	2.91%	0.82%
Buffalo	0.00%	0.00%	1.47%	8.47%	14.46%	0.09%	28.63%

Livestock	slurry	An lagoon	Dry lot	Daily spread	Solid storag	Other	Pasture
cow	0.39%	0.00%	0.22%	0.75%	27.28%	0.04%	21.71%
Pig	7.22%	16.69%	0.00%	1.27%	17.92%	2.18%	27.08%
Buffalo	1.23%	0.00%	0.00%	0.27%	50.31%	1.72%	0.00%

$N_{(T)}$

Animal T	N(T),h [#]
cow	6.19
pig	1.48
Buffalo	0.88

Animal T	N(T),h [#]
cow	5.35
pig	3.20
Buffalo	0.83

PL	0.5%	0.9%
$W_{(site)}$	87.04	68.52

General observations on values with significant difference:

- $H_{S,Y}$ has slightly increased, this could be attributed the sampling are different
- $U_{p,y}$ has increased back to similar level of that under CP3-MP2, this could be attributed the post COVID-19 where after service to users are back to normal after the government removes all the restriction measure in the whole country.
- $N_{b,y}$ is the same – this is simply because of the installation of biodigesters from 1 July 2021 are excluded from the current carbon project. They are counted for the new NBP phase IV carbon project.
- $N_{(T)}$ has increased, this could be the result of a favorable market and COVID-19 related restriction on cross-border trade
- W(site) has increased, this could indicate a professionalization of the sector.

D.4. Implementation of sampling plan

>>

Background of usage survey (US), carbon monitoring survey (CMS) and project fuel test

Both the US and the CMS were executed in February and March 2023 concurrently amongst a representative sample of biodigester households. For this MP, project fuel test was not executed, PD uses the result from the last fuel test conducted in 2022 and it is in line with the registered methodology in which the result of the test is valid for two years.

The US provides a single usage parameter that is weighted based on drop off rates that are representative of the age distribution for project technologies in the database. A usage parameter must be established to account for drop off rates as project technologies age and are replaced. Prior to a verification, a usage parameter is required that is weighted to be representative of the quantity of project technologies of each age being credited in a given project scenario.

The CMS is executed with the objective to obtain reliable and unbiased data on the impact of the program on sustainable development (SD) and on GHG emission modalities, such as fossil and fuel wood consumption and manure management practices. The questionnaire also included a number of questions on potential sources of leakages other than physical leakage, incomplete combustion and continues use of baseline fuel, despite the fact that it demonstrated during PDD development that leakage is negligible and does not have to be monitored. In fact, no sources of leakage were ever identified during CPI and CPII

US and CMS design

For this monitoring period, instead of conducting the usage survey by themselves as in the previous MPs, NBP has contracted ACS consulting company to conduct both US and CMS. This is being done to reduce the workload of NBP's staff. So that they have more time to focus on

their work supporting promotion and providing after-sales services. Furthermore, a third-party conducting monitoring survey may reduce the conflict of interest.

Thus, for this MP, sampling method is designed slightly different from what as described in PDD. However, the approach is in line with the registered methodology as detail below:

- **Sample size estimation**

Based on the GS's TPDDTEC V3.1 and project database, a proposed sample plan and sample size are made as following:

Table 6. Sample size per each survey

No	Sample per survey	Number of sample (planned)	Actual implementation	GS min requirement	Source
1	Usage survey	624	624	450	TPDDTEC V3.1
2	CMS survey	374	349	100	TPDDTEC V3.1
Total sample (Max of all the smaple size)		624	624	Calculated	
Number of survey household per village		10		Assumption	

Based on Table 6, the total surveyed households are estimated to be 624 including both active users (still use biodigester) and non-active users (stop using the biodigester) which is more than the minimum requirement from GS (450, (30*15 age group). First the US is conducted, then if the user is an active user, then CMS will be conducted otherwise move to next household (see Figure 5). Based on previous usage rate, it is expected that among 624 users, about 374 household are still using the Biodigester while the actual survey there was only 349 users which lower than anticipated but higher than GS minimum sample size of 100 households.

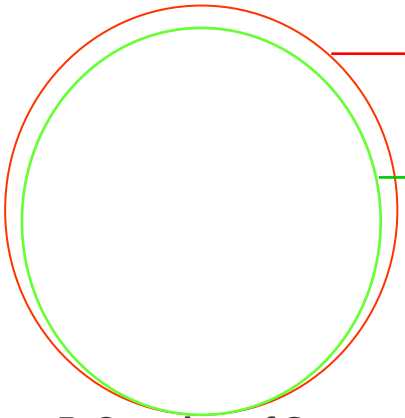

Figure 5. Overview of Survey sample

- **Sample selection**

The selection of provinces should be done based on both the Cambodia region classification (Plateau/mountains, Tonle Sap lake Zone, Plain Zone and Costal Zone) and the top sale province of each zone. This is done to reduce the burden on the finance for this survey without compromising its representativeness. It is observed that the 7 selected provinces cover more than 80% of the total users and spread out across the four regions of Cambodia as shown in

Table 7. The number of villages per selected provinces is calculated proportionally to its sale share of the provinces. To reduce the logistic arrangement 10 households per village will be selected for interview which result in 62 villages to be visited (theoretically). However, based on the usage survey requirement (15 age groups) and actual sale data per selected villages, the total villages to be visited are 65 villages.

Table 7. Selected provinces

No	Cambodia Region	Province	# plants	Share per province (%)	# sample	# Village (theoretically calculated)	# Village (classifying with 15 age groups)
4	Plateau/Mountains	Kampong Spue	3,127.00	13.13%	82	8	7
3	Tonles Sap Lake Zone	Kampong Chhnang	1,559.00	6.55%	41	4	5
13	Plains Zone	Prey Veng	2,587.00	10.86%	68	7	6
16		Svay Rieng	4,208.00	17.67%	110	11	13
17		Takeo	5,264.00	22.10%	138	14	14
9		Kompomg Cham	2,360.00	9.91%	62	6	7
6	Coastal	Kampot	4,714.00	19.79%	123	12	13
	Total		23,819.00	100.00%	624	62	65
	Share of total recorded users		82%				

The following figure depicts the locations of the survey, which are all concentrated in the areas were by far the most digesters are installed over 80% of the total:

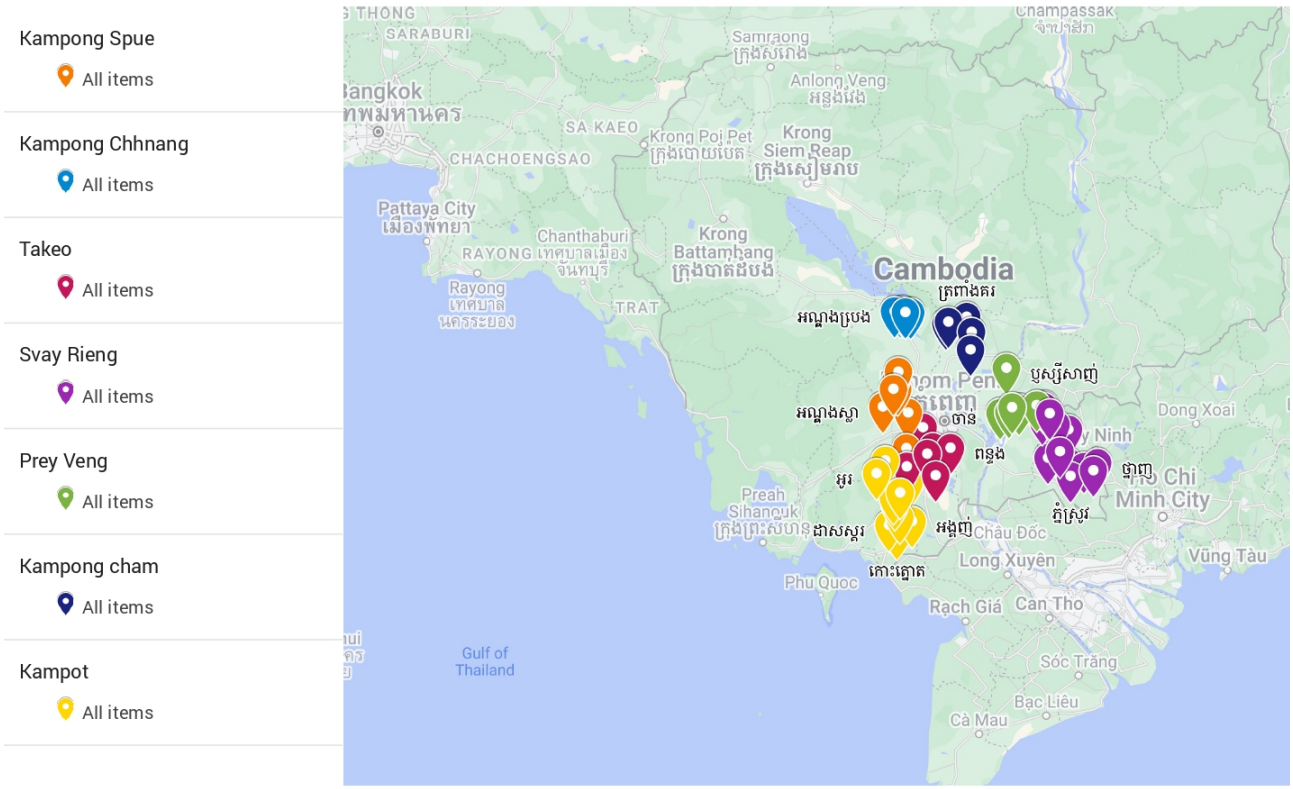

Figure 6. Selected 7 provinces and 65 villages

The next table shows the number of households selected by age group and the population of units that belongs to that age group:

Table 8: Usage survey selection by age group

Age group	Period, inclusive of begin and end date		Units built in that period (age group population)	Planned sample (at cluster random)	Actual sample[13] (at cluster random)
1 to 2	1-Jul-20	30-Jun-21	694	40	34
2 to 3	1-Jul-19	30-Jun-20	684	40	37
3 to 4	1-Jul-18	30-Jun-19	668	38	37
4 to 5	1-Jul-17	30-Jun-18	832	40	31
5 to 6	1-Jul-16	30-Jun-17	1,092	42	45
6 to 7	1-Jul-15	30-Jun-16	1,892	42	38
7 to 8	1-Jul-14	30-Jun-15	1,906	42	54
8 to 9	1-Jul-13	30-Jun-14	1,527	41	37
9 to 10	1-Jul-12	30-Jun-13	2,232	43	47
10 to 11	1-Jul-11	30-Jun-12	4,450	43	53
11 to 12	1-Jul-10	30-Jun-11	4,793	43	45
12 to 13	1-Jul-09	30-Jun-10	3,079	47	49
13 to 14	1-Jul-08	30-Jun-09	2,504	41	44
14 to 15	1-Jul-07	30-Jun-08	1,956	42	33
15 to 16	13-Mar-06	30-Jun-07	666	40	40
Total				**624**	**624**

[13] Usage and CMS data sheet, tab Usage_Analysis cell D11:D25. During the actual survey, some selected household's owner were not at home. To cope with this, replacements were made and this leads to the differences between the planned samples and actual samples per age group. However, the minimum number of survey households per age group is more than 30 which is in line with the registered methodology.

The next table shows the sampling plan of the US and CMS.

Table 9: US and CMS survey design summary

Item	Conversion in US
Sampling objective	The objective of the sampling effort is to obtain reliable data for the US and CMS survey
Field Measurement Objectives and Data to be collected	The survey will consist of household visit in random selected end-users to collect (1) for US: usage data and (2) for CMS: the impact of the program on sustainable development (SD) and on GHG emission modalities, such as fossil and fuel wood consumption and manure management practices.
Target Population and Sampling Frame	The sampling frame will be drawn from the database of each age group
Sampling method (approach)	Please refer to the sample size and sample selection sections above.
Implementation	The US and CMS were executed concurrently in February and March 2023 by ACS, consulting company under the supervision of NBP's carbon expert.
Desired Precision/Expected Variance and Sample Size	The minimum total sample size is 100, with at least 30 samples for project technologies of each age being credited. The applied methodology does not prescribe a desired precision. However, the total sample size is much larger than 100, see Table 8 for details.
Procedures for Administering Data Collection and Minimizing Non-Sampling Errors	The survey was executed ACS's enumerator who has more than three years up to over ten years of the same or similar survey.

Implementation of usage guideline 2.0 is demonstrated in the table below:

Mandatory requirements	Definition	Implementation
Define use and non use	Use = using biogas at least once daily Non-use is defined as a period without using biogas. Monitored will be the 'down-time' of biogas plants, thus in case there are periods without biogas	Biodigester usage, non-usage, and temporarily non-usage has been monitored the usage survey

	due to lack of feeding, technical issues or other reasons.	
In person household usage survey	The project developer shall carry out an in-person usage survey to determine the project technology use. The sampling will follow the guidance in the applied methodology. In addition, the usage survey will cover: - Kitchen observations to asses if the technology is indeed used - Interview with the main cook or a person frequently involved in cooking. In case the main cook is not available, it is permissible to follow up with phone calls to confirm collected data from other household members - Photo's of cooking areas (only after consent is obtained) - GPS coordinates collection	Kitchen observations took place and are recorded. The main cook was interviewed each time. Photos of the cooking areas are recorded GPS coordinates are standard and included in the excel sheets
Verification checks	The verification checks of survey data shall be performed by the project developer prior to verification by the Verification/Validation Body (VVB).	All the data are verified and crossed cheeked by field manager for any irregular data, the enumerators will be asked and a follow upcall to end user is made.

Survey selection and survey teams:

The ACS Survey Team consisted of a lead consultant, field coordinator and 10 trained and experienced surveyors. All the data collectors have extensive experience in interviewing households in the rural areas. The field coordinator used to coordinate the US and CMS with good quality of deliverables, while the 10 enumerators used to conduct similar carbon monitoring survey with the field experience from three to over ten years. To ascertain that all surveyors have the same understanding and to update their knowledge on the subject a three-day training was organized, and this included a test in the field. A separate training report and participant list is available at request.

Questionnaire: A combined questionnaire[14] for both usage and CMS's survey was developed by the carbon consultant, NBP and ACS based on last MP usage and CMS questionnaire. Then, the questionnaire was put into digital format using the application KoBoCollect (https://www.kobotoolbox.org/) for field data collection[15]. The aim of using this method was to improve data collection, data consistency and to reduce costs. The questionnaire was pilot tested during the surveyor training using tablets or mobile phones on which the application was installed. Feedback from the field was used to finalize and improve the questionnaire. Subsequently, the questionnaire was translated into Khmer.

SECTION E. CALCULATION OF SDG IMPACTS

E.1. Calculation of baseline value or estimation of baseline situation of each SDG Impact

>>

Goal 2 contribution

SDG 2.4.1: Proportion of agricultural area under productive and sustainable agriculture

Target: Total area on which bio-slurry is applied

This will be calculated with the following equation

$$A_{bs,y} = N_{b,y} \times U_{p,y} \times \%BS_y \times A_{bs,h,y} \quad \textbf{(4)}$$

Where:

$A_{bs,y}$	=	Total area on which bio-slurry is applied in year y in hectare
$N_{b,y}$	=	Total number of biodigesters in year y
$U_{p,y}$	=	Usage rate in year y
$\%BS_y$	=	Share of households that use bio-slurry for crop production in year y
$A_{bs,h,y}$	=	Average area per household on which bio-slurry is applied in year y

Baseline situation: In the baseline no construction of biodigesters occurred. Therefore, baseline outcome benefit is zero

[14] Combined questionnaire US and CMS
[15] Combined questionnaire US and CMS in Kobo Collecttool format.

Goal 7 contribution:
SDG 7.2.1: Proportion of population with primary reliance on clean fuels and technology

Target: Number of people benefitting from biogas

This will be calculated with the following equation

$$P_{clean,y} = N_{b,y} \times U_{p,y} \times B_{daily} \times H_{s,y} \quad \textbf{(5)}$$

Where:

$P_{clean,y}$	=	Total number of households using primarily biogas in year y
$N_{b,y}$	=	Total number of biodigesters in year y
$U_{p,y}$	=	Usage rate in year y
$B_{daily,y}$	=	Share of biogas households that uses biogas at least once per day for cooking in year y
$H_{s,y}$	=	Number of family members permanent residing in the household in year y

Baseline situation: In the baseline no construction of biodigesters occurred. Therefore, baseline outcome benefit is zero

Goal 13: Baseline estimate/ emission reductions

SDG 13.2.1 "Number of countries that have communicated the establishment or operationalisation of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production

The baseline for this project is determined in accordance with the following paragraph from the applied methodology:

"the baseline emissions involve emission from use of fossil fuel and non-renewable biomass for cooking and heating, and emissions from the handling of animal waste in the baseline situation"

1. Estimation of the baseline emission from the thermal energy demand (BE_{th})

Emission reductions are credited by comparing fuel consumption in a project scenario to the three baseline scenarios. As the baseline fuel and the project fuel and the corresponding emission factors are different, the overall GHG reductions achieved in year *y* are calculated as follows (equation 2 TPDDTEC V3.1):

$$\mathbf{ER_y} = \sum_{b,p1} N_{p1,y} * U_{p,y} * \left(f_{NRB} * ER_{b,p,y,CO2} + ER_{b,p,y,non-CO2}\right) - \sum LE_{p1,y} \quad \textbf{(6)}$$

Where:

$\sum_{b,p}$	Sum over all relevant (Baseline b/project p) couples

$N_{p,y}$	Cumulative number of biodigesters months[16] included in the project database for project scenario p in against baseline scenario b in year y. $N_{p,y}$ applied is the value of last month to allow for a 1 month period for digester starting up. This is conservative because in most cases within 2 weeks biogas is being produced
$U_{p,y}$	Cumulative usage rate for technologies in project scenario p1 in year y, based on cumulative adoption rate and drop off rate (fraction)
$ER_{b,p,y,CO2}$	Specific CO_2 emission savings for an individual technology of project p1 against an individual technology of baseline b1, b2, b3 in year y, in tCO_2/year, and as derived from the statistical analysis of the data collected from the field tests
$ER_{b,p,y,non\text{-}CO2}$	Specific non-CO_2 emission savings for an individual technology of project p1 against an individual technology of baseline b1, b2, b3 in year y, converted in tCO_2/year, and as derived from the statistical analysis of the data collected from the field tests
f_{NRB}	Fraction of biomass used that can be established as non-renewable biomass
$LE_{p1,y}$	Leakage for project scenario p1 in year y (tCO_2e/yr)

Charcoal emissions will be calculated by expressing the total amount of charcoal consumed in wood equivalents and multiplying this with the wood emission factors. The applied charcoal to wood ratio is 1 to 6 as per IPCC 1996 revised guidelines chapter 1 page 45[17].

As specific non-CO_2 emission savings are treated in a separate equation: see

$$\sum ER_{CO2,y} = (\sum BE_{b,CO2,y} - \sum PE_{p1,CO2,y} - \sum LE_{p1,CO2,y}) * U_{p1,y} \quad \textbf{(7)}$$

Where:

$\sum ER_{CO2,y}$	Cumulative CO_2 emission reductions from the substitution of non-renewable biomass and fossil fuels

[16] Contrary to the methodology NBP measures this in months and not days as it takes 2 weeks before biogas is produced. In each case, the next month after installation is taken as the technology starting date of operation which is conservative.

[17] http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref3.pdf

$\sum BE_{b,CO2,y}$ Cumulative baseline emissions as calculated below under formula (**8**)

$\sum PE_{p1,CO2,y}$ Cumulative project emissions as calculated below under formula (**14**)

$\sum LE_{p1,CO2,y}$ Cumulative leakage as per methodology guidance[18]

$U_{p1,y}$ Cumulative usage rate for technologies in project scenario p1 in year y, based on cumulative adoption rate and drop off rate (fraction)

The following formula calculates the baseline emissions per household (equation 3 of TPDDTEC v3.1):

$$BE_{b,y} = B_{b,y} * ((f_{NRB,\,y} * EF_{b,fuel,\,CO2}) + EF_{b,fuel,\,nonCO2}) * NCV_{b,\,fuel} \quad \textbf{(8)}$$

Where:

$BE_{b,y}$	Emissions for baseline scenario b during the year y in tCO2e
$B_{b,y}$	Quantity of fuel consumed in baseline scenario b during year y, in tons, as per by-default factors (cases with project performance field test only)
$f_{NRB,\,y}$	Fraction of biomass used during year y for the considered scenario that can be established as non-renewable biomass (drop this term from the equation when using a fossil fuel baseline scenario)
$NCV_{b,fuel}$	Net calorific value of the fuel that is substituted or reduced (IPCC default for wood fuel, 0.015 TJ/ton)
$EF_{b,fuel,CO2}$	CO_2 emission factor of the fuel that is substituted or reduced. 112 tCO2/TJ for Wood/Wood Waste, or the IPCC default value of other relevant fuel
$EF_{b,fuel,nonCO2}$	Non-CO_2 emission factor of the fuel that is substituted or reduced

2. Baseline and project emissions from AWMS:

[18] Technologies and practices to displace decentralized thermal energy – v3.1 p.20

The emissions from the animal waste management system of the baseline are determined using the IPCC 2006 Tier 2 approach. This approach is applicable for households with distinctive animal waste management system, where the majority of the waste is collected and where the animals are kept near the houses. The following formulas are used to estimate the animal waste management emissions.

$$BE_{awms,h} = GWP_{CH\ 4} * \sum_T (EFawms(T) * N(T), h) \quad (9)$$

Where

$BE_{awms,h}$	=	The baseline emission from handling of animal waste in for premise h (tCO_{2e} per year)
N(T),h	=	Number of animals of livestock category T in premise h
$EF_{awms,(T)}$	=	Emission factor for the defined livestock category T, (tonCH4 per animal per year)
GWP_{CH4}	=	Global warming potential of methane (tCO_2e per tCH4): 28

The emission factor ($EF_{awms(T))}$ for tier 2 approach is calculated as follows (equation 16 of the applied methodology),

$$EF_{awms(T)} = (VS_{\mathrm{T}} \times 365) \times \left[Bo_{\mathrm{T}} \times \frac{0.67kg}{m^3} \times \sum_k^1 \frac{MCF_{T,k}}{100} \times MS_{(\mathrm{T,k})}\right] \quad \textbf{(10)}$$

Where:

$EF_{awms(T)}$	=	CH_4 emission factor for livestock category T, (tCH_4 per animal per year)
$VS_{(T)}$	=	Daily volatile solid excreted for livestock category T, kg VS.animal $^{-1}$
365	=	Basis for calculating annual VS production, days yr^{-1}
Bo_T	=	Maximum methane producing capacity for manure produced by animal T m^3 CH_4 kg^{-1} of VS
0.67	=	Conversion factor of m^3 methane to kg methane
$MCF_{T,K}$	=	Methane conversion factors for the animal waste handling system from livestock category T of MS system k
$MS_{T,k}$	=	Fraction of livestock category T's manure in the animal waste management system k

Country specific default data is not available for VS, Bo, MCF and MS. Thus, IPCC 2006 and IPCC 2019 default values will be used. VS and Bo are from default value of IPCC 2006, MCF is

from IPCC 2019, while MS is obtained from CMS survey. IPCC 2006 default values is used for VS except for pigs which is determined ex-post with the following equation[19]:

$$VS_{LT,y} = \left(\frac{W_{site}}{W_{default}}\right) \times VS_{default} \times nd_y \qquad \textbf{(11)}$$

Where:

W_{site}	=	Average animal weight of a defined livestock population at the project site (kg)
$W_{default}$	=	Default average animal weight of a defined population, this data is sourced from IPCC 2006 guidelines (kg)
$VS_{default}$	=	Default value for the volatile solid excretion rate per day on a dry-matter basis for a defined livestock population (kg dm/animal/day)
nd_y	=	Number of days in year *y* where the animal manure management system is operational
$VS_{LT,y}$	=	Adjusted VS value for year y

The average weight (Wsite) is the average of entry weight at the farm and weight when the pig leaves the farm. Farmers are often able to estimate the weight of fattening pigs reliably as the weight of birth is known and the value of selling the pigs is based on their weight. However, in the case of boars and sows this is not known as those animals are not sold and reside on the farm. In order to ascertain the weight of sows and boars, the method described on the Pig Site[20] was adopted, which is a common practice in the livestock industry and this was done during the last 4 verifications. This is possible with the following equation:

$$Pig\ weight = Hg^2 \times L \times 69.3 \qquad \textbf{(12)}$$

Where:

Hg	=	Hearth girth in meter
L	=	length in meter

The Hg and the L are explained in the figure below:

[19] As per equation 3 of AMS-III.D v21

[20] As per the method described on this website http://www.thepigsite.com/articles/541/weighing-a-pig-without-a-scale/

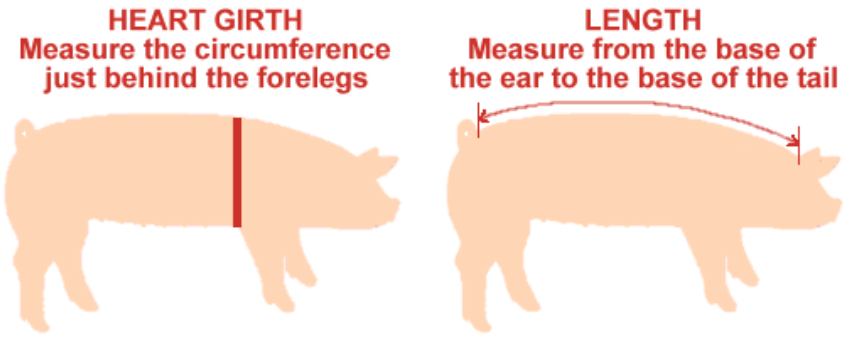

Figure 7: Hearth girth and length measurement

It is however challenging to measure sows and boars, as these are large animals weighing over 120 kg and sometimes over 180 kg and do not stand still and may behave aggressively. Previous experiences have shown that it is possible to divert attention of sows by giving them something to eat, but nevertheless, it remains a challenge. It is expected however that at least 25% of sows in the survey population can be measured.

The next equation from the methodology is used to calculate the project emissions from the biodigester system, the emission resulting from physical leakage (PL_y) and resulting from incomplete combustion.

$$PE_{awms,h,y} = GWP_{CH4} \times \sum\left(N_{(T),h,y} \times EFawms_T\right).PL_y + \sum\left(N_{(T),h,y} \times EFawms_T\right) \times \left(1 - \eta_{biogasstove}\right)(1 - PL_y) \quad \textbf{(13)}$$

Where:

$N_{T,h,y}$	=	Number of animals of livestock category T in year y in premise h
EF_{awmsT}	=	Emission factor for the defined livestock category T, (ton CH_4 per animal per year).
PL_y	=	Physical leakage of the biodigester in year *y* (10 %)[21]

[21] Default value of the applied methodology is adopted (TPDDTEC page 68)

GWP_{CH4}	=	Global Warming Potential (GWP) of methane (tCO_2eq per tCH_4): 28
$\eta_{biogasstove}$	=	Combustion efficiency of the biogas stove

Using the formulas from above the baseline estimate is calculated on a per month basis and the summed to obtain the total baseline emissions in this MP (AWMS and thermal energy). The total is 69,458 tCO2[22]

E.2. Calculation of project value or estimation of project situation of each SDG Impact

>>
SDG2
The Area on which bio-slurry is applied is estimated to be 11,882 hectare[23] based the below formula and the result for usage and CMS survey.

SDG 2 **Zero hunger**

$$A_{bs,y} = N_{b,y} \times U_y \times \%BS_y \times A_{bs,h,y}$$

Where:		Description	Value	Comment
$A_{bs,y}$	**=**	**Area on which bio-slurry is applied**	11,882	Hectare
$N_{b,y}$	=	Total number of biodigesters in year y month 11	28,975	Value of month 11 taken to account for digester start up time (if applicable)
U_y	=	Usage rate in year y	50.58%	Usage survey
$\%BS_y$	=	Share of households that uses bio-slurry for crop production in year y	95.70%	CMS survey
$A_{bs,h,y}$	=	Average area per household on which bio-slurry is applied in year y	0.85	CMS survey

SDG7
The number of people benefiting from biogas is estimated be 77, 296 people[24] based on below formula and the result from usage and CMS survey.

[22] See ER spreadsheet SDG2,7,13_database_month cell O17
[23] See ER spreadsheet SDG2&7_Cal F5
[24] See ER spreadsheet SDG2&7_Cal F14

SDG 7	Ensure access to affordable, reliable, sustainable and modern energy for all				
	$P_{clean,y} = N_{b,y} \times U_y \times B_{daily} \times H_{s,y}$				
	Where:		Description	Value	Comment
	$P_{clean,y}$	**=**	**Number of people benefitting from biogas**	77,296	total household members
	$N_{b,y}$	=	Total number of biodigesters constructed at the end of year y	28,975	Value of month 11 taken to account for digester start up time (if applicable)
	U_y	=	Usage rate in year y	50.580%	Usage survey
	$B_{daily,y}$	=	Share of biogas households that uses biogas at least once per day for cooking in year y	99.713%	CMS survey
	$H_{s,y}$	=	Number of family members permenent residing in the household in year y	5.29	CMS survey

SDG 13: Estimation of project emissions

The project emission is happened due to the continuation of using baseline fuel in the project scenario.

Project emissions:

The project scenario is defined by the fuel consumption of end users within the targeted population that adopts the biodigester technology. This formula calculates the project emissions per household (as per equation 5 of TPDDTEC v3.1)

$$PE_{p,y} = B_{p,y} * ((f_{NRB,\,y} * EF_{p,fuel},\, CO_2) + EF_{p,fuel},\, _{nonCO2}) * NCV_{p,\,fuel} \quad \textbf{(14)}$$

Where:

$PE_{p,y}$	Emissions for project scenario p during year y in tCO2e
$B_{p,y}$	Quantity of fuel consumed in project scenario p during year y, in tons, and as derived from the statistical analysis conducted on the data collected during the project performance field tests (cases when no baseline performance field test are performed, e.g. by-default baseline factors)
fNRB, y	Fraction of biomass used during year y that can be established as non-renewable biomass (drop this term from the equation when using a fossil fuel baseline scenario)
$NCV_{p,fuel}$	Net calorific value of the project fuel (IPCC default for wood fuel, 0.015 TJ/ton). This is equal to the baseline fuel NCV in projects which use the same fuel.

$EF_{p,fuel,CO2}$	CO_2 emission factor of the project fuel. This is equal to the baseline fuel EF in projects which use the same fuel, 112 tCO2/TJ for Wood/Wood Waste, or the IPCC default value of other relevant fuel
$EF_{p,fuel,nonCO2}$	Non-CO2 emission factor of the project fuel. This is equal to the baseline fuel EF in projects which use the same fuel.

Fuel usage data for the three baseline scenarios and project scenario was collected by the PFT survey, as explained above. Not all fuels will be replaced by biogas. The table below shows the outcome of the PFT that was organized for this MP and the project emissions associated:

Table 10: Estimated project emissions from thermal energy use

Fuel *i*	Average per household	Calculated PE
	(kg/year)	(tCO_2e/yr)
LPG	19.102	0.058
Charcoal in wood eq	63.112	0.141
Firewood	142.286	0.319

The project emissions are then, after adjustment with the usage rate and by multiplying with the number of units installed 7,594 tCO2[25]

E.3. Calculation of leakage

>>

Emissions attributed to AWMS in the project scenario, incomplete combustion and physical leakage

The project emissions involve emissions from the bio-digester, which include physical leakage and incomplete combustion of biogas, as well as emissions from the animal waste not treated in the bio-digester.

[25] See ER spreadsheet SDG2,7,13_database_month cell Q17

The EF_{AWMS} in the project scenario has been calculated using the IPCC Tier 2 approach using default values for the maximum methane potential (Bo), volatile solids excretion (VS) and methane density and the manure management category biodigester.

Table 11: Emission factor for the defined livestock category T of the project situation[26]

Animal	Volatile Solids (VS) (kg/day)	Maximum Methane potential (Bo_T)	∑MCF x MS	Density methane (kg/m^3)	EF_{AWMS} ($kgCH_4$/head/year)
Cow	2.300	0.100	7.272%	0.670	**4.090**
Pig	0.734	0.290	14.146%	0.670	**9.356**
Buffalo	3.900	0.100	6.099%	0.670	**5.817**

The project emissions are then the multiplication of the EF_{AWMS} with the physical leakage emissions and the stove efficiency, see section D for the default values. The physical leakage estimate was obtained from the survey as determined per section D.2.

In total 19 households out of 349 suspected leakage, the percentage with a leaking plant is then 19/349 = 5%. PL was then determined as 5% * 10% = 0.5%.

In the next table the calculated physical leakage emissions from the biogas plant and the stoves are shown:

Table 12: Physical leakage emission from biodigester[27]

Animal	PL_{AWMS} (tCO_2/year)	PL_{stove} (tCO_2/year)
Total	0.0067	0.00004

Other leakage sources:

Practically all household keep their baseline stove, 345 out of 349, which is logical as the amount of biogas produced is fixed while the thermal energy requirement varies with the number of

[26] NBP CPIII-MPIV ER spreadsheet sheet ER_AWMS cell C41:H45
[27] NBP CPIII-MPIV ER spreadsheet sheet ER_AWMS cell E68:E69

eaters and type of dishes cooked. 4 out of 349 throw their stove away because they are broken (see the ER spreadsheet sheet ER_fuel cell k16:17 for the data).

In conclusion, most household keep their baseline stove for logical reasons, a negligible percentage throw their stove away which does not lead to additional fuel usage. This result supports the PDD argument that leakage is negligible and can be ignored in this CPIII as it was in CPI and CPII.

The leakage emissions are then, after adjustment with the usage rate and by multiplying with the number of units installed 99 tCO2[28].

E.4. Calculation of net benefits or direct calculation for each SDG Impact

SDG	SDG Impact	Baseline estimate	Project estimate	Net benefit
13	Emission reductions	69,458[29]	7,693[30]	61,764
2	Hectares area on which bio-slurry is applied	0	11,882	11,882
7	Number of people benefiting from biogas	0	77,296	77,296

E.5. Comparison of actual SDG Impacts with estimates in approved PDD

SDG	Values estimated in ex ante calculation of approved PDD for this monitoring period	Actual values[31] achieved during this monitoring period
13	78,402 tCO_{2e}	61,764 tCO_{2e}
2	48,150 hectares	11,882 hectares
7	117,438 People	77,296 people

E.5.1. Explanation of calculation of value estimated ex ante calculation of approved PDD for this monitoring period

[28] See ER spreadsheet, tab SDG2_7_13_DB_Month cell P17
[29] See ER spreadsheet, tab SDG_ex-ante_ex-post cell D7
[30] See ER Spreadsheet, SDG_ex-ante_ex-post cell E7

[31] Whenever emission reductions are capped, both the original and capped values used for calculations must be transparently reported. Use brackets to denote original values.

The calculation method of value estimated in ex ante calculation of approved PDD for this monitoring period is the same as the one in this monitoring period.

E.6. Remarks on increase in achieved SDG Impacts from estimated value in approved PDD

>>
No increase occurred in achieved SDG impacts, see section E.5 for the difference. The reasons leading to these differences are mainly due to social change and lifestyle change: reduction of number of households who raise animal, and farmers having more access to other cooking technology devices such as LPG stove, rice cooker. These lead to the reduction of some parameters: Sale (28,975 compared to 31,135 installed biodigesters estimated in PDD), usage rate (50.58% compared to 79% estimated in PDD) and area of farm applied bio-slurry (0.85 compared to 1.9 hectare per household estimated in PDD and these parameters are directly proportional to those SDG impacts.

SECTION F. SAFEGUARDS REPORTING

>>

In the safeguard assessment conducted for this CP, no safeguards were identified which require monitoring. Moreover, none have the status potentially or have requirements that call for regular re-assessment.

SECTION G. STAKEHOLDER INPUTS AND LEGAL DISPUTES

G.1. List all Inputs and Grievances which have been received via the Continuous Input and Grievance Mechanism together with their respective responses/mitigations.

>>

In total 50 times NBP was contacted, a breakdown of the grievances is shown in the table below

Table 13: Grievance breakdown[32]

Type	*number*
Information request	38
technical issue	11

[32] Grievance list 2022 sheet analysis cell B13:C17

Type	*number*
Other	1
total	50

All 50 cases are closed[33]. A separate file details all the comments.

The detail of technical issue of the 11 plants are described as following [34]:

Technical issue	Number of cases
Broken stove	3
Issues with gas tap (clogging)	2
Request for repairing gas pipe network	1
Stopping using biodigester for a while and now want to use it again	1
Issues with gas pipe network	1
Issues with gas stove tap	3
Grand Total	**11**

G.2. Report on any stakeholder mitigations that were agreed to be monitored.

>>
No mitigations were identified that require monitoring

G.3. Provide details of any legal contest that has arisen with the project during the monitoring period

>>
No legal contents have arisen during this monitoring period. Most comment related to common practices, such as information request and repair requests.

[33]Grievance list 2022 sheet analysis cell B5 and C10
[34] See Grievance list 2022 sheet issues cell B25:C31

Revision History

Version	Date	Remarks
1.1	14 October 2020	Hyperlinked section summary to enable quick access to key sections Improved clarity on Key Project Information Section for POA monitoring Forward action request section Improved Clarity on SDG contribution/SDG Impact term used throughout Clarity on safeguard reporting Clarity on design changes Leakage section added for VER/CER projects Addition of Comparison of monitored parameters with last monitoring period Provision of an accompanying Guide to help the user understand detailed rules and requirements
1.0	10 July 2017	Initial adoption