Gold standard for the global goals
Monitoring report

June 2017, version 1

Title of the project	National Biodigester Programme, Cambodia
Gold Standard project id	GS751
Version number of the monitoring report	1.4
Completion date of the monitoring report	16/07/2020
Date of project design certification	24/05/2011 (retroactive, 24/5/2009)
Start date of crediting period	01/01/2019
Duration of this monitoring period	01/01/2019 to 31/12/2019
Duration of previous monitoring period	01/01/2018 to 31/12/2018
Project representative(s)	Mr Kim Savoeun[1]
Host Country	Cambodia
Certification pathway (activity certification/impact certification)	Impact Statements & Products - SDG 13: Gold Standard Emissions Reductions (carbon credits)
SDG Contributions targeted (as per approved PDD)	1 – SDG 13: Climate Action (Cumulative VERs) 2 – SDG 2: Zero Hunger: Area on which bio-slurry is applied 3 – SDG 7: Affordable and Clean Energy: Number of people benefitting from biogas
Gold Standard statement/product certification sought (GSVER/ADALYs/RECs etc.)	N/A
Selected methodology(ies)	TPDDTEC 3.1
Estimated amount of annual average certified SDG impact (as per approved PDD)	SDG 2: 48,315 SDG 7: 117,838 SDG 13: 78,699
Total amount of certified SDG impact (as per approved methodology) achieved in this monitoring period	SDG 2: 17,055 SDG 7: 78,853 SDG 13: 62,440

[1] New project representative, see section B2.2 on the correction

SECTION A. Description of project

A.1. Purpose and general description of project

The National Biodigester Programme
In January 2006, the Ministry of Agriculture, Forestry and Fisheries (MAFF) and SNV[2] 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 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 commercial, market oriented, biodigester sector in eight selected provinces of Cambodia. 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
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

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

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)

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

Host country: Cambodia

Table 1: GPS coordinates of the provincial capital in the current NBP provinces

#	Province	Latitude (xx° xx' xx" N)	Longitude (xx° xx' xx" W)
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

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.

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)

SECTION B. Implementation of project

B.1. Description of implemented project

NBP is a market-based programme and the actual number of digesters installed depends on the market conditions

Table 2: Total Number of units installed by year and cumulative

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

The number of units installed in 2019 increased compared to 2018, this was attributed to:

- Introduction of the composite digester – a prefabricated digester from Vietnam (with similar operating principle as the current digester types). This model proved quite popular compared to the farmer's friend digesters which requires a much longer time to install.

NBP has installed 7 different digester sizes:

Table 3: Digesters installed by size

Size (m^3)	units	share (%)
2	55	0.2%
3	736	2.6%
4	16124	57.6%
6	9827	35.1%
8	879	3.1%
10	248	0.9%
15	111	0.4%
sum	**27980**	**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 4.89 m3, 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 4: Units installed by digester type

Type	units	share (%)
FF	26,943	96.3%
NBP S1	820	2.9%
Composite	193	0.7%
PE	24	0.1%
sum	**27980**	**100%**

The main digester installed is the FF (Farmer's friend digester) in the sizes of 4 to 15 m^3 and the scaled down version of that plant, the NBP S1 (2 and 3 m^3 only). The composite and PE digester are both sized 4 m^3.

B.2. Post-registration changes

B.2.1. Temporary deviations from Certified Key Project Information, Project Design Document, Monitoring & Reporting Plan, applied methodology or applied standardized baseline

N/A

B.2.2. Corrections

The BFT scenario B3 if fixed for CPIII as per PDD, however was calculated incorrectly. The LPG data was obtained from the baseline survey data executed for CPIII. The LPG consumption calculated however was the average over the whole population irrespective of the baseline fuel use scenario of the sampled household. Thus, it includes households that did not have LPG as their main fuel which is not correct.

In this MR, the LPG consumption of B3 scenario was recalculated by extracting the data of the households that indicated that LPG is their main fuel. The data is included in the ER spreadsheet sheet BFT_LPG. Households in scenario B3 may use next to LPG quantities of firewood and charcoal, this is however not accounted for, which is conservative.

The NBP project representative has changed, the updated contact details are

Registration number with relevant authority	National Biodigester Programme

Street/P.O. Box	PO Box 2590
Building	N/A
City	Phnom Penh
State/Region	N/A
Postcode	N/A
Country	Cambodia
Telephone	+855078724111
Fax	N/A
E-mail	admin@nbp.org.kh
Website	www.nbp.org.kh
Contact person	Mr. Kim Savoeun
Title	Programme Director
Salutation	Mr.
Last name	Savoeun
Middle name	N/A
First name	Kim
Department	N/A
Mobile	+855012824425
Direct fax	N/A
Direct tel.	N/A
Personal e-mail	savoeun@nbp.org.kh

B.2.3. Changes to start date of crediting period

N/A

B.2.4. Permanent changes from registered 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

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The objective of the monitoring effort conducted under this VPA 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 and passport a number of monitoring activities were undertaken for this monitoring period. The person in charge of all these monitoring activities and this report is Eric Buysman, the selected consultant by NBP. The surveys that were and the entities involved are shown in the next figure:

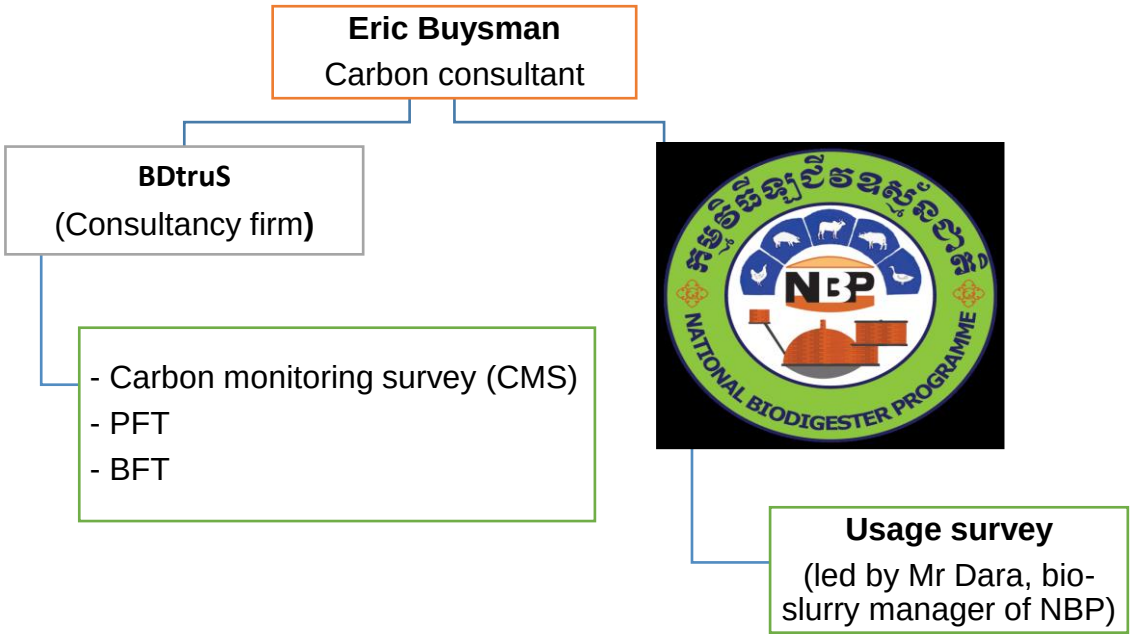


Figure 1: Surveys executed in this MP and entities involved

Eric Buysman: The key responsible person for the carbon monitoring is Eric Buysman. Eric was selected based on a tendering process. He has been involved in NBP since 2006 and was leading all the pervious registration and verification activities. Eric oversees all the activities, from ensuring proper data collection by the contracted parties to reporting and DOE assistance in the field.

BDtruS: is a consultancy firm and has worked before on NBP monitoring surveys and KPT monitoring. BDtruS was selected for this task by Eric and NBP.

NBP Cambodia: NBP Cambodia is the project owner and executed under the guidance of Eric the USAGE survey. As per methodology, the usage survey does not have to be executed by a third party. However, to minimize any conflict of interest, the usage survey was executed by, as much as possible, bio-slurry coordinators or related staff, if available at the provincial office, and if not by the quality control technicians. The usage survey is executed in the same manner as the last MR.

SECTION D. Data and parameters

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

Relevant SDG indicator	**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
Value(s) applied	Fuel *b* / $EF_{CO2,}$ (kg/TJ) LPG / 63100 Charcoal in wood eq / 112000 Firewood / 112000
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 may be estimated as above or alternatively by researching a conservative wood to charcoal production ratio (from IPCC, credible published literature, project-relevant measurement reports, or project-specific monitoring) and multiplying this value by the pertinent EF for wood.

Relevant SDG indicator	**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_{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 / 1224 Firewood / 1224
Choice of data or Measurement methods and procedures	IPCC default value
Purpose of data	Calculation of baseline and project emissions

Additional comment	CO2 and non-CO_2 emissions factors for charcoal may be estimated as above or alternatively by researching a conservative wood to charcoal production ratio (from IPCC, credible published literature, project-relevant measurement reports, or project-specific monitoring) and multiplying this value by the pertinent EF for wood. 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.

Relevant SDG indicator	**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:	$EF_{i,N2O}$
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	CO2 and non-CO2 emissions factors for charcoal may be estimated as above or alternatively by researching a conservative wood to charcoal production ratio (from IPCC, credible published literature, project-relevant measurement reports, or project-specific monitoring) and multiplying this value by the pertinent EF for wood. 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*	$EF_{N20,}$ (kg/TJ)
LPG	2.1
Charcoal in wood equivalent	11.25
Firewood	11.25

Relevant SDG indicator	**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:	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	In case charcoal is expressed in wood equivalents, the NCV of firewood will be applied

Relevant SDG indicator	**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:	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

Relevant SDG indicator	**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	$B_{b1,wood}$
Unit	Tonnes/year
Description	Amount of woody biomass used in the baseline scenario b1
Source of data	BFT study MPI – file CPIII MPI spreadsheet sheet BFT_wood
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.

Relevant SDG indicator	**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	$B_{b2,charcoal}$
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 MPI 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.

Relevant SDG indicator	**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	$B_{b3,LPG}$
Unit	Tonnes/year
Description	Amount of LPG used in the baseline scenario b3
Source of data	CPIII baseline study (see spreadsheet ER database tab BFT_LPG
Value(s) applied	0.070993

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 90/10% was achieved and thereby meeting the minimum requirements stipulated by the methodology. See sheet Gen_Analysis in the ER speadsheet Corrected value, see chapter 2.2 for the justification. NBP will consider redoing BFT_b3 in MPIII depending on the budget available as the scenario currently ignores other fuels that households may use, such as firewood and is therefore overly conservative. NBP will seek TAC approval if necessary

Relevant SDG indicator	**13.2.1** "Number of countries that have communicated the establishment or operationalization 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:	GWP_{CH4}
Unit	tCO_2e per tCH4
Description:	Global Warming Potential (GWP) of methane
Source of data	AR IPCC
Value (s) applied	25
Choice of data or Measurement methods and procedures	N/A
Purpose of data	Calculation of baseline and project emissions
Additional comment:	25 for the second commitment period. Shall be updated to any future COP/MOP decisions

Relevant SDG indicator	**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:	GWP_{N2O}
Unit	tCO_2e per tN_2O
Description:	Global Warming Potential (GWP) of nitrous oxide
Source of data	AR IPCC
Value (s) applied	298
Choice of data or Measurement	N/A

methods and procedures	
Purpose of data	Calculation of baseline and project emissions
Additional comment:	298 for the second commitment period. Shall be updated to any future COP/MOP decisions

Relevant SDG indicator	**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:	$VS_{(T)}$
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 for buffalo and 28 kilo 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

Relevant SDG indicator	**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:	$Bo_{(T)}$
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 Cattle: 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

Relevant SDG indicator	**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	MCF(k)
Unit	%
Description	Methane conversion factors for each manure management system by climate region k (Cambodia 27.7 C)
Source of data	IPCC default values for the region Asia from 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	*Anaerobic lagoon*: 80%; *Slurry*: 78%; *Dry lot*: 2%; *Daily spread*: 1.0%; *Solid storage*: 5%; *Other*: 1%; *Pasture*: 2%
Choice of data or measurement methods and procedures	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 The IPCC is a standard, credible source of emissions factors.
Purpose of data	Calculation of baseline and project emissions
Additional comment	IPCC (2006); May be updated according to any future changes by the IPCC Categry other includes manure that is sold, or not collected and the lowest MCF is adopted (of daily spread) which is conservative

Relevant SDG indicator	**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:	$LE_{p,y}$
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

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.

Relevant SDG indicator	**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:	$EF_{awms,T}$
Unit	$kgCH_4$ per animal per year for livestock type T in the project
Description:	Animal waste methane emission factor by average temperature
Source of data	Baseline survey and data from IPCC default values for the region Asia from 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: Value Cow: 5.952 Pig: 14.928 Buffalo: 14.266
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 The IPCC is a standard, credible source of emissions factors.
Purpose of data	Calculation of baseline emissions
Additional comment:	IPCC (2006); May be updated according to any future changes by the IPCC

Relevant SDG indicator	**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:	$\eta_{biogasstove}$
Unit	[-]%
Description:	Combustion efficiency of the biogas stove
Source of data	Centre for Energy Studies, Institute of Engineering for the Nepal Biogas Support Programme[3].

[3] 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

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

D.2. Data and parameters monitored

(Copy this table for each piece of data and parameter)

Relevant SDG indicator	**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:	**$f_{NRB,y}$**
Unit	Fraction of Non-Renewable Biomass
Description:	Non-renewability status of woody biomass fuel in scenario i during year y
Measured/calculated /default	UNFCCC default value
Source of data	UNFCCC default, see CDM SSC WG43 and accepted in EB meeting 77[4]
Value(s) of monitored parameter	77%
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	The fNRB default value was valid at the start of this MP.

Relevant SDG Indicator	**SDG 7.2.1: Proportion of population with primary reliance on clean fuels and technology**
Data / Parameter	**Bdaily,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

[4] https://cdm.unfccc.int/filestorage/e/x/t/extfile-20140210181830731-SSCWG43_Annex_4_Info_note_fNRB_Cambodia_ver_01.0.pdf/SSCWG43_Annex%204_Info%20note_fNRB%20Cambodia_ver%2001.0?t=V1R8cWNpdjV0fDAtUTbeAA-3IdK3EqNgUSgt

Source of data	Excel file CPIII MPI spreadsheet SDG2&7 calculation
Value(s) of monitored parameter	96%
Monitoring equipment	N/A
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	N/A

Relevant SDG Indicator	**SDG 7.2.1: Proportion of population with primary reliance on clean fuels and technology**
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
Source of data	Excel file CPIII MPI spreadsheet SDG2&7 calculation
Value(s) of monitored parameter	4.59
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

Relevant SDG Indicator	**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
Source of data	Excel file CPIII MPI spreadsheet SDG2&7 calculation
Value(s) of monitored parameter	96%
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:	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.

Relevant SDG Indicator	Indicator 2.4.1 "Proportion of agricultural area under productive and sustainable agriculture
Data/parameter:	Abs,h
Unit	hectare
Description	Total area on which bio-slurry is applied
Measured/calculated/default	Measured
Source of data	Excel file CPIII MPI spreadsheet SDG2&7 calculation
Value(s) of monitored parameter	0.99
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

Relevant SDG Indicator	**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:	**$B_{p,y}$**
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 MPI spreadsheet ER_fuel
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>4.186</td></tr><tr><td>Firewood</td><td>69.466</td></tr></table>
Monitoring equipment	Determined using survey methods, newton scale

Measuring/reading/recording frequency:	Biennial, starting from MPI
Calculation method (if applicable):	N/A
QA/QC procedures:	Transparent data analysis and reporting The test, including LPG, achieved a level of precision/confidence of 90/27 and thereby meeting the requirements. See in the same file sheet Gen_analysis
Purpose of data:	Calculation of project emissions
Additional comments:	N/A

Relevant SDG Indicator	**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:	**$B_{p,LPG}$**
Unit	kg/ project household-year
Description	Amount of LPG used in the project scenario
Measured/calculated/default	Determined using survey methods
Source of data	Excel file CPIII MPI spreadsheet ER_fuel
Value(s) of monitored parameter	16.423
Monitoring equipment	Determined using survey methods, newton scale
Measuring/reading/recording frequency:	Measured
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 Bp,y for the achieved confidence/precision interval

Relevant SDG Indicator	**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:	**$B_{b,ratio}$**
Unit	%
Description	Baseline scenario ratios

<table>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>Excel file CPIII MPI spreadsheet ER_fuel</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th>Baseline scenario</th><th colspan="2">% of users</th></tr>
<tr><td>Households with main fuel wood</td><td>Bb1,ratio</td><td>91.5%</td></tr>
<tr><td>Households with main fuel charcoal</td><td>Bb2,ratio</td><td>1.2%</td></tr>
<tr><td>Household with main fuel LPG</td><td>Bb3,ratio</td><td>6.1%</td></tr>
<tr><td>Households using other fuels</td><td>n/a</td><td>1.2%</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Determined using survey methods</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Annual</td></tr>
<tr><td>Calculation method (if applicable):</td><td>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.</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 baseline emissions</td></tr>
<tr><td>Additional comments:</td><td>N/A</td></tr>
</table>

Relevant SDG Indicator	**Indicator 2.4.1 "Proportion of agricultural area under productive and sustainable agriculture** **SDG 7.2.1: Proportion of population with primary reliance on clean fuels and technology** **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:	**$U_{p,y}$**
Unit	Percentage
Description	Percentage of bio-digesters in use in monitoring period y
Measured/calculated/default	Measured and calculated
Source of data	Usage survey spreadsheet USAGE_sampling and analysis sheet 'analysis'
Value(s) of monitored parameter	64.402%
Monitoring equipment	Determined using survey methods
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>
<tr><td>Additional comments:</td><td>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</td></tr>
</table>

Relevant SDG Indicator	**Indicator 2.4.1 "Proportion of agricultural area under productive and sustainable agriculture** **SDG 7.2.1: Proportion of population with primary reliance on clean fuels and technology** **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:	**$N_{b,y}$**
Unit	units
Description	Number of biogas plants commissioned
Measured/calculated/default	Measured
Source of data	CPIII MPI ER spreadsheet tab 'GEN_analysis cell D30
Value(s) of monitored parameter	27,980
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 is approved by NBP, data is entered into the central database. All Form 3, the hard copies, are stored at NBP.
Purpose of data:	Calculation of emission reductions
Additional comments:	Np,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

Relevant SDG Indicator	**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:	**$MS_{(T,S,k)}$**
Unit	[-] %

Description	Fraction of livestock category T's manure fed into the bio-digester, S in climate region k
Measured/calculated/default	Measured
Source of data	Excel file CPIII MPI spreadsheet MS AWMS
Value(s) of monitored parameter	**Livestock** / **% fed into Biodigester**: cow 59.60%; Pig 39.78%; Buffalo 56.72%
Monitoring equipment	Determined using survey methods
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	See section D3
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

Relevant SDG Indicator	**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:	**$MS_{(P,S,K)}$**
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 MPI spreadsheet MS AWMS
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
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

	slurry	An lagoon	Dry lot	Daily spread	Solid storag	Other	Pasture
cow	0.04%	0.00%	0.44%	0.95%	10.44%	4.44%	24.1
Pig	2.34%	13.70%	1.48%	2.75%	20.61%	15.50%	3.8
Buffalo	0.00%	0.00%	2.43%	0.17%	12.18%	1.38%	27.1

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%

Relevant SDG Indicator	**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:	**$N_{(T)}$**
Unit	[-]
Description	Number of animals of livestock category T
Measured/calculated/default	Measured
Source of data	Excel file CPIII MPI spreadsheet ER_AWMS
Value(s) of monitored parameter	
Monitoring equipment	Determined using survey methods
Measuring/reading/recording frequency:	Annual
Calculation method (if applicable):	See section D3
QA/QC procedures:	Transparent data analysis and reporting
Purpose of data:	Calculation of contribution to SDG13
Additional comments:	N/A

Animal (T)	$N_{(T),h}$
Cow	4.785
Pig	1.989
Buffalo	0.534

Relevant SDG Indicator	**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:	**PL**
Unit	%
Description	Physical leakage of the biodigester
Measured/calculated/default	Measured
Source of data	Excel file CPIII MPI spreadsheet ER_AWMS

Value(s) of monitored parameter	0.8%
Monitoring equipment	Determined using survey methods
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

Relevant SDG Indicator	**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:	**$W_{(site)}$**
Unit	(kg)
Description	Average pig weight at the project site (kg)
Measured/calculated/default	Measured and calculated
Source of data	Excel file CPIII MPI spreadsheet ER_AWMS
Value(s) of monitored parameter	52.75
Monitoring equipment	Determined using survey methods
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 reliably5.
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
Purpose of data:	Calculation of VS excretion
Additional comments:	The value of 1 pig farmers was removed, this was a commercial farm with over 700 pigs (HH#75 in sheet CMS_PFT) producing for CP. This farm is considered an outlier and not representative. The weight of 15 sows was obtained out of 61, which is approximately 25%. The weight of only 2 boars was measured, and thus the average weight of sows was used as per PDD requirements.

D.3. Implementation of sampling plan

A. USAGE Survey

Background
The usage survey 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.

Usage survey design (US)
The usage survey is designed based on the following guidelines as per PDD:

- Each year NBP will monitor the usage of the biogas units by selecting randomly at least 30 samples (biogas households)[6] from each year credited, the total sample will be over 100 units each time;
- To ensure conservativeness, only technologies will be selected that are in use for at least 0.5 year, for year 1-2 only technologies that are in use for at least 1.5 years etc. for the other years.

After random selection of the households by age group, the obtained drop-off rate of each year will be weighted per the numbers of units built in that period. The US monitoring procedure applied in this MP consisted of the following steps:

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

[6] See page 24 of the methodology

I. Details of the biogas households of each age group are gathered.
II. Simple random selection of at least 30 households from each age group (35 were selected by applying oversampling). The sampling is executed using a web based random number generator[7]. Screenshots were made of the generated numbers are available at request.
III. The generated numbers were linked to the households, i.e. randomly generated number 97 was linked with number 97 of the age group, number 97 was then included in the list of samples.
IV. PBPO bio-slurry coordinators[8] surveyed the sampled households, and the gathered data was entered into a database at the head office after inspection of the quality by the NBP bio-slurry officer, staff from the NBP technical unit and the carbon consultant.

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

Table 5: Usage survey selection by age group

Age group	Period, inclusive of begin and end date		Units built in that period (age group population)	Sample drawn from units built (at random)
12 to 13	13/03/06	30/06/07	666	35
11 to 12	01/07/07	30/06/08	1956	35
10 to 11	01/07/08	30/06/09	2504	35
9 to 10	01/07/09	30/06/10	3079	35
8 to 9	01/07/10	30/06/11	4793	35
7 to 8	01/07/11	30/06/12	4450	35
6 to 7	01/07/12	30/06/13	2232	35
5 to 6	01/07/13	30/06/14	1527	35
4 to 5	01/07/14	30/06/15	1906	35
3 to 4	01/07/15	30/06/16	1892	35
2 to 3	01/07/16	30/06/17	1092	35
1 to 2	01/07/17	30/06/18	832	35
0 to 1	01/07/18	30/06/19	666	35
Total				**455**

Of each age group 35 units were selected randomly, for example, in age group 12 to 13 out of the 666 35 units were selected. Age group 12 to 13 is a little longer than 1 year, 1 year and 3 months and 17 days. In the period 13/03/2006 to 30/06/2006 only 103 units were built and given that the number of units is much smaller than any other age group, it was decided to include those units in age group 12 to 13. During the last verifications that was accepted by both the GS and the DOE and therefore again implemented in this MP. The next table shows the sampling plan of the US.

[7] http://www.graphpad.com/quickcalcs/index.cfm

[8] Unless there is no bio-slurry advisor employed by the PBPO (Provincial Biogas Programme Office)

Table 6: Usage survey design summary

Item	Conversion in US
Sampling objective	The objective of the sampling effort is to obtain reliable data for the US survey
Field Measurement Objectives and Data to be collected	The survey will consist of household visit in random selected end-users to collect usage data
Target Population and Sampling Frame	The sampling frame will be drawn from the database of each age group
Sampling method (approach)	Simple random sampling in each age group, each observation is chosen randomly and entirely by chance, such that each observation has the same probability of being chosen. Age groups can be considered clusters and the sampling method is therefore cluster sampling
Implementation	The US was executed in January - February 2020 by trained PBPO staff under supervision of NBP
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. By surveying 455 households, it is ensured that the minimum requirements were easily met.
Procedures for Administering Data Collection and Minimizing Non-Sampling Errors	The survey was executed by bio-slurry supervisors or coordinators and not by quality control technicians to minimize conflict of interest. Furthermore, data was entered and checked by another party, the NBP national office.

The usage survey was executed by NBP provincial slurry coordinators, extension worker, supervisors or coordinators, where possible. They were selected to avoid a potential conflict of interest that the quality control technicians may experience.

A simple two-page questionnaire was developed for this purpose and available for DOE inspection. Although they are very knowledgeable about the programme and the technology, a training was nevertheless organized on the 16th of January 2020. A separate training report is available at request.

On top of this, the households that did not have a digester in operation during CPII MPVII *and* claimed that they would restore their digester were re-visited. In total these were 1 household.

In total 456 households were physically visited, 455 usage survey households and 1 household of CPII MPVII.

B. CMS

A carbon and sustainable development monitoring survey (CMS) was executed in February 2020amongst a representative sample of biodigester households 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.

CMS survey design

The CMS sampling plan is developed using guidance of the applied GS methodology and the registered PDD. The surveys is conducted on a sample size estimated by using the “General

Guidelines for Sampling and Surveys for Small-scale CDM Project Activities" (CDM EB 69 Annex 5) which prescribes a 90% confidence interval with a 10 % error margin. The sample size is calculated using the next equation[9].

$$n = \frac{N}{1+N(e)^2} \times D \times 110\% \quad \textbf{(1)}$$

Where:

n	=	minimal sample size
e	=	level of precision (10%)
N	=	The biogas population
D	=	Design effect
110%	=	Oversampling of 10%

The D is set at 1.5 as per registered PDD. With a N of 27,980, the calculated sample size n is (27,980 / (1+27,980 *10%^2)*1.5*110% = 164 ~ 165.

The number of clusters is calculated with the following formula:

$$k \geq \left(\frac{n}{2}\right)^{1/2} \quad \textbf{(2)}$$

Where
k = the minimum sample of clusters
n = total population of clusters.

A cluster is a district, and there are 129 districts is NBP. The calculated number of clusters is then 8. As per PDD, the number of clusters is at least k, or 8 in this case, but preferably more. This MP, like all other MP's in CPII, this number was set at 15. The sample size per cluster is calculated with the following formula:

$$n_{cl} = \frac{n}{\#CL} \quad \textbf{(3)}$$

Where:

n	=	minimum sample size
#CL	=	Number of clusters
n_{cl}	=	Cluster sample size

With the calculated sample size of 165 households, the cluster sample size is consequently 165/15 = 11.

Survey implementation

Survey selection and survey teams: The BDtruS Research Team consisted of a lead consultant and 6 trained and experienced surveyors. All of the data collectors have extensive experiences in interviewing households in the rural areas. Among the six data collectors who have been recruited, four used to carry out the CMS last year with good quality of deliverables, while the remaining two data collectors who have had at least some basic knowledge about biodigester will be paired with the one who used to conduct the CMS last year. To ascertain that all surveyors have the same understanding and to update their knowledge on the subject a training was organized on 31 January to 2 February 2020 and this included a test in the field. A separate training report and participant list is available at request.

[9] http://edis.ifas.ufl.edu/pd006 and *Yamane, Taro. 1967. Statistics, An Introductory Analysis, 2nd Ed., New York: Harper and Row.*

Questionnaire: The questionnaire was developed by the carbon consultant together with BDtruS and is based on previous questionnaires that were used for the monitoring. This year the questionnaire was administered digitally using the application KoBoCollect. 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.

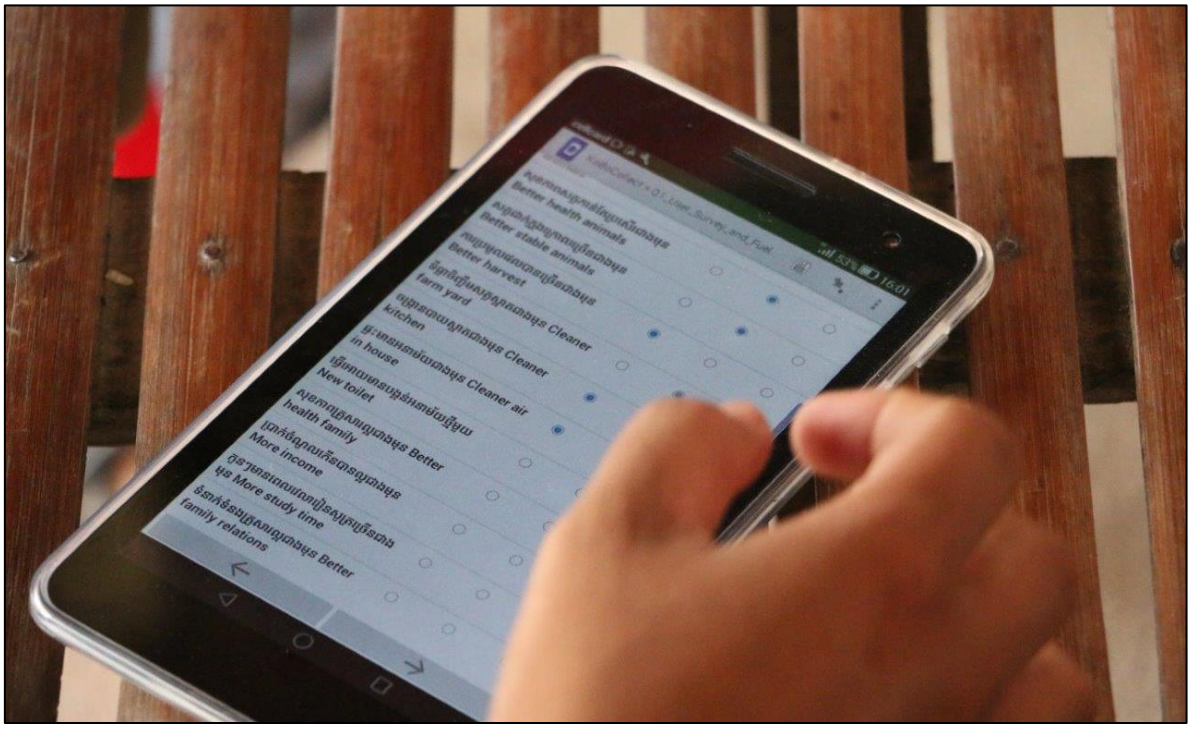
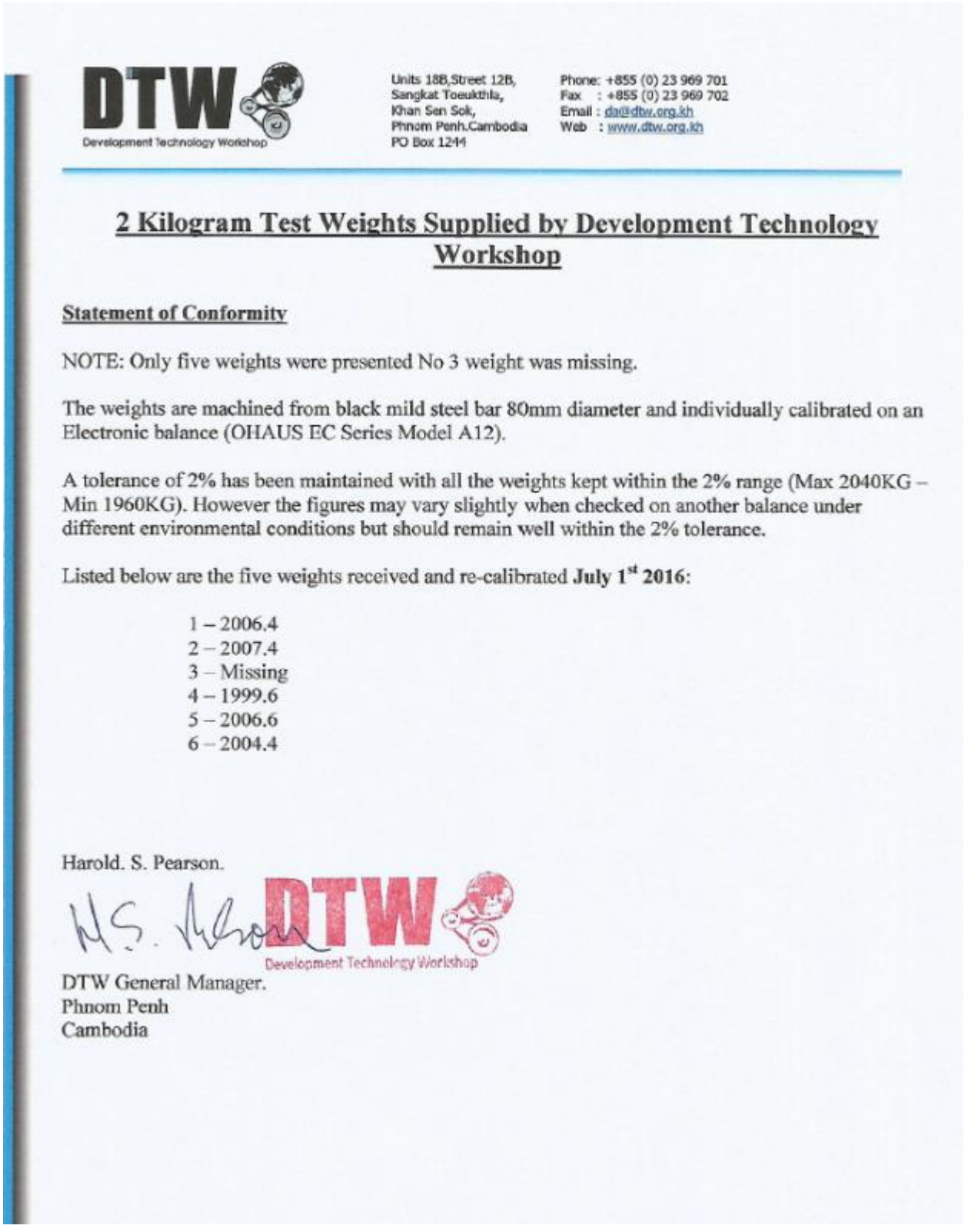


Figure 2: Tablet with questionnaire in KoboCollect

Newton scales were sometimes used to assist the surveyor with determining the fraction of manure that flows in to the different manure management systems. In most cases however, all manure was fed into the biodigester (=100%) and the newton scale were not sued. In other cases, it was easy to determine the share fed, i.e. 2 out of 3 buckets etc. In case this was not clear, surveyors measured the amount of manure fed to the biodigester and the amount not fed into the biodigester. Five calibrated weights were made for NBP and these are used every year to check if the scales are working correctly, see the picture hereunder:

Figure 3: Weight check on Electronic Balance and the electronic Newton scale

The same weight stones as in CPII were used, which were at the time calibrated by DtW in 2016.The calibration evidence is shown here below. Weight stone 3 was not used.



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2 Kilogram Test Weights Supplied by Development Technology Workshop

Statement of Conformity

NOTE: Only five weights were presented No 3 weight was missing.

The weights are machined from black mild steel bar 80mm diameter and individually calibrated on an Electronic balance (OHAUS EC Series Model A12).

A tolerance of 2% has been maintained with all the weights kept within the 2% range (Max 2040KG – Min 1960KG). However the figures may vary slightly when checked on another balance under different environmental conditions but should remain well within the 2% tolerance.

Listed below are the five weights received and re-calibrated **July 1st 2016**:

1 – 2006.4
2 – 2007.4
3 – Missing
4 – 1999.6
5 – 2006.6
6 – 2004.4

Harold. S. Pearson.

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Phnom Penh
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Sampling

The survey was executed in the following randomly probability proportional to size (PPS) selected districts.

Table 7: PPS randomly selected districts in the NBP project area

# District	Province	District name	Samples in district Surveyed	Spare
1	Kampong Chhnang	Sameakki Mean Chey	11	14
2	Kampong Chhnang	Kampong Tralach	11	14
3	Kampong Spue	Phnum Sruoch	11	14
4	Kampong Spue	Kong Pisei	11	14
5	Kampong Spue	Odongk	11	14
6	Kampot	Chhuk	11	14
7	Kampot	Chum Kiri	11	14
8	Kampot	Kampong Trach	11	14
9	Kampong Cham	Kang Meas	11	14
10	Svay Rieng	Romeas Haek	11	14
11	Svay Rieng	Svay Chrum	11	14
12	Takeo	Prey Kabbas	11	14
13	Takeo	Samraong	11	14
14	Tboung Khmum	Ou Reang Ov	11	14
15	Tboung Khmum	Memot	11	14
sum			165	210

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

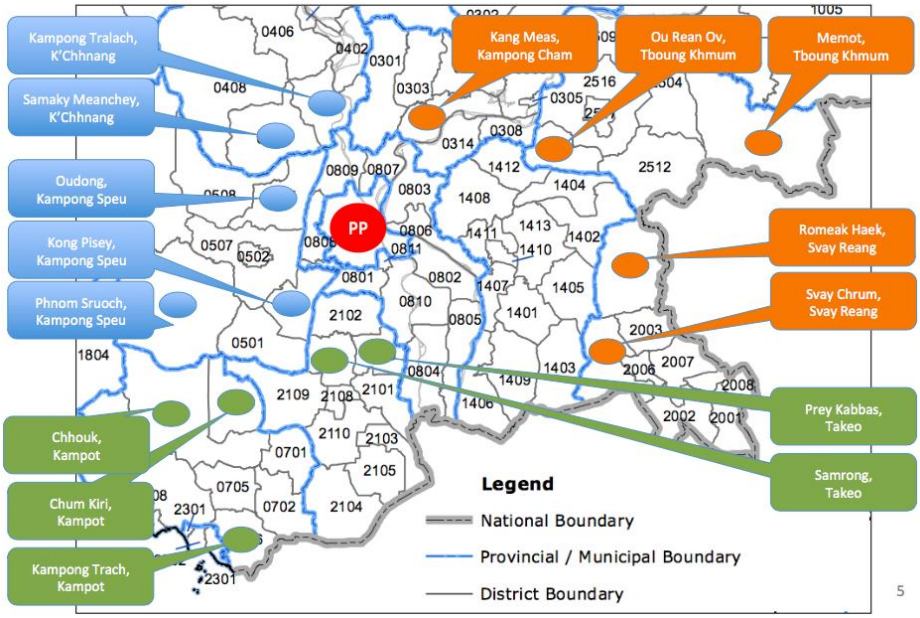

Figure 4: Geographical presentation of the survey districts

Of the total 165 selected HHs, only 76 were interviewed and 87 additional household were visited of the spare list of randomly selected households. The reasons why not all visited households could not be interviewed are the following according to BdTrus:

- 75 did not use their biodigester as they sold their animals

- 44 experienced technical problems and did not use their plant
- 10 households could not be located (probably migration)
- 9 households were busy
- 3 households did not want to participate
- 2 household had a biogas plant but did not use the gas
- 27 due to various reasons, like house renovation, no space, moving, land sold, lack of labor to take care of their animals and feed the plant

For those reasons, in 5 provinces it was necessary to sample extra households, which was conducted by the carbon consultant. The file sampling CMS district and household selection provides an overview of the sampling including the sampling evidences

C. Baseline Fuel test and Project Fuel test

The KPT includes two groups:

Table 8: KPT target groups

Group	Description of target group	Target sample size
PFT_update	All CMS households	165
BFT scenario b1	Equivalent households to PFT hh	60
BFT scenario b2	Equivalent households to PFT hh	60
Total sample		**285**

Table 9: KPT update survey design

Item	Description
Sampling objective:	obtain reliable fuel use data of project and equivalent baseline households
Field Measurement Objectives and Data to be collected:	The survey will consist of a 24-hour measurement campaign amongst KPT households as per registered PDD
Target Population and Sampling Frame:	The sampling frame are the selected CMS households
Sampling method (approach):	PPS random cluster sampling
Implementation:	The PFT was executed in February 2020
Implementer	BDtrus
Desired Precision/Expected Variance and Sample Size.	90/30 rule of the applied methodology
Procedures for Administering Data Collection and Minimizing Non-Sampling Errors:	The survey data was entered by the survey team leader and served as an independent check on the data

Representativeness of the KPT

The next table details how representativeness is safeguarded.

Table 10: KPT representativeness issues and conversion

#	Issue	Conversion
1	Questionnaire design	The questionnaire includes a question on if this is a normal day without extra eaters. If there are extra eaters, an appointment would be made with the household for a day with normal cooking conditions. A non-normal day is also a holiday but not necessarily a weekend day; a typical week/weekend rhythm does not exist in Cambodia for most rural households.
2	Seasonality	People indicated in the CMS survey of CPII MPI that they do not cook more during the dry season. The dry season can therefore be assumed to be representative
3	Applicability	The KPT is basically a test designed for improved cook stoves. As these stoves typically only reduce 20% of fuel a longer test period is necessary. Biogas project on the other hand replace typically 90 to 100% of the baseline fuel and it is therefore much easier to measure savings in a shorter period.

Household reached

In total 165 household participated in the PFT, 59 in the B1 and 37 in B2 and 45 in B3, see sheet Gen_analysis in the CPIII MPI ER spreadsheet. Scenario B3 was re-analyzed using the data collected during the CPIII baseline study, see chapter B.2.2 for the justification.

Table 11: KPT samples and valid samples

Test	Sample size	Number valid samples	Reason difference
PFT	165	158	• In 2 cases the day was not an ordinary day due to extra eaters • In 2 cases the household was using biomass fuel every 2-3 days, the 1 day test could not capture that information • In 4 cases the visited day was not a normal day, thus not representative • 1 value was removed using the Grubbs test for outliers
BFT_B1	60	59	• 1 value was removed using the Grubbs test for outliers
BFT_B2	60	37	The survey team faced significant challenges locating household using charcoal as main fuel. With the recent surge in LPG use and aggressive LPG marketing, people often opt for LPG instead of charcoal
BFT_B3	N/A	45	The data from the CPIII baseline survey was re-analysed for the household only using LPG to obtain a figure for scenario B3, see chapter B.2.2 for this correction

Achieved precision

All KPT's achieved the desired level of confidence and precision, see below (source Gen_analysis excel file CPIII MPI ER spreadsheet)

Table 12: Achieved level of confidence/precision

KPT	Scenario	Confidence	Precision
PFT	P1	90%	27%
BFT wood	B1	90%	8%
BFT charcoal	B2	90%	12%
BFT LPG	B3	90%	10%

SECTION E. Calculation of SDG outcomes

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

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

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

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_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

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

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

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_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

SDG 13: Baseline estimate/ emission reductions

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):

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

Where:

$\sum_{b,p}$	Sum over all relevant (Baseline b/project p) couples
$N_{p,y}$	Cumulative number of biodigesters months[10] 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
$ER_{b,p,y,non-CO2}$	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)

[10] 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.

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[11].

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

$$\sum \mathrm{ER}_{\mathrm{CO2,y}} = (\sum \mathrm{BE}_{\mathrm{b,CO2,y}} - \sum \mathrm{PE}_{\mathrm{p1,CO2,y}} - \sum \mathrm{LE}_{\mathrm{p1,CO2,y}}) * \mathrm{U}_{\mathrm{p1,y}} \quad \textbf{(7)}$$

Where:

$\sum ER_{CO2,y}$	Cumulative CO_2 emission reductions from the substitution of non-renewable biomass and fossil fuels
$\sum BE_{b,CO2,y}$	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[12]
$U_{p1,y}$	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

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

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

2. Baseline and project emissions from AWMS:

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): 25 for the second commitment period. It shall be updated to any future COP/MOP decision

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. IPCC 2006 default values will be used for Bo and MCF. MS will be obtained using survey methods (see section B.7.1). IPCC 2006 default values will be used except for pigs which will be determined ex-post with the following equation[13]:

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

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

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[14] 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:

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

Where:

Hg	=	Hearth girth in meter
L	=	length in meter

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

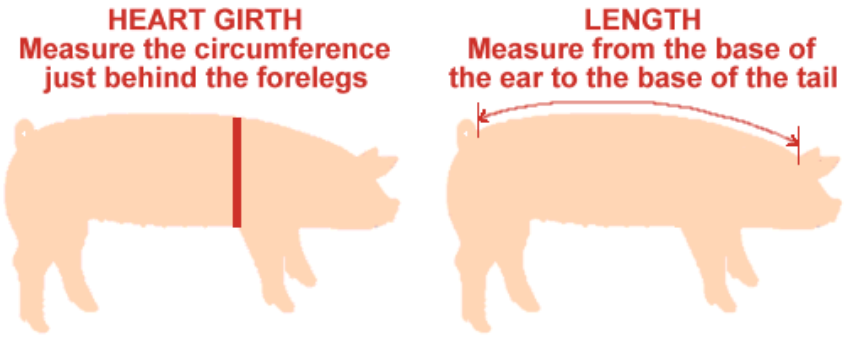

Figure 5: Hearth girth and length measurement

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

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 %)[15]
GWP_{CH4}	=	Global Warming Potential (GWP) of methane (tCO_2eq per tCH_4): 25 for the second commitment period. It shall be updated according to any future COP/MOP decisions.
$\eta_{biogasstove}$	=	Combustion efficiency of the biogas stove

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

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

>> (Provide details of equations and approaches used to calculate/estimate project values.)

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

Target: Households that reply on bio-slury as sustainable organic fertilizer

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

Where:		Description	Value	Comment
$A_{bs,y}$	**=**	**Area on which bio-slurry is applied**	17055	
$N_{b,y}$	=	Total number of biodigesters in year y month 11	27885	Value of month 11 taken to account for digester start up time
U_y	=	Usage rate in year y	64%	
$\%BS_y$	=	Share of households that uses bio-slurry for crop production in year y	96%	
$A_{bs,h,y}$	=	Average area per household on which bio-slurry is applied in year y	0.99	

SDG 7 **Proportion of population with primary reliance on clean fuels and technology**

Target: household members relying on clean fuels and technology: biogas

$$P_{clean,y} = N_{b,y} \times U_y \times B_{daily} \times H_{s,y}$$

Where:

		Description	Value	Comment
$P_{clean,y}$	**=**	**Total number of household members using primarily biogas in year y**	78853	total household members
$N_{b,y}$	=	Total number of biodigesters constructed at the end of year y	27885	Value of month 11 taken to account for digester start up time
U_y	=	Usage rate in year y	64%	
$B_{daily,y}$	=	Share of biogas households that uses biogas at least once per day for cooking in year y	96%	
$H_{s,y}$	=	Number of family members permanent residing in the household in year y	4.59	

SDG 13: Estimation of project and leakage emissions

As per PDD section B.6.2, table 6 only the following project and leakage emissions will be calculated:

1. Continued use of baselines fuels in the project scenario
2. Emissions attributed to AWMS in the project scenario, incomplete combustion and physical leakage

1. Continued use of baselines fuels 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)

$$PE_{p,y} = B_{p,y} * ((f\,NRB, y * EF_{p,fuel}, CO2) + EF_{p,fuel}, _{nonCO2}) * NCV_{p,\,fuel} \quad \textbf{(14)}$$

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 tests are performed, e.g. by-default baseline factors)
*f*NRB, y	Fraction of biomass used during year y that can be established as nonrenewable 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 KPT 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 13: Estimated project emissions from thermal energy use

Fuel *i*	**Average per household**	**Calculated PE**
	(kg/year)	(tCO_2e/yr)
LPG	16.423	0.050
Charcoal in wood eq	4.186	0.008
Firewood	69.466	0.130

2. 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.

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 14: Emission factor for the defined livestock category T of the project situation

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	7.055%	0.670	3.968
Pig	0.565	0.290	18.082%	0.670	7.248
Buffalo	3.900	0.100	6.887%	0.670	6.569

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 14 households out of 165 suspected leakage, the percentage with a leaking plant is then 14/165 = 8%. PL was then determined as 8% * 10% = 0.8%.

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

Table 15: Physical leakage emission from biodigester

Animal	PL_{AWMS} (tCO_2/year)	PL_{stove} (tCO_2/year)
Total	0.00783	0.00005

Other leakage sources:

Practically all household keep their baseline stove, 153 out of 165, which is logical as the amount of biogas produced is fixed while the amount of thermal energy requirements varies depending on the number of eaters and dishes cooked. 12 out of 165 gave their stove away, all to secondary or tertiary family members. Of those that gave the stove away, 25% claimed it did not lead to more fuel use and 33% did and 42% did not know (see the ER spreadsheet sheet ER_fuel for the data).

Those that used more fuel also saved consumption of other fuels in 2 cases (1 case more LPG, less wood, 1 case more wood, less LPG) and only 1 case used more wood. Thus, the increased consumption was in 2 cases offset by reduced use of another fuel and only 1 case used more fuel. However, 3 cases, or 25%, mentioned less fuel use, which is likely offsetting any increase wood usage of that 1 case.

In conclusion, most household keep their baseline stove for logical reasons, a small percentage give 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

E.3. Calculation of net benefits as difference of baseline and project values or direct calculation for each SDG outcome

>>

SDG2 and SDG 7 – the net benefits are the same as the project value, see section E.2 for the calculation

SDG13: The ex-ante emission reductions are calculated with the following calculation:

$$ER_{y,h} = U_{y,h} \times (BE_{y,h} - PE_{y,h}) \times N_{p,y} \quad \textbf{(15)}$$

Where:

$ER_{y,h}$	=	Annual average emission reductions in year y
$U_{y,h}$	=	Cumulative usage rate for technologies in project scenario p in year y, based on cumulative adoption rate and drop off rate revealed by usage surveys
$BE_{y,h}$	=	Annual average baseline emissions per household in year y
$PE_{y,h}$	=	Annual average project activity emissions per household in year y
$N_{p,y}$	=	Total number of biogas units commissioned as of year y

The next table shows the ex-ante estimate of the emission reductions calculated using the obtained usage rate from the usage survey (see section D2), sheet AWMS, sheet ER fuel and sheet SDG 2,7,13 database of the ER spreadsheet.

Table 16: Average annual emission reductions

ER by source	ER (tCO_{2e}/hh/year)
Fuel use	1.912
AWMS	1.605
Sum	**3.517**

E.4. Summary of ex-post values of each SDG outcome for the current monitoring period

SDG	Unit	Baseline estimate	Project estimate	Net benefit
SDG2	Hectares on which bio-slurry is applied	0	17,055	**17,055**
SDG7	Total number of households using primarily biogas	0	78,853	**78,853**
SDG13	tCO2	65,915	3,474	**62,440**

See sheet SDG_performance in the ER database for more details

E.5. Comparison of actual value of outcomes with estimates in approved PDD

Item	Values estimated in ex ante calculation of approved PDD	Actual values achieved during this monitoring period
SDG 2	*42,829*	**17,055**
SDG 7	*104,458*	**78,853**
SDG 13	*69,865*	**62,440**

See sheet SDG_ex-ante and ex-post in the ER database for more details

E.6. Remarks on difference from estimated value in approved PDD

>>
The main cause of the difference is a reduction in the usage rate, from 79% assumed in the PDD to 64.4% and a smaller than average area on which bio-slurry is applied, 1.9 hectare ex-ante estimated versus 0.99 in this MP.

See sheet SDG_performance in the ER database for more details

SECTION F. Stakeholder inputs and legal disputes

F.1. List all inputs/grievances which have been received for the project during the monitoring period together with their respective answers/actions

>> 73 forms of input were received. A separate spreadsheet is available with the list including the respective answers/actions (excel file NBP CPIII MPI 2019 Grievance list_updated)

Table 17: Channels through which input was received in 2019

Channel	number
Facebook comment	25
Telephone	17
Facebook messenger	31
Sum	**73**

The inputs where categorized as following:

Table 18: Inputs by type

Input type	number
Information request	55
Technical issue	18
Other	0
sum	**73**

Of the 18 inputs with technical issues, NBP connected the user with the respective BCA (Biodigester construction Agent). 14 of those were repaired, 4 are pending.

F.2. List all inputs/grievances from previous monitoring period where follow up action is to be verified in this monitoring period

>> No follow up was required of the input of the previous monitoring period

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

No legal contests or disputes have arisen in this MP.