Gold Standard®

Gold Standard for the Global Goals
Key Project Information & Project Design Document (PDD)

Version 1.1 – August 2017

National Biodigester Programme
GS751

KEY PROJECT INFORMATION

Title of Project:	National Biodigester Programme
Brief description of Project:	Development of a market-oriented biodigester sector in Cambodia with the aim to exploit the potential of biogas in Cambodia enabling rural households to switch to clean cooking from relying on wood, reduce deforestation and improve agricultural yields through the use of bio-slurry
Expected Implementation Date: Expected duration of Project:	Since 13 March 2006 25-5-2023
Project Developer:	National Biodigester Programme (NBP)
Project Representative:	Saoleng Lam
Project Participants and any communities involved:	NBP
Version of PDD: Date of Version:	1.0 11-8-18
Host Country / Location:	Cambodia
Certification Pathway (Project Certificating/Impact Statements & Products	N/A
Activity Requirements applied: (mark GS4GG if none relevant)	GS4GG
Methodologies applied:	TPDDTEC 3.1
Product Requirements applied:	N/A
Regular/Retroactive:	Retroactive
SDG Impacts:	1 – SDG 13: Climate Action 2 – SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture 3 – SDG 7: Ensure access to affordable, reliable and modern energy for all
Estimated amount of SDG Impact Certified	N/A

SECTION A. Description of project

A.1. Purpose and general description of project

>> *(Provide a brief description of the project including the description of scenario existing prior to the implementation of the project.)*

The National Biodigester Programme

In January 2006, the Ministry of Agriculture, Forestry and Fisheries (MAFF) and SNV 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 causing substantial exposure to hazardous household air pollution (with related health hazards) and contributes 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 first phase 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;

A.2. Eligibility of the project under Gold Standard

>> *(Describe how the project meets the eligibility criteria as per section 3.1.1 of GS4GG Principles & Requirements document and the relevant activity requirements document)*

The project is eligible as per section 3.1.1 of the GS4GG Principles and Guidelines as there is a Methodology associated with the activity: Technologies and Practices to Displace Decentralized Thermal Energy Consumption v3.1. In section 1.0 of the methodology is described that bio-digesters are eligible.

A.3. Legal ownership of products generated by the project and legal rights to alter use of resources required to service the project

>> (Justify that project owner has full and uncontested legal ownership of the products that are generated under Gold Standard Certification and has legal rights concerning changes in use of resources required to service the Project for e.g. water rights, where applicable.)

Households that invest in a biodigester have to sign a sales contract, called form 03. In that form, a clause is included on the VER rights transfer from the households to NBP. This clause, No 19 states:

"*Transfers all rights, credits, entitlements, benefits or allowances arising from or in connection with any greenhouse gas emissions reductions arising from the operation of the biodigester (Emission Reductions), and agrees to take all necessary action required to ensure the transfer of those Emission Reductions to the National Biodigester Programme*"

Moreover, a clause is included in the biodigester franchise contract between the BCA (Biodigester Construction Agency), PBPO (Provincial Biodigester Programme Office) and the NBPO (NBP office)

NBP itself is entitled to utilize carbon credits to advance the programme development. This is stipulated in a MoU between NBP and MAFF (Ministry of Agriculture, Fisheries and Forestry).

A.4. Location of project

A.4.1. Host Country

Cambodia

A.4.2. Region/State/Province etc.

NBP is currently active in the following provinces:

#	Province	Active since
1	Kampong Cham	Mar-06
2	Kandal	Mar-06
3	Svay Reang	Mar-06
4	Takeo	Oct-06
5	Kampong Speu	Oct-06
6	Kampong Chhnang	Dec-07
7	Kampot	Dec-07
8	Kampong Som (Preah Sihanouk)	Nov-09
9	Kep	Dec-09
10	Prey Veng	Oct-08
11	Siem Reap	Dec-09
12	Pursat	Jan-10
13	Battambang	Jan-10
14	Kampong Thom	Sep-10
15	Tbong khmum	Sep-14
16	Phnom Penh	May-06[1]

[1] *Orginally NBP was not active in Phnom Penh. However, several districts were transferred from Kandal to Phnom Penh and as a result NBP is now also activity within the Phnom Penh administrative zone*

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.4.3. City/Town/Community etc.

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All the households with the technical potential (>15kg of manure at their disposal on a daily basis) within the project area are targeted, irrespective of district, commune or village. However, since the objective of the programme is to establish a commercially viable market for domestic biogas, the biodigester dissemination will follow market demand. Consequently, location details will only be available *after* households and biogas construction enterprises have entered into a contractual agreement with the BCA.

A.4.4. Physical/Geographical location

>> (*Include information allowing the unique identification of this project.*)

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′00” N	104°55′00” E

In case NBP extends to other provinces, location details will be included in the monitoring report.

A.5. Technologies and/or measures

>> *(Describe the technologies and measures to be employed and/or implemented by the project, including a list of the facilities, systems and equipment that will be installed and/or modified by the project. Include information essential to understand the purpose of the project and how it will contribute positively to three SDGs.)*

NBP installs, through franchised Biodigester Company Agencies (BCA), biodigesters. The main type of digester NBP installs is the Farmer's Friend digester and a scaled down version of this model, the S1. The programme is otherwise biodigester technology agnostic, provided that technologies meet the following requirements:

1. Durability: Biodigesters are expected to last for over 20 years
2. Gas storage: At least 50% of daily gas production should be stored
3. Warrantee: A minimum warrantee of 1 year shall be offered

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

- Inlet (for mixing the manure with water)
- Biodigester and integrated gasholder
- Compensation tank
- Slurry pit (to store overflown slurry temporarily before it is scooped to the compost hut)
- Compost hut (optional)
- Toilet (optional)
- Gas piping and water trap (water trap is necessarily to remove condense water from the biogas)
- Two biogas stoves (stoves produced under 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)

A.6. Scale of the project

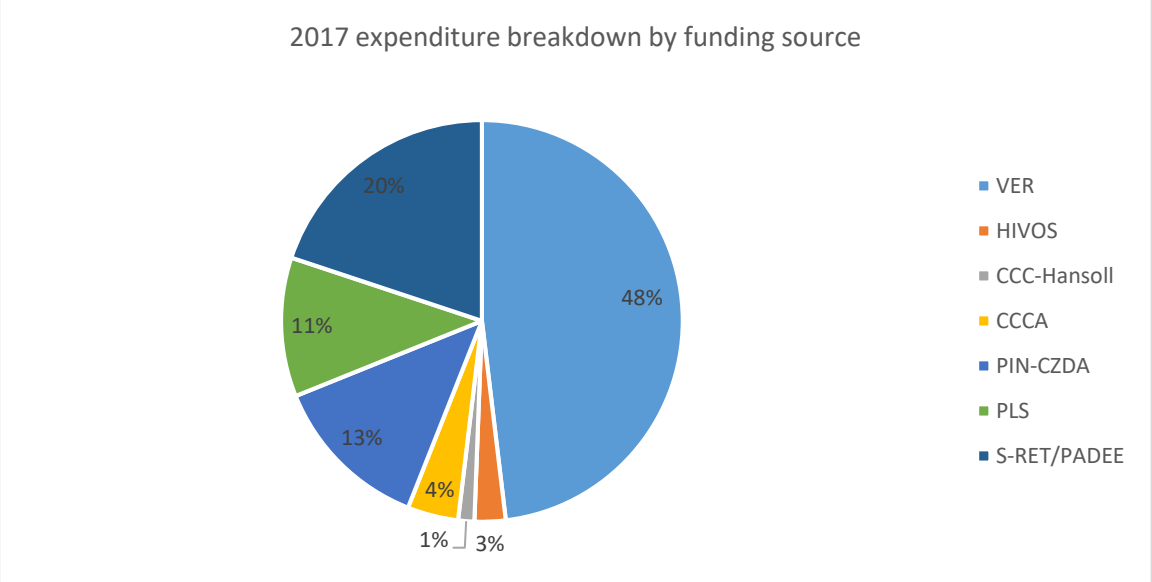
>> (Define whether project is micro scale, small scale or others. Justify the scale referring to relevant activity requirement.)

As per [201] RE Gold Standard Renewable Energy requirement paragraph 1.2.4, the NBP project activity is defined as non-microscale. The emission reductions are over 10,000 tCO_{2eq} annually.

A.7. Funding sources of project

>> (Provide the public and private funding sources for the project. Confidential information need not be provided.)

NBP received a mix of funding sources, including VER income, HIVOS, CCC-Hansoll, CCCA, PIN-ZCDA, PLS, S-RET/PADEE. The funding breakdown is shown here below[2]:



The figure shows clearly that carbon finance plays a very important role in financing the project.

[2] NBP 2017 Annual report

A.8. Assessment that project complies with 'gender sensitive' requirements

>> (Answer the four mandatory questions included under Step 1 to 3 in "Gold Standard Gender Equality Guidelines and Requirements" available here.)

Step 1 to 3 of the Gold Standard Gender Equality Guidelines and Requirements are assessed below:

Step 1: Basic context

1M: Does the project reflect the key issues and requirements of gender-sensitive design and implementation as outlined in the gender policy?

This applies to item 15 in the Gold Standard Gender policy. Yes, NBP has a gender sensitive design and ensures that both women and men are involved during trainings and village group meetings. For example, trainings are organized at a moment that is convenient for women and not interfering with their other (domestic) chores.

1.2 . Does the project align with existing country policies, strategies and best practices?

Key national policies are:

- Neary Rattanak IV – five year strategic plan for Gender Equality and Women's empowerment 2014-2018 of the Ministry of Women's affairs
- Gender Mainstreaming Policy and Strategic Framework in Agriculture 2016-2020

The latter document is most relevant, and addresses issues like time / labour to collect firewood limits women's capacity for higher value tasks which limits nutrition, health, education and life opportunities, limited access to energy that makes women's lives even more difficult.

NBP adheres to strategic objective 1.1: enabling women to have access to agricultural inputs (bio-slurry) and great access to information, objective 1.2: by training them on proper manure management.

Step 2: Apply GS safeguarding principles

3. Does the project address the questions raised in the Gold Standard Safeguarding Principles & Requirements document?

Yes, please refer to Section D.1 of the LSCR. In that report all questions raised in the Gold Standard Safeguarding Principles & Requirements document are addressed.

4. Does the project address the questions raised in the Gold Standard Safeguarding Principles & Requirements document? Explain how.

Yes, the LSCR describes this in detail, see section B.1.iii, and includes consideration of all stakeholder categories, ethnicities, gender and races.

SECTION B. Application of selected approved Gold Standard methodology

B.1. Reference of approved methodology

>>

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

B.2. Applicability of methodology

>> (Justify the choice of the selected methodology(ies) by demonstrating that the project meets each applicability condition of the applied methodology(ies))

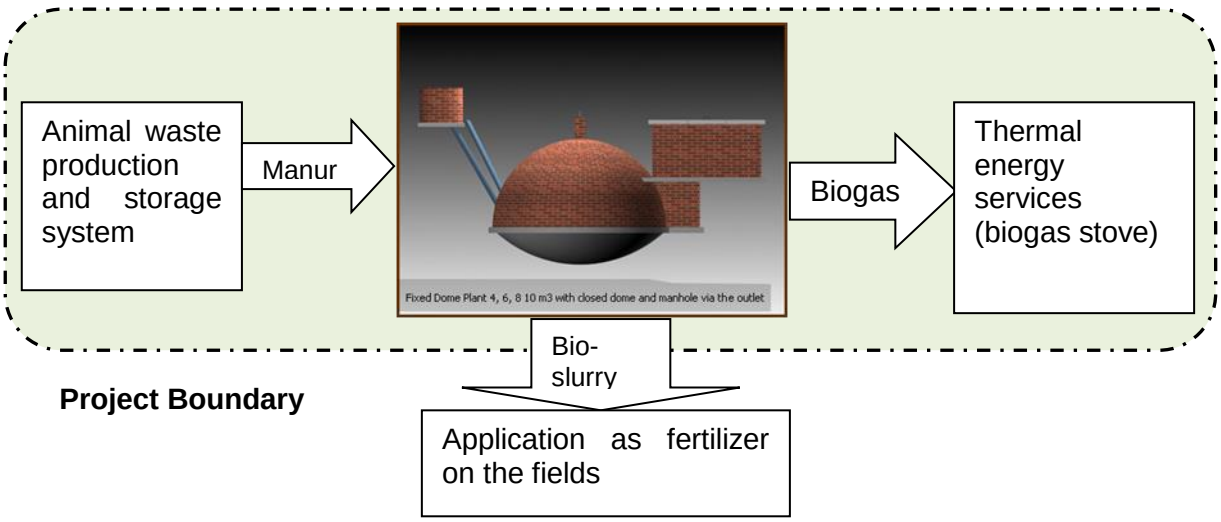
Table 2: Eligibility assessment

Eligibility criteria	Assessment
1. The project boundary needs to be clearly identified, and the technologies counted in the project are not included in any other voluntary market or CDM project activity (i.e. no double counting takes place). In some cases, there maybe another similar activity within the same target area. Project proponents must therefore, have a survey mechanism in place together with appropriate mitigation measures so as to prevent any possibility of double counting.	All biodigesters installed under NBP have a unique registration number. That number indicates when and where the digester was built, based on that numbers double counting can be avoided. There are no similar activities in the project area that claim carbon finance.
2. The technologies each have continuous useful energy outputs of less than 150kW per unit (defined as total energy delivered usefully from start to end of operation of a unit divided by time of operation).	The largest biogas plant produces 11.23 kW/day at maximum (see 15 OCT2015 NBP PDD CPII v2.3) This is much lower than the 150 kW threshold.
3. The use of the baseline technology as a backup or auxiliary technology in parallel with the improved technology introduced by the project activity is permitted as long as a mechanism is put into place to encourage the removal of the old technology (e.g. discounted price for the improved technology) and the definitive discontinuity of the use.	NBP does not install an improved baseline technology, but a different technology. The baseline technology will remain in use in cases there is not enough biogas (i.e. festivities) or for specific activities such a grilling of food which is not possible with a biogas stove. Fuel use by the baseline technology in the project scenario will be accounted for as project emissions. Encouraging households to give up their baseline technology would create an adverse situation because they would revert back to three stone stoves in case there is not enough biogas instead of a better baseline technology. Corresponding emissions are accounted for as part of the project emissions
4. The project proponent must clearly communicate to all project participants the entity that is claiming ownership rights of and selling the emission reductions resulting from the project activity.	This is ensured in the sale contract between the household and the biodigester installer, see section A.3
5. Project activities making use of a new biomass feedstock in the project situation (e.g.	The project does not make use of a new biomass source. The project utilizes manure to produce biogas.

shift from non-renewable to green charcoal, plant oil or renewable biomass briquettes) must comply with relevant Gold Standard specific requirements for biomass related project activities, as defined in the latest version of the Gold Standard rules	
5 A. Adequate evidence is supplied to demonstrate that indoor air pollution (IAP) levels are not worsened compared to the baseline, and greenhouse gases (as listed in section 2.1) emitted by the project fuel/stove combination are estimated with adequate precision	The area with the cleanest air in rural areas are biogas kitchens according to a household air pollution study executed by E.buysman in 2015[3]. The study showed that biogas reduces PM2.5 levels, with a reduction of around 36% reduction in exposure and 88% reduction in kitchen concentrations. CO levels are also much lower, but in most cases, including the baseline households lower than the 24-hour WHO guidelines.
5B. Records of renewable fuel sales may not be used as sole parameters for emission reduction calculation, but may be used as data informing the equations in section 2.0 of this methodology.	Not applicable, household use manure from their own manure.
6. Regarding application of the methodology to bio-digesters, including animal waste management. If more than one climate zone is included in the project activity, a distinction per climate zone must be considered. The distinct geographical boundary of each project area must be clearly documented in the project documentation, using representative GPS data.	The climatic conditions in the NBP project area are practically uniform with an average temperate of 27◦C with little variation in the provinces, see http://www.cambodia.climatemps.com/. The climate type in Cambodia is Rainforest, see http://www.naturalhistoryonthenet.com/Continents/asia.htm

B.3. Project boundary

The project boundary encompasses the geographical sites all the units commissioned from 13/3/2006 of all biodigester under the project. The project will, depending on external financing and the VER price, extend to the whole of Cambodia the project boundary is therefore Cambodia. The wood fuel collection and production area are also Cambodia.



[3] http://www.ccacoalition.org/en/news/report-biogas-and-household-air-quality-rural-cambodia

Table 3: GHG Emission sources included in the project boundary

	Source	GHG	Included?	Justification / explanation
Baseline	Thermal energy demand for human food preparation and water boiling	CO_2	Yes	Major source of GHG emission
		CH_4	Yes	Major source of GHG emission
		N_2O	Yes	Major source of GHG emission
		BC	No	Major source of GHG emission but excluded for simplification
	Animal waste handling and storage	CO_2	No	Excluded as CO_2 emissions from animal waste are CO_2 neutral
		CH_4	Yes	Major source of emissions
		N_2O	No	Excluded for simplification; conservative
Project activity	Biodigester system	CO_2	No	Excluded as CO_2 emissions from bio-slurry are CO_2 neutral
		CH_4	Yes	Emissions from physical leakage
		N_2O	No	Excluded as a biodigester does not produce N_2O gasses
	Thermal energy demand for human food preparation and water boiling	CO_2	Yes	Major source of GHG emission
		CH_4	Yes	Major source of GHG emission
		N_2O	Yes	Major source of GHG emission

B.4. Establishment and description of baseline scenario

>> (Explain how the baseline scenario is established in accordance with guidelines provided in GS4GG Principles & Requirements and the selected methodology(ies). In case suppressed demand baseline is used then same should be explained and justified.)

The baseline scenario is defined by the typical baseline fuel consumption patterns in a population that is targeted for adoption of the project technology.

The baseline from AWMS is the emissions from animal manure management systems resulting from the anaerobic biodegradation of organic matter

B.5. Demonstration of additionality

>> (If the proposed project is not a type of project that is deemed additional, as stated below, then follow guidelines in section 3.5.1 of GS4GG Principles & Requirements to demonstrate additionality.)

The table below is only applicable if the proposed project is deemed additional, as defined by the applied approved methodology or activity requirement or product requirement.

Specify the methodology or activity requirement or product requirement that establish deemed additionality for the proposed project (including the version number and the specific paragraph, if applicable).	TPDDTEC v3.1 page 11 chapter 3. Additionality. CDM tool 21 applied: Demonstration of additionality of small-scale project activities see "https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-21-v1.pdf Paragraph 11c
Describe how the proposed project meets the criteria for deemed additionality.	Project activities solely composed of isolated units where the users of the technology/measure are households or communities or Small and Medium Enterprises (SMEs) and where the size of each unit is no larger than 5% of the small-scale CDM thresholds do not need to demonstrate barriers and are on the positive list of technologies and project activity types that are defined as automatically additional. As demonstrated in section B.2 item 2 in the table 2 the individual capacity of a biodigester is at maximum 11.23 kW which is much smaller than 5% of 45 MW

B.6. Sustainable Development Goals (SDG) outcomes

B.6.1. Relevant target for each of the three SDGs

>> (Specify the relevant SDG target for each of three SDGs addressed by the project. Refer most recent version of targets here .)

Goal	Target	Output indicator
Sustainable Development Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all	7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.2: Proportion of population with primary reliance on clean fuels and technology
Sustainable Development Goal 2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2.4.1: Proportion of agricultural area under productive and sustainable agriculture
Goal 13: Take urgent action to combat climate change and its impacts	13.2 integrate climate change measures into national policies, strategies, and planning	Defined herein as Emissions Reductions or Removals and/or Adaptation to climate change[4]

B.6.2. Explanation of methodological choices/approaches for estimating the SDG outcome

>> (Explain how the methodological steps in the selected methodology(ies) or proposed approach for calculating baseline and project outcomes are applied. Clearly state which equations will be used in calculating net benefit.)

[4] See https://globalgoals.goldstandard.org/100-gs4gg-principles-requirements/

Goal 7 contribution:

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

Target: households that reply on clean fuels and technology: biogas

This will be calculated with the following equation

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

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

Project situation: The contribution to this SDG are all the digesters in operation since the on-set of NBP.

Goal 2 contribution

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

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

This will be calculated with the following equation

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

Where:

BS_y	=	Total number of household using bio-slurry year y
$N_{b,y}$	=	Total number of biodigesters in year y
U_y	=	Usage rate in year y
$\%BS_y$	=	Share of households that uses bio-slurry for crop production in year y

Goal 13 contribution

SDG13.2: GHG emission reductions

Emission reductions are calculated as the difference between the baseline emissions and the project emissions. This project includes two sources of emission reduction:

1. Displacement of non-renewable biomass
2. Avoidance of methane emissions from AWMS.

GHG emissions under the baseline condition comprise two sources:

3. CO2 , CH4 and N2O emission from combustion of non-renewable cooking fuels;

4. CH4 emission from the animal waste management system.

The total average baseline emissions per household are calculated as the sum of the total CO_2 equivalent emissions as:

$$\boldsymbol{BE_h = BE_{b,h} + BE_{awms,h}}$$

Equation 1: Estimation of baseline emissions

Where:

BE_h	=	Total baseline emissions in the pre-project situation of household *h* (tCO_2e/year)
$BE_{b,h}$	=	Baseline emissions from fuel consumption for thermal energy needs of households *h* (tCO_2e/year)
$BE_{awms,h}$	=	Baseline emissions from animal waste handling of household *h* (tCO_2e/year)

1. Emission reductions from thermal energy use

Baseline fuel scenario

The baseline scenario is defined by the typical fuel consumption for household cooking among the target population prior to adopting the project technology. The baseline studies executed are:

A. Baseline non-renewable biomass (NRB assessment);
B. Baseline survey of target population characteristics
C. Baseline fuel test (will be executed during MPI of CPIII)

The project scenario is the population of users that have installed a biogas plant. The emission reductions are ascribed by comparing the fuel consumption in the project scenario with the baseline fuel use of the biogas users for cooking only.

Other uses of biogas, such as electricity generation or displacement of electricity by, for example biogas water heaters, is only practiced by a minor part of the biogas population. Emission reductions arising from electricity generation are not accounted for however, this is conservative.

A. Baseline Non-Renewable Biomass Assessment

The fraction of NRB is identified following the guidelines of applied methodology 'Technologies and practices to displace decentralized thermal energy consumption' version 3.1. The NRB assessment may be updated prior to verification if further analysis and or surveys are conducted after the baseline study. The NRB assessment will be reassessed when renewing the crediting period based on the most recent information available.

The DNA approved NRB fraction as per CDM SSC 43 Annex 4 for Cambodia[5] is adopted for CPIII.

B. Baseline survey with target population characteristics

A baseline survey was executed for this PDD. The survey design is discussed in annex 3. A separate report has been developed detailing the baseline characteristics of the target population. [study is at the moment being undertaken]

C. Baseline fuel test

The BFT will be executed during MPI as per applied methodology

Emission reductions from thermal energy displacement

Fuel consumption will be measured with a representative sample of end users in order to measure real, observed technology performance in the field; the so-called Project Fuel Test. The emission reductions from fuel displacement will be calculated as per option 2 of the methodology for each verification[6]. The emission reductions from fuel use are calculated with the following equation.

Equation 2: Calculation of the baseline emissions

$$BE_{b,y} = B_{b,y} \times ((f_{NRB,y} \times EF_{b,fuel,CO2}) + EF_{b,fuel,CO2}) \times NCV_{b,fuel}$$

Practically all households use wood in the baseline scenario and only a small percentage charcoal. For example, in the BFT executed for MPI 2 out of 50 households used charcoal, or 4% of the total.

In that case, the charcoal consumption will be expressed in wood-equivalents, as allowed in TPDDTEC on page 16. The conservative charcoal to wood ratio applied is 1 to 6 as per IPCC 1996 revised guidelines[7] chapter 1 page 45. This will also apply in case project households use charcoal.

A BFT and a PFT will be executed to estimate the emission reductions as per procedure described in section B.7.1 and per equation 2 of the methodology:

Equation 3: Emission reductions from thermal energy displacement

$$ER_y = \sum_{b,p} N_{p,y} * U_{p,y} * (f_{NRB,b,y} * ER_{b,p,y,CO2} + ER_{b,p,y,non\text{-}CO2}) - \sum LE_{p,y}$$

Where:

$\sum_{b,p}$ = Sum of all relevant (baseline b/project p) couples

[5] *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=a3l8bnc4b2xpfDBQIyOyLzi-Fkd3xcEwGMcE*

[6] *The PP decided not to adopt the per capita default of 0.5 ton wood per annum and this was deemed not representative for Cambodia and the region.*

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

$N_{p,y}$	=	Cumulative number of project technology months included in the project database for project scenario p in against baseline scenario b in year y. *The $N_{p,y}$ applied to each month is the value of last month to allow for a 1 month period for starting up the digester. 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 p in year y, based on cumulative adoption rate and drop off (fraction)
$ER_{b,p,y,CO2}$	=	Specific CO2 emission savings for an individual technology of project p against an individual technology of baseline b in year y, in tCO2/day, and as derived from the statistical analysis of the data collected from the field tests
$ER_{b,p,y,non-CO2}$	=	Specific non-CO2 emission savings for an individual technology of project p against an individual technology of baseline b in year y, in tCO2/day, and as derived from the statistical analysis of the data collected from the field tests
$f_{NRB,y}$	=	Fraction of biomass used in year y for baseline scenario b that can be established as non-renewable biomass
$LE_{p,y}$	=	Leakage for project scenario p in year y (tCO2e/yr)

2. Baseline emission from animal waste handling:

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.

$$BE_{awms,h} = GWP_{CH4} * \sum \left(EF_{awms(T)} * N_{(T),h} \right)$$

Equation 4: Calculation of baseline emissions

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, (ton_{CH4}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 (EFawms(T)) for tier 2 approach is calculated as follows,

$$EF_{awms(T)} = N_{T,h} \times (VS_{\mathrm{T}} \times 365) \times GWP_{CH_4} \times \left[Bo_{\mathrm{T}} \times \frac{0.67kg}{m^3} \times \sum_k \frac{MCF_{BL,k}}{100} \times MS_{(\mathrm{T,k})} \right]$$

Equation 5: Baseline emissions from animal waste management by animal category T (see 16 of the applied methodology)

Where:

$EF_{awms(T)}$	=	CH4 emission factor for livestock category T, (tCH4per animal per year)
$N_{T,h}$	=	The number of animals of livestock species per animal category T
$VS_{(T)}$	=	Daily volatile solid excreted for livestock category T, kg VS.animal $^{-1}$
365	=	Basis for calculating annual VS production, days yr^{-1}
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
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_S	=	Methane conversion factors for the animal waste handling system of MS system S
MS_T	=	Fraction of livestock category T's manure treated in the animal waste management system k

3. Project and leakage emissions

The project proponent should investigate the following potential sources of leakage emissions (LE):

Table 4: Leakage emission sources to be assessed

#	Leakage source
a	The displaced baseline technologies are reused outside the project boundary in place of lower emitting technology or in a manner suggesting more usage than would have occurred in the absence of the project.
b	The non-renewable biomass or fossil fuels saved under the project activity are used by non-project users who previously used lower emitting energy sources.
c	The project significantly impacts the NRB fraction within an area where other CDM or VER project activities account for NRB fraction in their baseline scenario.
d	The project population compensates for loss of the space heating effect of inefficient technology by adopting some other form of heating or by retaining some use of inefficient technology
e	By virtue of promotion and marketing of a new technology with high efficiency, the project stimulates substitution within households who commonly used a technology with relatively lower emissions, in cases where such a trend is not eligible as an evolving baseline.

Not all fuels will be replaced by biogas. The fuels that people continue to use in the project scenario will be obtained from the monitoring surveys. The project emissions (PE) involve emissions from the bio-digester, which include physical leakage, potential emissions from digestate and incomplete combustion of biogas, as well as emissions from the animal waste not treated in the bio-digester.

Project emission from fuel use are already accounted for in equation 2 in this PDD.

$$\boldsymbol{PE_{p,y} = B_{p,y} \times ((f_{NRB,y} \times EF_{b,fuel,CO2}) + EF_{b,fuel,CO2}) \times NCV_{b,fuel}}$$

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.

Equation 6: PE from AWMS, see equation 17 of the applied methodology

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

Where:

$N_{T,h,y}$	=	Number of animals of livestock category T in year y in premise h
$PE_{awms,h,y}$	=	Mean emission per household *h* (tCO_2e/year)
$EFawms_T$	=	Emission factor for the defined livestock category T, (ton CH_4 per animal per year). Estimated using the IPCC TIER 2 approach.

PL_y	=	Physical leakage of the biodigester in year *y* (10 %)[8]
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

The EF_{AWMS} will be calculated using the IPCC tier 2 approach and VS will be determined ex-post with the following equation:

Equation 7: Weight adjusted VS excretion

$$VS_{T,y} = \left(\frac{W_{site}}{W_{default}} \right) \times VS_{default} \times nd_y$$

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 (kg)
VS	=	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
$VS_{T,y}$	=	Adjusted VS value for year y

The average weight (Wsite) is the average of entry weight at the farm and weight when the pig left 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 and given that those animals can become very heavy they can influence the results considerably. In a question to improve the quality of the data, this year the weight is not only estimated but also calculated as per methods described on the Pig Site[9]. This is possible with the following equation:

Equation 8: Weight a pig without scale[9]

$$Pig\ weight = Hg^2 \times L \times 69.3$$

Where:
Hg = Hearth girth in meter and L = length in meter

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

[8] Default value of the applied methodology is adopted (TPDDTEC page 52)

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

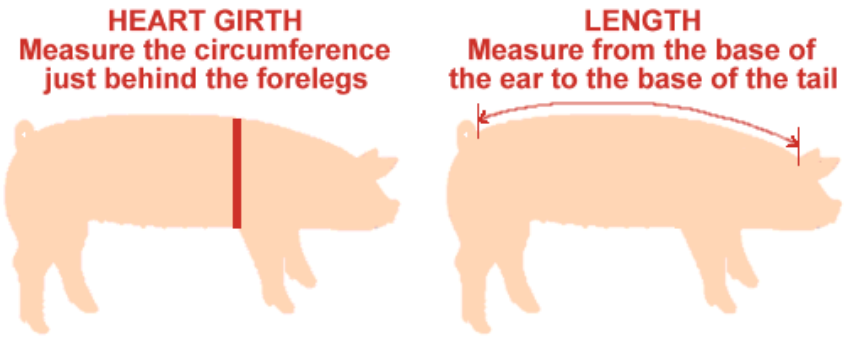


Figure 1: Hearth girth and length measurement

Emissions from digestate

The following leakage emission source is accounted for: CH_4 emissions from the anaerobic decay of the residual organic content of digestate subjected to anaerobic storage.

The emissions assessment from digestate will be based on the same equation as for the emission from animal waste management (see second equation on the previous page). Applicable VS, B_0, MCF values will be sourced from credible literature sources or the IPCC.

Digestate typically has low biodegradability because easily biodegradable organic matter has been converted in the anaerobic digester and therefore the biodegradability of digestate is much lower than manure[10].

This emission source will be determined through the following steps:

1. Estimation of the total amount of VS entering the biodigester
2. Assessment of remaining VS content of digestate
3. Assessment of methane potential of bio-slurry
4. MCF of the digestate management systems (DMS)
5. Calculation of PE_{dig} using the information obtained in the previous steps

1. **Estimation of the total amount of VS entering the biodigester**

The total amount of VS entering the biogas plant depends on the type of animal and the share of manure that is fed into the biogas plant and is calculated as follows:

Equation 9: Calculation of MS fed

$$MS_{fed\ in\ digester,T} = 1 - MS_{not\ fed,T}$$

Where, $MS_{fed\ in\ digester}$ is the share of manure fed into the digester and $MS_{no\ fed}$ the share not fed into the digester of animal category T.

The total amount of VS entering the average biodigester of each animal category T is then:

Equation 10: Calculation of amount of VS entering the average digester

$$VS_{dig,T} = MS_{fed\ in\ digester,T} \times VS_T$$

Where VS_T is amount of VS of animal category T (unit kg VS/day) and VS_{dig} the amount of VS that enters the biodigester from animal category T.

B.6.3. Data and parameters fixed ex ante for monitoring contribution to each of the three SDGs

(Include a compilation of information on the data and parameters that are not monitored during the crediting period but are determined before the design certification and remain fixed throughout the crediting period like IPCC defaults and other methodology defaults. Copy this table for each piece of data and parameter.)

Goal	13
Data / Parameter:	**$EF_{b,CO2}$**
Data unit:	$kgCO_2/TJ$ fuel
Description:	CO2 emission factor arising from use of fuels in the baseline scenario
Source of data used:	2006 IPCC Guidelines defaults, see chapter 2 Stationary Combustion: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
Value applied:	**Fuel *b*** / **EF_{CO2}, (kg/TJ)** LPG / 63100 Charcoal* / 112000 Firewood / 112000
Any 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.

Goal	13
Data / Parameter:	**$EF_{i,CH4}$**
Data unit:	$kgCH_4/TJ$ fuel
Description:	CH_4 emission factor arising from use of fuels in the baseline scenario
Source of data used:	2006 IPCC Guidelines defaults see chapter 2 Stationary Combustion: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html, table 2.9
Value applied:	**Fuel *i*** / **EF_{CH4}, (kg/TJ)** LPG / 11.95

	Charcoal	330.5
	Firewood	1224
Any 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.	

Goal	13
Data / Parameter:	**$EF_{i,N2O}$**
Data unit:	kgN_2O/TJ fuel
Description:	N_2O emission factor arising from use of fuels in the baseline scenario
Source of data used:	2006 IPCC Guidelines defaults, see chapter 2 Stationary Combustion, table 2.9 http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
Value applied:	**Fuel *i*** / **$EF_{N20,}$ (kg/TJ)** LPG: 2.1 Charcoal: 5.45 Firewood: 11.25
Any 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.

Goal	13
Data / Parameter:	**NCV_i**
Data unit:	TJ/Gg
Description:	Net calorific value of the fuel i used in the baseline
Source of data used:	2006 IPCC Guidelines defaults, see chapter 1 Energy table 1.2 http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
Value applied:	Fuel *i* / **NCV_i (TJ/Gg)** LPG: 47.3

	Charcoal: 29.5 Firewood: 15.6
Any comment:	In case charcoal is expressed in wood equivalents, the NCV of firewood will be applied

Goal	13
Data / Parameter:	**Charcoal to wood ratio**
Data unit:	[_]
Description:	Charcoal to wood conversion ratio
Source of data used:	SAR IPCC
Value Applied	1:6
Any comment:	From IPCC 1996 revised guidelines, Chapter 1, page 45: http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref3.pdf

Goal	13
Data / Parameter:	**GWP_{CH4}**
Data unit:	tCO_2e per tCH4
Description:	Global Warming Potential (GWP) of methane
Source of data used:	AR IPCC
Any comment:	25 for the second commitment period. Shall be updated to any future COP/MOP decisions

Goal	13
Data / Parameter:	**GWP_{N2O}**
Data unit:	tCO_2e per tN_2O
Description:	Global Warming Potential (GWP) of nitrous oxide
Source of data used:	AR IPCC
Any comment:	298 for the second commitment period. Shall be updated to any future COP/MOP decisions

Goal	13
Data / Parameter:	$VS_{(T)}$
Data unit:	kg dry matter per animal per day
Description:	Daily volatile solid excreted for livestock category T
Source of data used:	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 applied:	Animal: kgVS/day Pig: 0.3 Buffalo: 3.9 Other cattle: 2.3
Any comment:	Any comment: 365 = basis for calculating annual VS production, days per year, region Asia and for animal weights of 319 kg for other cattle, 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 2 of AMS-III.D v19

Goal	13
Data / Parameter:	$Bo_{(T)}$
Data 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 used:	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 applied:	Animal T: $Bo_{(T)}$ m^3CH_4/kgVS Pig: 0.29 Buffalo: 0.10 Cattle: 0.10
Any comment:	

Goal	13
Data / Parameter	**MCF(k)**
Unit	%
Description	Methane conversion factors for each manure management system by climate region k
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	
Additional comment	

Goal	13
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 temperatures
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)
Additional comment	

Goal	13
Data / Parameter:	**$\eta_{biogasstove}$**
Data unit:	[-]%
Description:	Combustion efficiency of the biogas stove
Source of data used:	99.4%
Value applied	99.4%

Any comments	Source: Centre for Energy Studies, Institute of Engineering for the Nepal Biogas Support Programme[11]. BSP is the mother programme of NBP. The combustion efficiency is according to the study 99.4%. That figure is assumed reasonable and conservative and accepted during the last verifications

B.6.4. Ex ante estimation of outcomes linked to each of the three SDGs

>> (Provide a transparent ex ante calculation of baseline and project outcomes (or, where applicable, direct calculation of net benefit) during the crediting period, applying all relevant equations provided in the selected methodology(ies) or as per proposed approach. For data or parameters available before design certification, use values contained in the table in section B.6.3 above. For data/parameters not available before design certification and monitored during the crediting period, use estimates contained in the table in section B.7.1 below)

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

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

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

Where:			Example calculation ex-ante estimate for 2019	source
BS_y	=	Total number of household using bio-slurry year y	21676	
$N_{b,y}$	=	Total number of biodigesters in year y month 11	28402	estimated units constructed in month 11 of MPI of CPII
U_y	=	Usage rate in year y	0.79	
$\%BS_y$	=	Share of households that uses bio-slurry for crop production in year y	96%	Value from MPVI CPII (latest available data)

[11] http://www.snvworld.org/sites/www.snvworld.org/files/publications/efficiency_measurement_of_biogas_kerosene_and_lpg_stoves_nepal_2001.pdf

SDG 7	Proportion of population with primary reliance on clean fuels and technology **Target:** households that reply on on clean fuels and technology: biogas			
	$P_{clean,y} = N_{b,y} \times U_y \times B_{daily} \times H_{s,y}$			
	Where:		**Example calculation ex-ante estimate for 2019**	**source**
	$P_{clean,y}$ =	Total number of household using primarily biogas in year y	104458	
	$N_{b,y}$ =	Total number of biodigesters in year y month 11	28402	estimated units constructed in month 11 of MPI of CPII
	U_y =	Usage rate in year y	0.79	
	$B_{daily,y}$ =	Share of biogas households that uses biogas at least once per day for cooking in year y	0.99	Value from MPVI CPII (latest available data)
	$H_{s,y}$ =	Number of family members permenent residing in the household in year y	4.69	

SDG 13: Emission reductions

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"

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

1. BFT- Thermal energy demand

The total amount of the fuel used for thermal energy demand of the households with the technical potential is listed hereunder (source: BFT MPI)

Table 5: Fuels used in the baseline

Fuel use	*N*	*%*
Fuelwood	48	96%
Charcoal	2	4%

Most households use wood and only a minor percentage charcoal. The next table displays the annual consumption, the conversion of this to wood equivalents and the wood equivalent consumption per capita.

Table 6: Baseline charcoal and wood equivalent consumption in the population

Charcoal consumption kg/year/hh	Conversion factor (charcoal:wood)	Wood equivalents (kg/year/hh)
35.916	1:6	215.5

The total baseline emissions from fuel wood use is shown in the next table

Table 7: Thermal energy demand of the households with the technical potential

Fuel *i*	Consumption Kg/year/hh	NCV_i (TJ/Gg)	Thermal energy demand (TJ/year)
Wood	1435.1	15.6	0.022387669
Charcoal in wood equivalences	215.5	15.6	0.003361738

2. Applicable emission factors

In absence of national relevant emission factors, the default emission factors from the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, volume 2: Energy, Chapter 1 are used and referenced in section xxx.

3. Fraction of Non-Renewable biomass ($f_{NRB.}$)

The $f_{NRB.}$ is estimated at 77%, see section B.6.2. The f_{NRB} is applicable to CO_2 emissions from firewood and charcoal consumption and production. Methane and nitrous oxide emission are 100% non-renewable by definition.

4. Baseline emissions by fuel, GHG and total

The baseline emission is the baseline thermal energy consumption multiplied by emission factors and the global warming potential of each GWP.

Table 8: Baseline emission of each fuel and total from thermal energy use

Fuel i	Baseline emissions from CO_2 (tCO_2e/yr)	Baseline emission from CH_4 (tCO_2e/yr)	Baseline emission from N_20 (tCO_2e/yr)	Total (tCO_2e/yr)
Firewood	1.931	0.58	0.075	2.581
Charcoal in wood eq	0.290	0.09	0.011	0.388
			sum	2.969

Step 2: Determination Baseline Emission from AWMS

1. Determination of the management system (MS)

The baseline survey, see annex 3, included a survey on the MS according to the IPCC tier 2 approach. Results from the survey showed that not all animals are stabled during the whole day and there are differences during the dry and the wet season. Assumed is that the animal waste excreted is proportional to the time spent either stabled or in the field, thus, if an animal is in the field for 25% of the time, assumed is that 25% of the animal waste is excreted in the field and the other 75% when stabled. All the excreted waste in the field belongs to the animal waste management system (AWMS) 'pasture'. The manure management systems and the respective MCF by type of animal are found in the baseline study are depicted in the next table (please refer to ER worksheet for detailed calculation in the next table):

Table 9: Manure management systems [data not yet available]

Animal	Anaerobic Lagoon	slurry	Solid storage	Compost	daily spread	drying	fishpond	other	Pasture
Other cattle									
Pig									
Buffalo									
MCF*	80%	78%	5%	1.5%	1%	1%	1%	1%	2%

* at 27ºC[12]

To calculate the EF per animal *T* the default IPCC values are used for VS and Bo since no country specific data is available. The next table shows the default 2006 IPCC values and the number of average number of animal kept by the households with the technical potential.

Table 10: IPCC 2006 default values for VS and Bo

Animal T	**VS (kg/day)**	**Bo (m^3/kg)**
Other cattle	2.3	0.1
Pig	0.59[13]	0.29
Buffalo	3.9	0.1

With the data from the previous tables the emission factor of animal *T* can be determined.

[12] The IPCC default value depends on the average annual temperature. The average annual temperature in Cambodia is 27.7ºC, see http://www.cambodia.climatetemp.info/

[13] Calculated using MPVI survey values; average pig weight 55.12 and therefore VS excretion was adjusted with the factor 55.12 (Wsite)/28 (Wdefault) * 0.3 (VS default excretion)

Table 11: The calculated emission factor of animal *T*

Animal T	EF_T ($kgCH_4/yr/animal\ T$)
Other cattle	
Pig	
Buffalo	

The emission per household of all the animals from the animal waste management systems are calculated and depicted in the next table. The number of animals originates from the baseline survey and used as an ex-ante estimate on animal ownership of potential biodigester users.

Table 12: Ex-ante Baseline emission from animal waste management

Animal T/hh	Average population N_T/hh	EF_T ($kgCH_4$/year)	GWP_{CH4}	$BE_{aw,T,h}$ (tCO_2e/year)
Other cattle			25	
Pig			25	
Buffalo			25	
		Total		

Total Baseline emissions

The total BE emissions resulting from both manure management practices and thermal energy needs, are depicted in the next table.

Table 13: Total baseline emission of the targeted households

Emission source	Acronym	BE (tCO_2/year/h)
Thermal energy demand	BE_{th}	
AWMS	BE_{AW}	
Total	**BE**	

C. Estimation of project and leakage emissions

The project proponent should investigate the following potential sources of leakage:

Table 14: Leakage emission assessment

#	Leakage source	Applicability
a	The displaced baseline technologies are reused outside the project boundary in place of lower emitting technology or in a manner suggesting more usage than would have occurred in the absence of the project.	The baseline technologies are not reused outside the project boundary. Furthermore, the baseline technologies outside the project boundary are the same with the same efficiencies
b	The non-renewable biomass or fossil fuels saved under the project activity are used by non-project users who previously used lower emitting energy sources.	Most household rely on wood in Cambodia. The small share of household that use a lower emitting energy source, such as LPG, are not likely to use NRB instead of LPG due to the project activity.
c	The project significantly impacts the NRB fraction within an area where other CDM or VER project activities account for NRB fraction in their baseline scenario.	NBP is active in my provinces and spread out over a large area. The impact on the NRB is therefore negligible
d	The project population compensates for loss of the space heating effect of inefficient technology by adopting some other form of heating or by retaining some use of inefficient technology	Space heating does not occur in Cambodia
e	By virtue of promotion and marketing of a new technology with high efficiency, the project stimulates substitution within households who commonly used a technology with relatively lower emissions, in cases where such a trend is not eligible as an evolving baseline.	The baseline is not fixed in this project, and the combustion of biogas always leads to lower emissions compared to all baseline fuels as it is 100% renewable.

Not all fuels will be replaced by biogas. The fuels that people continue to use in the project scenario will be obtained from the monitoring surveys. The next table shows the estimated remaining fuel consumptions from the PFT executed in MPI

Table 15: Estimate project emissions from thermal energy use (MPVI CPII)

Fuel *i*	Average per household (kg/year)	NCV_i (TJ/Gg)	Thermal energy demand (TJ)
Firewood			
Charcoal			

The ex-ante estimated project emissions are shown in the next table by fuel and GHG.

Table 16: Estimate ex-ante project emission from thermal energy use

Fuel	Baseline emissions from CO_2 (tCO_2e/yr)	Baseline emission from CH_4 (tCO_2e/yr)	Baseline emission from N_20 (tCO_2e/yr)	Total (tCO_2e/yr)
Firewood				
Charcoal in wood eq				
			sum	

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.

Ex-ante AWMS data applied is taken from MRVI of CPII. The remaining emissions are therefore only physical leakage and incomplete combustion. 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 17: 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} ($kgCH_4/year$)
Other cattle	2.3	0.1		0.67	
Pig	0.59	0.59		0.67	
Buffalo	3.9	0.1		0.67	

The project emissions are then the multiplication of the EF_{AWMS} with the physical leakages emissions and the stove efficiency.

Table 18: Physical leakage emission parameters

Item	Value	Source
Physical leakage	**10%**	IPCC default value for biodigesters independent on annual temperatures
Stove combustion efficiency	**99.4%**	http://www.snvworld.org/sites/www.snvworld.org/files/publications/efficiency_measurement_of_biogas_kerosene_and_lpg_stoves_nepal_2001.pdf

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

Table 19: Physical leakage emission from biodigester

Animal	$PL_{\_AWMS}$ ($kgCH_4$/year)	PL_{stove} ($kgCH_4$/year)
Other cattle	2.630	0.014
pig	0.472	0.003
Buffalo	0.136	0.001
Total	**3.237**	**0.017**

The physical leakage emissions and the emissions from incomplete combustion are 3.237 + 0.017= 3.255 $kgCH_4$/household/year equivalent to 0.081 tCO_2/household/year.

D. Ex-ante estimate of the emission reductions

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

$$ER_{y,h} = U_{y,h} \times (BE_{y,h} \_ PE_{y,h}) \text{ x } N_{p,y}$$

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 usage rate of MRVI of CPII (79.3%)

Table 20: Average annual emission reductions

Emission source	BE (tCO_{2e}/h/year)	PE (tCO_{2e}/h/year)	ER (tCO_{2e}/h/year)
Fuel use			
AWMS			
Sum			

The estimated emission reductions are 5.54 tCO_2 per household per year

B.6.5. Summary of ex ante estimates of each SDG outcome

SDG 2

Year	Baseline estimate	Project estimate	Net benefit
2019	0	21,676	21,676
2020	0	22,509	22,509
2021	0	23,418	23,418
2022	0	24,369	24,369
2023	0	25,358	25,358
2024	0	26,385	26,385
2025	0	27,451	27,451
Total	0	171,166	171,166
Total number of crediting years	*7*		
7Annual average over the crediting period	24,452		

SDG 7

Year	Baseline estimate	Project estimate	Net benefit
2019	**Baseline estimate**	**Project estimate**	**Net benefit**
2020	0	104,458	104,458
2021	0	108,473	108,473
2022	0	112,856	112,856
2023	0	117,438	117,438
2024	0	122,204	122,204
2025	0	127,154	127,154
Total	0	132,287	132,287
Total number of crediting years	0	824,869	824,869
7Annual average over the crediting period	*7*		

SDG 13 [data not yet available]

Year	Baseline estimate	Project estimate	Net benefit
2019	0		
2020	0		
2021	0		
2022	0		
2023	0		
2024	0		
2025	0		
Total	0		

Total number of crediting years	*7*		
7Annual average over the crediting period			

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

(Include specific information on how the data and parameters that need to be monitored in the selected methodology(ies) or proposed approaches or as per mitigation measures from safeguarding principles assessment or as per feedback from stakeholder consultations would actually be collected during monitoring. Copy this table for each piece of data and parameter.)

Relevant SDG Indicator	*7*
Data / Parameter	$B_{daily,y}$
Unit	percentage
Description	Share of biogas uses that uses biogas at least once per day for cooking in year y
Source of data	Carbon monitoring survey
Value(s) applied	Ex-ante: 100%
Measurement methods and procedures	Determined using survey methods
Monitoring frequency	Annual
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	
Additional comment	

Relevant SDG Indicator	*7*
Data / Parameter	$\%BS_y$
Unit	percentage
Description	Share of households that uses bio-slurry for crop production in year y
Source of data	Carbon monitoring survey
Value(s) applied	Ex-ante: 100%
Measurement methods and procedures	Determined using survey methods
Monitoring frequency	Annual
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	
Additional comment	This questions cannot be answered be 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	*7*

Data / Parameter	$Hs_{,y}$
Unit	Household size
Description	Number of family members permanent residing in the household in year y
Source of data	Carbon monitoring survey
Value(s) applied	Ex-ante: 100%
Measurement methods and procedures	Determined using survey methods
Monitoring frequency	Annual
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	
Additional comment	This questions cannot be answered be 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	**SDG13**
Data / Parameter	$\mathbf{P_{p,y}}$
Unit	kg/ project household-year
Description	Quantity of fuel that is consumed in the project scenario in year y
Source of data	Project performance test
Value(s) applied	Ex-ante value applied is xx
Measurement methods and procedures	Updated for every 2 years or more frequently after the first verification
Monitoring frequency	Biennial, starting from MPI
QA/QC procedures	Transparent data analysis and reporting

Relevant SDG Indicator	**SDG13**
Data / Parameter	$\mathbf{P_{b,y}}$
Unit	kg/ project household-year
Description	Quantity of fuel that is consumed in the baseline scenario in year y
Source of data	Baseline performance test
Value(s) applied	Ex-ante value applied is xx
Measurement methods and procedures	Updated for every 2 years or more frequently after the first verification
Monitoring frequency	Once per CP, to be executed during MPI
QA/QC procedures	Transparent data analysis and reporting

Relevant SDG Indicator	**SDG13**
Data / Parameter	$\mathbf{fNRB_{,l,y}}$
Unit	Fraction of Non-Renewable Biomass
Description	Non-renewability status of woody biomass fuel in scenario i during year y
Source of data	The fNRB is calculated from FAO and IPCC, and this is also indicated in UNFCCC SSC WG 35 Annex 20 with same approach of fNRB estimation,

	see http://cdm.unfccc.int/Panels/ssc_wg/meetings/035/ssc_035_an20.pdf
Value(s) applied	77%
Measurement methods and procedures	the latest approved fNRB figure by the Cambodia DNA will be used for each monitoring period
Monitoring frequency	Fixed by baseline study for a given crediting period, updated if necessary as specified in section 3.1 of the applied methodology
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	Calculation of GHG emissions from NRB
Additional comment	As applicable, NRB assessment may be used for multiple scenarios

Relevant SDG Indicator	**SDG13, SDG7, SDG x**
Data / Parameter	**$U_{p,y}$**
Unit	Percentage
Description	Percentage of bio-digesters in use in monitoring period y
Source of data	Usage survey
Value(s) applied	Ex-ante value applied:
Measurement methods and procedures	A survey consisting of sample of 30 households for each year credited, with a total minimum sample of at least 100 U_p will be calculated as follows: $$U_p = U_{us} \times UP_{us} \times C_y$$ Where U_p = Percentage of biodigesters in use U_{us} = Percentage of biodigesters in use during the usage survey UP_{us} = Fraction of the year that digesters were temporarily out of use due to repairs or sale of animals on average Cy = Correction factor of the number of days out of operation biodigesters were in in operation during monitoring year y. Calculated as $C_y = 1 + \frac{OUT_y}{TOT_y}$ Where, OUT_y = 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 monitoirng period, e.g. times 1 year during annual monitoring)
Monitoring frequency	Annual
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	Calculation of share of units in use
Additional comment	The usage survey will be implemented by NBP or a third party.

Relevant SDG Indicator	**SDG,13, SDG7, SDG**
Data / Parameter	**$N_{p,y}$**
Unit	units
Description	Number of biogas plants commissioned
Source of data	NBP database
Value(s) applied	Ex-ante:
Measurement methods and procedures	100% of all plants are checked after completion of the construction by the PBPO technician. This figure may be reduced in case of experienced BCAs (i.e. those that have built over 500 digesters, the completion check for those BCAs will be at random)
Monitoring frequency	Continuously
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	Calculation of emission reductions
Additional comment	$N_{p,y}$ 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	**SDG 13**
Data / Parameter	**$LE_{p,y}$**
Unit	tCO_{2e}/year
Description	Leakage emission in project scenario during year y
Source of data	Carbon monitoring survey
Value(s) applied	Ex-ante value applied:
Measurement methods and procedures	CMS survey
Monitoring frequency	Updated for every year or more frequently
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	Calculation of emission reductions
Additional comment	

Relevant SDG Indicator	**SDG13**
Data / Parameter	**$MS_{(P)}$**
Unit	[-]
Description	Fraction of livestock category *T*'s manure fed in the biodigester and other MS
Source of data	Monitoring survey
Value(s) applied	Annual
Measurement methods and procedures	See section B.7.2, data will be collected according to the CMS sampling plan
Monitoring frequency	Annual
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	Calculation AWSM emissions
Additional comment	

Relevant SDG Indicator	**SDG13**
Data / Parameter	**$N_{(T)}$**
Unit	[-]
Description	Number of animals of livestock category T
Source of data	CMS survey
Value(s) applied	Annual
Measurement methods and procedures	CMS survey
Monitoring frequency	Annual
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	
Additional comment	

Relevant SDG Indicator	**SDG13**
Data / Parameter	**PL**
Unit	%
Description	Physical leakage of the biodigester
Source of data	IPCC default value for plants that leak
Value(s) applied	10% of those that leak
Measurement methods and procedures	In case household report that their digester leak, in case there is a biogas smell, or when there is visible leakage, i.e. bubbling, the 10% leakage is applied to those households. PL is therefore calculated as: PL = 10% * $\%BD_{leak}$ where $\%BD_{leak}$ = the share of households with a leaking biodigester
Monitoring frequency	Annual
QA/QC procedures	Transparent data analysis and reporting
Purpose of data	
Additional comment	Physical leakage of the bio-digester

Relevant SDG Indicator	**SDG 13**
Data / Parameter	W(site)
Unit	(kg)
Description	Average pig weight at the project site by pig type (sow, boar, fattening pig and piglet (kg)
Source of data	Carbon monitoring survey
Value(s) applied	When IPCC values of VS are adjusted for site specific animal weight as per para 16(c) and equation 2 of AMS-III.D v19 and sampling procedures can be used to estimate this variable as per the “Standard for sampling and surveys for CDM project activities and Programmes of Activities”
Measurement methods and procedures	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 B6.1. In section B6.1 it is described how based on the girth and the length of the pig the weight can be determined reliably[14].
Monitoring frequency	See section B.7.2, data will be collected according to the CMS sampling plan.
QA/QC procedures	
Purpose of data	Calculation of VS excretion
Additional comment	

B.7.2. Sampling plan

>> (If data and parameters monitored in section B.7.1 above are to be determined by a sampling approach, provide a description of the sampling plan.)

The CMS sampling plan is developed using guidance of the applied GS methodology and the UNFCCC standard on sampling (EB 69 annex 5: Standard for Sampling and Survey for CDM Project Activities and Programme of Activities)[15]

1. Sample design of CMS

#	Item	Description
1	Objectives and Reliability Requirements	The objective is to obtain unbiased and reliable estimates of the monitoring parameters at a confidence / precision level of 90/10.
2	Target population	Households that have installed an NBP certified biodigester
3	Sampling method and sampling frame	Probability-Proportional-to-size (PPS) random cluster sampling using a two-stage cluster design: (1) Clusters are selected with probability-proportional-to-size (PPS) at the first stage of sample selection and (2) households are randomly from each cluster at the second stage[16]. The primary sampling units are districts and the second sampling units are randomly selected households belonging to the target group in the clusters. PPS sampling is statistically the most significant sampling method as ensures that each household has the same probability to be selected[16].
3.1	Number of clusters	The selection of clusters involves three primary considerations[17]: **1.** The first is the magnitude of the cluster sampling design effect (D). The design effect is caused by the loss of efficiency as there is a risk that the sample is not as varied as it would be with

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

[15] http://cdm.unfccc.int/UserManagement/FileStorage/S9J6CIEN84WGU1KQBA2MRFH0ZO5LX3

[16] *Magnani (1997) Sampling guide. Food and Nutrition Technical Assistance Project*

17 Robert Magnani, 1997. Sampling guide. Food and Nutrition Technical Assistance project (FANTA). Academy for Educational Development

		simple random sampling. The loss of effectiveness by the use of cluster sampling, instead of simple random sampling, is the design effect. The design effect is basically the ratio of the actual variance, under the sampling method actually used, to the variance computed under the assumption of simple random sampling. The smaller the number of households per cluster and the lower the intra-class correlation[18] the less pronounced is the design effect. This is because elementary units within clusters generally tend to exhibit some degree of homogeneity with regard to background characteristics and possibly behaviours. As the number of households per clusters increases, sampling precision is lost. **2.** Secondly, the numbers of households in a given cluster or site places a limit on how large the per-cluster sample could potentially be. **3.** Third, the resources available to undertake the survey fieldwork dictate what is feasible. Transporting and sustaining field staff and supervisors constitute the major costs of carrying out survey field work, and these tend to vary more or less directly with the number of clusters to be covered. Accordingly, field costs are minimized when the number of clusters is kept small. Because the latter two considerations are likely to vary substantially across applications and settings, only general guidance is offered by Magnani (1997). From a sampling precision point of view smaller clusters are to be preferred over larger clusters. Magnani (1997) mentions that there is no general rule on the number of clusters to be selected, however, the more clusters the more significant it becomes. According to Purnami et al (2011) a reliable way of cluster selection is with the following equation: $$k \approx \left(\frac{n}{2}\right)^{1/2}$$ *Where k is the minimum sample of clusters and n the total population of clusters.* The number of cluster chosen will be > k and preferably around 15 which was custom during CPII
3.2	Design effect and Sampling Design Effect	Usually the design effect (D) of 1 to 3[19] is used. However, in case there is a low degree of homogeneity within the clusters (a district is a large administrative unit and consists of multiple communes (around 10 in each district), each commune contains many villages and important ER variables such as type of fuel, type and number of animal and biodigester size vary considerably amongst households), the households are known ex-ante (all household data is recoded and stored in the project database)

[18] *The intra-class correlation is a measure of the degree of homogeneity (with respect to the variable of interest) of the units within a cluster. Since units in the same cluster tend to be similar to one another, the intra-class correlation is almost always positive (United Nations (2005) Household sample Surveys in Developing and Transition Countries)*

[19] http://faculty.smu.edu/slstokes/stat6380/deff%20doc.pdf

		and the number of units taken from each cluster is small, a low D can be justified. A D of 1.5 is adopted by NBP as the households to be surveyed are known. It is good practice to employ oversampling not only to compensate for any attrition, outliers or non-response associated with the sample but also for the reason that in the event the required reliability is not achieved additional sampling efforts would be required to determine the parameter value (CDM EB 65 Annex 2). Oversampling is employed by increasing the sample size by 10%.
3.3	Sample size	The surveys will be conducted on a sample size estimated by using the "General Guidelines for Sampling and Surveys for Small-scale CDM Project Activities" (CDM EB 65 Annex 2) which prescribes a 90% confidence interval with a 10 % error margin. The VGS methodology applied specifies that if the sample size is large enough to satisfy the 90/10 rule, the overall emission reductions per unit can be calculated per unit or MEAN fuel annual savings per unit. The sample size is calculated using the next equation[20]. $$n = \frac{N}{1 + N(e)^2} \times D \times 110\%$$ Where: n = minimal sample size e = level of precision (10%) N = the biogas population D = design effect 110% = Oversampling of 10% For example, if N is 20,000, the calculated n is (20,000/(1+20,000*10%^2)*1.5*110% = 164 ~ 165. The sample size per cluster is then calculated as: $$n_{cl} = \frac{n}{\#CL}$$ Where: n = minimum sample size #CL = Number of clusters n_{cl} = Cluster sample size With the example sample size of 165 households, the cluster sample size is consequently 165/15 = 11. In case a district is selected as cluster containing less than 11 biogas households, the neighbouring district will be added to the

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

		cluster to ensure that the cluster contains 11 or more households. This may happen if NBP recently started in the particular district.
4	Sampling frame	The sampling frame is a random selection of households that belong to the target population in the selected cluster

2. Data

#	Item	Description
i	Field measurements	The survey will consist of household visit in random selected end-users to collect data described in section B.7.1 with the objective to collect reliable and unbiased fuel data. The data will be collected using interview methods, the interviewee will be either the head of the household or the wife of the head of household. Ensured is that seasonal pattern of fuel use of the thermal application is captured by collecting data about fuel consumption for each season. The results will be scaled up to the whole year.
ii	Quality Assurance/Quality Control	Several mechanisms will be put into place to avoid non-sampling errors (bias) and to obtain reliable date for each parameters: • **Good Questionnaire Design and piloting** The survey questionnaire will be developed and tested under real life conditions (pilot testing: taken to the field and tested with farmers as interviewees). The outcome of that testing will result in an improved questionnaire and will only be used after approval of NBP • **Data collection** Data will be collected for each season to ensure that seasonal pattern of fuel use of the thermal application is captured. Data on annual fuel consumption will be cross-checked with purchase receipts where possible. When fossil fuel receipts are not available, the household will be asked to gather the fuel consumption consumed over a recent period of time; calibrated weighing scale will be used by the surveyor to measure the fuel consumption reliably. • **Cross checking** A random selection of 10% of the surveyed households will be crosschecked by telephone. All important ER relating data collected during the survey will be cross checked with the respondent during the telephone call or household visit. • **Data entry and cross checking** Data will be entered by trained personal.
iii	Procedures for Administering Data Collection and Minimizing Non-Sampling Errors	The survey team will interview a random selected household and answers will be recorded in a questionnaire, in case of non-response the surveyor will proceed to the next household. The surveyor will document the out of population cases, refusals and other sources of non-response. Also, the surveyor will only interview informed interviewees, i.e. interviewees with knowledge on cooking and the

		biogas plant. The original questionnaire used will be made available for inspection by DOE.

3. Implementation

#	Item	Description
i	**Implementation**	The CMS will be executed at least annual or more frequent. The data collection will be executed by an independent entity which is selected on a number of criteria (experience, legal status of the company, quality of their proposal). Persons involved will have the following qualifications and experience: • Surveyors: Person that is trained by the survey team leader • Survey team leader: Experience person and has been involved in at least 2 other surveys • Reporting and PDD updating: Person that is involved in at least one verification or in large related surveys
ii	**Data storage arrangement:**	All data obtained from the CMS will be stored in a database, which will contain the data of the sampled households for each monitoring interval: 1. Location of each biogas plant surveyed; 2. Name of each biogas plant owner; 3. Unique code of each surveyed biogas plant; 4. Size of each surveyed biogas plant; 5. Type of biogas plant; 6. Name and ID of mason that built the biogas plant; 7. Number of animals (Pig, buffalo, cattle and dairy Other cattle); 8. Fuel consumption (kg/year) of surveyed households; 9. Date of commissioning for each plant;

C. Usage survey

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.

The majority of interviews in a usage survey will be conducted in person and include expert observation by the interviewer within the kitchen in question, while the remainder may be conducted via telephone by the same interviewers on condition that in kitchen observational interviews are first concluded and analysed such that typical circumstances are well understood by the telephone interviewers.

The usage survey procedure is as follows:

- Each year NBP will monitor the usage of the biogas units by selecting randomly at least 30 samples (biogas households)[21] 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.

The US sampling plan

- **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 visits 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, each observation is chosen randomly and entirely by chance, such that each observation has the same probability of being chosen.
- **Implementation:** The US will be executed at least annually or more frequent. The data collection will be executed by PBPO or NBP staff.
- **Desired Precision/Expected Variance and Sample Size.** The minimum total sample size is 100, with at least 30 samples for project technologies of each age being credited. The applied methodology does not prescribe a desired precision. However, since the sample size will be larger than 100, the minimum monitoring requirement for monitoring surveys are met.
- **Procedures for Administering Data Collection and Minimizing Non-Sampling Errors:** As per CMS monitoring plan

D. Baseline and Project Fuel test

The baseline performance field test (BFT) and the project performance field test (PFT) measure real, observed technology performance in the field. Consumption is measured with a representative sample of end users under each defined baseline scenario (in the absence of the project technology) and project scenario.

The BFT/PFT is executed according to this protocol:

- The minimum recommended test period is 3 days as per methodology. NBP however had with success applied a lower than recommended test period of 1 day during the previous MP. Therefore, the test period shall be 1 days[22]
- The selected test day will span fuel measurement consumption for human food cooking and boiling water totalling 24 hours.
- Cooking practices shall be during 'normal days'. Normal days are defined as periods without extra eaters. Depending on the family, this excludes days like festivals or holidays or weekend days. The MC can take place in the weekend if it can be proven that fuel use is not higher during these days (i.e. the same number of people eat meals as during the week).

[21] See page 24 of the methodology

[22] *A MC of 1 days (24 hour) is allowed by the GS*

- Households are instructed that they cook normally during the test. The aim is to capture their usual behaviour in the kitchen, as if no tests were happening, to feed the usual variation of people with the usual variation of food types.
- To conduct the tests, ensured is that the cook uses fuel only from a designated stock which is pre-weighed.
- During the tests, also was find out how many people have eaten and how many meals each, so that you can enter into the data sheet the number of "person-meals" (individual meals as opposed to meals shared) cooked with the weighed fuel each day. Note that this count can include meals sold commercially as well as meals consumed in the domestic environment. The number of people eating meals shall be recorded using the following categories: Child 0-14 years, Female over 14 years, male 15-59 and male over 59 years old.
- Fuel will not be provided to the households, but they will be assisted with gathering enough wood if necessary. The reason being is that the main fuel, wood, is not purchased but collected. Subjects can be told they will be rewarded for their effort and time at the end of the test, once it is successfully completed. The PFT design is depicted in the table below

Table 21: PFT and BFT survey design

Item	Conversion in PFT	Conversion in BFT
Sampling objective:	The objective of the sampling effort is to obtain reliable fuel use data of project households	Idem but of baseline households
Field Measurement Objectives and Data to be collected:	The survey will consist of a 24 hour measurement campaign	idem
Target Population and Sampling Frame:	The sampling frame will be drawn from the project database	Households are those with the technical potential for biogas and with the same socio-economic and cultural practices as the PFT households and similar stove and fuel usage as collected by the baseline survey
Sampling method (approach):	Cluster random sampling using the CMS sampling frame with a minimum sample of 30 households	Neighbouring households to the PFT households
Implementation:	Biennial	Once in CPIII and to be executed for MPI
Desired Precision/Expected Variance and Sample Size.	90/10 rule of the applied methodology or the lower bound of the one-sided 90% confidence interval in case 90/10 is not achieved	
Procedures for Administering Data Collection and Minimizing Non-Sampling Errors:	The test will be executed by a third party and 10% of the households will be double checked either by visits or telephone calls	

B.7.3. Other elements of monitoring plan

>>
N/A

SECTION C. Duration and crediting period

C.1. Duration of project

C.1.1. Start date of project

>> (Specify start date of the project, in the format of DD/MM/YYYY. Describe how this date has been determined as per the definition of start date provided in section 3.4.3 of GS4GG Principles & Requirements document and provide evidence to support this date.)

The starting date is 13 March 2006
The starting date for retroactive Gold Standard application 24/05/2009

C.1.2. Expected operational lifetime of project

>> (Specify in years)

The expected operational lifetime of the project is 25 years.

C.2. Crediting period of project

C.2.1. Start date of crediting period

>> (Specify in dd/mm/yyyy. This can be start of project operation or two years prior to the date of Project Design Certification, whichever is later.)

Start date of third crediting period is 1/1/2019

C.2.2. Total length of crediting period

>> (Specify the total length of crediting period sought in line with GS4GG Principles & Requirements or relevant activity requirements.)

7 years

SECTION D. Safeguarding principles assessment

D.1. Analysis of social, economic and environmental impacts

>> (Refer the GS4GG Safeguarding Principles and Requirements document for detailed guidance on carrying out this assessment.)

Safeguarding principles	Assessment questions	Assessment of relevance to the project (Yes/potentially /no)	Justification	Mitigation measure (if required)
3.0 SOCIAL & ECONOMIC SAFEGUARDING PRINCIPLES				
3.1 Principle 1 - Human Rights	1. Does the project respect internationally proclaimed human rights and is not be complicit in violence or human rights abuses of any kind as defined in the Universal Declaration of Human Rights? 2. Does the project discriminate with regarding to participation and inclusion?	No	1. Cambodia has signed and ratified the "International Convention Economic, Social and Cultural Rights" and the "International Covenant on Civil and Political Rights[23]". The project respects human rights, including dignity, cultural property and uniqueness of indigenous people. The installation of biodigesters relies on individual households voluntarily investing. The voluntary nature of this purchase will ensure that the individual dignity, cultural property and uniqueness of indigenous peoples are respected. Thus, the project is not complicit in Human Rights abuses 2. Cambodia ratified the ILO Convention C087 (Freedom of Association and Protection of the Right to Organise Convention, 1948) and C098 (Right to Organise and Collective	N/A

[23] *https://tbinternet.ohchr.org/_layouts/TreatyBodyExternal/Treaty.aspx?CountryID=29&Lang=EN*

			Bargaining Convention, 1949)[24] All staffs are voluntary working under NBP and are free to form association and provide feedback. Employment at NBP, PBPO or franchised enterprises, BCAs, do not discriminate against individuals and employment of staff is not based on gender, race, religion, sexual orientation or on any other basis.	
3.2 Principle 2 - Gender Equality and Women's Rights	**Gender assessment question** 1. Is there a possibility that the Project might reduce or put at risk women's access to or control of resources, entitlements and benefits? 2. Is there a possibility that the Project can adversely affect men and women in marginalised or vulnerable communities (e.g., potential increased burden on women or social isolation of men)? 3. Is there a possibility that the Project might not take into account gender roles and the abilities of women or men to participate in the decisions/designs of the project's activities (such as lack of time, child care duties, low literacy or educational levels, or societal discrimination)? 4. Does the Project take into account gender roles and the abilities of women or men to benefit from the Project's activities 5. Does the Project design contribute to an increase in women's workload that	No	1. No, the project does not affect control of resources, entitlements and benefits as, on the contrary, it brings benefits on time and resources savings which are mainly accrued to women 2. Project does not adversely affect men and women in marginalised or vulnerable communities 3. No, on the contrary as per item 2 above. It frees up time. NBP is open to all but there are certain societal barriers that prevent women to attend certain meetings due to household chores. Therefore, users' trainings and small group meetings are organized at a time convenient for women, around 8:30-9:30. In fact, in 2017, 1342 out of 2338 participants on compos training were female and 5868 out of 9117 participants of the small group meetings were female and 55% of the	N/A

[24] http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:11200:0::NO::P11200_COUNTRY_ID:103055

	adds to their care responsibilities or that prevents them from engaging in other activities? 6. Would the Project potentially reproduce or further deepen discrimination against women based on gender, for instance, regarding their full participation in design and implementation or access to opportunities and benefits? 7. Would the Project potentially limit women's ability to use, develop and protect natural resources, taking into account different roles and priorities of women and men in accessing and managing environmental goods and services? 8. Is there a likelihood that the proposed Project would expose women and girls to further risks or hazards?		user trainings were female[25] 4. The Project has taken into account gender roles and the abilities of women or men to benefit from the Project's activities. The Project is demand driven and any minority, if they have the ability to pay and enough manure, can invest. 5. On the contrary, it saves women a lot of time by no having to collect wood, faster and more convenient cooking and less cleaning of pots and pans as not soot is produced. 6. No, most of the benefits are accrued to women, see item 5 and the project does therefore not deepen discrimination 7. The Project does not limit women's ability to use, develop and protect natural resources as it would help women eliminate the need to collect firewood and therefore it protects natural resources. 8. Biodigesters are a safe and established technology in Cambodia, so no risks are anticipated regardless of gender, women, girls or boys.	
	The Project shall not directly or indirectly lead to/contribute to adverse impacts on gender equality and/or the situation of women. Specifically, this shall include (not exhaustive):	No	**1. T**he project is not complicit in Sexual harassment and/or any forms of violence against women - address the multiple risks of gender-based violence, including sexual exploitation or human trafficking.	

[25] NBP 2017 annual report

			Slavery, imprisonment, physical and mental drudgery, punishment or coercion of women and girls. There are no restriction of women's rights or access to resources (natural or economic).	
	Projects shall apply the principles of non-discrimination, equal treatment, and equal pay for equal work, specifically: • Where appropriate for the implementation of a Project, paid, volunteer work or community contributions will be organised to provide the conditions for equitable participation of men and women in the identified tasks/activities. • Introduce conditions that ensure the participation of women or men in Project activities and benefits based on pregnancy, maternity/paternity leave, or marital status. • Ensure that these conditions do not limit the access of women or men, as the case may be, to Project participation and benefits.	No	- Contributions are equal and equitable. Pay is fixed for masons and independent of gender. - both men and women are free to participate in any of the activities. - There are no restrictions. The program is demand driven and has therefore no influence on who wants to invest	
3.3 Principle 3 - Community Health, Safety and Working Conditions	1. Are adverse impacts on the health and safety of affected communities during the Project's life cycle from both routine and non-routine circumstances happening?	1. no	The Cambodian Constitution provides Cambodians with a range of rights and obligations such	

	2. Are workers provided with safe and healthy working conditions and to prevent accidents, injuries, and disease?	2.?	as Articles 228-232 of the Labour Law[26] 1. Biodigesters hygienically treat waste and eliminate household air pollution. Health consequently will be improved 2. All masons are trained and certified on safe working conditions. NBP obliges mason to buy an accident insurance which is the most dangerous activity.	
3.4 Principle 4 - Cultural Heritage, Indigenous Peoples, Displacement and Resettlement	**3.4.1 Sites of Cultural and Historical Heritage** 1. Does the Project Area include sites, structures, or objects with historical, cultural, artistic, traditional or religious values or intangible forms of culture (e.g., knowledge, innovations, or practices)? **3.4.2 Forced Eviction and Displacement** 2. Does the Project require or cause the physical or economic relocation of peoples (temporary or permanent, full or partial)? **3.4.3 Land Tenure and Other Rights** 3. Does the Project require any change to land tenure arrangements and/or other rights? **3.4.4 Indigenous Peoples** 4. Are indigenous peoples present in or within the area of influence of the Project and/or is the Project located on land/territory claimed by indigenous peoples?	1. No	Cambodia has signed and ratified the "Convention for the Safeguarding of the Intangible Cultural Heritage, 2003"[27] 1. The project area are most provinces in Cambodia, but the site of the digesters is located at backyard of farms without any objects with historical, cultural, artistic, traditional or religious values or intangible forms of culture on a voluntary basis and does not involve and is not complicit in the alteration, damage or removal of any cultural heritage., 2. No, biodigesters are only built at the premise of a household farm 3. No, as above, the project does not result	

[26] http://www.cambodiainvestment.gov.kh/the-labor-law-of-cambodia_970313.html

[27] http://portal.unesco.org/en/ev.php-URL_ID=33391&URL_DO=DO_TOPIC&URL_SECTION=201.html

			in a change in land tenure rights. 4. No, no land claims by indigenous people occur nor do indigenous people live in the project area.	
3.5 Principle 5 - Corruption	The Project shall not involve, be complicit in or inadvertently contribute to or reinforce corruption or corrupt Projects.	1. no	Cambodia ratified the United Nations Convention against Corruption in September 2007[28] The NBP, PPBO, BCA masons etc. do not engage in any type of corruption activities	
3.6 Principle 6 - Economic Impacts	**Does the project:** 1. Promote equitable, sustainable economic growth and stability and Projects that are appropriate and considerate of the economic situation in which they are developed? 2. Respect and promote worker's rights, to promote the right to decent work, fair treatment, non-discrimination, and equal opportunity for workers, and to avoid the use of forced labour and child labour? 3. Prioritise appropriate and properly considered local employment and procurement wherever possible? **3.6.1 Labour rights** 1. Are working conditions in compliance with national labour and occupational health and safety laws? 2. Are workers allowed to establish and join labour organisations?	1. no 2. No 3. no	1. Yes, most farmers rely on wood for cooking and biogas is a solution to their problems related to wood collection and air pollution. Also, the bio-slurry helps them to improve farm economics. All farmers have access to the biodigester, provided they have the ability to pay and enough livestock. Those without it, could become masons and earn an income by constructing biodigesters 2. Yes, because masons can only get certified when 18 years old, likewise unskilled masons are at least 18 years old because as per Cambodian labour law. The selection of masons is not based on gender, race, or religion, but based on ability, willingness to work, basic education etc. 3. All employment is local, and masons live in the same district as where they work **3.6.1 labour rights**	

[28] http://www.unodc.org/unodc/en/corruption/ratification-status.html

	3. Are working agreements with all individual workers documented and implemented? Are working hours not more than 48 hours per week? Is there a provision for overtime? Modalities on health insurance? Modalities on termination of contract with provision of voluntary resignation. Is there provision for annual leave of 10 days or more? 4. Is the employment model applied local and culturally appropriate? 5. Is there child labour? What age verification mechanisms does the project employ to prevent this? **3.6.2 Negative economic consequences** 1. Can NBP demonstrate that the Project implemented (Biodigesters) are financially sustainable beyond the project crediting period? 2. Does the project consider potential risk to the local economy and have these been taken into account in the project design, implementation, operation and after the project? Including ensuring that the benefits are socially inclusive and	3.6.1 labour rights no **3.6.2 negative social** consequences no	1. Yes, working conditions of masons are in compliance with national labour law and occupational health and safety laws. 2. Yes, they are allowed to join any organisations, union or labour. Cambodia ratified the ILO Convention C087 (Freedom of Association and Protection of the Right to Organise Convention, 1948) and C098 (Right to Organise and Collective Bargaining Convention, 1949)[29] 3.BCAs and masons are independent from NBP, however the franchise contract with NBP stipulates that they have to follow the labour law. There is no provision for overtime – as workers are all freelance. An accident insurance is provided to the masons by the BCA. No, but masons work on a freelance basis, and work is often one digester or a few at the time 4. Yes, all is the employment model is culturally appropriate 5. Certification of masons is only possible aged 18 and above. The certification is the ID card. NBP verifies this with the ID card or birth certificate **3.6.2 Negative economic consequences** 1. Yes, warrantee is still offered after the crediting period by locking a after warrantee fee for BCAs that will only be released after the warrantee period. Furthermore, once a biodigester is constructed,	

[29] http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:11200:0::NO::P11200_COUNTRY_ID:103055

	sustainable also to vulnerable and marginalized social groups?		they last for around 20 years. 2. No risks are attributed or associated with this project. On the contrary skilled and non-skilled employment is created benefitting the rural economics reducing the need to migrate for good quality jobs.	
4.0 ENVIRONMENTAL & ECOLOGICAL SAFEGUARDING PRINCIPLES				
Principle 1 - Climate and Energy	**1.** Will the Project increase greenhouse gas emissions over the Baseline Scenario? 2. Will the Project use energy from a local grid or power supply (i.e., not connected to a national or regional grid) or fuel resource (such as wood, biomass) that provides for other local users?	No	1. No, as can be observed from the results from CPII and CPI 2. No, the project relies on manure which is currently not used a fuel	
Principle 2 – Water	Will the Project affect the natural or pre-existing pattern of watercourses, ground-water and/or the watershed(s) such as high seasonal flow variability, flooding potential, lack of aquatic connectivity or water scarcity?	No	1. No the construction of biodigesters does not affect natural or pre-existing pattern of watercourses, ground-water and/or the watershed	
4.2.2 Erosion and/or Water Body Instability	1. Could the Project directly or indirectly cause additional erosion and/or water body instability or disrupt the natural pattern of erosion? If 'Yes' or 'Potentially' proceed to question 2 2. Is the Project's area of influence susceptible to excessive erosion and/or water body instability?	No	1. No, the construction occurs in backyards and does not cause erosion 2. Not applicable.	
Principle 3 – Environment, ecology and land use				
4.3.1 Landscape Modification and Soil	1. Does the Project involve the use of land and soil for production of crops or other products?	no	1. No, the construction of biodigesters does not use soil or crops.	

4.3.2 Vulnerability to Natural Disaster	Will the Project be susceptible to or lead to increased vulnerability to wind, earthquakes, subsidence, landslides, erosion, flooding, drought or other extreme climatic conditions?	no	1. No, the construction of biodigesters is not related to these risks.	
4.3.3 Genetic Resources	Could the Project be negatively impacted by the use of genetically modified organisms or GMOs (e.g., contamination, collection and/or harvesting, commercial development)?	No	1. This is not applicable to the project as it does not produce crops	
4.3.4 Release of pollutants	Could the Project potentially result in the release of pollutants to the environment?	No, or not larger than the baseline	1. Digester effluent can cause local eutrhopifcaiton if not use similar to the baseline situation. However, most farmers use bio-slurry which is a superior fertilizer compared to farm yard manure and the impact is therefore less on the environment compared to the baseline.	
4.3.5 Hazardous and Non-hazardous Waste	Will the Project involve the manufacture, trade, release, and/ or use of hazardous and non-hazardous chemicals and/or materials?	No	1. No hazardous and non-hazardous chemical are involved in biodigester use and construction	
4.3.6 Pesticides & Fertilisers	Will the Project involve the application of pesticides and/or fertilisers?	Yes	1 Farmers are trained to use bio-slurry as effective organic fertilizer which can improve yields and soil quality. However, the project does not encourage using chemical fertilizers	
4.3.7 Harvesting of Forests	Will the Project involve the harvesting of forests?	No	On the contrary, the project will result in a lower demand for firewood	
4.3.8 Food	Does the Project modify the quantity or nutritional quality of food available such as through crop regime alteration or export or economic incentives?	No	On the contrary, bio-slurry is a very good fertilizer which improves crop quality	
4.3.9 Animal husbandry	Will the Project involve animal husbandry?	No	The project involves the construction of biodigesters through the development of a private sector. Households that	

			invest however, raise animals, but the project only focusses on the manure excreted and managed	
4.3.10 High Conservation Value Areas and Critical Habitats	Does the Project physically affect or alter largely intact or High Conservation Value (HCV) ecosystems, critical habitats, landscapes, key biodiversity areas or sites[12] identified?	No	Not applicable, the project only built digesters in backyards of farmers	
4.3.11 Endangered Species	1. Are there any endangered species identified as potentially being present within the Project boundary (including those that may route through the area)? 2. Does the Project potentially impact other areas where endangered species may be present through transboundary affects	No	1. No, the project only focusses on rural areas with technical potential for biogas. These exclude area where endangered species may live 2. No, as above	

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from stakeholders

>> (Describe how stakeholder consultation was conducted in accordance with GS4GG Stakeholder Procedure Requirements and Guidelines.)

The stakeholder feedback round was organized as per GS4GG Stakeholder procedure requirements and guidelines. A 2 month feedback period was initatied on the 10th of August until the 10th of October. Stakeholders were pro-actively contacted by email and through Facebook. It is anticipated that through Facebook over 100,000 Cambodians will be reached. Botht the email and the facebook advertisement include a link to the NBP website were all documents, including the PDD, can be found.

E.2. Summary of comments received

>> (Provide a summary of key comments received during the consultation process.)

N/A – will be made available after the closing of the SFR

E.3. Report on consideration of comments received

>> (Describe how the comments have been addressed by providing a clarification to the stakeholder or by altering the design of the project or by proposing to monitor any anticipated negative impacts etc.)

N/A – will be made available after the closing of the SFR

Appendix 1. Contact information of project participants

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
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Salutation	Mrs.
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Middle name	N/A
First name	Saoleng
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Appendix 2. Summary of post registration design changes

N/A

Revision History

Version	Date	Remarks
1.1	24 August 2017	Updated to include section A.8 on 'gender sensitive' requirements
1	10 July 2017	Initial adoption